DYNAMIC ANALYSIS AND DESIGN OF R.C.C SOLIDS STORAGE STRUCTURE BY WITH REFERENCE TO IS 1893:2016

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Abstract: Aim of research paper is to compare and briefly describe about the advantage and limitations of solid storage structure by using Staad Pro Structural software. Solid storage structures are considered as special structures as its design is based on the properties of materials stored. The pressure exerted by the stored material on the side of a bin varies with the processes and arrangements of filling and emptying operations. Due to this variation, it is extremely difficult to analyze the pressure exerted on the walls of the bins. In our research work, we are designing the RCC solid storage structure located in all seismic zones with the help of structural software Staad Pro. The design concept include, all dimensions of structural component based on trial and error method, using Equivalent lateral force method in term of Comparison of different models of concrete solid storage structure for earthquake such as nodal displacement, stress and vertical or horizontal pressure on walls etc. for volume of 180 m3. All the designs have been based on the recommendations of I.S 4995 -1974 (part 1&2) and I.S 456 – 2000 codes, Based on these designs, that dimension of solid storage structures shows least amount of concrete and steel. Main objective of our research work is to compare of different models of concrete solid storage structure for earthquake in terms of nodal displacement, stress and vertical or horizontal pressure on walls etc.

***IndexTerms* - Staad-Pro, Baseshare, Displacement, Absolute wall stress, Bending moment, IS1893:2016 etc.**

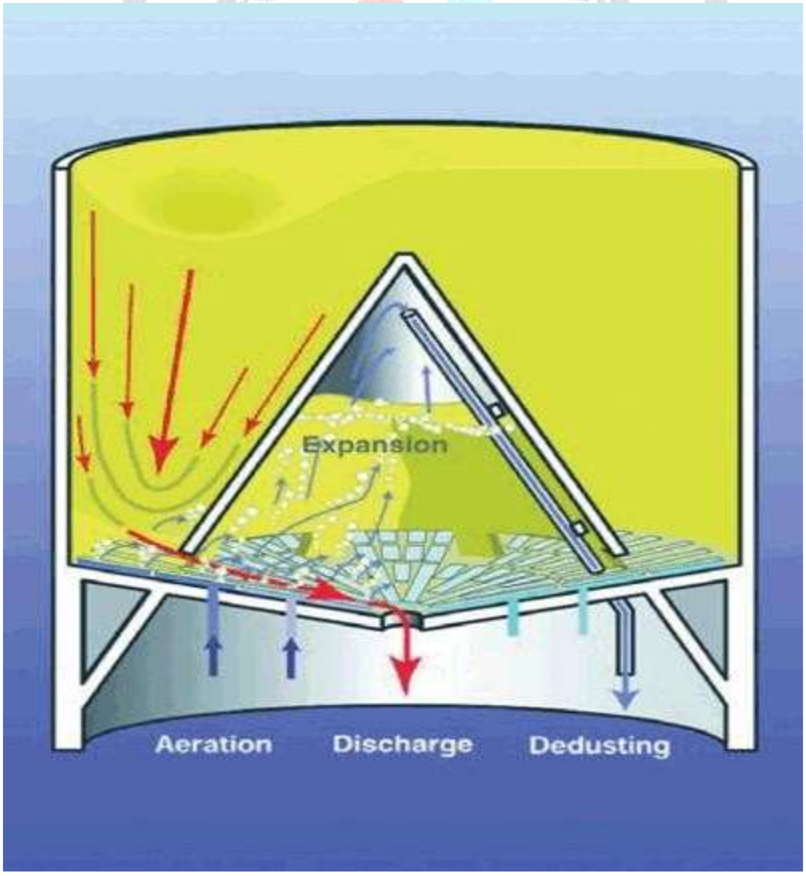
I. INTRODUCTION

The word “solid storage structure” or “Silo” includes equally deep bins and shallow bins; the latter are on occasion called bunkers. Wherever the term “solid storage structure” is used in the Design requirement, it should be interpreted as meaning a solid storage structure, bin, or bunker of any proportion, shallow or deep. Solid storage structures and bunkers are remarkable structures, and countless engineers are unknown with computation of their design loads and with other design and detail requirements. It is important that the design and the preparation of project drawings and project specifications for solid storage structures and bunkers be done under the supervision of an engineer with specialized knowledge and experience in design of such structures. If possible, the properties of the stored materials to be used in the design should be obtained from tests of the actual materials to be stored or from records of tests of similar materials previously stored. Solid storage structure failures alerted design engineers to the danger of designing solid storage structures for only static pressures due to stored material at rest. Those failures have inspired wide- spread research into the variations of pressures and flow of materials. The research thus far has established beyond doubt that pressures during withdrawal may be significantly higher or significantly lower than those present when the material is at rest. The excess (above static pressure) is called “overpressure” and the shortfall is called “under pressure.” One of the causes of overpressure is the switch from active to passive conditions which occurs during material withdrawal Under pressures may occur at a flow channel in contact with the wall and overpressures may occur away from the flow channel at the same level. Under pressures concurrent with overpressures cause circumferential bending in the wall. Impact due to filling may cause total pressure to exceed the static. While overpressures and under pressures are generally important in deeper solid storage structures, impact is usually critical only for shallow ones (bunkers) in which large volumes are dumped suddenly. Solid storage structure is a substantial capacity in the cement industry may cause large eccentricities during discharge due to their individual bottom aeration sections. A large eccentricity is classed as when a discharge flow channel is more than half the radius of a solid storage structure from the solid storage structure mid-point. From different investigations, it is known that horizontal pressures in a flow channel are smaller than in the bulk material outside the flow channel. This results in a reduction in horizontal pressures in the zone in which the flow channel contacts the wall, compared to the horizontal pressure on the remaining wall circumference that corresponds with the fill pressures.[2] In the transformation from flow zone to static zone, horizontal pressures even higher than the fill pressure occurs due to the load balance. The result was an alternating pressure distribution when discharging large capacity solid storage structure, which could lead to critical wall loads in certain cases. Solid storage structure with bottom aeration was generally viewed as ‘slender’ solid storage structures.

Below fig 1 shows the solid storage structure with central cone for the cement industry Where all the dust which is generate in solid storage structure is discharge with the help of dusting pipe and discharge gape is also mean as hopper which is us to provide discharging all the row material The largest solid storage structures in the cement industry are built with diameters up to 30 meter; typical solid storage structures for storage of 20000 tons cement are, for example, 20 m in diameter and 60 m high. Although there is different design variations by the leading supplier, large capacity solid storage structures with diameters above 12 m are mainly executed as central cone versions. The central cone has a material displacement function, which allows the material in the solid storage structure to come into motion during discharge. All solid storage structures with a central cone (Figure 1) was designed as quasi flat bottom solid storage structures, whereby the solid storage structure bottom forms a ring space. This are divided into individual aeration sections that are slightly declined towards the outlet by approximately 10°.

The solid storage structure bottom is equipped with so-called fluid slides that have an air-permeable fabric on the upper side. The aeration air is blown under the fabric in order to fluidize the bulk material on the fabric. The amount of coverage of the solid storage structure bottom with fluid slides varies between 35 and 50% depending on system and requirements. In order to make problem-free discharge of material, air amounts and aeration pressure must be adjusted to each other. The air amounts increase roughly linearly from a minimum air amount with the required discharge throughputs. As a rule, blowers with 500 mbar pressure are sufficient for aeration. The solid storage structure bottom was aerated section by section, so that all sections are aerated in a complete cycle. It is insignificant whether two or more sections are connected for aeration. Correspondingly, only the parts of the bulk materials above the actively aerate solid storage structure section was in motion, and a flow channel forms increasing upwards, which can include almost the entire cross section, depending on discharge amount, solid storage structure height and aeration time. Within the flow channel there is a convergent material flow. The gradient of flow is illustrated in the figure by the increasing width of the blue and white material elements. As only the bulk material above the aerated section was in motion, no mass flow will occur in the solid storage structure. With mass flow the entire material in the solid storage structure would be in motion uniformly. Due to the cyclic aeration of the ring zone, one section after another, the discharge process in the solid storage structure must be strongly eccentric. There are different types of cement solid storage structure such as the low-level mobile solid storage structure and the static upright cement solid storage structure, which are used to hold and discharge cement and other powder materials such as PFA (Pulverized Fuel Ash). The low-level solid storage structure is fully mobile with capacities from 100 to 750 tons. This is simple to transport and are easy to set up on site. These mobile solid storage structures generally come equipped with an electronic weighing system with digital display and printer. This allow any quantity of cement or powder discharge from the solid storage structure to control and also provides an accurate indication of what remains inside the solid storage structure. The static upright solid storage structure have capacities from 200 to 800 tons. This is considered as a low-maintenance option for the storage of cement or other powders. Cement solid storage structure can be used in conjunction with bin-fed batching plants. Cement can be stored in different types of Solid storage structures like Horizontal Solid storage structures, Concrete Solid storage structures, and Steel Panel Solid storage structures etc. depends upon the requirement of the end user. While Mobile Solid storage structure come in a relatively small storage capacity of approximately 90MT of Cement, Concrete Solid storage structure can be store practically thousands of MT of Cement. A majority of Solid storage structure that store more than 5000 Cements are constructed from Concrete. A good compromise between cost, construction time and ease of operation is Steel Panel Solid storage structures. These solid storage structures can manufacture in a factory, and then erect at site using small panels that are bolted together to form a Solid storage structure that is watertight because of a sandwiched layer of special rubber seals.

Fig1: Solid storage structure with central cone for the cement industry



1. **Stress condition within the solid storage structure accumulate material**

The pressure applied on a solid storage structure fence by the accumulate material is different when the material is running and when it is motionless. For design purposes it is essential to establish the stress at the solid storage structure wall during filling of the solid storage structure, when the stored material is static and when the material is discharging. Each of these cases is discussed below. The discussion includes other factors which affect pressure such as moisture content, temperature variation and segregation and degradation of the stored material.

2. **Static stress state**

The stored material in a solid storage structure will be either in a state of elastic or plastic equilibrium. The active and passive states are the two limiting states. They are plastic states of equilibrium and are reached after lateral expansion of the stored material (active state) or lateral contraction of the stored material (passive state) when a critical combination of shearing and normal stress leads to shear failure. Every state between the active and passive states, including the at-rest state, is a state of elastic equilibrium. Shear failure is defined by the Mohr-Coulomb criterion. For cohesion less material this reduces to

T = Q x Tan ø

Where T is the maximum shear stress at failure within the stored material, and Q- is the stress normal to the failure plane. The stress state at any point within the solid storage structure contents will depend upon the distance to the surface of the stored material, the material properties, the wall roughness and the wall deformation.

Discharge loads

The stress state within a stored material will change as flow commences. Material expands vertically in the bin and hopper and in the hopper contracts laterally (4). The stress field changes so that orientation of the direction of the maximum principal stress changes from vertical when the stored material is stationary towards horizontal during discharge. In mass flow, the stress state of all the stored material in the solid storage structure changes. In funnel flow, only the material within the flow channel experiences such a major stress change, and so the wall pressure in mass flow and funnel flow solid storage structures must be determined using different criteria.

3. Mass flow

In a mass flow solid storage structure the boundaries of the flow channel coincide with the solid storage structure wall and so the channel is defined and constant. (In a funnel flow solid storage structure, the flow channel is not defined because it forms within the stored solid). Many authors have proposed methods for the calculation of pressures in mass flow solid storage structures. Other investigations of the pressures at the walls of mass flow solid storage structures have been conducted and have highlighted the erratic behaviour during flow. The walls are subjected to high localized pressures of short duration. Research studies have identified two types of overpressure during discharge. Both are due to a re-orientation of stress within the stored material. The first is known as the switch, which occurs at the start of flow as the material changes from one stress state to another. The second type of overpressure is attributed to a local stress reorientation within the flowing stored material as it passes imperfections on the solid storage structure walls. Such imperfections may be formed by welds in steel solid storage structures or formwork scams in reinforced concrete solid storage structures. Although overpressures and their fundamental causes have been identified, they Are difficult to quantify and so it is common practice for designers of mass flow solid storage structures to multiply the calculated static pressure by a constant derived from experimental data. The overpressure factor has traditionally been applied to the static pressure without any regard to the structural response of the solid storage structure. Since the overpressures only affect local areas, they result in a pressure variation which may result in a worst stress state in the solid storage structure wall than a high uniform pressure. Therefore, the assumption of a high but constant pressure at any level is not necessarily safe.

Other Loading Considerations

Pressure distributions can be affected by factors which may either increase or decrease wall loads. Such factors are difficult to quantify, and will be more noticeable in some solid storage structure cases than others. A limited list is given below.

1. Temperature

Temperature variation Thermal contraction of a solid storage structure wall will be restrained by the stored material. The magnitude of the resulting increase in lateral pressure will depend upon the temperature drop, the difference between temperature coefficients of the wall and stored material, the number of temperature changes, the stiffness of the stored solid and the stiffness of the solid storage structure wall.

2. Consolidation

Consolidation of the stored material may be due to release of air causing particles to compact (a particular problem with powders) physical instability due to changes in surface moisture and temperature, chemical instability due to chemical changes at the face of the particles, and vibration of the solid storage structure contents. The accurate determination of wall pressures requires knowledge of the variation of bulk density and the angle of internal friction with depth. Moisture Content

An increase in the moisture content of the stored material can increase cohesive forces or cause the formation of links between the particles of water-soluble substances. The Australian code recommends that wall friction for calculations should be determined using both the driest and wettest material likely to be encountered.

3. Segregation

Solid with a wide range of particle sizes and blends, containing particles with a wide range of density, size and shape, tend to segregate. The greater the height of free falls on filling the greater the segregation. This may create areas of dense material. More seriously, coarse particles may flow to one side of a solid storage structure and fine cohesive particles remain on the opposite side. An eccentric flow channel can form leading to unsymmetrical loads on the wall.

4. Corrosion

Stored solid may chemically attack the storage structure altering the angle of wall friction and wall flexibility.

5. Abrasion

Large granular particles such as mineral ores can wear the wall surface resulting in problems similar to those described for corrosion. A lining may be provided to the structural wall, but care should be taken to ensure that wall displacement does not cause damage to the lining.

6. Impact Pressures

The charging of large rocks can lead to high impact pressures. Unless there is sufficient material to cushion the impact, special protection must be given to the hopper walls. In solid storage structures with flow problems, strong Janssen arches may form. They bridge across the solid storage structure and prevent flow of the contents above the arch whilst material below continues to flow. Collapse of the arch can lead to severe impact pressures. In this case preventive action at the geometric design stage is required.

7. Rapid Filling and Discharge

The code warns that the rapid discharge of bulk solid having relatively low permeability to gasses can induce negative air pressures in the solid storage structure. Rapid filling can lead to greater consolidation. The effects of which are discussed above.

8. Powders

The rapid filling of powders can aerate the material and lead to a temporary decrease in bulk density, cohesiveness, internal friction and wall friction. In an extreme case, the pressure from an aerated stored material can be hydrostatic.

The method of calculation of stresses at the solid storage structure wall is influenced by the stored material stress state. This is a function of the material properties and the boundary conditions and is different when the stored material is stationary to when it is flowing. The method of static pressure calculation must be selected in accordance with the mode of wall deformation. The same method will be used irrespective of the filling technique but the type of filling will influence the compaction and particle distribution within the stored material. The filling method must be considered when the material properties are determined and may lead to complications of the analysis if. For example, it generates an anisotropic medium. An analysis of the pressure during the discharge of a funnel flow solid storage structure is not usually necessary since the flowing contents have a negligible effect on the stationary material near the wall (provided that the flow channel is concentric). In mass flow solid storage structures, the wall pressure may be much greater during discharge and this should be incorporated into the method of analysis. There are no proven methods to determine the mass flow pressure state and so it is usual practice to apply a safety factor to the pressure calculated under static conditions.

II. AIMS AND OBJECTIVES OF THE RESEARCH WORK

The aim of this research is to compare and briefly describe about the advantage and limitations of solid storage structure by using Staad Pro Structural software. Solid storage structures are considered as special structures as its design is based on the properties of materials stored. In addition to the loads that are acting on the normal structures such as seismic and external loads, the solid storage structures are specially designed for the loads that are induced by the stored materials. Engineers ensure that the solid storage structure is built to be strong and stable enough to resist structural loads and loads due to materials stored. The pressure exerted by the stored material on the side of a bin varies with the processes and arrangements of filling and emptying operations. Due to this variation, it is extremely difficult to analyze the pressure exerted on the walls of the bins. The approximate methods suggested by Janssen are commonly followed for the calculation of pressure in this study. In this project, we are designing the RCC solid storage structure located in all seismic zones with the help of structural software Staad Pro. The design concept include, all dimensions of structural component based on trial and error method, using Equivalent lateral force method in term of Comparison of different models of concrete solid storage structure for earthquake such as nodal displacement, stress and vertical or horizontal pressure on walls etc. for volume of 180 m3. All the designs have been based on the recommendations of I.S 4995 -1974 (part 1&2) and I.S 456 – 2000 codes, Based on these designs, that dimension of solid storage structures shows least amount of concrete and steel. These findings will be useful for the designers of solid storage structures.

1. A clear and broad learning of recent available international paper on solid storage structures.
2. To perform the Analysis of solid storage structure using Equivalent lateral force method and to study the performance of structure located in all seismic regions.
3. Design of different models of RCC silo in STAAD pro for different seismic zones by using IS-4995:1974(Part-I,Part-II).
4. Comparison of different models of concrete solid storage structure for earthquake in terms of nodal displacement, stress and vertical or horizontal pressure on walls etc.
5. To compare the results obtained to assess their potentiality and suitability in understanding the true behavior of such a structure.
6. Presentation of the result in tabular appearance to simply be familiar with the analysis of structure.

III. LITERATURE REVIEW

Literature Review for Paper [1] shows a Fly ash storing in solid storage structure and check stresses, bending moment and design of solid storage structure in this paper. Also, done a comparison between manual load calculation for three solid storage structures and calculating results of stresses and bending moment in STAAD Pro software After both load calculation and find the stresses, bending moment of three of solid storage structures comparing and design best solid storage structure. In this paper, author comparing the three types of solid storage structure such as square, rectangular & circular. On these solid storage structure what effects (shear stresses, bending moment) takes places after applied load such as ash loading, seismic load & wind load with the help of STAAD-PRO software.

In these analyses, the different results of stress and bending moment during comparison of three types of solid storage structures in staad pro software, It is concluded that, the change of in manual calculation of load circular solid storage structure is very easy. Value of these loading is very less. Applied the loading in staad pro v8i is very easy in the circular solid storage structure comparative other solid storage structures and load combination also very easy. Stress and bending moment value very low of circular solid storage structure and near same value of rectangular and square solid storage structure. But in literature surveys, more storage capacity in rectangular solid storage structure and square solid storage structure. The power tool for computerized structural engineering STAAD Pro is the most popular structural engineering. Analysis & multi material design prepare 3D finite model of solid storage structure in STAAD.

The aim of paper [2] is to compare and briefly describe about the superiority and limitations of four codes. This paper looks over the superiority and limitations of the four codes namely Bureau of Indian Standard (BIS), American Concrete Institute (ACI), German Standard (DIN) and British Standards Institution (BSI). For the sake of complete, logical and relevant analysis, this study has been divided into two parts. In the first part, each code was thoroughly studied and the basic concepts behind each code were explained. The second part presents the comparison and discussion of similarities and dissimilarities of each code and the analysis of the parameters involved in the design of the solid storage structure. The insight of loads exerted by the stored materials and external forces to the solid storage structure is significant for designing the safe solid storage structure. A slight modifications in the parameters, namely the effect of the thermal variation and the properties of stored materials, if taken into account in the analysis of solid storage structure, the discrepancies associated with various codes can be further reduced.

Paper [3] describes a brief descriptions of each of codes, their limitations, and common design conditions that are not covered are identified. Users of solid storage structure codes will find this information invaluable, as will code writers who will benefit by being given direction as to how to improve their codes to make them more useful. External equipment such as electric or pneumatic vibrators, vibrating bin discharger (bin activator), localized aeration devices, and air cannons impart significant forces to a solid storage structure structure that must be taken into account. They can also affect the stored bulk solid in such a way that its properties change, resulting in different solid storage structure loads. AS 3774-1996 provides some limited guidance on this phenomenon, but it does not cover loads acting on external equipment itself by the stored bulk solid. The other three solid storage structure design codes do not cover these at all Feeders and gates are also critical to a safe and properly functioning solid storage structure. AS 3774-1996 provides guidance regarding loads imposed on them, but the other three codes do not. Knowledge of the loads applied to the walls and internals (if any) of a solid storage structure is extremely important. Such loads must not be ignored if a stable, safe solid storage structure is to be designed. Much progress has been made in the last 50 years in providing solid storage structure load guidance to design and structural engineers. EN 1991-4:2006 is a significant advance over all previous codes, but even it does not cover many common load cases.

For load cases not covered by the codes, the design/structural engineer is left with two choices: Be extremely conservative in estimating applied loads. This approach can be quite expensive and yet still may not be conservative enough to prevent the solid storage structure from failing and Rely on design engineers who have significant experience in calculating solid storage structure loads.

In Paper [4] study the most economical configuration of solid storage structures to store a given volume of a material, twenty eight samples of solid storage structures have been designed by changing the ratio of height to diameter for storing a given material, namely, bituminous coal. In this investigation, for volume of 125m3, the diameter to height ratio is varied and has been designed and finally, the most economical size is found out. This method is carried out for volume of 125m3. All the designs have been based on the recommendations of I.S 4995 -1974 (part 1&2) "Criteria for Design of Reinforced Concrete Bins for The Storage of Granular and Powdery Materials" and I.S 456 – 2000 codes Based on these designs, those dimensions of solid storage structures which will lead to least amount of concrete, steel and total cost to store a given amount of material have been found out. These findings will be useful for the designers of solid storage structures. H/D ratio and Total cost in INR are taken in x and y axis respectively. The most economical solid storage structure has been found to the dimension of height: 8.35m. And diameter: 4.2m. The total cost required for economical solid storage structure is Rs. 116682.48 and for uneconomical one is Rs. 163763.56. It is found that the requirement of cost for construction of solid storage structure is directly proportional to height and inversely proportional to that of diameter.

In [5] paper Manual design of circular solid storage structure for various material and also done .net programming for different material storing in solid storage structure & check pressure and design of reinforcement and also done a comparison between manual design and.net programming. In both designs, influence of different parameters discussed. The same result of stress and area of steel has been found during comparison of manual design and .net (VB) programming. When increasing height and diameter ratio decreases thickness of wall . It is concluded that, ease to various results of various material storing in solid storage structure in Design of .net (VB) programming.

In Paper [6] Structures used for storing bulk solid are called bins, bunkers, solid storage structures, or tanks. There is no generally accepted definition for these terms, shallow structures containing coal, crushed stone, gravel, and similar materials are called bins or bunkers and tall structures containing materials such as grain, cement and wheat are usually called solid storage structures. Elevated solid storage structures generally consist of a conical roof, a cylindrical shell and a conical hopper and they could be elevated and supported by frames or reinforced concrete columns. Circular solid storage structures (both steel and reinforced concrete) are used to store material in various industries like cement plants (clinkers), power plants(raw coal), oil and gas industry(sulfur pellets) etc. Elevated steel and reinforced concrete circular solid storage structure for storage show performance in earthquake reinforced concrete solid storage structure stability increases by using shear wall but loss of steel solid storage structure in earthquake stability increases using steel panel on opposite side Displacement of structure decreases in case of shear wall panel and stiffness increases, R.C.C. Solid storage structures and steel solid storage structures in RSM method with shear wall displacement of structure is reduce compare to without shear wall. Due to using shear wall time period of structure is reduces. In Time history analysis acceleration of solid storage structure structure is decreases and base shear is increases in both cases R.C.C. Solid storage structures and steel solid storage structures with shear wall.

The paper [7] shows an industrial solid storage structure analyzed and designed according to the Indian standards (IS 4995) and also by referring Euro code (EN 1998 -4: 1999 & EN 1991-4: 2006) and ACI code (ACI 313). In this study, a 450 cum capacity flat bottom solid storage structure design & analysis. Concrete flat bottom circular solid storage structures are often deployed to store material in various industries like cement plants, power plants, oil and gas industry etc. Solid storage structures are special structures subjected to many different unconventional loading conditions, which result in unusual failure modes. Failure of a solid storage structure can be devastating as it can result in loss of the container, contamination of the material it contains, loss of material, cleanup, replacement costs, environmental damage, and possible injury or loss of life. The best design of solid storage structure has helped in safe structure.

Paper [8] describes four and a half decades and resulted from all and introduced the first integrated method for characterizing powders for flow, and using this information to design a solid storage structures and bunkers that would discharge without hang-up. Sadly, many users and designers of solid storage structures and bunkers still do not benefit from this, so a lot of process vessels in industry still suffer from rat-holing, arching and bridging. Objections of cost, time and questionable accuracy were levelled at the original hopper design method, in spite of the breakthrough it represented. However, over the last 40 years these problems have been overcome with the introduction of faster, easier to use and more sensitive powder flow ability measurement techniques, and a lot of experience of what measurements matter with which materials and in what operational scenarios. Solid storage structure and bunker failure can occur due to many reasons, following these1) Due to design, 2) Fabrication and erection error, 3) Improper usage,4) Improper maintenance. Now this design project will pull together various lessons learned from many years of solid storage structures and bunkers design projects, and show a practical approach to deciding) Flow pattern is required (mass flow or core flow), b) Measurements need to be made of the powder properties, c) Design models should be used, based on the material being handled and the operational requirements of any given case.

In paper [9] Thin shell structures have given considerably attention for the at least six decades especially during the war time because of their importance in aircraft and missile applications. Shells of various shapes were investigated such as elliptical hemispherical, conical and cylindrical shells. These structures are mostly failing by bucking under external pressure. Cylindrical steel solid storage structures are tall slender structures used for storing materials like cement, grains, fly ash, carbon black, coal saw dust etc. They are special structures subjected to many different unconventional loading conditions, ranging from few tones to hundreds to thousands of tones which results in unusual failure modes.[3] Failure of a solid storage structure can be devastating as it results in loss of the containers, contamination of material it contains, loss of materials environmental damages, and possible injuries and loss of life. Solid storage structures are subjected to normal pressure and axial compressive loads along with the self-weight. They also carry lateral loads due to wind and seismic forces[10]. The major assumptions used in many or all the above theories are summarized and discussed below:

1. The stored material is isotropic and homogeneous.
2. The angle of internal friction is used to describe the strength of the stored material. Soil strength is dependent on the stress path to failure. The stress path is determined by the solid storage structure aspect ratio and the solid storage structure wall stiffness. The angle of internal friction represents the strength for a single stress path to failure and so it does not necessarily represent the strength of all the material in the solid storage structure.
3. Many theories assume that the major principal stress aligns with the vertical axis and the minor principal stress aligns with a horizontal axis perpendicular to the bin wall when the stored material is static. Some researchers have incorporated a distribution factor to allow for the effect of wall friction on the direction of the principal stresses but none have allowed for any change due to wall slope on a horizontal plane.
4. The ratio of horizontal to vertical pressure is usually assumed to be constant with the stored material in either an at-rest or an active state of equilibrium. This is not however a limitation of the theories, but users have generally adopted a single value of K which suggests that

the walls are rigid and non-deforming or that they arc rigid and rotate about the base. Other modes of wall deformation have not been incorporated into design calculations.

5. Wall friction is usually assumed to be constant and fully mobilized at every point on the wall although again this is not a limitation of the theory.

6. The stored material is assumed to be incompressible. This may lead to errors in the calculation of hopper pressures. In compressible stored materials consolidation during or after filling will cause slip along the inclined hopper walls. Lateral contraction of the contents will change the stress state toward a passive plastic state of equilibrium.

7. The effect of discharge on the stored material stress state in the bin has usually only been incorporated into design using an overpressure factor applied to the static pressure. Two factors are specified, one for mass flow and one for funnel flow. They arc applied to all solid storage structures that fall within these categories without consideration of the structural form or susceptibility to different load conditions.

- **Conclusion Based on Literature Review**

Resolve of masses play considerable responsibility in the design of solid storage structure. The solid storage structure is an arrangement used for storeroom of bulk materials, in which the loads due to stored materials has to be taken into account in addition to seismic load. The different codes and standards specify guidelines for the solid storage structure design, a) Indian Standard IS 4995 - 1974 b) American Concrete Institute ACI 313 – 97 c) German Standard DIN 1055 – 6: 2005 – 03 and d) British Standard BS EN 1991-4: 2006.

Despite the fact that, the analysis and design of solid storage structure cannot be performed using single code, the lack of compatibility among various codes make the designers laborious in designing the solid storage structure. The consideration of compact modifications in the analysis and design of solid storage structure makes it possible to construct and operate safe and economical solid storage structure. The aim of this paper is to compare and briefly describe about the advantage and limitations of solid storage structure by using Staad Pro Structural software. Solid storage structures are considered as special structures as its design is based on the properties of materials stored. In addition to the loads that are acting on the normal structures such as seismic and external loads, the solid storage structures are specially designed for the loads that are induced by the stored materials. Engineers ensure that the solid storage structure is built to be strong and stable enough to resist structural loads and loads due to materials stored. The pressure exerted by the stored material on the side of a bin varies with the processes and arrangements of filling and emptying operations. Due to this variation, it is extremely difficult to analyze the pressure exerted on the walls of the bins. The approximate methods suggested by Janssen are commonly followed for the calculation of pressure in this study. In this project, we are designing the RCC solid storage structure located in all seismic zones with the help of structural software Staad Pro. The design concept include, all dimensions of structural component based on trial and error method, using Equivalent lateral force method in term of Comparison of different models of concrete solid storage structure for earthquake such as nodal displacement, stress and vertical or horizontal pressure on walls etc. for volume of 180 m3. All the designs have been based on the recommendations of I.S 4995 -1974 (part 1&2) and I.S 456 – 2000 codes, Based on these designs, that dimension of solid storage structures shows least amount of concrete and steel. These findings will be useful for the designers of solid storage structures.

IV. METHODOLOGY

IS: 4995-1968* covered the requirements of the structural design for storage bins (solid storage structures). It has been, felt that instead of bringing out one separate standard to cover the requirements of all materials other than food grains it would be useful to cover the subject under one standard in which the requirements of different materials could be dealt with adequately. The different stored materials, such as coke, coal, ores, food grains, fertilizers, cement, flour etc, can be classified either as granular or powdery materials. Extensive research work all over the world has indicated that assessment of bin loads caused due to a stored material would require different treatment depending upon whether it is a granular or powdery material. Taking this into consideration this standard is being revised and is published in two parts namely, Part I General principles and assessment of bin loads and Part II Design criteria.

Solid storage structure - A unit consisting of several tall bins having height greater than their diameter used for storage and handling of grains in bulk and fitted with necessary equipment and accessories.

Aeration - A process in which air is moved through the stored material for ventilation. Arching - A phenomenon in the bin during the emptying of a stored material giving rise to formation of arches of the material across the bin walls.

Bin - A storage structure circular or polygonal in plan and meant for storing bulk materials in vertical direction. Solid storage structure is a bin circular for polygonal in plan. Bunker is a bin whose cross section in plan would be square or rectangular.

Bin Loads - Loads exerted by a stored material on the walls of a bin.

Granular Materials - All materials having mean particle size more than 0.2 mm and No cohesion between the particles is assumed.

Powdery Materials - All materials having mean particle size less than 0.06 mm

Angle of Repose - An angle formed with the horizontal plane, at which the loose grain, when piled, will retain its position.

Garner - An intermediate hopper for storage of grains to ensure desired flow for further handling of grains.

The solid storage structure structure shall rest on reinforced cement concrete raft foundation supported on piles or laid directly on soil, depending on the soil condition. The type of foundation for the storage bins shall be decided taking into account the layout, nature of soil and the loads transferred. The solid storage structure failures such as cracking in the walls of the bin, buckling of unsupported walls and the settlement of the soil and foundation are caused mainly due to unequal loads, pressures, moments and stresses. The main reasons which induced these failures are categorized as material loads, flow pattern and its filling conditions.

4.1 Material Loads

The material load is considered as the first category in which the failure of solid storage structure takes place. The walls of solid storage structures can expand during the day and contract at night as the temperature drops. If there is no discharge taking place and the material inside the solid storage structure is free flowing, it will settle as the solid storage structure wall expands. However, it cannot be pushed back up when the solid storage structure walls contract, so it resists the contraction, which in turn causes increased tensile stresses in the wall. The arches and rat holes cause unexpected structural loading by the formation of material caking and segregation. The material to be stored in the solid storage structure should be same at the time of design and usage. Otherwise the load may vary which leads to the formation of arches and rat holes. Gas or liquid pressure is constant around a solid storage structure. But the pressure exerted by the bulk solid against a solid storage structure wall increases in areas where the walls are deforming inward, and decreases where the walls are expanding. This provides a significant restraining effect once buckling of unsupported wall begins. Support beams, inverted cones and other types of internals can impose large concentrated loads or non-symmetric pressures on a solid storage structure wall. The weight of the material and the structure produce large axial stresses at the base which in turn cause the settlement of soil and the foundation.

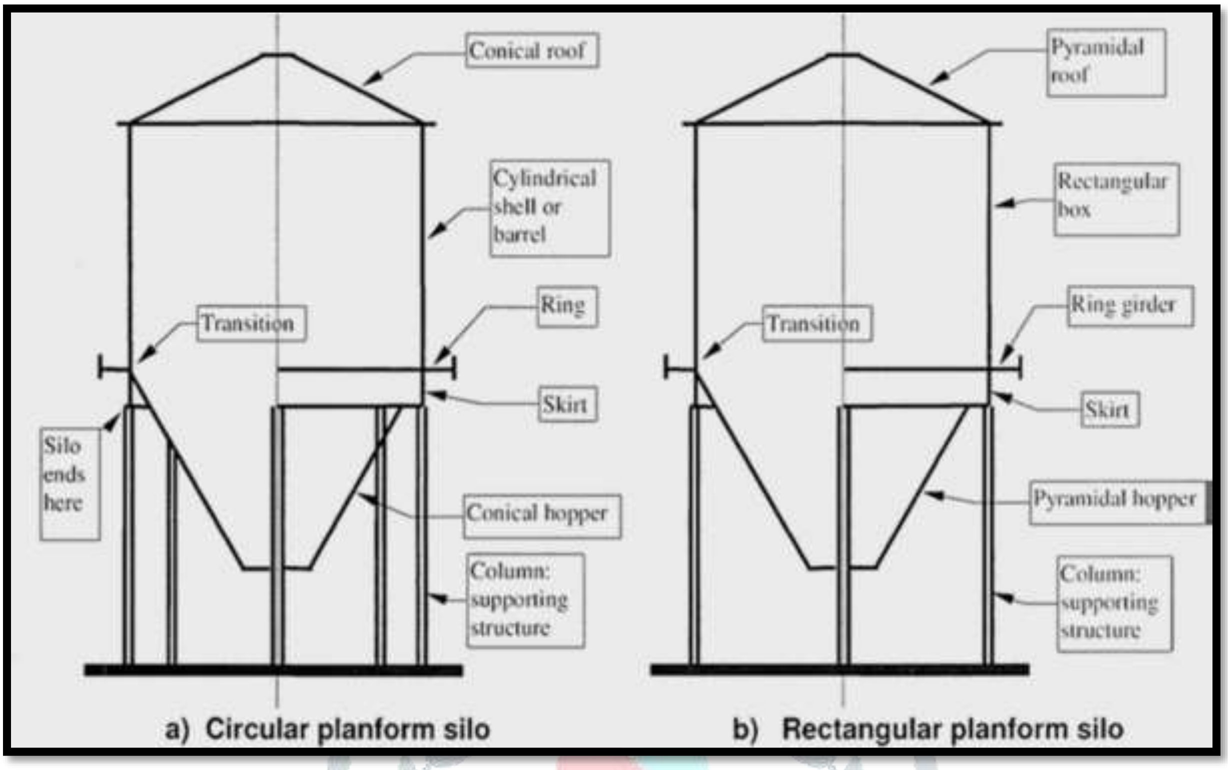


Fig 2: Terminology used in solid storage structure structures

4.2 Load Calculation

Load consider for Solid storage structure Design Loads should be applied to the structural design of a solid storage structure according to its intended use, size, structure type, materials, design lifetime, location and environment, in order to assure life safety and to maintain its essential functions. The applied loads should be as follows, and their combinations should be defined considering the actual probability of occurrence.

- Dead loads
- Live loads
- Snow loads
- Wind loads
- Seismic loads
- Impulse and suction due to content sloshing, and pressure due to content
- Thermal stresses
- Shock, e. g., by crane
- Fatigue load

In general, the loads determined for designing the normal structures as per codal provisions are Dead load, Live load, Wind load, Seismic load, Temperature load and Load combinations. For the design of Solid storage structure, the load due to stored materials is to be considered in addition to the loads acting on the normal structures. The loads for the design of solid storage structure are explained in detail.

Dead Load

Dead loads shall include the weight of all structural components such as beams, floor slabs, columns and walls and other permanent applied external loads. In solid storage structures, the dead loads shall be calculated by taking the weight of the components such as ring beams, stiffeners, internals and shell. The dead loads are static forces exerted in vertical plane and relatively constant throughout the life time. The building materials are not considered as dead loads till they are constructed in the position permanently. The unit weight of the building materials, parts and components are given in the Indian Standard IS 875 – 1987 "Code of Practice for Design loads (Other than earthquake) for buildings and structures. Part 1: Dead loads – Unit weight of building materials and stored materials" (Bureau of Indian Standard, 1987)

Imposed Loads

Live loads are the temporary loads which occur over the short duration of time. The imposed loads are produced by live loads, dust loads, minor equipment loads, erection loads, operation/maintenance loads and load produced by personnel, tools, and other items placed on the structure, but not permanently attached to it. The floor live loads and roof live loads is to be taken for the load calculation of solid storage structure. Unless specified otherwise, the minimum live load values are to be considered as per the IS specifications. The Indian Standard IS 875–1987 "Code of Practice for Design loads (Other than earthquake) for buildings and structures. Part 2: Imposed loads", provides the roof live loads and floor live loads for the structure (Bureau of Indian Standard, 1987).

Seismic Load

The inertia force created by ground accelerations during an earthquake results in the seismic loads. The application of earthquake generated agitation to the building structure is the concept of seismic load. The mass of the building, the dynamic properties, intensity, duration and frequency of the ground motion are the functions in which the magnitude of loads depends. The national building codes prescribed the

requirements of buildings under seismic performance. Seismic analysis for foundation of solid storage structure structure is determined as per IS 1893 – 2002 “Criteria for Earthquake resistant design of structures.
Part 1: General Provisions and buildings” (Bureau of Indian Standard (BIS), (2002)
The seismic pressure on the solid storage structure walls is calculated as per the guidelines for calculations of seismic actions provided by Indian standards.

Load Combination

More than one type of load that acts on the structure will result in the load combination. The load combination is to be calculated for the structure contains more than one type of loading. As per the Building codes, the safety of the structure is ensured by specifying the load combinations with the factors. The structure shall be analyzed for the load combinations and each structural element (wall, beam, column etc) shall be designed for the load combination producing most unfavorable effect on it. The special loads and the load combinations are given in the Indian Standard IS 875–1987 “Code of Practice for Design loads (Other than earthquake) for buildings and structures. Part 5: Special loads and Load combinations” (Bureau of Indian Standard (BIS), 1987) Moments (horizontal and vertical) due to temperature gradient shall be combined.

V. STRUCTURAL MODELING AND CALCULATION

An idea of considering the earthquake loads for the analysis of Rectangular RCC Solid storage structure. Analysis of solid storage structure is done using Equivalent lateral force method. These solid storage structures are studied for varying zones of seismicity. The analysis is done using Staad Pro as per IS 1893 (Part I): 2002 in order to compute the Nodal displacements, stresses and lateral and vertical pressure on wall of the solid storage structure for different conditions is tabulated.

Table 5.1: stored material load calculation

SN	DESCRIPTION (Assumed Standard)	VALUES	UNITS
1	Fuel required for produce powdered material	430	T/Hrs
	After its processing,		
2	Powdered materials found in the hopper (41.2 % of Total) =430 X (41.2/100)	177.16	T/Hrs
3	From Hopper to solid storage structure powdered materials coming 70% =177.16 x (70/100)	124.012	T/Hrs
4	safety factor taking .09 =177.16 X 0.09	159.444	T/Hrs
	For 12 Hrs, Powdered materials found =159.44 X 12	1913.328	T/12Hrs
5	Density of powdered material	1.4	T/CUM
		14.12	KN/CUM
6	Angle of repose	30	Degree
7	n=((1-sin$)/(1+sin$))	1	
8	Height of solid storage structure	20	M
9	Max pressure on hopper γ x h x k, Where k is 0.25, Janssen constant	75	KN/M2

- **Problem Statement:**

Purpose of solid storage structure	**M1**	**M2**	**M3**	**M4**
Type	R.C.C solid storage structure	R.C.C solid storage structure	R.C.C solid storage structure	R.C.C solid storage structure
Configuration	Rectangular shape	Rectangular	Rectangular	Rectangular
Height of solid storage structure	20 meters	20 meters	20 meters	20 meters
Height of support	10 meters	10 meters	10 meters	10 meters
Width of solid storage structure	8 meters	8 meters	8 meters	8 meters
Thickness of solid storage structure	200 mm	200 mm	200 mm	200 mm
Storage product density	14.41	14.41	14.41	14.41
Storage product pressure	75 KN/M3	75 KN/M3	75 KN/M3	75 KN/M3
Grade of concrete	M30	M30	M30	M30
Grade of steel	Fe-415	Fe-415	Fe-415	Fe-415
Design method	L.S.M	L.S.M	L.S.M	L.S.M
Seismic zone coefficient	0.1	0.16	0.24	0.36
Importance factor	1.5	1.5	1.5	1.5
Soil Condition	Medium	Medium	Medium	Medium
Time Period ($Ta=0.075h^{0.75}$)	0.96	0.96	0.96	0.96
Damping Ratio	0.05	0.05	0.05	0.05
Size of column	400 x 400 mm2	400 x 400 mm2	400 x 400 mm2	400 x 400 mm2

Manually calculate the stored material load and live load with self-weight (Y - direction) along with seismic load (X - direction) with the help of IS code. These three load functional on solid storage structure models in staad pro v8i. Loading applied on the solid storage structure wall and wall converted plate wises. Theses solid storage structure structure divided one meter by one meter plate. For calculation the powdered material collected in solid storage structure using the Janssen's theory and assuming data are given above.
As per objective of the study, there are four models of Thick solid storage structure "(thickness of wall 200 mm)" with wedge with conversing end wall hopper namely M1, M2, M3 and M4 were created in different Indian seismic zones such as Zone-II, Zone-III, Zone-IV and Zone-V respectively. All models have same dimensions were analysed by the help of Staad Pro.
Fig 3 shows the total graphical user interface of staad pro it incudes menu bar, tool bar, working area, data area and page controller in working area we can see the skeleton of solid storage structure it is basically show 3D view if solid storage structure.

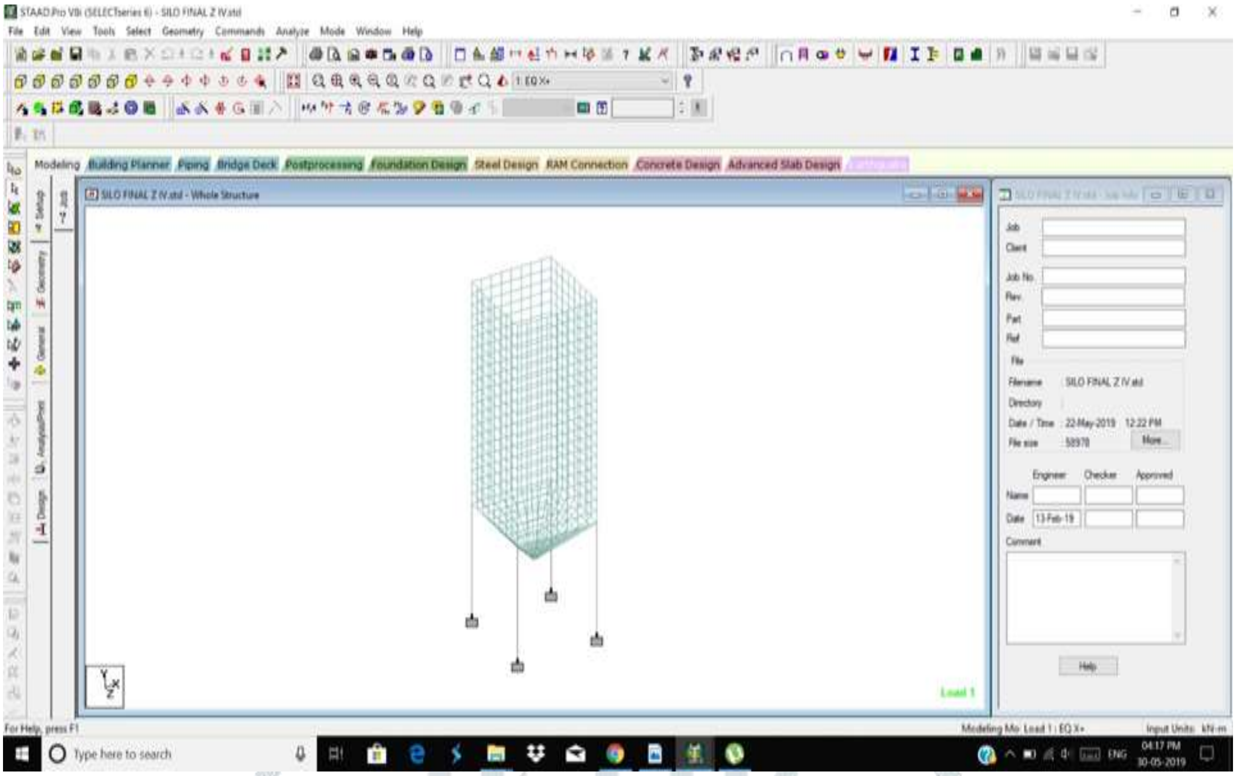


Fig 3: skeleton structure of Solid storage structure

VI. RESULTS AND DISCUSSION

The analysis is done using Staad Pro as per IS 1893 (Part I): 2002 in order to compute the Nodal displacements, stresses and lateral and vertical pressure on wall of the solid storage structure for different conditions is tabulated.

- **Maximum nodal displacement in X direction:**

Table 6.1: max nodal displacement

Sr. No.	Model Name	Max displacement in X dir.
1.	M1	514.556 mm
2.	M2	708.306 mm
3.	M3	968.929 mm
4.	M4	1453.397 mm

Table 6.1 shows the maximum nodal displacement in solid storage structure with respect to different zone means zone II, III, IV, V. where zone II has least amount of minimum nodal displacement and zone V has maximum nodal displacement.

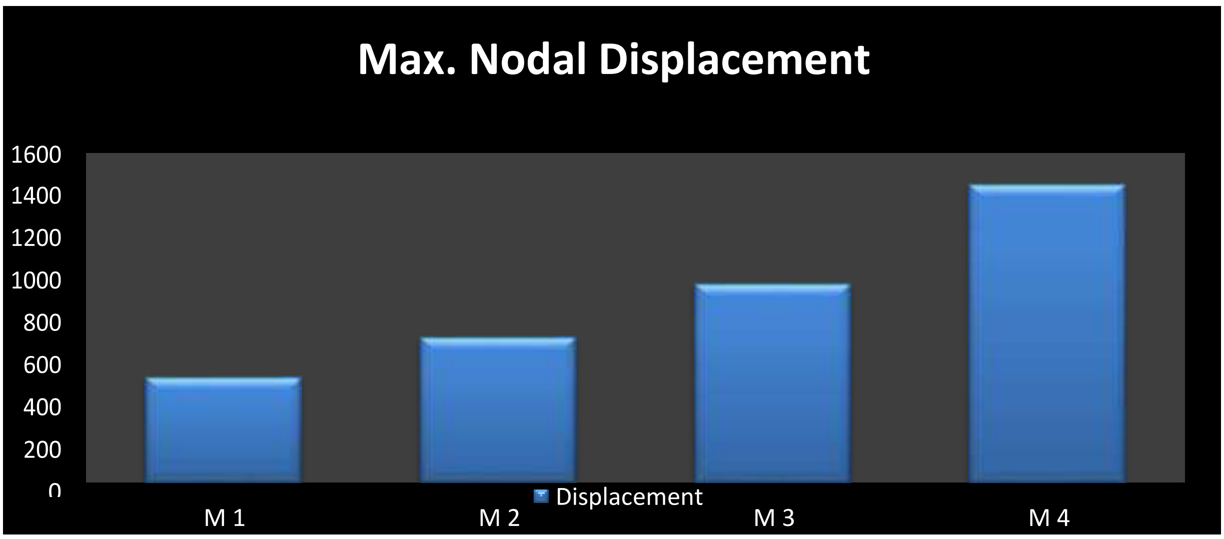


Fig 4: maximum nodal displacement in x direction for zone v

- **Maximum Nodal Displacement in Z direction:**

Table 6.2: Max Nodal Displacement in Z direction

Sr. No.	Model Name	Max displacement in Z dir.
1.	M1	403.729 mm
2.	M2	645.954 mm
3.	M3	968.929 mm
4.	M4	1453.397 mm

Table 6.2 shows the maximum displacement in Z direction. Where model 1 means zone II has least amount of nodal displacement in Z direction and model 4 means zone V has maximum nodal displacement so when we compare all 4 model the zone 2 is more safe than other model.

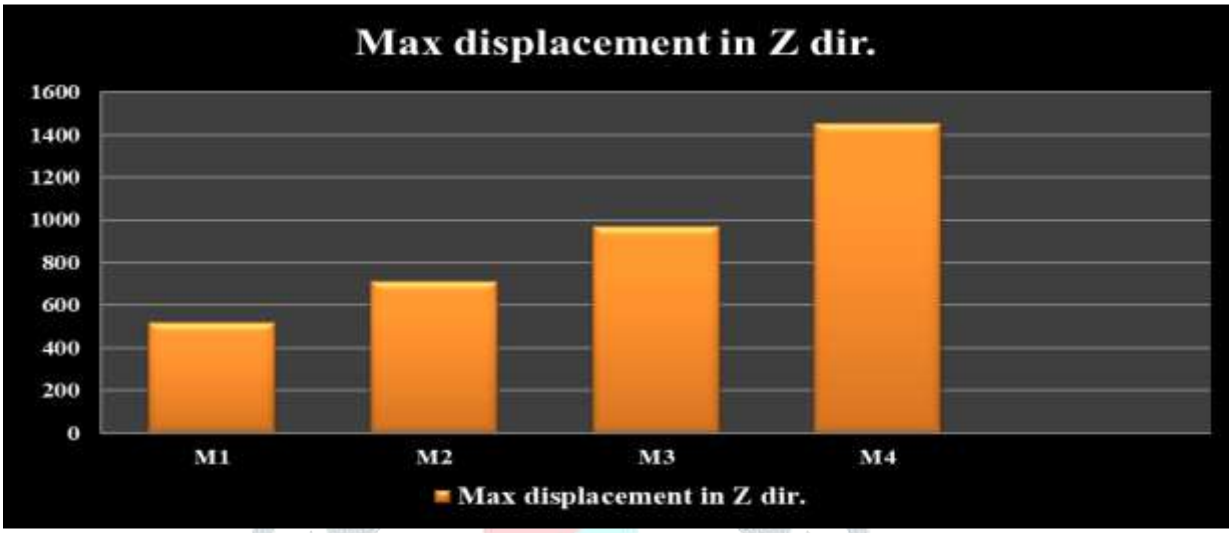


Fig 5: maximum nodal displacement in z direction for zone V

- **Max Absolute Wall Stress:**

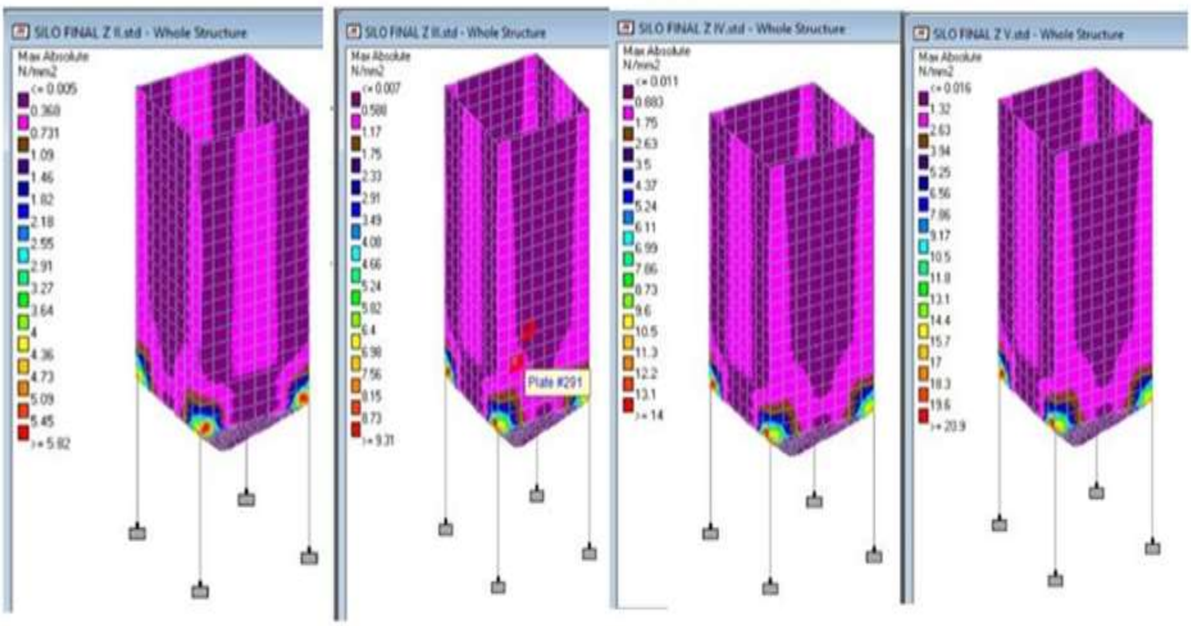


Table 6.3: Max Absolute Wall Stress

Sr. No.	Model Name	Max Absolute Wall Stress
1.	M1	5.817 N/MM2
2.	M2	9.307 N/MM2
3.	M3	13.961 N/MM2
4.	M4	20.942 N/MM2

Table 6.3 shows the maximum Absolute Wall Stress in solid storage structure. Where model 1 means zone II has least amount of Absolute Wall Stress and model 4 means zone V has maximum Absolute Wall Stress in Beam so when we compare all 4 model the zone 2 is more safe than other model.

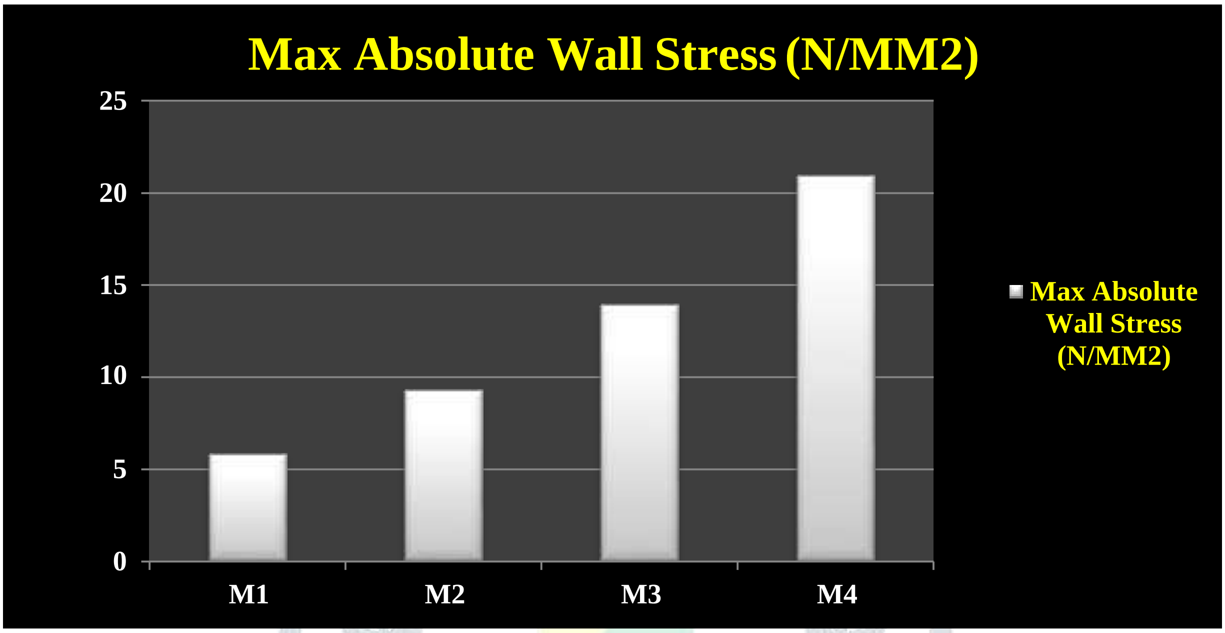


Fig 6: maximum Absolute Wall Stress for zone II to V

Figure 6 shows the maximum absolute wall stress for all zone II, III, IV, V in N/MM2. in staad pro post processing mode where dark purple colour shows the minimum stress on infill wall and red colour shows the maximum amount of stress in wall. This range varies for different seismic zone where seismic zone II have least amount of maximum stress and on the other hand seismic zone V has maximum stress as compare to all zones.

VII. CONCLUSION AND FUTURE SCOPE

This paper has to study the behaviour of the RCC solid storage structure structure in different seismic zones, which means the study was carried to observe RCC solid storage structure structure under the influence of horizontal force i.e. earthquake force or seismic force. According to my literature review lot of authors have mentioned how difficult it is to design a thick rcc solid storage structure with a single country's building standard code. The design and analysis of rcc solid storage structure was done on ' Staad Pro ' software which is used widely for similar purpose.

- In the study this is observed that the structure placed on the greater seismic zone have shown greater horizontal displacement than the one's placed in lower seismic zones.
- The maximum nodal displacement in x direction was noted in model M4 displacing 1453.397mm; other models have shown relative decrease in the displacement as the zone was lowered.
- The least value of displacement was noted on the model M1 located in the seismic zone II showing 514.556mm displacement.
- Model 3 and 4 have shown about 1 m nodal displacement in X direction which is necessary in revision of structural dimension and grade of materials.
- The maximum force at the base was noted in model M4 725.073 KN the value of base force kept decreasing as the seismic zone is lowered hence giving least base moment in model M1 202.468 KN.
- The maximum moment at the base was noted in model M4 3715.78 KN-m; the value of base moment kept decreasing as the seismic zone is lowered hence giving least base moment in model M1 1035.723 KN-m.
- The maximum Shear Force in Beam was noted in model M4 6058.655 KN; the value of maximum Shear Force in Beam kept decreasing as the seismic zone is lowered hence giving least maximum Shear Force in model M1 4882.82 KN.

- The maximum Bending Moment in Beam was noted in model M4 3715.78 KN-M; the value of maximum Bending Moment in Beam kept decreasing as the seismic zone is lowered hence giving least maximum Bending Moment in model M1 1277.66 KN-M.
- The maximum Absolute Wall Stress was noted in model M4 20.942 N/MM2; the value of maximum Absolute Wall Stress kept decreasing as the seismic zone is lowered hence giving least maximum Absolute Wall Stress in model M1 5.817 N/MM2.
- In manual estimate of load in RCC solid storage structure is very easy. Value of these loading is very less and when applied the loading in staad pro v8i is very easy.

Future Scope

1. H/D ratio of all types of solid storage structures needs to be studied this result can be used in IS: 9178 part II 2006. Comparison should be made under various type of eccentricity hopper bottom for various soil conditions.
2. Comparison should be made for different H/D ratios.
3. Solid storage structure structures can also be strengthened and upgraded using certain new materials and techniques including Post-Tensioning.
4. The study may be carried out with an opening for the movement of vehicles (i.e. removing diagonal bracings either on one side or two sides for the first storey).
5. The Study may be carried out with other materials carrying different flow pattern.
6. Analysis study can be carried out for typically filled conditions where there is no pressure induced on the wall (i.e. only for material filled in hopper plus the repose material forming cone).
7. The study may be carried out with other types of solid storage structure with different specifications.

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References

[1] Vivek Subhas rao, Dr. P Saklecha, Prof. R S Kedar (2016) "Design and Comparison of Types of Solid storage structure." International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Published by, www.ijert.org IC-QUEST - 2016 Conference Proceedings 2016.

[2] S. Chithra and G. Indupriya "Contributions of Different Standards and Codes for the Design of Solid storage structure: A Review." The Asian Review of Civil Engineering ISSN: 2249 - 6203 Vol. 5 No.2, 2016, pp.27-33 © The Research Publication, www.trp.org.in

[3] John Carson and David Craiga 2015 "Solid storage structure design codes: Their limits and inconsistencies" the 7th World Congress on Particle Technology (WCPT7) Procedia Engineering 102 (2015) 647 – 656

[4] Afzal Ansari1 Kashif Armaghan2 , Sachin S. Kulkarni3 "Design and Optimization of RCC Solid storage structure." International Journal for Research in Applied Science & Engineering Technology (IJRASET)

[5] Dharmendra H. Pambhar, Prof. Shraddha R. Vaniya "Design and analysis of circular solid storage structure (RCC) for storing bulk materials." International Journal of Advance Research in Engineering, Science & Technology (IJAREST), ISSN (O):2393-9877, ISSN (P): 2394-2444

[6] Chirag L. Korat, Jasmin A. Gadhiya ,Hardik A. Patel "A Review on Parametric Study of Circular RCC Solid storage structure having Hopper Bottom." International Journal of Advance Engineering and Research Development Volume 4, Issue 11, November -2017

[7] Krishna T. Kharjule , Minakshi B. Jagtap "SEISMIC ANALYSIS OF R.C.C. AND STEEL SOLID STORAGE STRUCTURES." International Journal of Computational Engineering Research (IJCER) ISSN (e): 2250 – 3005 || Volume, 05 || Issue, 07 || July – 2015 ||

[8] Suvarna Dilip Deshmukh, Rathod S. T.2 "Comparison of Design & Seismic Behavior of RCC SOLID STORAGE STRUCTURE." International Journal of Computational Engineering Research (IJCER) ISSN (O):2356 International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

[9] Xiong, D. X. and Zha, X. X. (2007). "A numerical investigation on the behavior of concrete-filled steel tubular columns under initial stresses." Journal of Constructional Steel Research, 63(5), 599-611.

[10] N Krishnaraju, "Advanced Reinforced Concrete Design" CBS Publisher (2010 Edi).

[11] Sagarika Panda & Dr M Mohanty, "The failure study of bed ash solid storage structures a case study", International Journal of Latest Trends in Engineering and Technology Vol. (9) Issue (3), pp.076-079 DOI: http://dx.doi.org/10.21172/1.93.15 e-ISSN: 2278-621X