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ANALYSIS AND DESIGN OF A WAREHOUSE STRUCTURE USING E-TABS

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Abstract: *In India, because of quick development of industrialization, there emerge a need of capacity and assembling of merchandise which can be satisfied by appropriate planned mechanical distribution center. This examination gives a plan to complete the structure of a modern distribution center. This point of work is chosen as to know the various kinds of power/load impacts to be considered while planning mechanical stockroom with the assistance of writing audit. This structure is proposed to configuration as per IS 800:2007 and the dead, live, the breeze load investigation is finished by IS 875:1987 (Part-I, Part-II, Part-III). In the Present investigation a steel confined distribution center structure is dissected and planned in seismic zone III by utilizing programming "ETABS". ETABS represents Extended Three-Dimensional Analysis of Building Systems. The primary motivation behind this product is to plan multistoried structure and steel structure in an efficient procedure. The powerful plan and development of seismic tremor safe structures have incredible significance everywhere throughout the world. So, this task displays the steel structure distribution center planned and examinations with parallel stacking impact of quake by utilizing ETABS programming. This undertaking is planned according to Indian code norms according to IS 1893-part2:2002 and IS 456:2000. The plan includes figuring relocations, shear and toppling minutes in seismic zone III. The even bracket components at the rooftop and mid-tallness of the structure are move supports to help convey toppling powers from the inside props to the structure outside.*

CHAPTER – 1
INTRODUCTION

1.0 General

A modern shed is any structure utilized by the business to store crude materials or for assembling results of the business is known as a mechanical structure. Modern structures might be sorted as Normal kind mechanical structures and Special sort mechanical structures. Typical sorts of modern structure are shed sort structures with straightforward rooftop structures on open edges. These structures are utilized for workshop, distribution centers and so forth. These structures require huge and clear zones unhampered by the segments. The huge floor territory gives adequate adaptability and office to later change in the creation design without significant structure adjustments. Unique kinds of modern structures are steel plant structures utilized for assembling of overwhelming machines, generation of intensity and so on. The capacity of the mechanical structure manages the level of advancement. A structure is an aggregate consequence of thought, plan, material, labor, time, account and so on. As need is the mother of innovation, correspondingly, kind of development and its legitimate required plan is a need.

1.1 Construction process of a warehouse Building

Steel confined structure development starts with the development of its establishment. For the most part, the kinds of establishment required for the given structure depends on the dirt bearing limit. Soil examination including surface and subsurface investigation is utilized to survey the state of soil on which steel casing structure rests. For model, when moderate or low loads are forced, at that point it is encouraged to utilize strengthened solid bearing cushions or strip establishment. These establishment types move burdens to soil equipped for supporting moved burdens.

Fig 1: the exterior of a warehouse building

Fig 2: the interior of a warehouse building

On the off chance that the quality of soil is poor and the forced burden is huge, at that point it is prescribed to consider heap establishment. The heap establishment would move the heap of the structure to the firm soil.

1.3 Steel Column Construction

The following stage of steel outline development is the position of steel segments. The segment of the steel is indicated dependent on the heap forced. There are different sizes of steel segment area to pick and these steel sections are ordinarily created ahead of time. The most noteworthy point in segment establishment is the association among establishment and segment and grafts between sections. As to segment joints, base plates are welded as far as possible of sections. The most wanted state of base plate is square and rectangular shape. Run of the mill subtleties of section to establishment association are appeared in Figure-6. It ought to be realized that, the most wanted state of base plate is rectangular and square shape on the grounds that such plates give biggest dispersing between the jolts which is alluring.

Fig 4: Pile foundation to transfer loads of steel frame structure though low soil bearing capacity of stiff soil with adequate bearing capacity

1.4 Erection of Steel Beams

Different pre-assembled pillar areas are accessible to be utilized in the development of multi story steel casing structure. Shafts usually move loads from floors and rooftop to the segments. Steel pillar individuals can length up to 18m, however the most common scope of steel shaft ranges rang from 3m to 9m. While steel shafts are raised, segment to bar association and bar to pillar associations are experienced. There are various kinds of segment to pillar association which are chosen dependent on the sort of burdens forced on the segment to shaft joint. For instance, on the off chance that the joint is exposed to vertical loads just, at that point basic associations are utilized.

CHAPTER – 2
LITERATURE REVIEW

2.0 Introduction

This part manages a concise survey of the past and late investigation performed by analysts on Industrial distribution center structures.

M. Suneetha finished a numerical report and presumed that Weight of single Truss using Angle and Pipe both is less contrasted with PEB yet as a result of Weight of Channel Purlin, Weight of Steel Truss Building is on higher side. Vaibhav B. Chavan, decided ideal range length for economy.

Creator C.M. Meera made a relative report between Pre-Engineered Building (PEB) and Conventional Steel Building (CSB) and breaking down the plan edges utilizing auxiliary investigation and structure programming STAAD PRO.

Subhrakant Mohakul planned an Industrial distribution center and did a careful investigation of conduct of individuals because of impact of disappointment at associating joints.

Manan D. Maisuri expressed that the utilization of steel of entire modern structure can be decreased by choosing fitting geometry of support and by utilizing empty steel segment with contrast with traditional steel segment. Subsequently expressing cylinder segments are generally affordable.

Research paper by Shaiv Parikh accentuation on the significance of pressure individuals and gives brief portrayal about the attributes and the conduct of steel pressure individuals.

A. Jayaraman presents an investigation on conduct and efficient of rooftop brackets and channel segment purlins by correlation of LSM and WSM. Yash Patel states the significance of rounded segments and finishes up the financial points of interest of cylindrical areas.

Aijaz Ahmad Zende, Prof. A. V. Kulkarni, Aslam Hutagi (2013),"Comparative Study of Analysis and Design of Pre-Engineered-Buildings and Conventional Frames. The present work includes the similar investigation of static and dynamic examination and plan of Pre-Engineered Buildings (PEB) and Conventional steel outlines. Plan of the structure is being done in Staad Pro programming and the equivalent is then contrasted and traditional sort, as far as weight which thus diminishes the expense. Three models have been taken for the examination. Correlation of Pre-Engineered Buildings (PEB) and Conventional steel casings is done in two models and in the third model, longer length Pre-Engineered Building structure is taken for the investigation. In the present work, Pre-Engineered Buildings (PEB) and Conventional steel casing's structure is intended for dynamic powers, which incorporates wind powers and seismic powers. Wind examination has been done physically according to IS 875 (Part III) – 1987 and seismic investigation has been done according to IS 1893 (2002). To Conclude "Pre-Engineered Building Construction gives the end clients a substantially more prudent and better answer for long range structures where enormous section free zones is required".

C. M. Meera (2013),"Pre-Engineered Building Design of an Industrial distribution center", International Journal of Engineering Sciences and Emerging Technologies. This paper is a near investigation of PEB idea and CSB idea. The investigation is accomplished by planning an ordinary edge of a proposed Industrial Warehouse building utilizing both the ideas and dissecting the planned casings utilizing the basic examination and structure programming Staad Pro. He inferred that PEB structures can be effectively planned by basic plan techniques as per nation norms. In light of the investigation, it tends to be presumed that PEB structures are more profitable than CSB structures as far as cost viability, quality control speed in development and effortlessness in erection. The paper likewise bestows basic and prudent thoughts on fundamental structure ideas of PEBs. The idea delineated is useful in understanding the plan strategy of PEB idea.

M.G. Kalyanshetti, Comparison between Conventional Steel Structures and Tubular Steel Structures. This examination includes the economy, load conveying limit of every single basic part and their comparing security measures. Economy was the principal objective of this investigation including examination of regular segmented structures with cylindrical separated structure for given necessities. For study reason superstructure-some portion of a modern structure is considered and correlation is made. Research uncovers that, up to 40 to half sparing in expense is accomplished for square and rectangular cylindrical segments.

Trilok Gupta, Ravi K. S Harma, "Investigation of Industrial Shed utilizing Different Design Philosophies". The research includes different sorts of modern rooftop brackets by utilizing PC programming. It likewise includes the learning in regards to steel rooftop brackets and the plan ways of thinking with worked models. From the perceptions they presumed that, the areas planned utilizing utmost state techniques are more practical than the segments utilizing working pressure strategy. It was seen that the rounded segment structured by cutoff state strategy was the most efficient among the three areas which were utilized.

CHAPTER – 3
METHODOLOGY

3.0 General

Structures on the earth are generally presented to sort of weight: Static and Dynamic. Static Loads are unfaltering with time while dynamic weights are time moving. All things considered the greater part of basic structure structures are arranged with the assumption that each applied weight are static. The effect of dynamic weight isn't considered in light of the fact that the structure is rarely presented to dynamic stacking; even more along these lines, its idea in examination makes the game plan progressively caught and monotonous. This segment of disregarding the dynamic weights transforms into the explanation behind catastrophe sometimes, especially because of tremors. The best and the progressing instance of this characterization is the Bhuj seismic tremor of January 26, 2001, which ensured more than 15000 lives and left various desperate and did huge damage in the region in all points of view. By and by a day there is a creating eagerness for the route toward arranging Civil planning structures equipped to withstand dynamic weights, particularly the seismic tremor started load.

3.1 Basic Theory

The key state of static congruity under evacuating strategy is given by F(ext) = ky where F (ext), is the external applied static weight control, k is the solidness resistance, and 'y' is the ensuing movement. The restoring power 'ky' contradicts the applied power.

By and by if the applied forces change to dynamic power or time varying force the state of static agreement power winds up one of the dynamic parity controls and has the structure

F(ext) = m y: + cy. +ky 3.1

In case quick assessment is done between the two conditions, by then two additional forces that contradict the applied forces with the restoring forces are found. These additional forces are called Inertia Force (m y:) and Damping power

(cy.) coming about as a result of the impelled expanding rate and speeds in the structure.

The nearness of the idleness and the damping powers in the structure during an interesting stacking is the hugest trademark capability between static stacking and dynamic stacking impacts.

The dynamic power may be a shudder power coming about in view of quick improvements along the plane of inadequacies inside the earth outside layer. This sudden improvement of inadequacies releases exceptional imperativeness as seismic waves, which are transmitted to the structure through their foundations, and cause development in the structure. These developments are unpredictable in nature and start unexpected level and vertical movements in structures, which result expanding rates, speeds, and dislodging in the structure. The activated expanding speeds make inertial powers in the structure, which are comparative with accelerating of the mass and acting opposite to the ground development.

The imperativeness made in the structure by the ground development is dissipated through internal contact inside the essential and non-helper people. This dissipating of essentialness is called Damping. The structures reliably have some natural damping, which diminishes with time once the seismic excitation stops. These dissipative or damping forces are addressed by gooey damping powers, which are comparative with the speed incited in the structure. The predictable of proportionality is called as immediate gooey damping.

The restoring power in the structures is comparing to the mutilation induced in the structure during the seismic excitation. The predictable of proportionality is suggested as immovability of the structure. Strength hugely impacts the structures take-up of tremor created powers.

The state of dynamic parity for the seismic tremor power has the structure where, latency, damping and restoring forces balance the applied power,

F(ext) = m y: (t) + cy. (t) +ky(t) 3.2

where is the dormancy forces acting toward a way pivot to that of the seismic progression applied to the base of the structure, whose tremendousness is the mass of the structure times its reviving, m is the mass and 'y:(t)' is the developing rate.

The above condition is a second deals differential condition that ought to be managed for the ousting y(t). The proportion of differential conditions required for picking the circumstance of the mass centers is known as the proportion of Degrees-of-Freedom required to get an adequate methodology. This depends on the multifaceted idea of the focal structure. Subordinate upon the degree of plausibility, particular partner models can be proposed for exploring the structure. A structure can be penniless somewhere around different models depending upon the objective of express examination.

3.2 Seismic Methods of Analysis Procedures

Precisely when the structure model is picked, it is required to perform appraisal to pick the seismically provoked powers in the structure. There are different strategies for assessment which gives different degrees of precision. The examination technique can be arranged dependent on three components. 1) The sort of remotely applied weights 2) the direct of structure or helper materials 3) and the kind of essential model picked.

Four strategies are being utilized for seismic assessment of structures: two straight procedures, and two nonlinear methodologies.

- Linear Static Procedure (LSP)
- Nonlinear Static Procedure (NSP) and
- Linear Dynamic Procedure (LDP)
- Nonlinear Dynamic Procedure (NDP)

Static Analysis

The most direct framework for seismic assessment of multi-praised structures is static examination. In this technique the structure is acknowledged to remain adaptable while being presented to static power load movement related with the significant strategy for vibration in this the forces are applied openly along the two boss tomahawks i.e., the longitudinal and explore tomahawks.

Direct Static Procedure

In an immediate static procedure, the structure is exhibited as a relative single-level of-chance (SDOF) system with a straight flexible solidness and an indistinguishable gooey damping. The seismic data is shown by an indistinguishable parallel power with the objective to make unclear weights and strains from the tremor it addresses. In perspective on an estimation of the principal head repeat of the structure using exploratory associations or Rayleigh's procedure, the spooky accelerating is settled from the reasonable response extend which, copied by the mass of the structure, realizes the impacts, immovability degradation, yet moreover power decline as a result of anticipated inelastic lead. The level power is then passed on over forces and expulsions are settled using direct flexible assessment. Straight techniques are appropriate when the typical level of nonlinearity is low. This is evaluated by part solicitation to confine extents (DCRs) of under 2.0.

These straight static techniques are used basically for design purposes and are combined in numerous codes. Their utilization is close to nothing. Regardless, their relevance is restricted to standard structures for which the important strategy for vibration is overpowering.

Non-Linear Static Procedure

The Nonlinear Static Procedure is palatable generally structures. This approach is an improvement over the LSP or LDP as in it permits the inelastic direct of the structure. In any case, this ought to be utilized related to the Linear Dynamic Procedure if mass energy for the essential mode is low. This technique expects a great deal of static enduring flat weight over the height of the structure. This procedure is commonly simple to be completed and gives information the

quality, misshapening and the flexibility of the structure and the allotment of the solicitations. This awards to perceive essential people inclined to land at most remote point states during the tremor. In any case, this strategy contains many obliged doubts which negligence the assortment of weight plans, the effect of higher modes, and the effect of resonation.

3.5 ETABS

ETABS (Extended Three-Dimensional Analysis of Building Systems) is a sophisticated structural analysis and design software developed by Computers and Structures, Inc. (CSI). It is tailored for the modeling, analysis, and design of multi-storey building systems, particularly buildings made of reinforced concrete and steel.

CHAPTER – 4
MODELLING OF STRUCTURE

4.1 Seismic Analysis Procedure as Per the Code:

Exactly when a structure is exposed to seismic tremor, it responds by vibrating. A quake power can be subsided into three normally inverse headings the two even orientation (x and y) and the vertical course (z). This development causes the structure to vibrate or shake in all of the three headings; the mind-boggling direction of shaking is level. All of the structures are basically planned for gravity loads-compel proportionate to mass time's gravity in the vertical bearing. Because of the basic factor of security used as a piece of the arrangement conclusions, most structures tend to be sufficient guaranteed against vertical shaking. Vertical accelerating should similarly be considered in structures with significant extents, those in which reliability for framework, or for general sufficiency assessment of structures.

IS 1893 (segment 1) code recommending that bare essential powerful examination, or pseudo static assessment should be finished depending upon the criticalness of the issue. IS 1893(part1): 2002 endorses use of particular examination using response go procedure and proportionate parallel power system for working of stature under 40 m in each seismic zone.

In all of the procedures for analyzing multi-story structures recommended in the code, the structure is managed as discrete system having amassed masses at floor levels, which fuse part of that of areas and dividers above and underneath the floor. Similarly, appropriate proportion of live burden at this floor is moreover lumped with it.

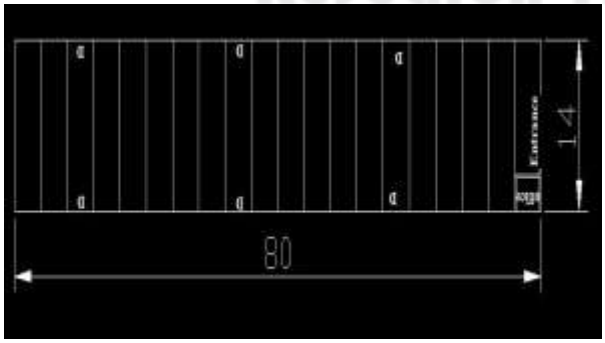


Fig 14: The plan of structure 80mx14m

4.2 Modelling

ETABS is one of the items which works over limited component technique created by PCs and structures, Inc. (CSI), which is utilized for planning and examination the tall structures with limited component techniques.

Bay Frame

Inserting no. of bays in x-axis and y-axis with spacing between the bays

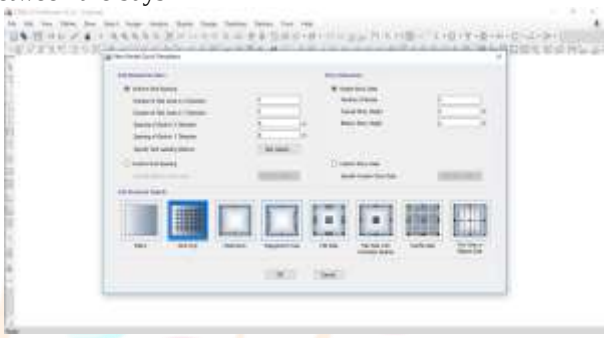


Fig 17: Model quick templates

Giving the storey details, which contains storey height and no. of stories?

Fig 18: Storey data

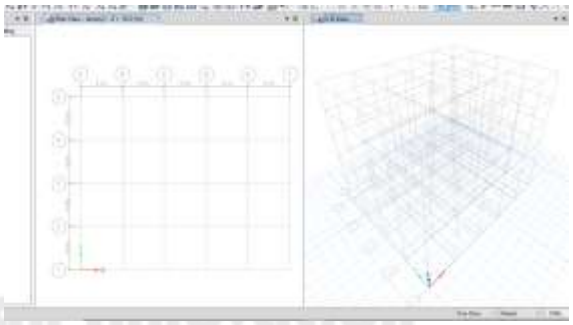


Fig 19: Plan chosen for modelling

4.2.2 Reinforcement

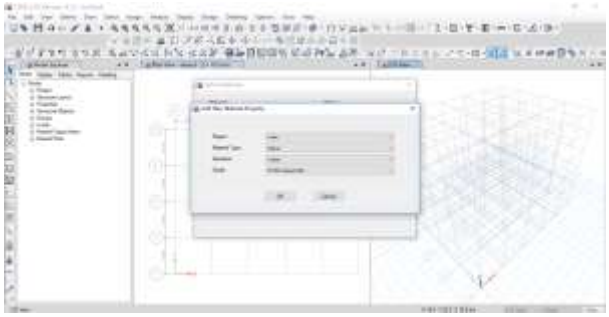


Fig 22: Rebar selection

Fig 23: Modifying the properties of reinforcement

Mass per unit volume = 76.9729kN/m3
Modulus of elasticity, E= 200000Mpa
Coefficient of thermal Expansion, A=0.0000117

4.3 Loads Applied

In this examination, the area for proposed structure and measurements were fixed by the prerequisite and considering various parameters like extra room required, sufficient lighting, and so forth. The insights regarding distribution center are given beneath;

An arrangement as indicated by necessity and considering compositional perspectives was readied. Triangular support was embraced with rooftop incline 1:5. For this range length, the Triangular supports would be typically effective and conservative. Inexact range to profundity proportion is about L/8 to L/12. Bracket Spacing might be in the scope of 1/fourth to 1/fifth of the range length. Profundity of bracket, dispersing of supports, separating of purlins were chosen by particulars. Size of GI sheeting differs from 8 to 11 layerings per sheet. The heaviness of sheet differs from 50-156 N/m2. Choice of gravity stacks for the most part control the straight size. For structures without cranes, a 9m straight is the most appropriate and practical decision. Capacity of propping is to move even loads from the edges to establishment. Purlins go about as parallel bracings to the pressure harmonies. The parallel binds give comparative capacities to the base harmony individuals when they are exposed to pressure because of inversion of stacking. Purlins are a piece of rooftop propping framework. The heaviness of purlins in the all-out weight of steel structure could shift from 10-25%. The heaviness of purlins might be equivalent to or more noteworthy than the heaviness of the supports. Separating of purlin depends to a great extent on the most extreme safe range of rooftop covering and the coating sheets. The purlin separating may change from 1.5-1.75m. The profundity of the support decides its firmness in connection to its range and furthermore its economy. Rooftop profundity run from 1/12 to 1/8 of the range for ceaseless brackets.

Stacking thought is as per the following: dead burden estimation incorporates GI sheeting weight, fixings, administrations, rooftop dead burden, weight of purlins, and self-weight of one bracket. At that point estimation is completed for nodal dead loads. According to IS 875 (Part 3)- 1987 breeze burden determined by considering essential breeze speed in Hyderabad = 44m/s. Wind load F on rooftop support by static breeze technique is given by (provision 6.2.3.2 of IS 875) as pursues:

F=(Cpi-Cpe) *A*Pd

In the wake of getting wind load, count of wind weight was completed and results are arranged. For structuring one ought to consider basic breeze weight/loads. After estimations of the considerable number of burdens, load blends received are as per the following:

(Statement 3.5.1 and 5.3.3 IS 800: 2007)

(DL*1.5) + (LL*1.5)
(DL*1.5) + (WL*1.5)

In the plan of any mechanical shed structure of bracket part is most significant part. There are different kinds of bracket King Post Truss, Pitched Pratt Truss, Fan Truss, Queen Post Truss, Trapezoidal Truss, Mansard Truss, Cambered Truss, and so on. For range of 14m support is generally practical.

Support comprises of individuals that are: Top harmony part, base harmony part, web part, side sprinter, tie sprinter, and so on. Prior to genuine structure of individuals, examination of support was done by straightforward manual strategy. Support individuals can convey pressure or strain power, subsequent to breaking down greatest power is considered for structure. The individuals from the supports are made of either moved steel segments or developed areas relying on the range length and power of stacking. Moved steel single or twofold edges, T segments, empty area, square or rectangular areas are utilized in rooftop brackets

Estimation Of Loads

A) Dead Load
Dead Load (Sheet + Purlin) = 0.15 KN/m2

B) Live Load
Live Load = 0.71 KN/m2

C) Calculation for Wind loads

Wind burdens are determined according to IS 875 Part-III (1987) and SP 64 in this model. For the present work, the essential breeze speed (Vb) is expected as 50 m/s and the structure is viewed as open landscape with all around dissipated obstacle having stature under 10.0 m with most extreme measurement more than 50.0 m and as needs be

factors K1, K2, K3 have been determined according to May be 875-Part-III (1987).

Territory Category – 2
Building Class – B
K1 = Probability Factor (chance coefficient) = 1.0
(General structures and structures)
K2 = Terrain tallness and size factor = 0.88
K3 = Topography factor = 1.0
Vb = 44 m/s (For Hyderabad Zone)

Configuration Wind speed
Vz = Vb (K1 x K2 x K3)
Vz = 44 (1 x 0.0.88 x 1)
Vz = 38.72 m/s

Configuration Pressure
Pz = 0.06
Pz = 0.06 x
Pz = 0.899 KN/
Proportion = H/W = 0.20, L/W = 1.33

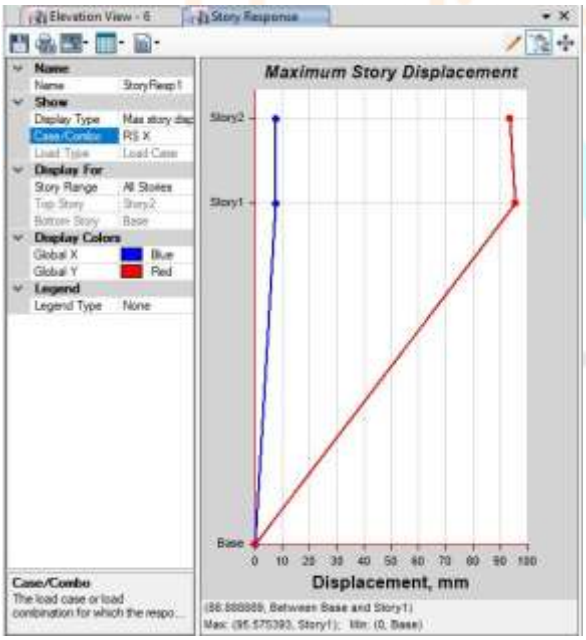
CHAPTER – 5
RESULT

All members are designed according to the loads coming on the structure and as per IS code specifications. Results obtained are as follows:

Member	Section provided
Top chord	ISA 200*200*25
Bottom chord	ISA 200*200*25
Web member	ISA 200*200*25
Column	ISWB 600@145.1 kg
Purlin	ISB 48*82*5.4

Table 2: Summary of Results

1. Maximum Storey Displacement



Maximum horizontal displacement recorded is 95.575 mm, indicating effective lateral flexibility.

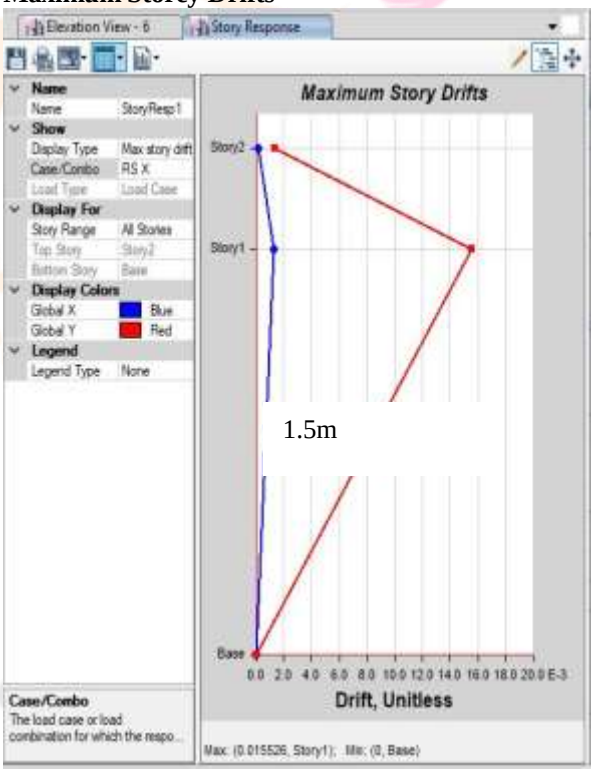
Result: Maximum storey displacement is 95.575mm

2. Overturning moment

Maximum overturning moment of 7.298 kNm confirms good resistance to seismic tipping forces.

Result: Maximum overturning moment is 7.298 kNm

3. Maximum Storey Drifts



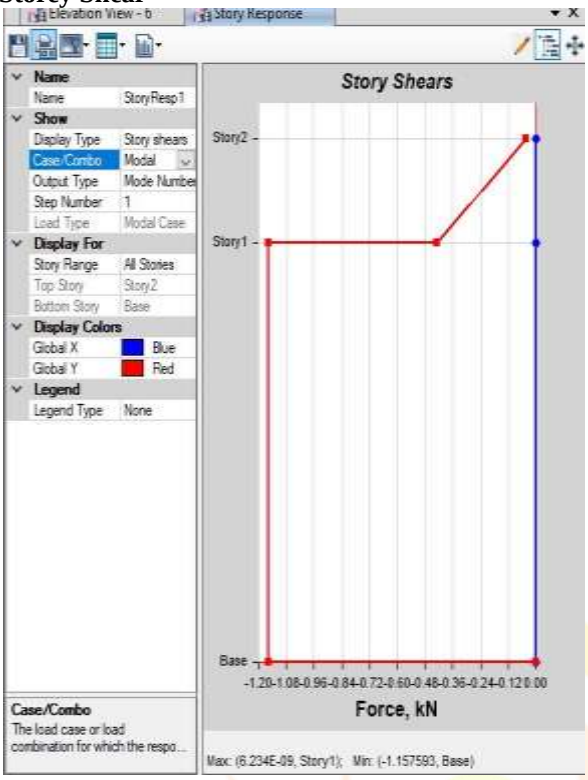
1.5m

Storey drift peaked at 0.0155 mm, well within safe seismic deformation limits.

Result: Maximum Storey Drift is 0.0155mm

6 m

4. Storey Shear



Maximum storey shear recorded is 6.234E-09, indicating low shear force transmission during loading.

Result: Maximum storey shear is 6.234E-09

CHAPTER – 6
CONCLUSION

6.1 Conclusion

The present study focused on the analysis and design of a steel-framed warehouse structure located in a Seismic Zone III region (Telangana) using the structural engineering software ETABS. The objective was to develop a safe, stable, and cost-effective warehouse design that adheres strictly to the provisions of relevant Indian Standards, including IS 800:2007, IS 875 (Part I, II, III):1987, and IS 1893 (Part 2):2002.

The study began by identifying the functional requirements of a warehouse, including a large column-free floor area, sufficient vertical clearance, lightweight but strong structural members, and resilience against lateral forces such as wind and earthquakes. Based on these requirements, a steel structural system was chosen due to its superior strength-to-weight ratio, ease of assembly, and potential for future expansion or relocation.

A detailed model of the warehouse was created in ETABS, including all structural components such as columns (ISWB 600), trusses (ISA 200×200×25), purlins (IS 48×82×5.5), and GI sheet roofing. The model accounted for all relevant load types—dead loads (including roof sheeting and structural self-weight), live loads, and lateral loads (wind and earthquake). Wind loads were calculated using IS 875 (Part III), considering a basic wind speed of 44 m/s, and seismic analysis was carried out using IS 1893 for Seismic Zone III.

The software provided critical insights into the performance of the structure under lateral loads, particularly seismic forces, through time history analysis and response spectrum analysis. Important structural responses such as storey displacement, shear, drift, and overturning moments were monitored and evaluated.

Structural Performance Highlights:

- Maximum Storey Displacement: 95.575 mm – within safe permissible limits.
- Maximum Storey Drift: 0.0155 mm – indicates excellent lateral stiffness.
- Maximum Overturning Moment: 7.298 kNm – shows resistance against overturning during seismic events.
- Maximum Storey Shear: 6.234E-09 – very low values, confirming effective structural stability.

The truss system adopted, with a slope of 1:5, proved structurally efficient for the given span and was found to be economical as well. Birla Aerocon wall panels were used in place of brick masonry to reduce dead load, thereby enhancing the overall seismic performance and allowing for faster construction.

The design process also highlighted the importance of bracing systems in transferring lateral forces to the foundations and maintaining the overall stability of the structure. Purlins and ties were designed to act as lateral supports and to manage forces from wind and seismic events effectively.

6.2 Broader Implications

This project clearly demonstrates the critical role of structural analysis software like ETABS in modern civil engineering practice. It significantly simplifies complex calculations, allows for visual validation through 3D modeling, and ensures compliance with seismic and wind load provisions efficiently and accurately.

By leveraging ETABS:

- The structure was designed with optimal material usage, improving cost-efficiency.
- Multiple load combinations and dynamic scenarios were analysed without manual complexity.
- Code compliance was verified across all members, reducing human error.
- The design process was accelerated, while maintaining a high level of accuracy and safety.

6.3 Final Thoughts

In conclusion, the warehouse structure analysed in this study has been thoroughly designed to ensure structural safety, durability, and code compliance, especially under seismic loading conditions. The use of ETABS provided powerful tools for accurate modeling, analysis, and design, making it a vital asset for engineers dealing with complex and safety-critical structures.

This project serves not only as a successful design example but also highlights a methodological approach for similar industrial structures in seismic regions. Future extensions of

this work could include cost analysis, construction sequencing using BIM tools, or retrofitting evaluation of existing warehouses using similar software platforms.

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