EXPERIMENTAL & ANALYTICAL EVALUATION OF BASE ISOLATED WATER TANK STRUCTURE[IDP]

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ORGANIZATION/FRAMEWORK

- Basic of Earthquake
- Seismic Waves
- Effects of Earthquake
- Earthquake lowering down Systems
- Concept of Base Isolation
- Types of Isolation
- Friction Pendulum System
- Types of Friction pendulum Bearing
- Implementation of Seismic Isolation
- Objective

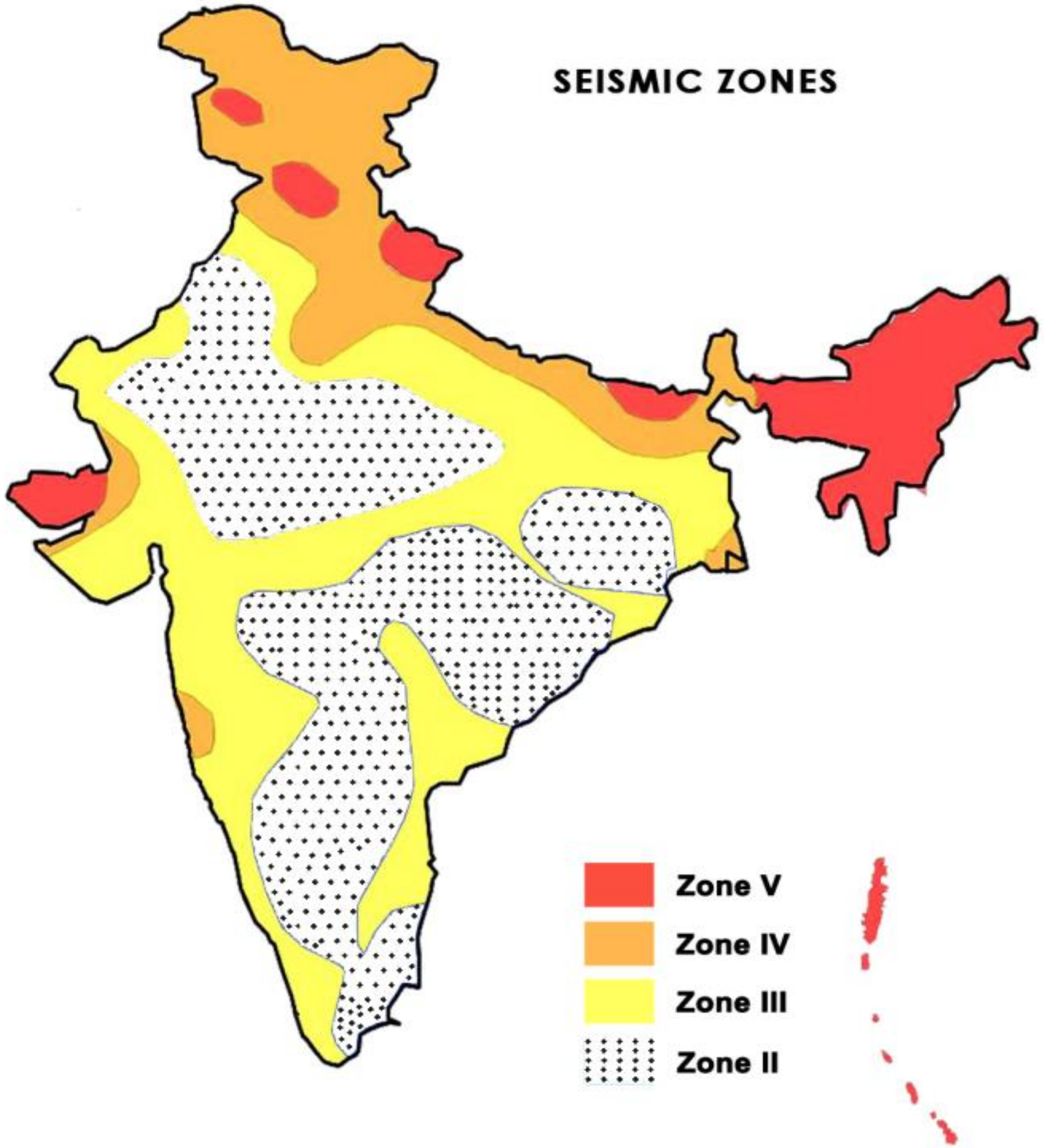
ORGANIZATION/FRAMEWORK

- Literature Review
- Design of Friction Pendulum Bearing
- Sap 2000 Software
- Conclusion
- Expected outcome
- Patent Search & Analysis Report (PSAR)
- Work Plan
- References

Earthquake

- Earthquakes are powerful forces of nature that are caused by movement of tectonic plates.
- The Earth’s crust is composed of seven major tectonic plates, as well as smaller secondary and tertiary plates.
- These plates are in constant motion. Tectonic plates are either sliding past, or moving towards or away from one another. These plates store potential energy.
- When the potential energy becomes too great, it is converted into kinetic energy from the movement of the plates and causes an earthquake.
- Since these plates are in constant motion, many earthquakes occur around their boundaries.

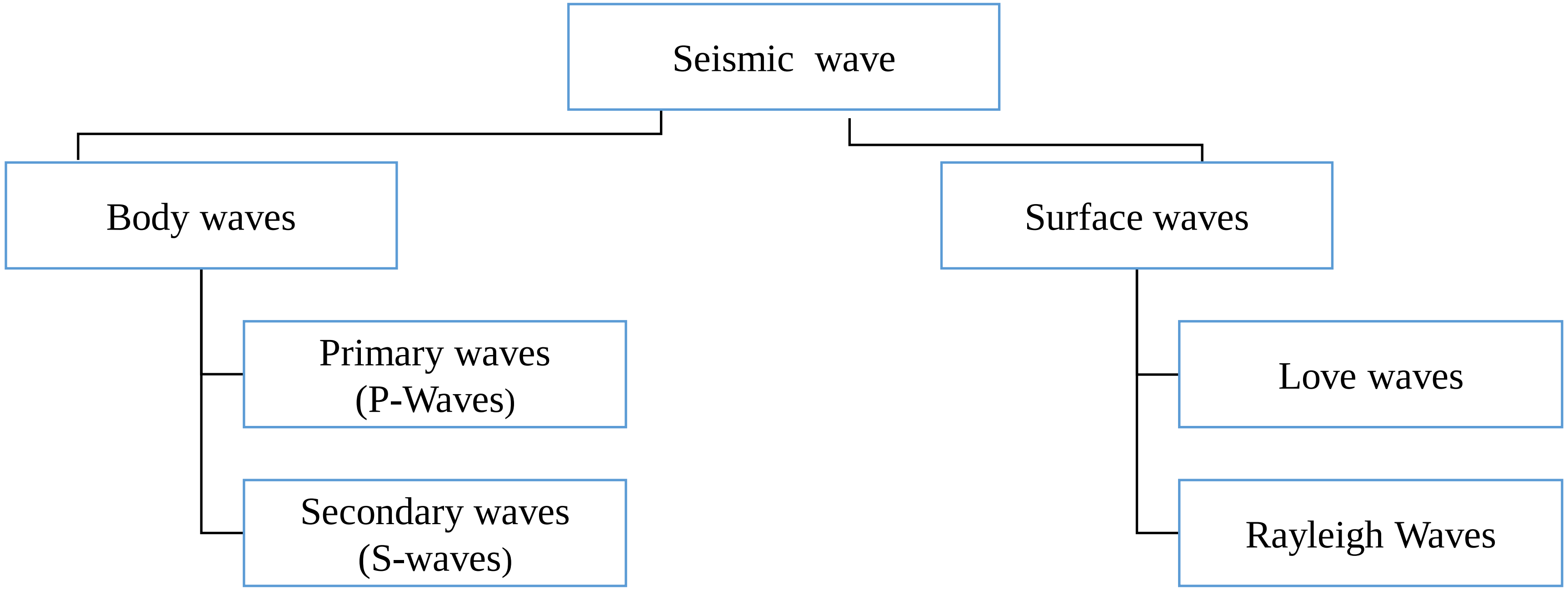
Seismic Zone Map of India



- About **59 percent** of land area of India is liable to seismic hazard damage

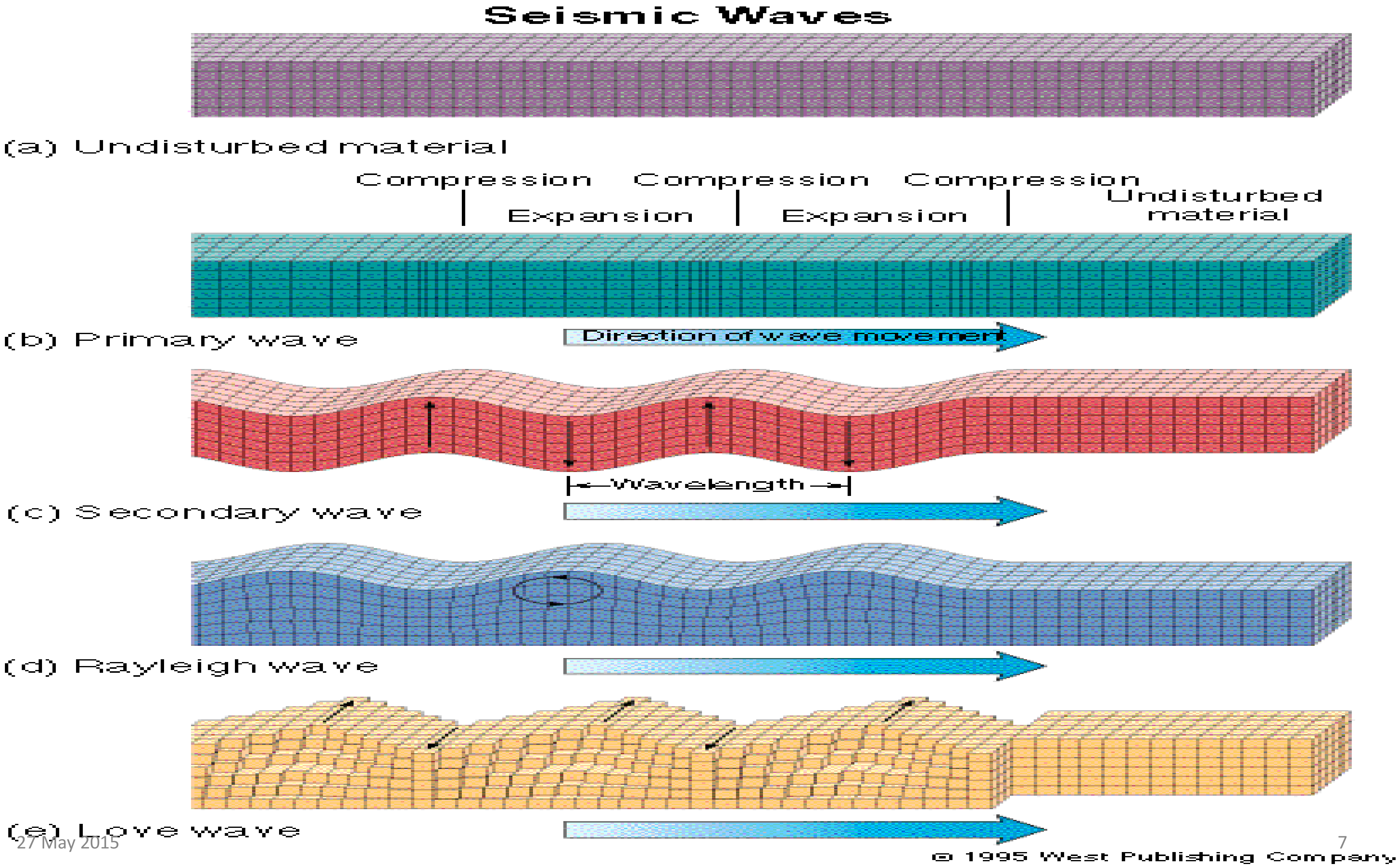
Seismic waves

- Seismic waves are characterized by whether the wave is on the Earth’s surface or below and by the direction of propagation the particles undergo relative to the direction of a wave.
- There are four different types of seismic waves in total.



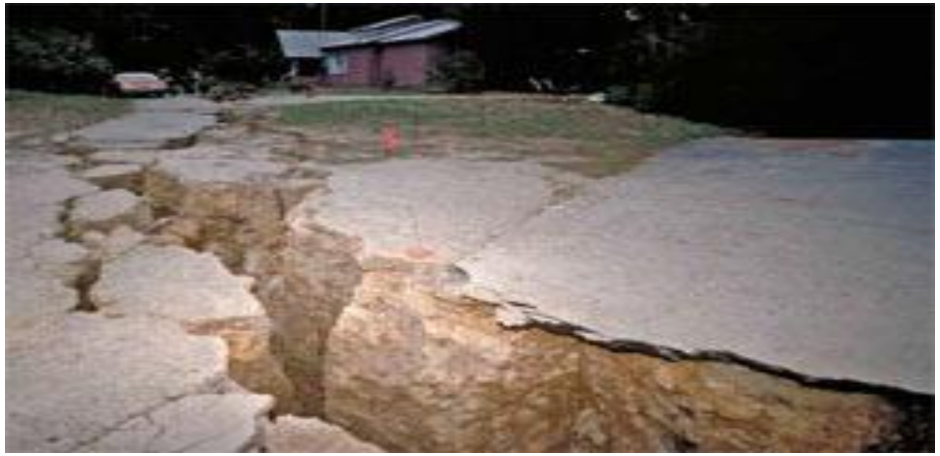
Primary wave

Secondary wave



Effects of earthquake

- **Shaking and ground rupture:-** Shaking and ground rupture are the main effects created by earthquake, principally resulting in more or less severe damage to buildings and other rigid structures as shown in Figure.



- **Landslides and avalanches:-** Earthquake, along with severe storms, volcanic activity, and coastal wave attack, and wildfires, can produce slope instability leading to landslides, a major geological hazard. Landslide danger may persist while emergency personnel are attempting rescue.

- **Fire:-** Earthquake can cause fires by damaging electrical power or gas lines. In the event of water mains rupturing and a loss of pressure, it may also become difficult to stop the spread of a fire once it has started.

Fire due to earthquake. Photo by M. Rymer, USGS

- **Soil liquefaction:-** Soil liquefaction occurs when, because of the shaking, water-saturated granular material (such as sand) temporarily loses its strength and transforms from a solid to a liquid. Soil liquefaction may cause rigid structures, like buildings and bridges, to tilt or sink into the liquefied deposits. This can be a devastating effect of earthquake.

•Tsunami:- Tsunamis are long-wavelength, long-period sea waves produced by the sudden or abrupt movement of large volumes of water. In the open ocean the distance between wave crests can surpass 100 kilometers (62 mi), and the wave periods can vary from five minutes to one hour. Such tsunamis travel 600-800 kilometers per hour (373–497 miles per hour), depending on water depth.

•Flood:- A flood is an overflow of any amount of water that reaches land. Floods occur usually when the volume of water within a body of water, such as a river or lake, exceeds the total capacity of the formation, and as a result some of the water flows or sits outside of the normal perimeter of the body.

- **Human impacts:-** An earthquake may cause injury and loss of life, road and bridge damage, general property damage (which may or may not be covered by earthquake_insurance), and collapse or destabilization (potentially leading to future collapse) of buildings. The aftermath may bring disease, lack of basic necessities, and higher insurance premiums. Also Earthquake affect the building like water tanks, commercial building, industry etc.

Unconventional Earthquake Lowering down Systems

Earthquake Lowering down Systems

- Passive Protective Systems
  - Tuned Mass Damper
  - Energy Dissipation
  - Base Isolation
- Hybrid Protective Systems
  - Active Isolation
  - Semi-Active Isolation
  - Semi-Active Mass Damping
- Active Protective Systems
  - Active Mass Damping
  - Active Bracing
  - Adaptive Control

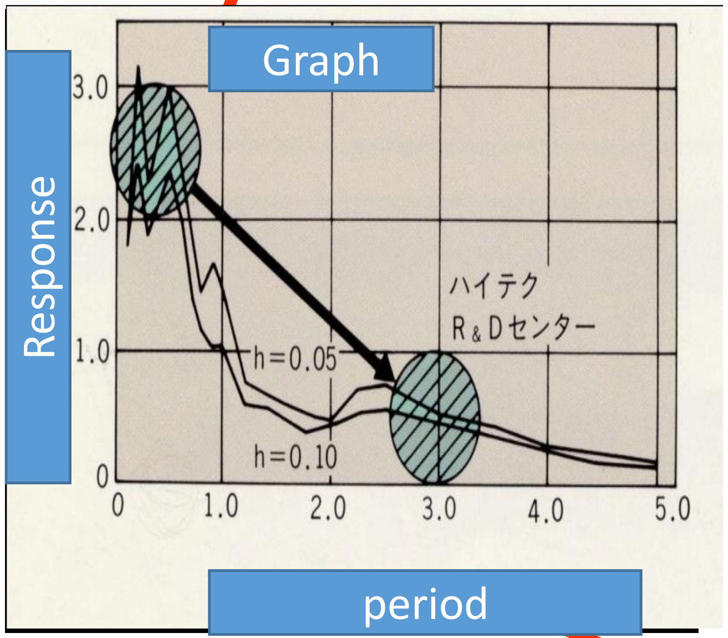
Seismic base isolation systems

- An isolation system should be able to support a structure while providing additional horizontal flexibility and energy dissipation. The three functions could be concentrated into a single device or could be provided by means of different components. Various parameters to be considered in the choice of an isolation system, apart from its general ability of shifting the vibration period and adding dumping to the structure are: (i) deformability under frequent quasi-static load (i.e., initial stiffness), (ii) yielding force and displacement (iii) capacity of self-centering after deformation and (iv) the vertical stiffness.
- There are two basic types of isolation systems. One is the elastomeric bearings and another is sliding isolation systems. The elastomeric bearings with low horizontal stiffness shift fundamental time period of structure to avoid resonance with excitations. The sliding isolation system is based on the concept of sliding friction.

THE CONCEPT OF BASE ISOLATION

Fixed Base

Response

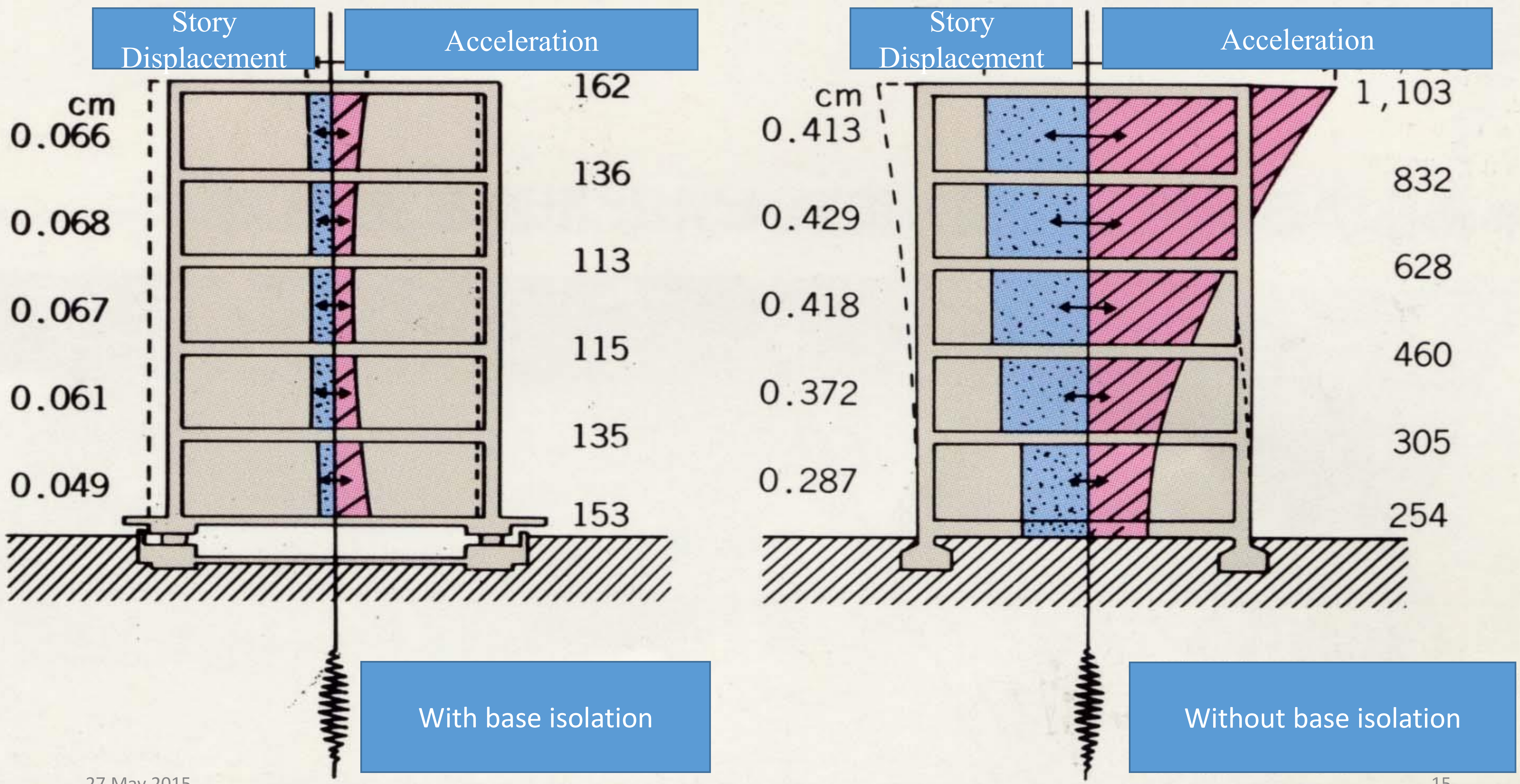


Period

Base Isolated

Significantly Increase the Period of the Structure and the Damping so that the Response is Significantly Reduced

WITH & WITHOUT BASE ISOLATION



Most common types of isolation components (Isolators)

- Isolation Devices
  - Elastomeric Isolators
    - Natural Rubber Bearings
    - Low-Damping Rubber Bearings
    - Lead-Plug Bearings
    - High-Damping Rubber Bearings
    - Laminated rubber bearing
  - Sliding Isolators
    - Pure friction system
    - Resilient Friction System
    - Sliding resilient friction
    - Resilient-friction base isolator
    - Electricite de France system
    - Friction Pendulum System

Comparison of natural rubber bearing and FPS (Sliding bearing)

Natural Rubber Bearings	Friction Pendulum System (**Sliding Bearing**)
1. It yields in shear at low stress levels. 2. Lead has good fatigue properties during cycling at plastic strain. 3. Lead is readily available at high purities. (allows properties to be predictable)	1. F.P. systems can accommodate much larger levels of displacements than rubber bearings. 2. F.P. systems offer more space efficiency (and are shorter) than rubber bearings with the same displacement capacity. 3. Reducing the coefficient of friction further reduces base shear and increases displacement. 4. Curvature of the F.P. controls the frequency of the device. 5. Offer very predictable performance. (particularly over rubber bearings).

Friction pendulum system (FPS)

- Sliding friction pendulum isolation system is one type of flexible isolation system suitable for small to large-scale buildings. It combines sliding a sliding action and a restoring force by geometry.
- The isolation system consists of FPS bearing which has an articulated slider and a concave surface. The resisting forces on the FPS are the sum of the restoring force due to the rise of the mass and the friction force between the slider and concave surface.
- The isolation period is a function of the radius of curvature which of the sliding surface is independent of the mass. Such bearings are particularly important for the base isolation of industrial tanks since the isolation period is independent of the storage level.

Friction Pendulum Bearings

SINGLE-PENDULUM BEARINGS

- The single concave friction pendulum bearing is the original Friction Pendulum System represents the first manufactured sliding-bearing to make use of the pendulum concept.
- This bearing consists of an articulated slider resting on a concave spherical surface. The slider is coated with a woven PTFE (poly tetra fluoro ethylene) composite liner, and the spherical surface is overlain by polished stainless steel.
- A picture showing an FP bearing and a cross-section is shown in Figure 1, indicating the above described components.

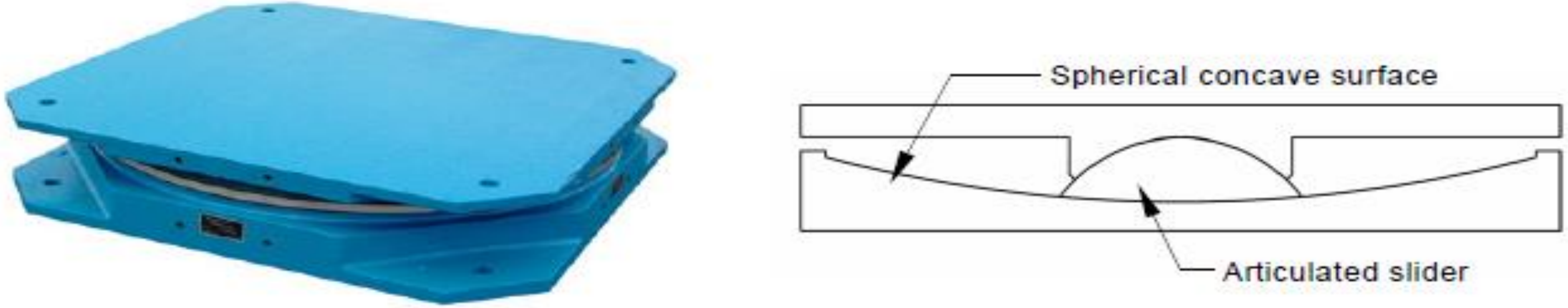


Figure 1: Photo (left) and section (right) of a typical FP bearing

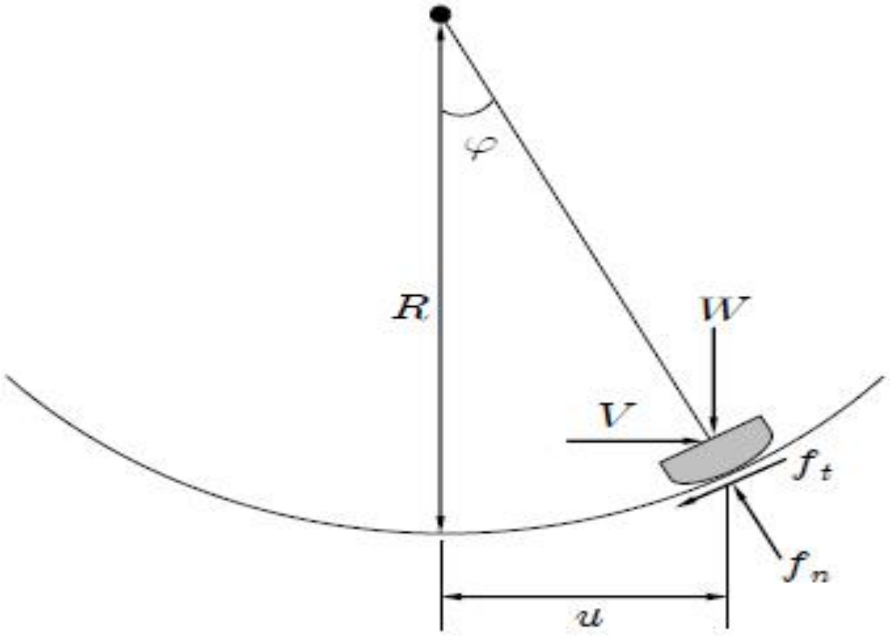


Figure 2: Idealized equilibrium of slider in displaced configuration

Double Pendulum Bearings

- Recent developments in the design and manufacturing of FP bearings have centered on the use of multiple pendulum mechanisms. Whereas the single concave FP bearing has two key parameters that characterize cyclic behavior (R and μ), a multi-stage FP bearing has greater design flexibility because the pendulum length and friction coefficient are specific for each independent pendulum mechanism.

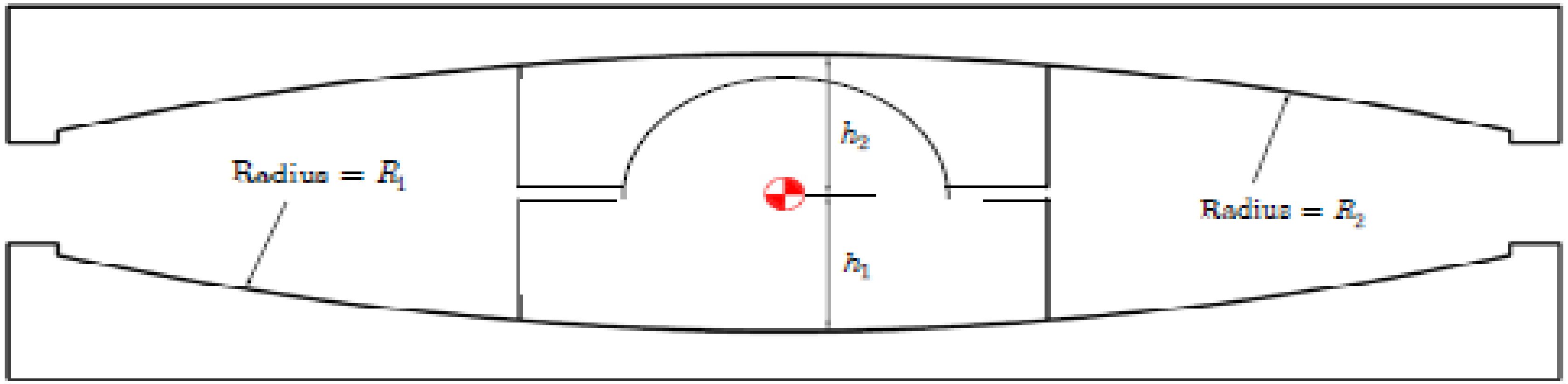
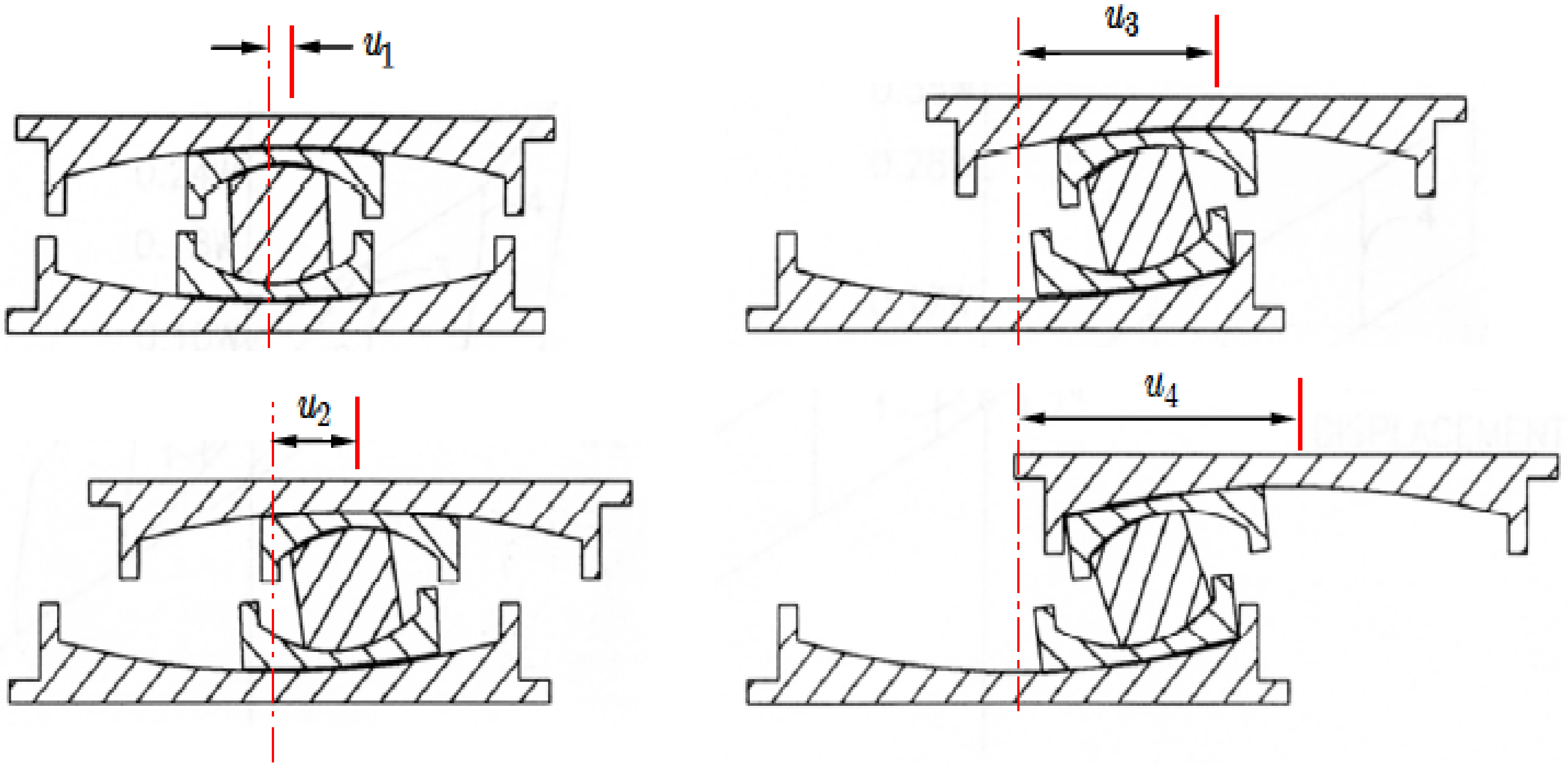


Figure 3 : Section through a typical DP bearing

Triple Pendulum Bearings

- The triple pendulum bearing introduced by EPS, Inc., consists of four concave surfaces and three independent pendulum mechanisms. The outer slider consists of concave surfaces on either side of a cylindrical inner slider with a low-friction interface on both ends.
- The outer slider also consists of sliding interfaces between top and bottom outer sliders and the major spherical surfaces of the bearing. The bottom sliding surface is in contact with a spherical surface of a particular radius of curvature, forming the second pendulum mechanism.
- A schematic description of each sliding mechanism as the TP bearing is subjected to increasing displacement demand in shown in next figure. In that figure, the friction coefficient on the lower major spherical surface is less than the friction coefficient on the upper major spherical surface.



Schematic description of sliding mechanisms for TP bearing, where $u_1 < u_2 < u_3 < u_4$ (adapted from figure courtesy of EPS, Inc.)

Implementation of Seismic Isolation

Mills-Peninsula Health Services New Hospital, California

- Located just two miles from California's San Andreas fault, the new, 450,000 square foot Sutter Health medical facility uses friction Pendulum system seismic isolation to Withstand a potentially strong, magnitude 8 earthquake.
- The 176 bearings are installed between the foundation and the columns of the building and allow the decoupled structure to move 30 inches in any direction during an earthquake.

Objective

- This study presents Development of a base isolation system to physically demonstrate the concept of friction pendulum single and double sliding system in laboratory.
- The responses of a water tank with & without base isolation are measured on shake table simultaneously using the accelerometer attached to the model structures.
- Further the analytic model of base isolation water tank is prepared and analyses using SAP 2000 will be done. The results will be verified with experimental results.

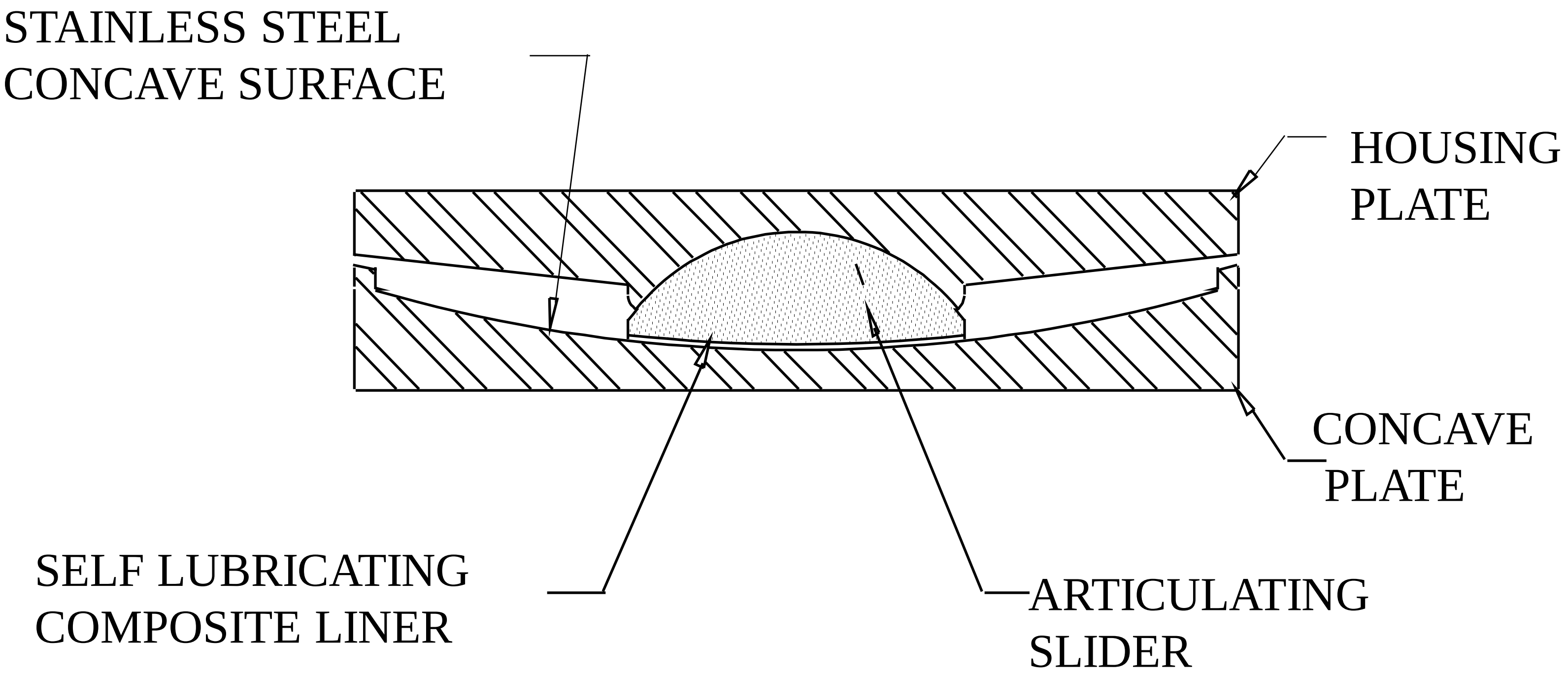
Literature Review

- Shenton III and Hampton (1999) investigated the seismic response of isolated elevated tanks and found that seismic isolation is effective in reducing the tower drift, base shear, overturning moment, and tank wall pressure for the full range of tank capacities.
- Shrimali and Jangid (2002) investigated the seismic response of liquid storage steel tanks isolated by lead-rubber bearings under bi-directional earthquake excitation and observed that the seismic response of isolated tanks is insensitive to interaction effect of the bearing forces.
- Shrimali and Jangid (2003) investigated earthquake response of elevated liquid storage steel tanks isolated by the linear elastomeric bearings under real earthquake ground motion.

- Jadhav and Jangid (2006) investigated the seismic response of liquid storage steel tanks isolated by elastomeric bearings and sliding systems under near-fault ground motions and observed that both elastomeric and sliding systems were effective in reducing the earthquake forces of the liquid storage tanks.

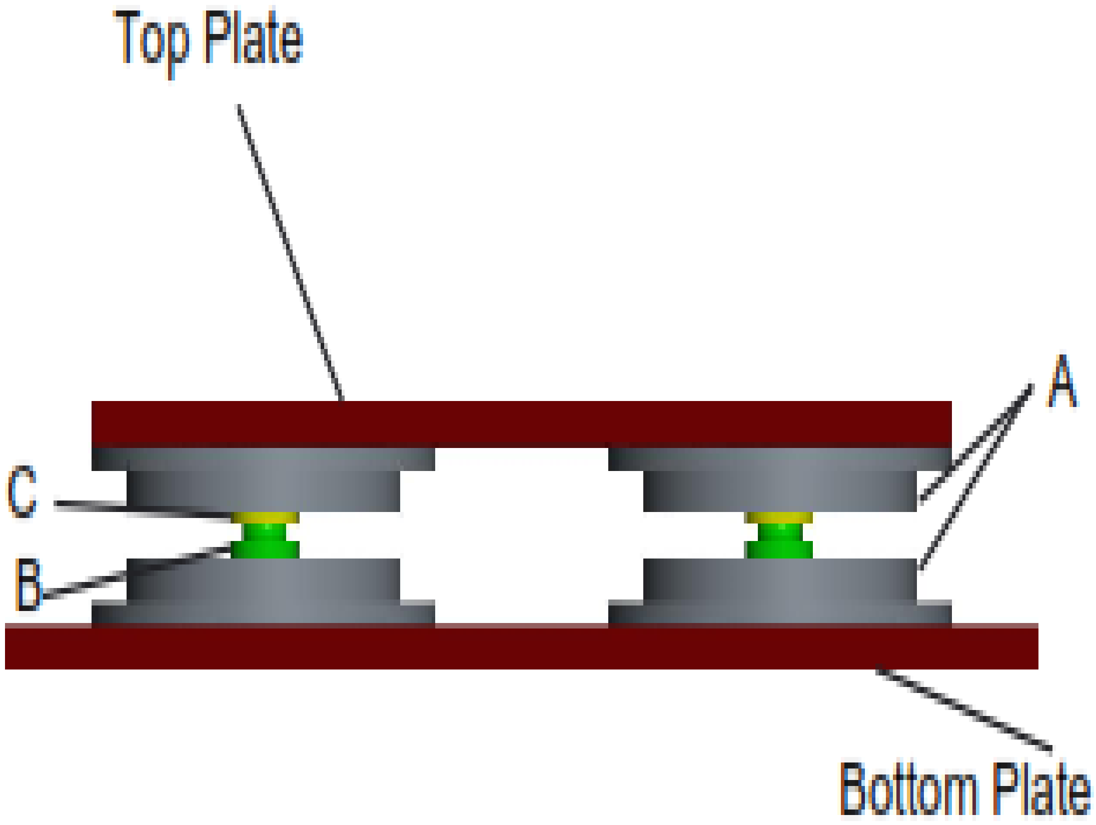
- Abali and Uçkan (2010) made a parametric study of liquid storage tanks isolated by curved surface sliding bearings to compute the sensitivity of critical response parameters such as, period of isolation, tank aspect ratio and the coefficient of friction of sliding bearings to various ground motions.

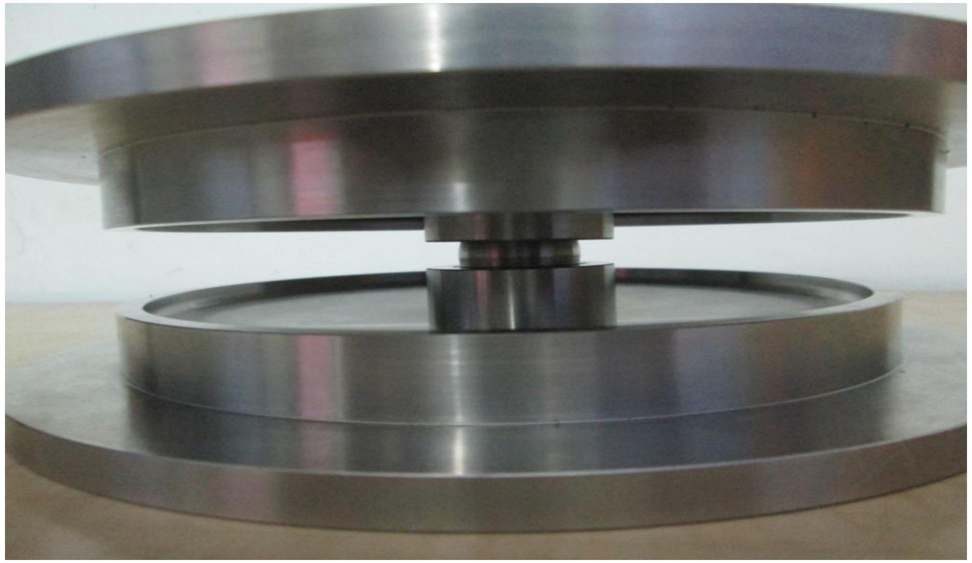
Sr. No.	Paper	Method	System used
1.	Shenton & Hampton(1999)	To find analytical investigation at the seismic response of the isolates elevated water tank.	Three degree of freedom model isolated structure is presented include isolated system.
2.	Shrimali & jangid (2002)	To find seismic response spectrum method applied liquid storage tank	Natural rubble bearing.
3.	Shrimali & jangid (2003)	To find earthquake response of elevated liquid storage steel tanks isolated by the linear elastomeric bearings under real earthquake ground motion.	Elastomeric bearings
4.	Jadhav & jangid (2006)	To find seismic response of the liquid storage tank. Elastomeric bearing are in used near-fault motion.	Friction pendulum system. Or sliding system
5.	Abalı & Uc-kan (2010)	To find curved surface sliding bearing in base isolation of liquid storage tank.	Friction pendulum system.
6.	Our project	To find seismic response of the liquid storage tank. By seismic response method and with shake table analysis.	Single system, double system & fixed system of Friction pendulum system. And determine the difference of all system.

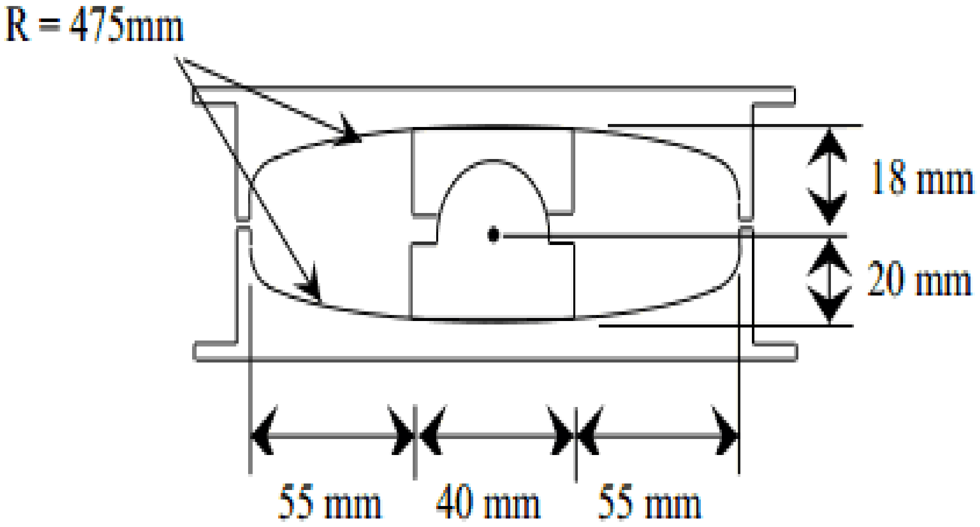


SECTION OF FRICTION PENDULUM BEARING

Design of Friction pendulum bearing

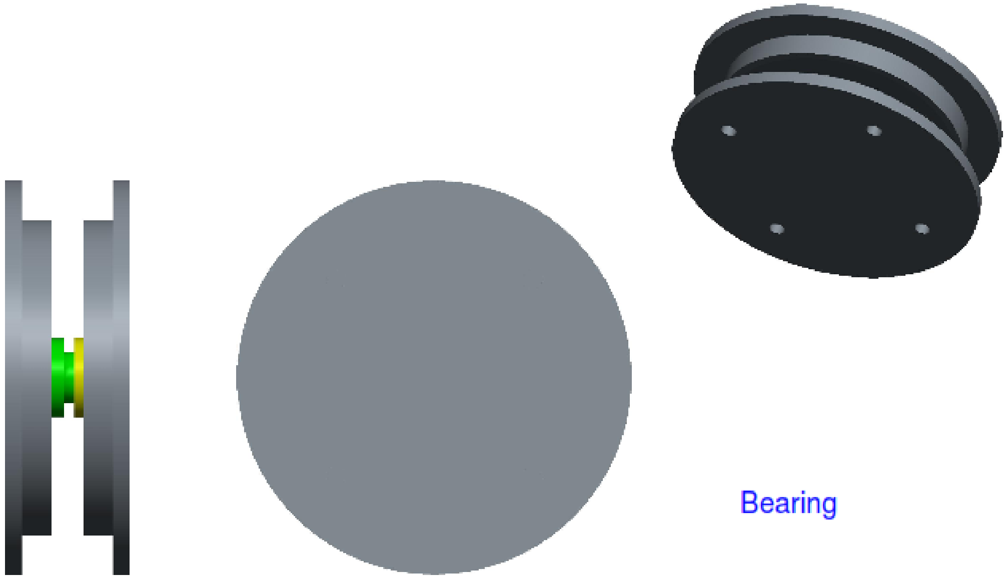






Bearing

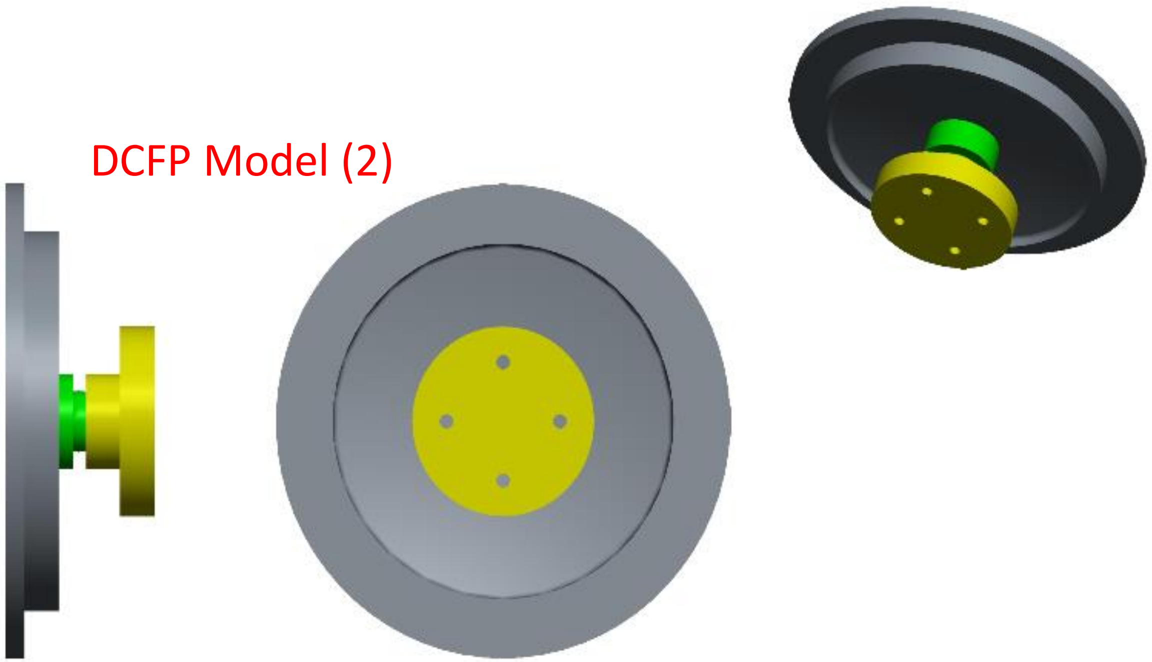
- Friction coefficient of that concave surface is 0.02 to 0.08.Friction coefficient of the concave surface is mostly very much important for the smoothness of the bearing.
- The coefficient of friction is dependent on the contact pressure between the Teflon-coated slider and the stainless steel surface.



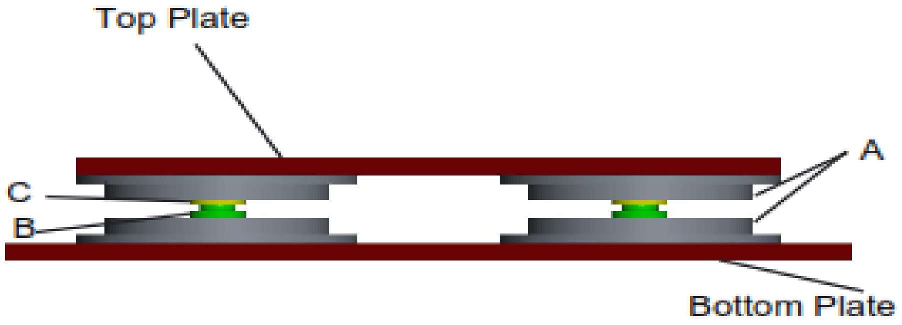
Models of Double Concave FP bearing

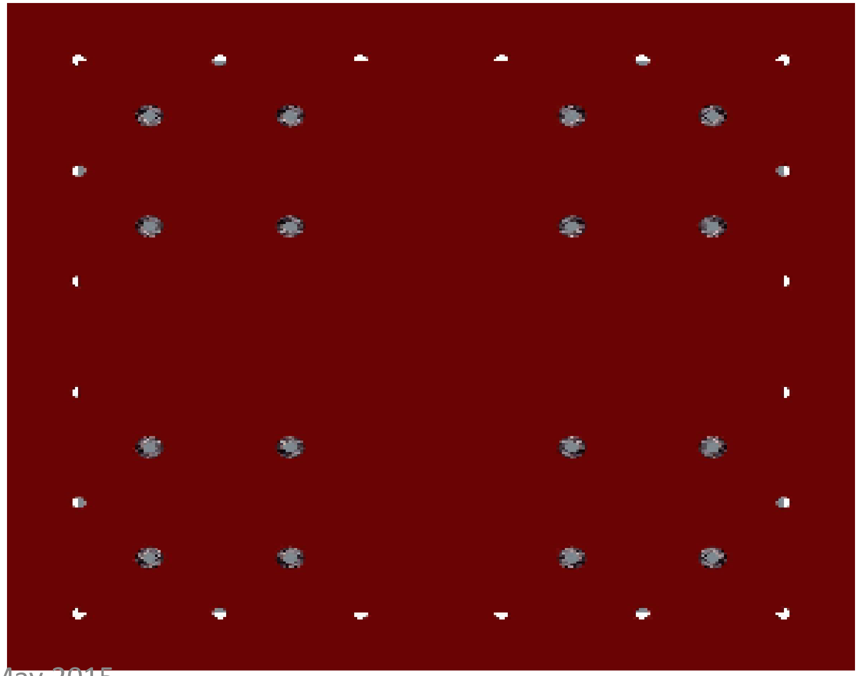
DCFP Model (1)

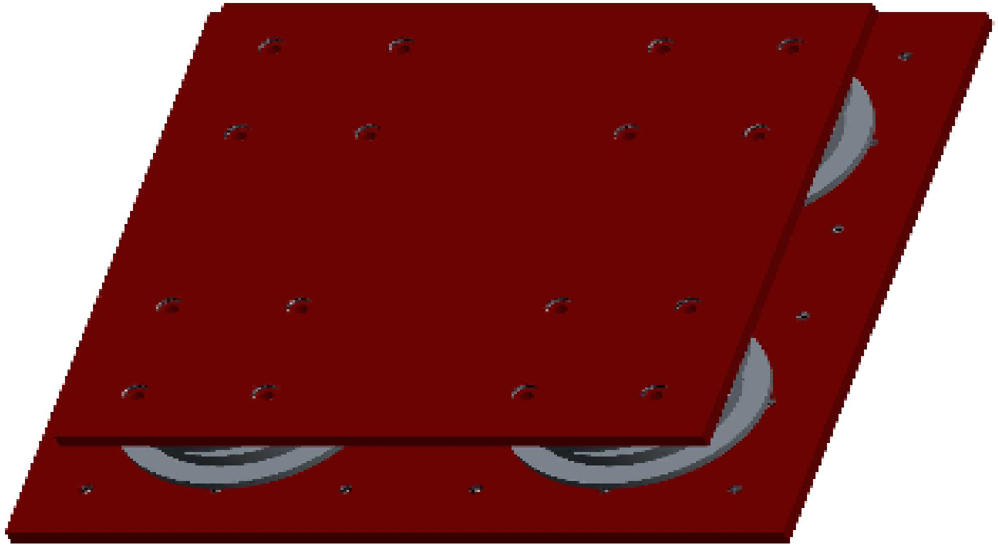
DCFP Model (2)



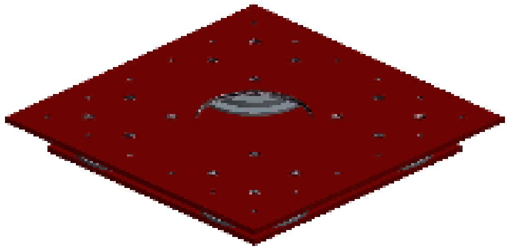
Main Assembly







SCALE 0.200

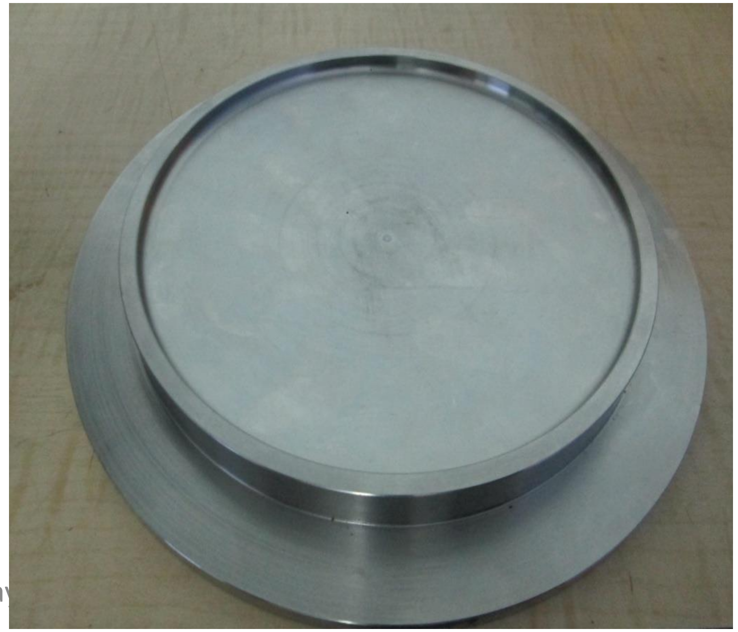


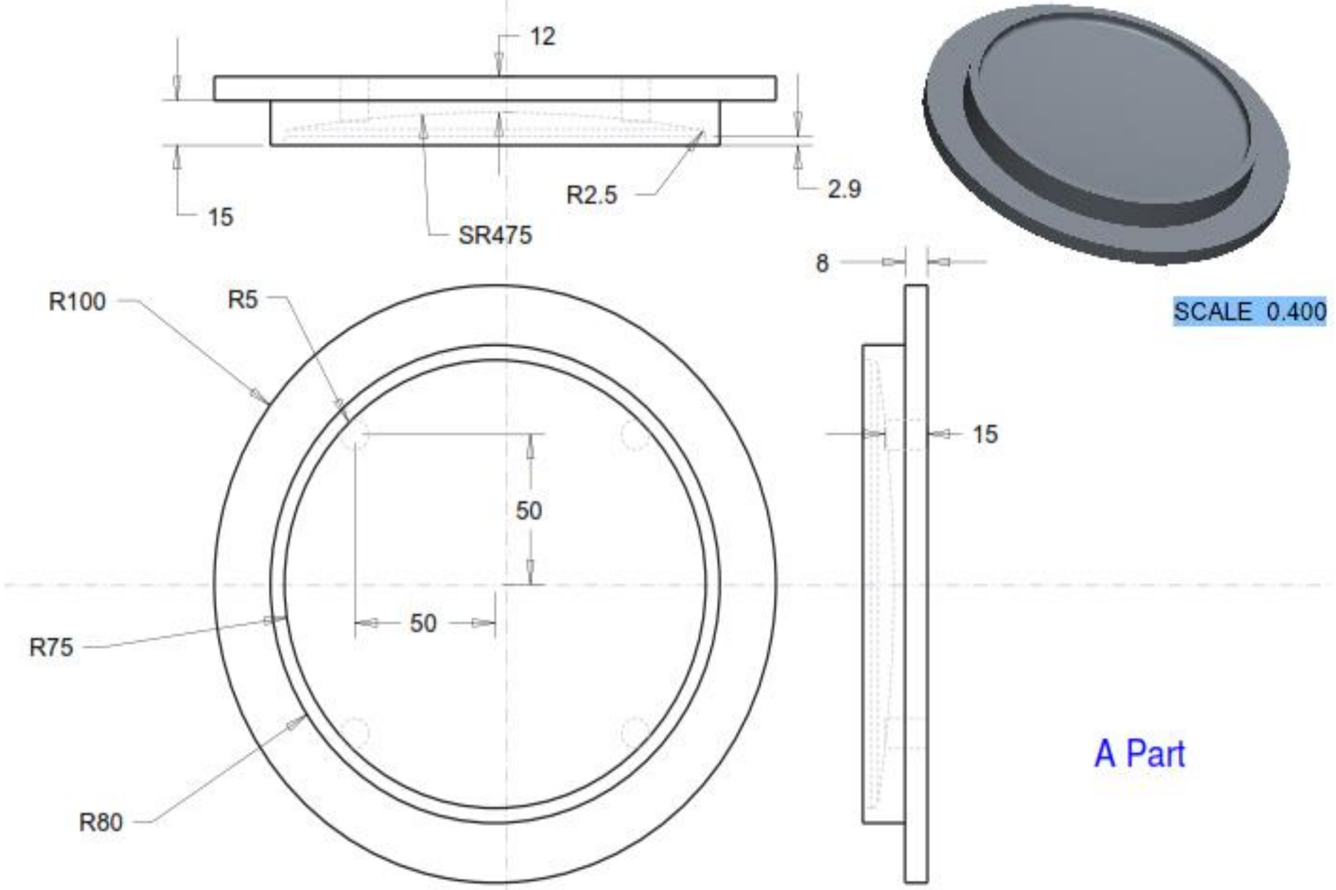
Main Assembly

SCALE 0.200

A-part

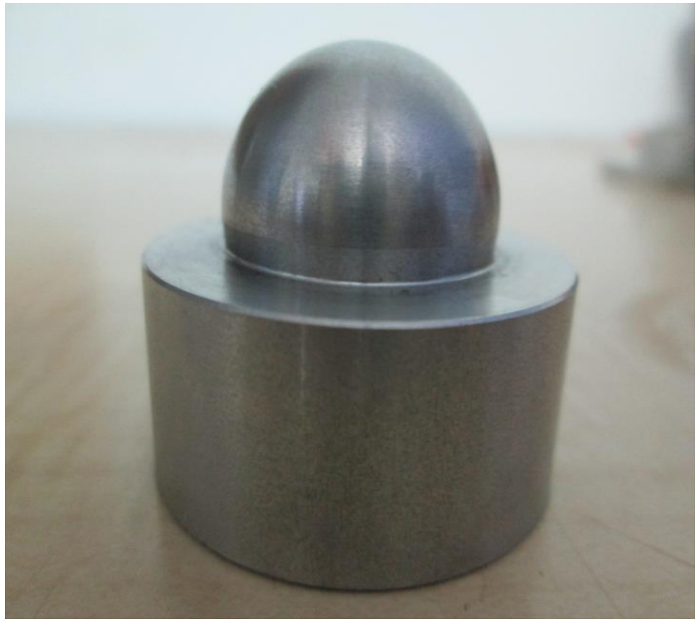
- A-part of the bearing is the concave surface for the B-part and C-part. A-part is connected both side with bearing top and bottom.

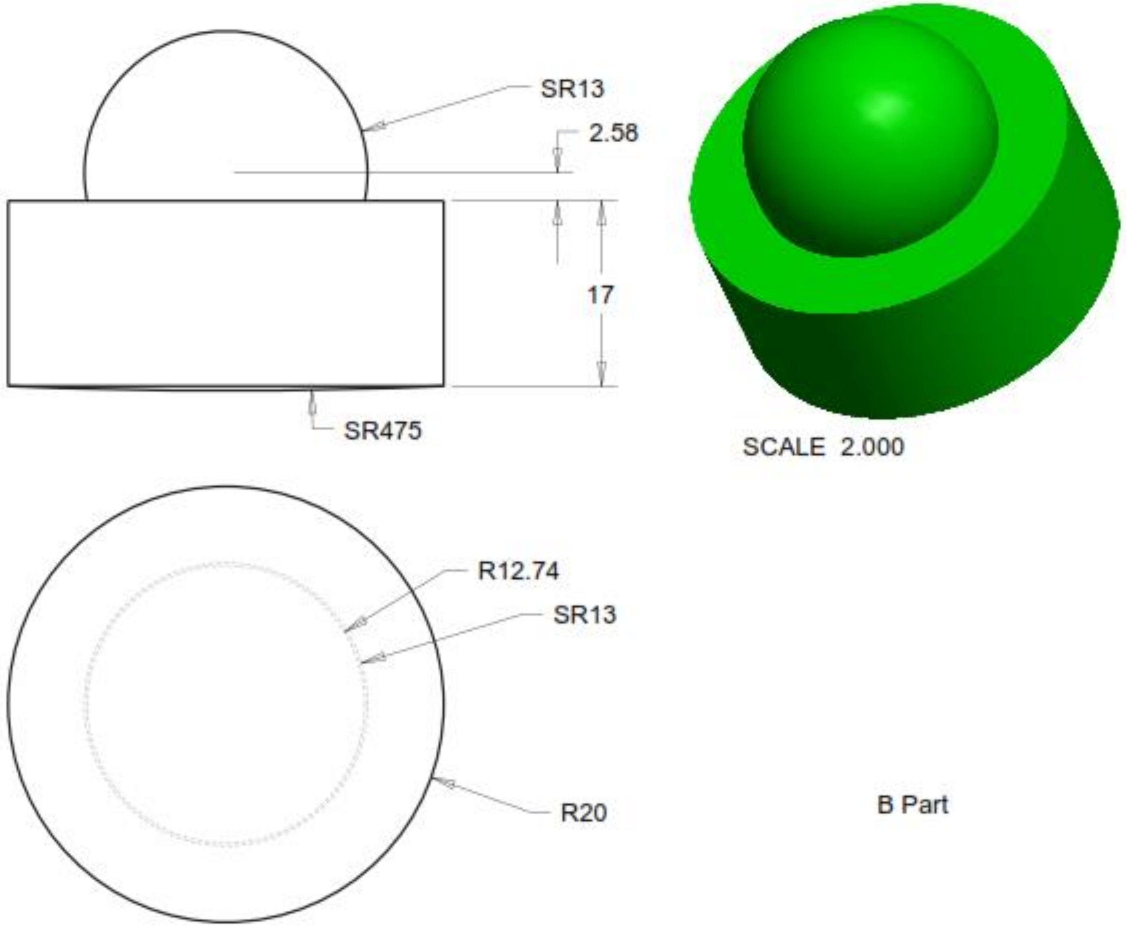




B-part

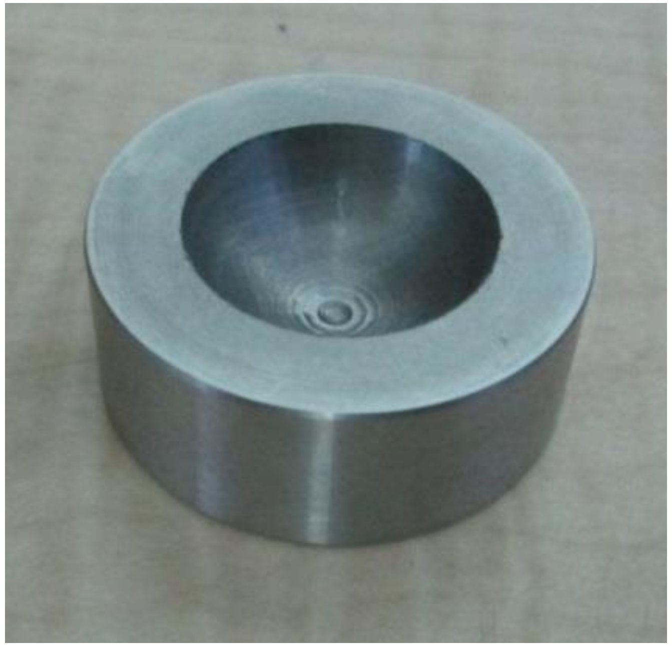
- B-part of the bearing is connected with the part A & C.B-part is one type of ball bearing.

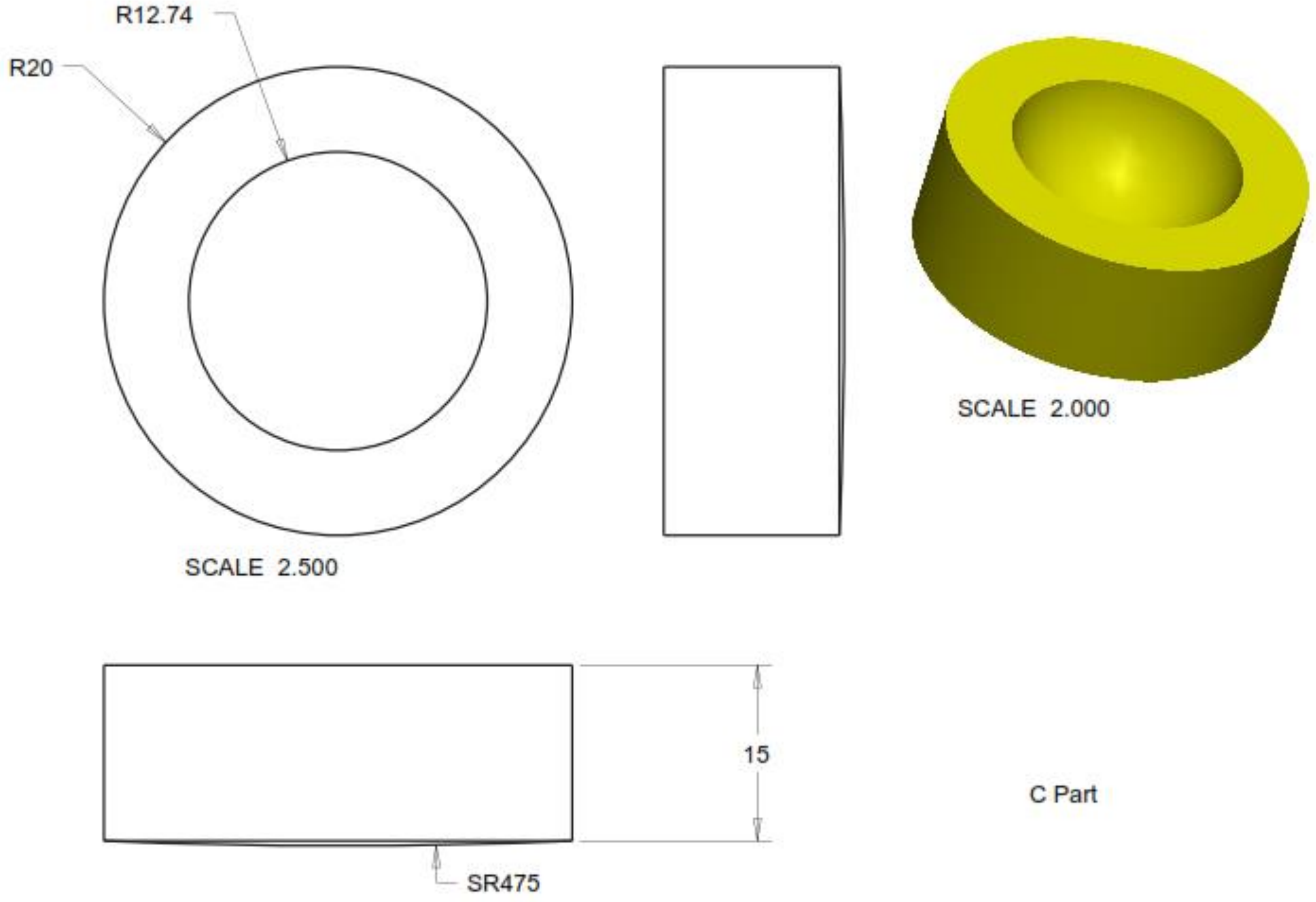




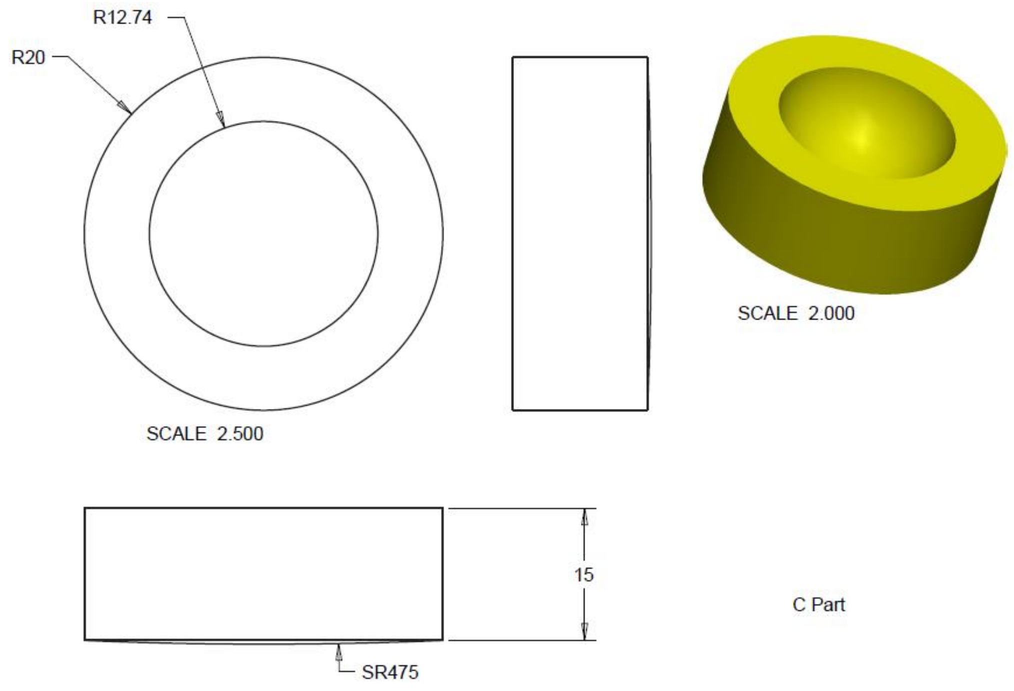
C-part

- C-part is connected with the part A & B .

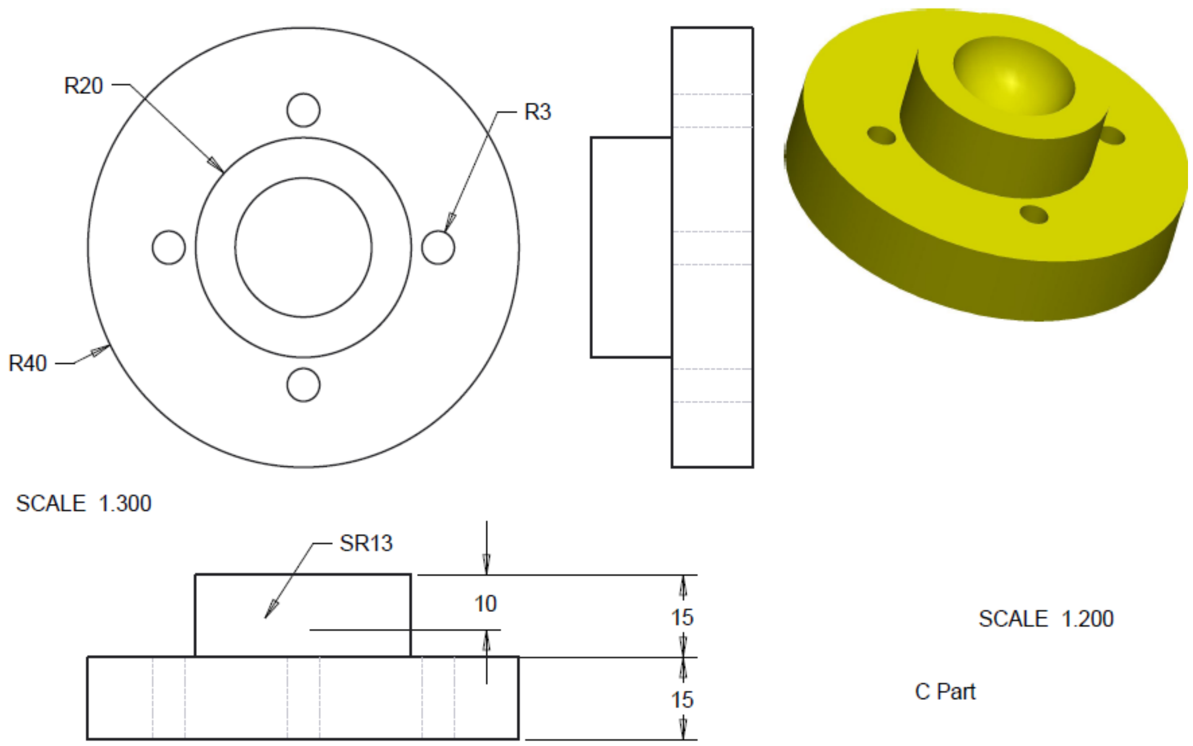




Part C: (For model 1)

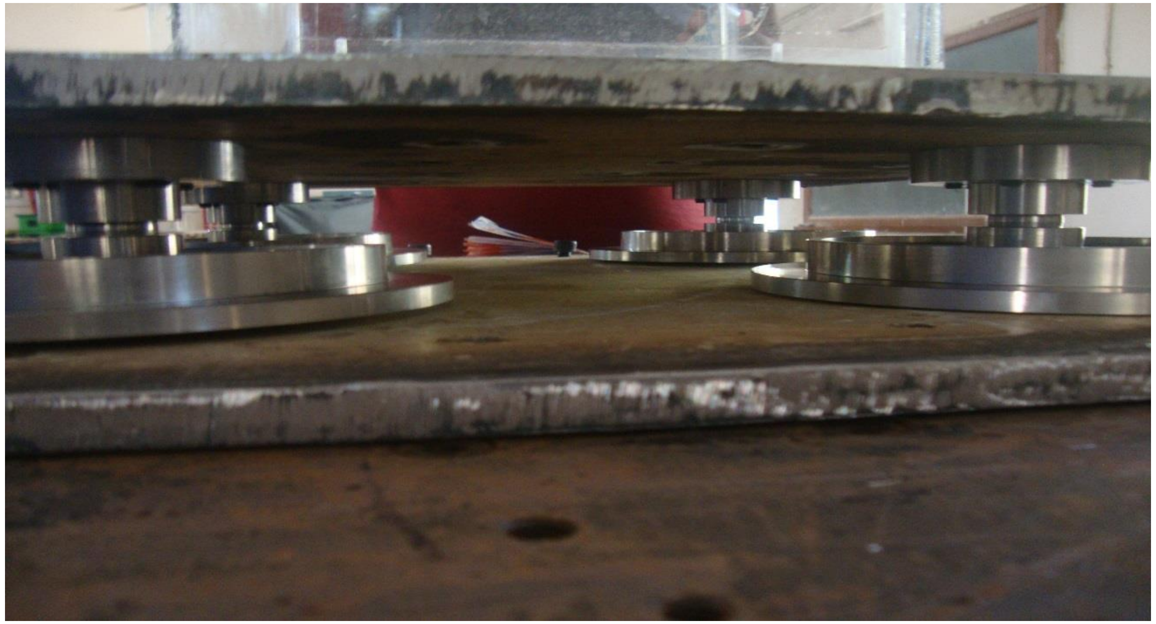


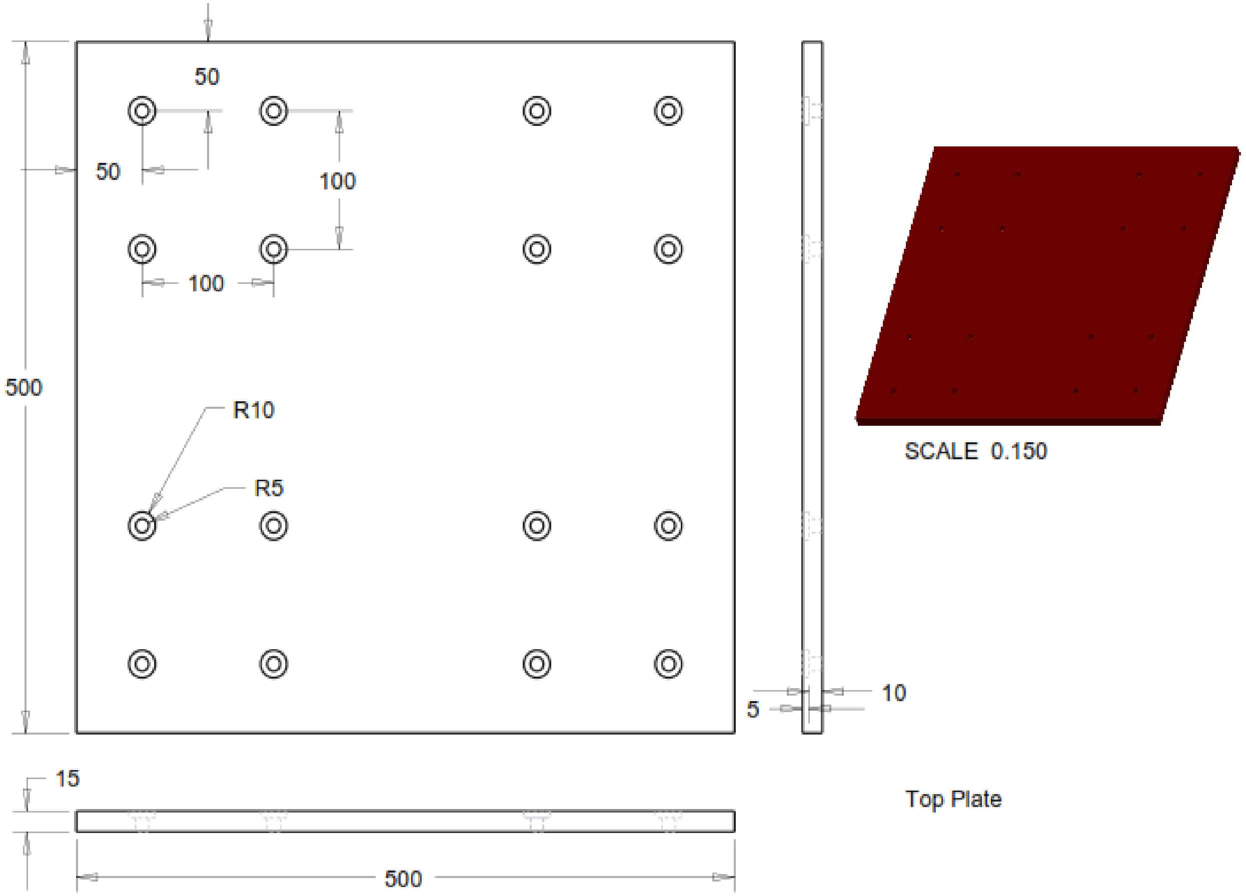
Part C: (For model 2)



Top Plate

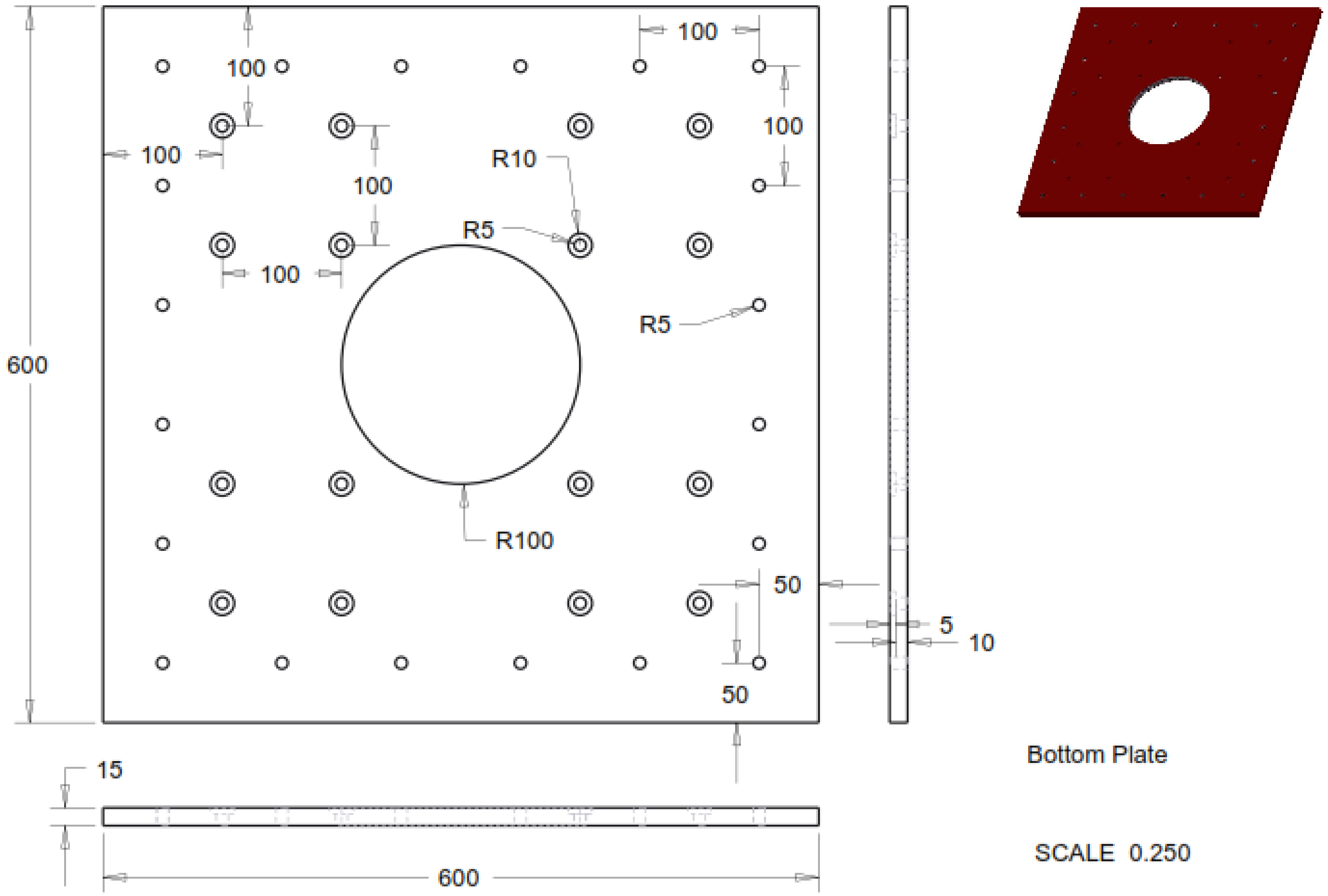
- Top plate is not a part of bearing but bearing is connected with it and top plate is connected with the model. water tank model is put on to the top plate for the shake table experiment.





Bottom plate

- Bottom plate is not part of the bearing but bearing is connected with the bottom plate and bottom plate is connected with the shake table for experiment.



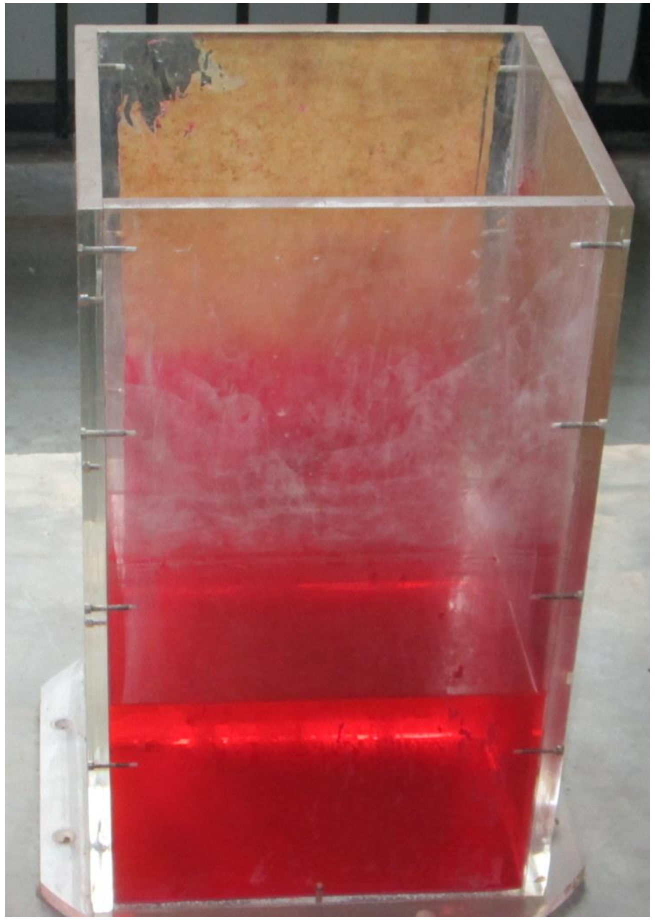
Water tank model

- Dimension of water tank model:-

Length = 270 mm

Breadth = 270 mm

Height = 515 mm



Shake Table

- Shake table is used for the experiment of water tank model. Shake table is use to find the displacement of water tank model of given frequency of the earthquake.
- Shake table is use to generate the graph of displacement with the help of accerometer and give the results of displacement at given amplitude.

Other Equipments for setup

Accelerometer

- An instrument, almost always electrical, that provides a signal (typically a Voltage) proportional to the acceleration occurring at the location of the instrument. Instruments can be based on the piezo-electric or piezo-resistive principle, strain gages, or servo accelerometers based on capacitance measurements.
- Accelerometer is use for to measure acceleration and displacement of the model and for generate graph of displacement.

Experiment and Analysis

❖ Experiment purpose

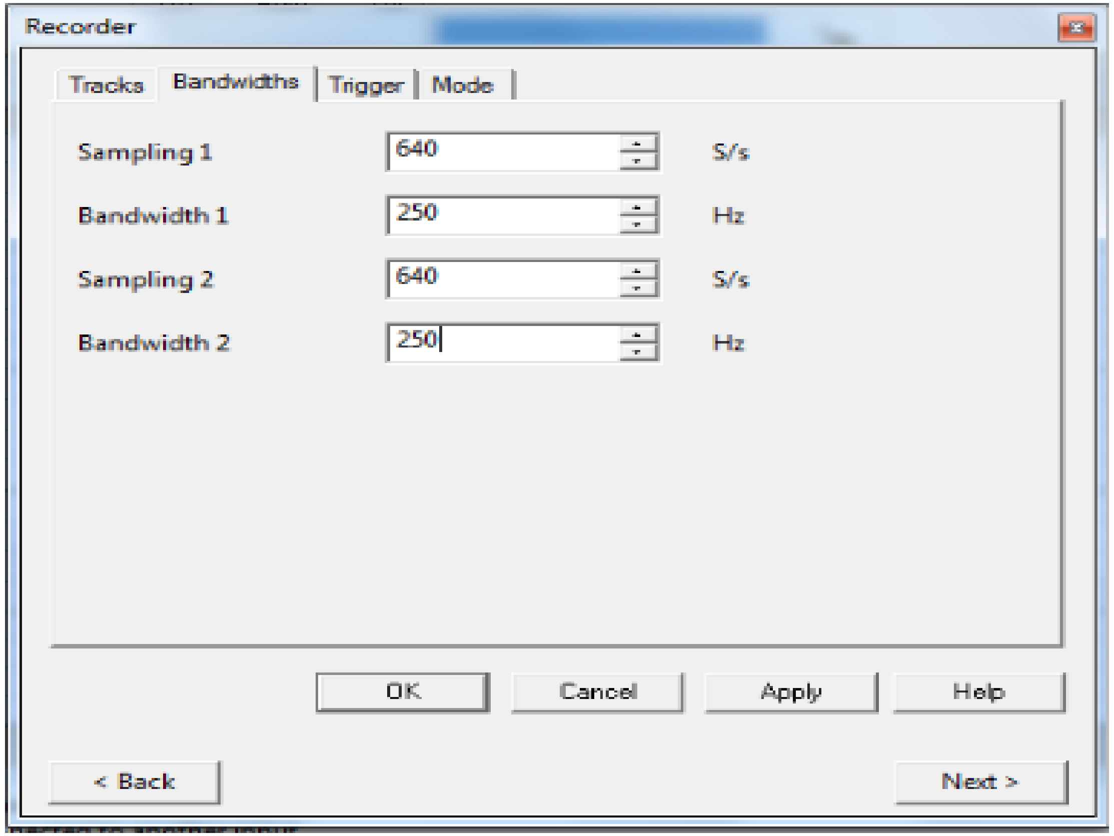
- The study of behavior of liquid storage tanks during an earthquake is one of the important problems in earthquake engineering. In the event of an earthquake there would be additional fluid pressures that would be created in the body of the liquid and an understanding of the nature of these pressure fields is vital for safe design of these tanks.
- It is of interest to note that water tanks need to be functional following a major earthquake since they would serve to control fires that often get triggered during a major earthquake.

Experiment setup

Input in Shaketable

- **Present Frequency:** 10 Hz
- **No. of Data:** 8
- **Present Travel (Amplitude):** 10 mm
- **Cycle Repeat:** 20

Input Data for software (NvGate) and accelerometer

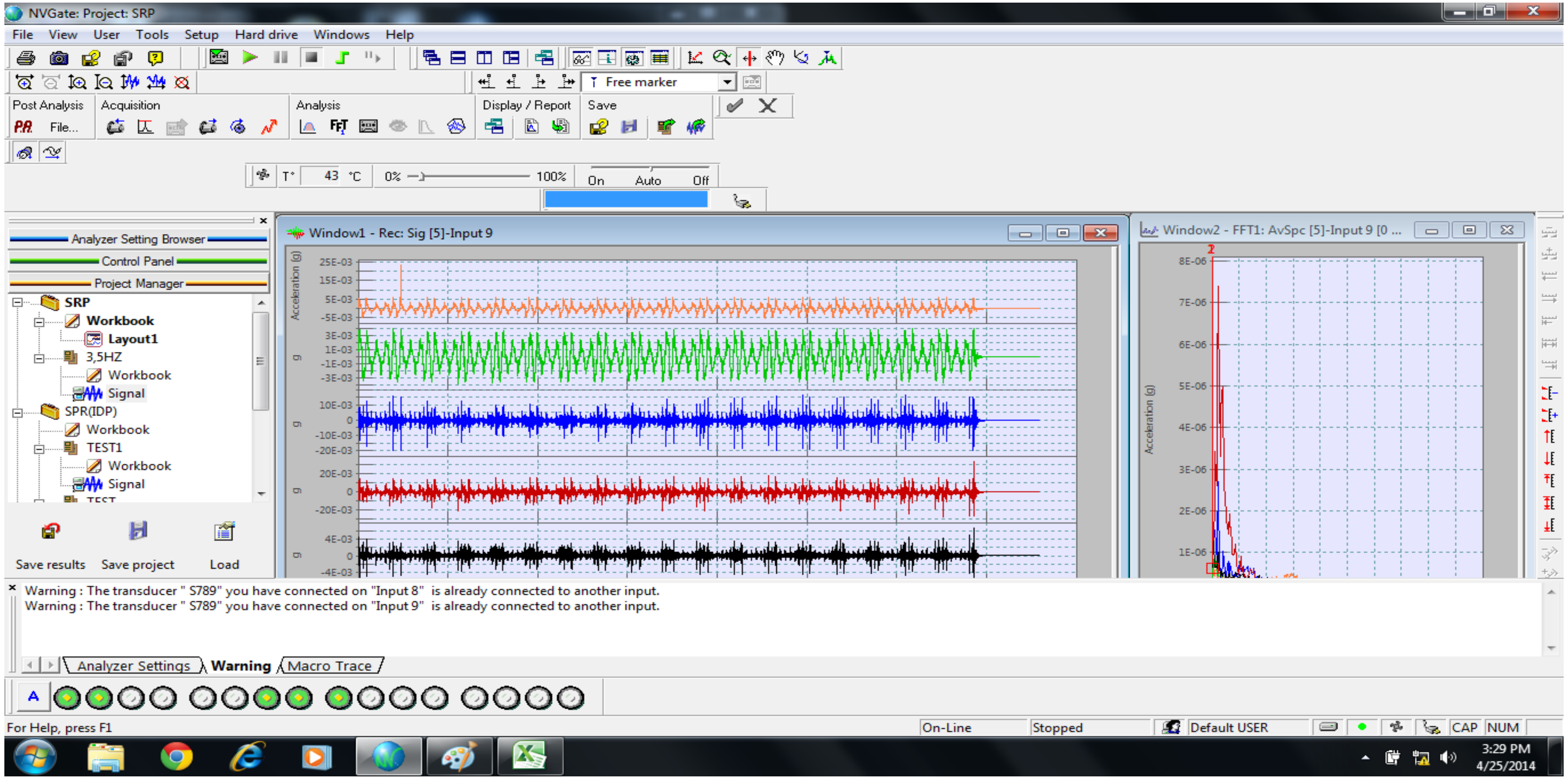


Detail of Experiment

- There are three sensor connected with the model of water tank. There are one triaxial sensor which is connected at the top of water tank model. And there are two uniaxial sensor which is connected with the top plate and bottom plate between friction pendulum bearing.
- All the sensor is connected with the accelerometer which is connected with computer with software NvGate.

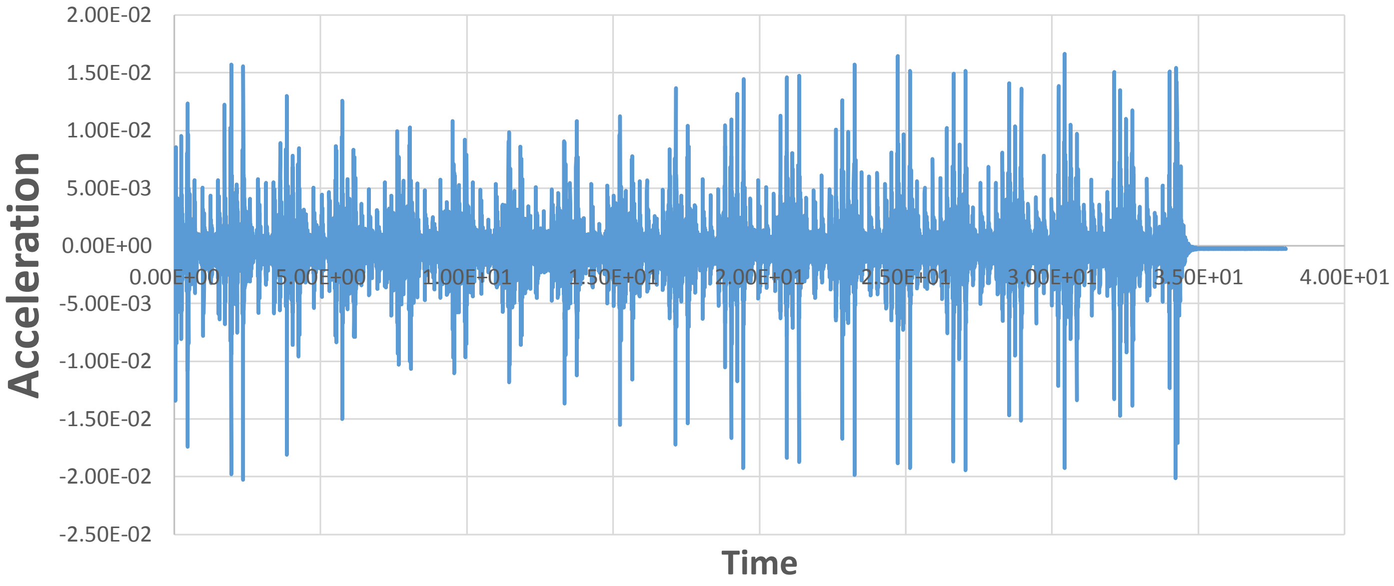
Result of Experiment

- Acceleration ⟶ Time Graph (screen shot of NvGate)

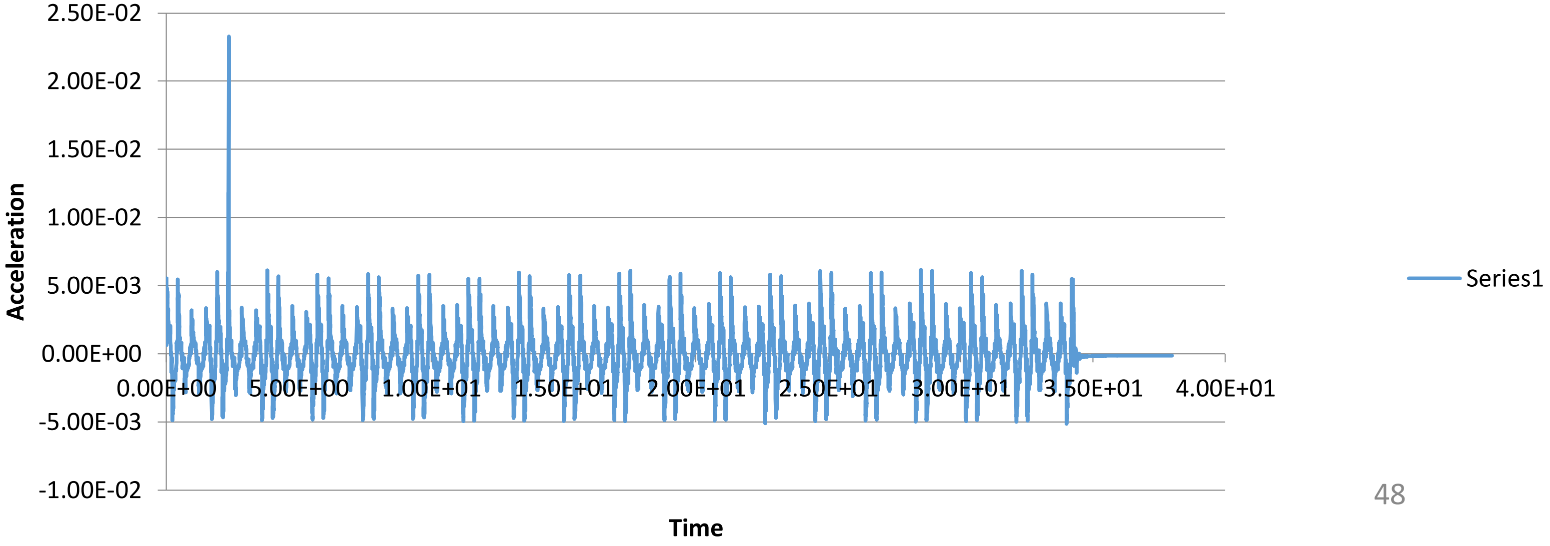


Result of Experiment

- Sensor-1 Graph
  Attach with bottom plate



- Sensor-2 Graph
  Attach with top plate



Modelling of B.I structure using SAP2000

- SAP2000 is a stand-alone finite-element-based structural program for the analysis and design of civil structures.
- It offers an intuitive, yet powerful user interface with many tools to aid in the quick and accurate construction of models, along with the sophisticated analytical techniques needed to do the most complex projects.
- SAP 2000 is object based, meaning that the models are created using members that represent the physical reality.

Create Model in Sap 2000

- Figure-1 is the water tank model create in the sap 2000 software.
- This figure is the indicate the water tank model properties in the software.
- This figure is shown 3-D view of the water tank model.

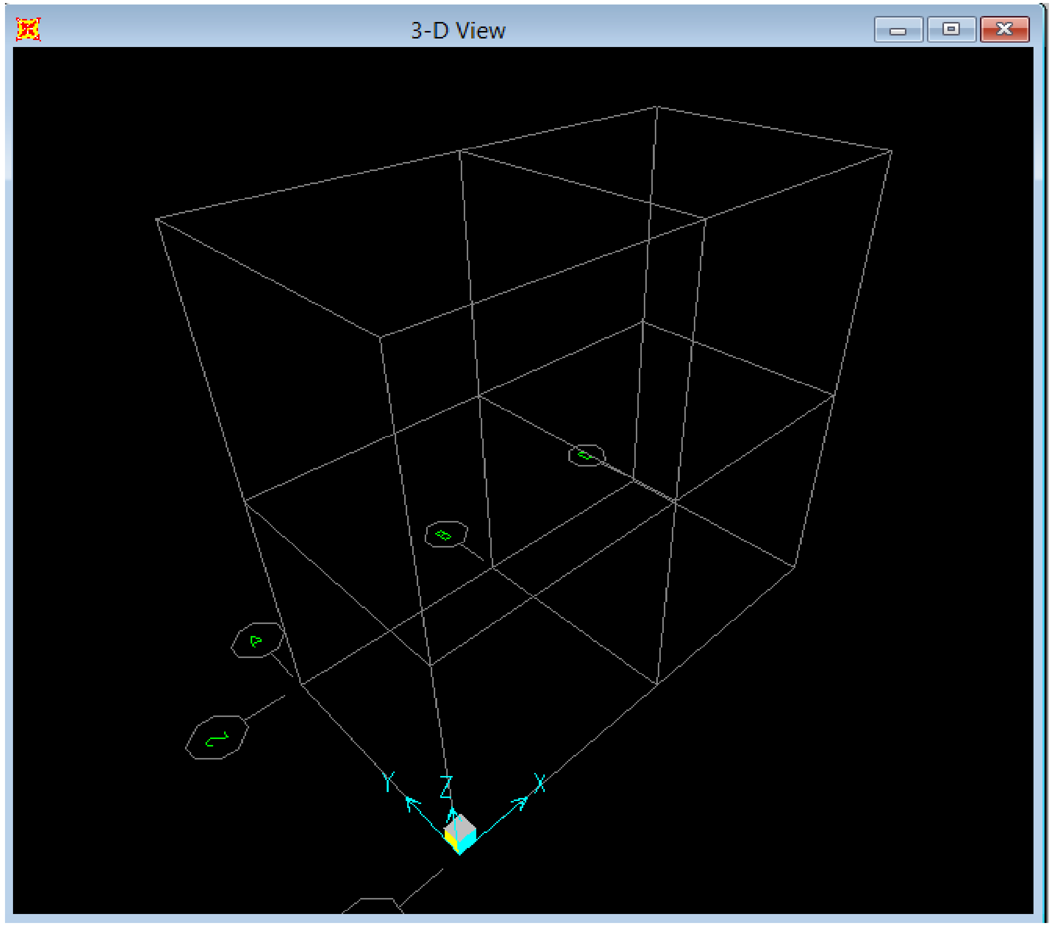


Figure-1

Create Material in Sap 2000

- Figure-2 is shown the table for the input the material data in the software and create own material in software.

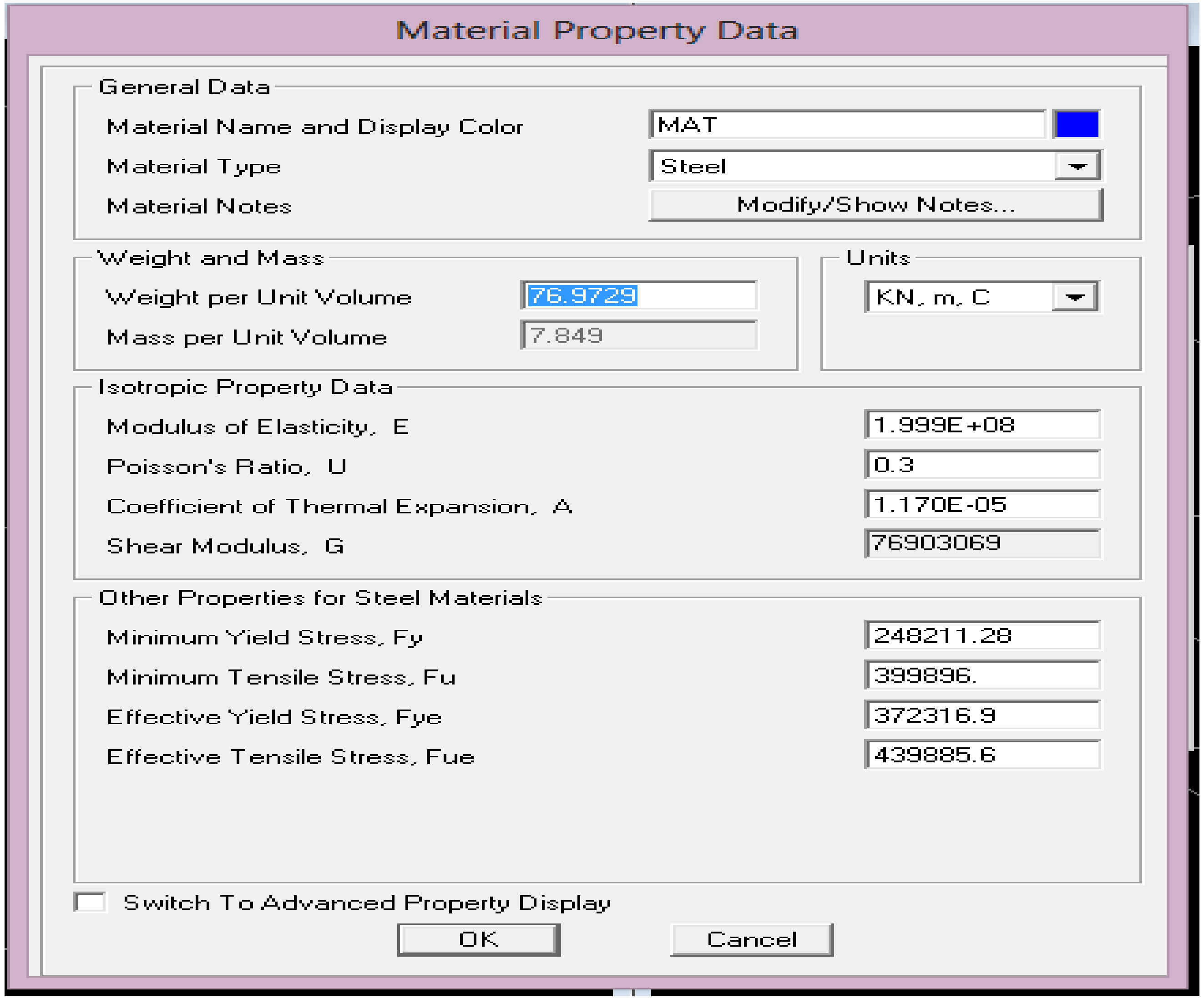


Figure-2

Create Foundation in Sap 2000

- Figure-3 shown the table for the input the foundation at bottom of the water tank model for provide base isolation.

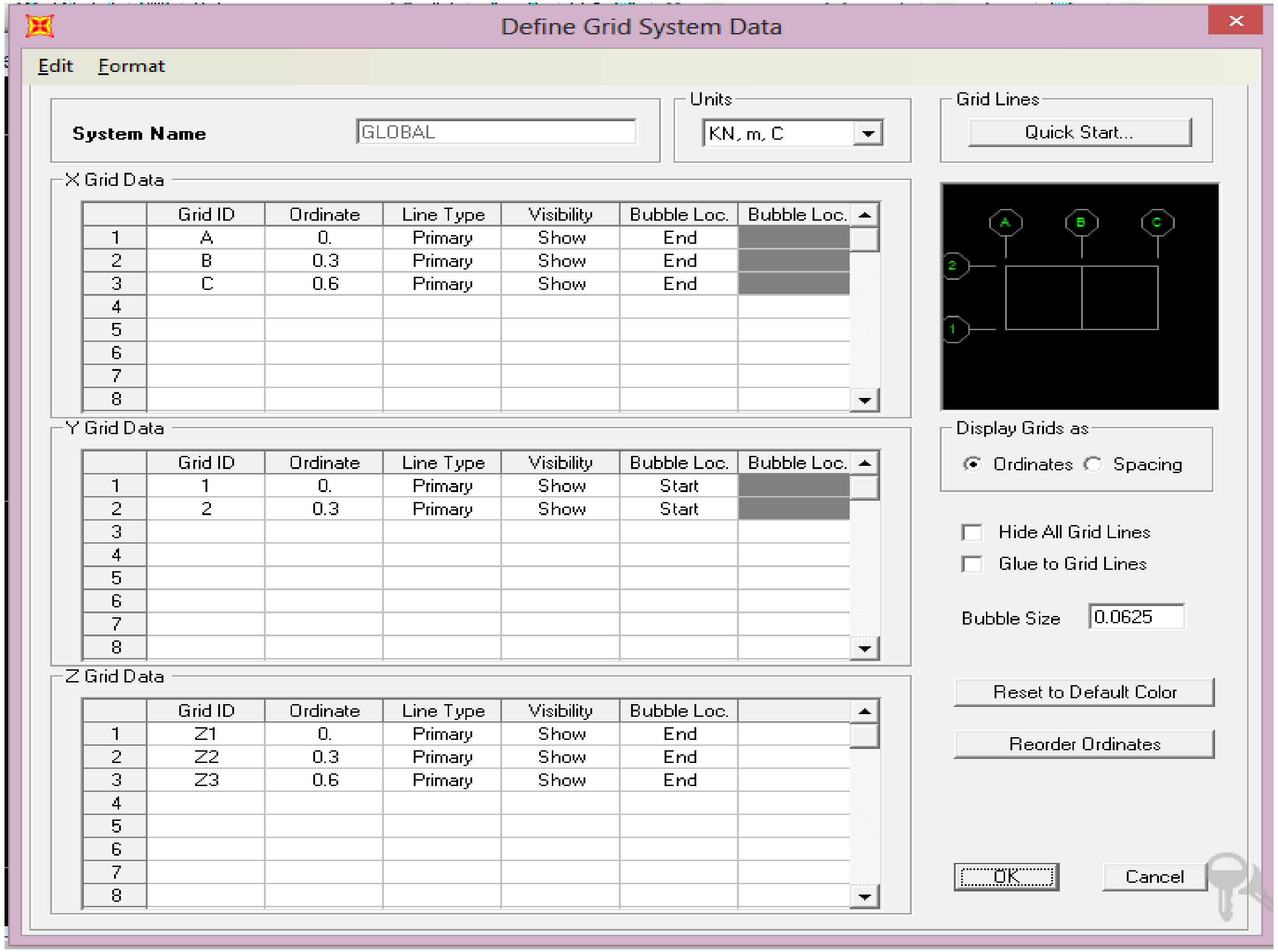


Figure-3

Create Base Isolation in Sap 2000

- Figure-4 is shown the table input data for the provision of friction pendulum bearing in the foundation as a part of base isolation.

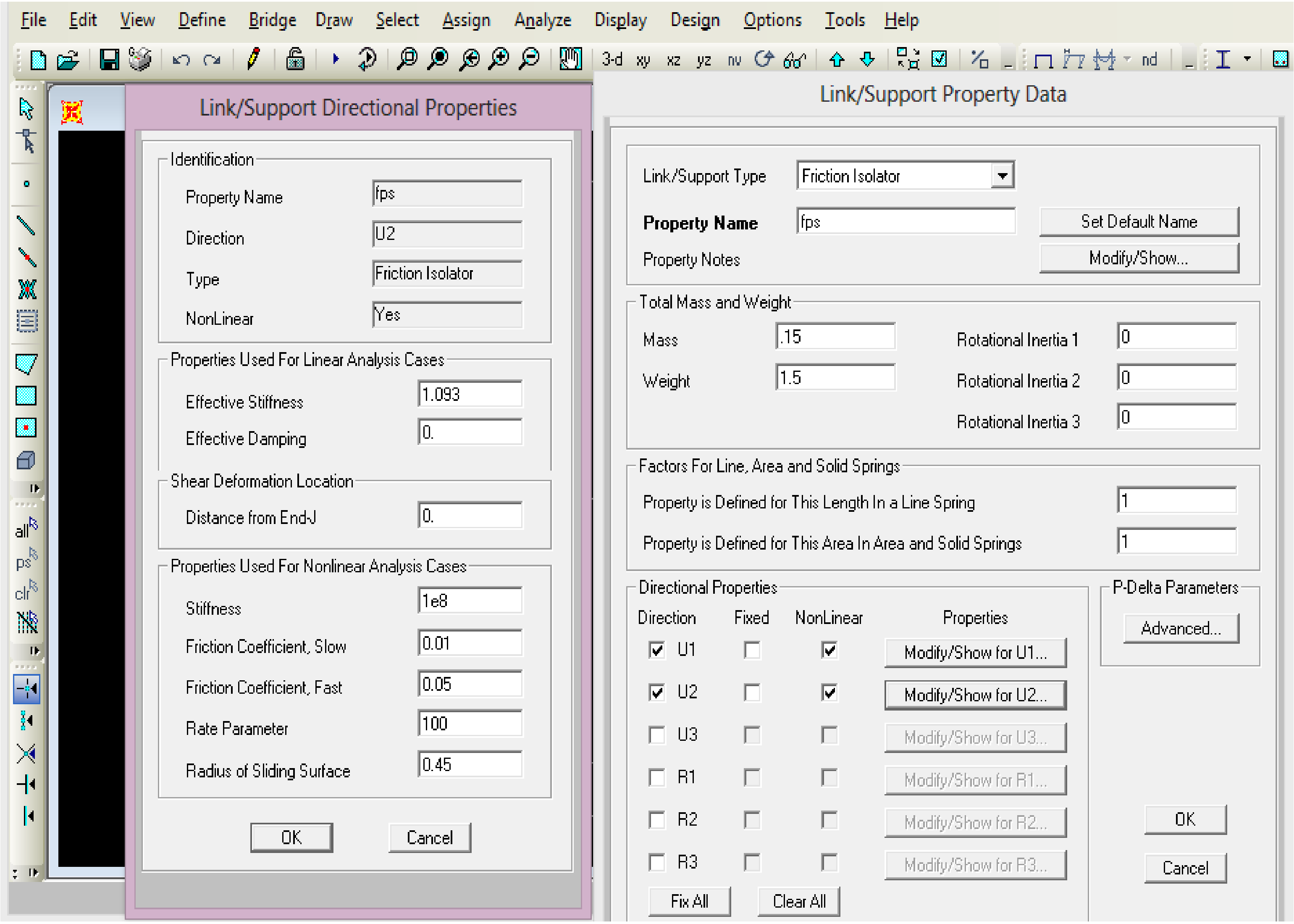


Figure-4

Create Base Isolation in Sap 2000

- Figure-5 is shown that at the bottom part of the water tank model is connected with friction pendulum bearing at foundation.

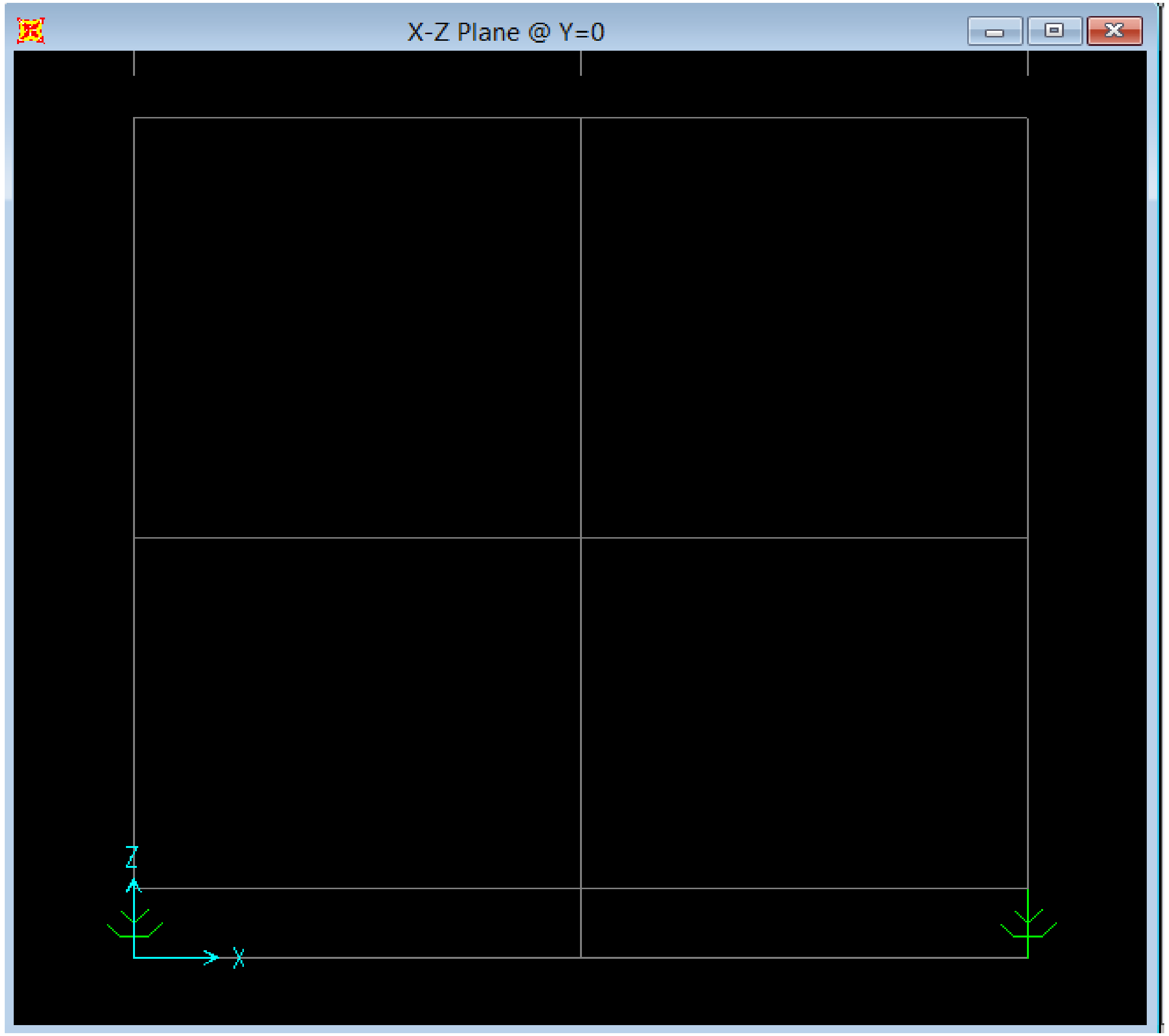
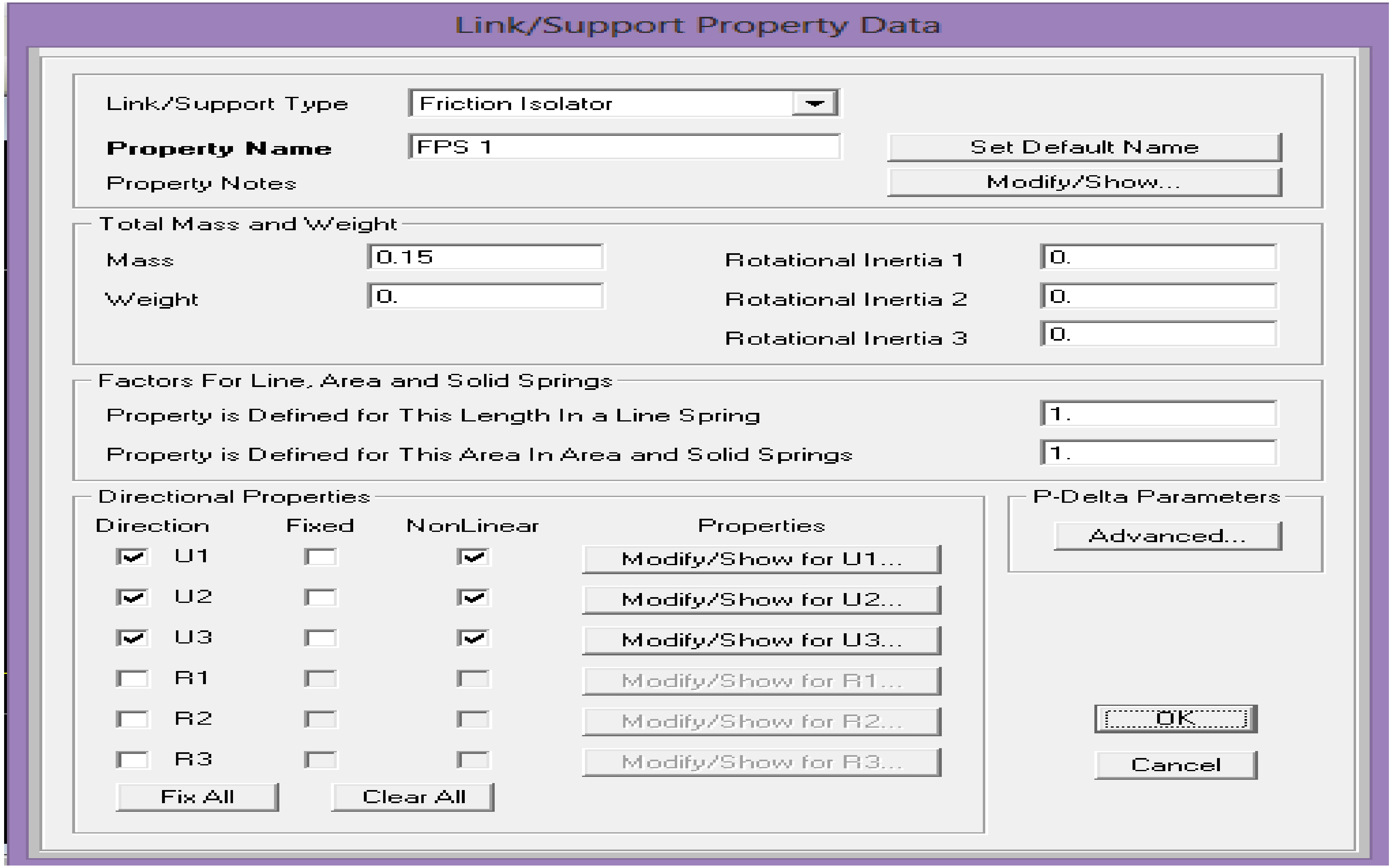


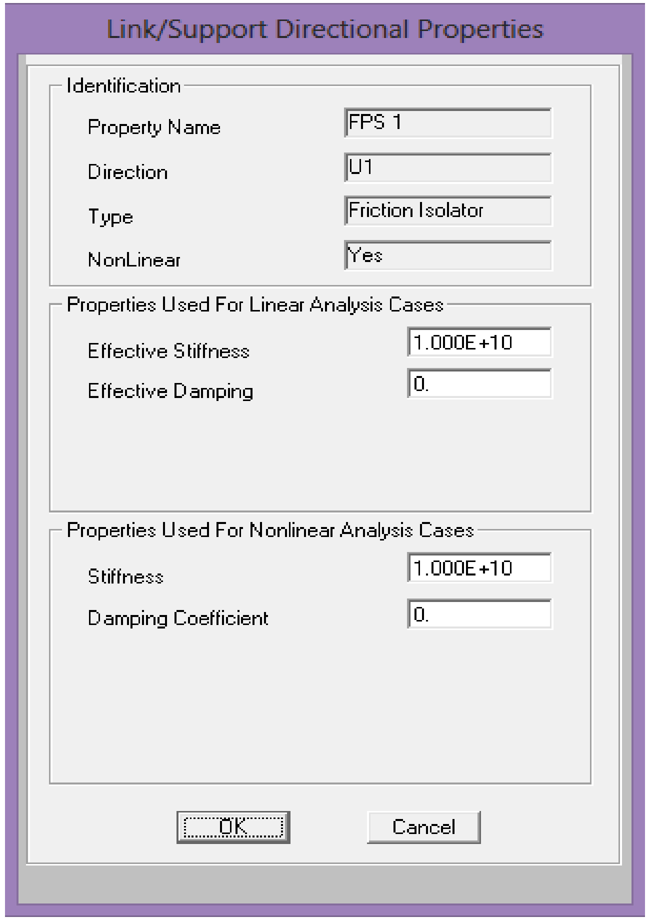
Figure-5

Properties of Base Isolation

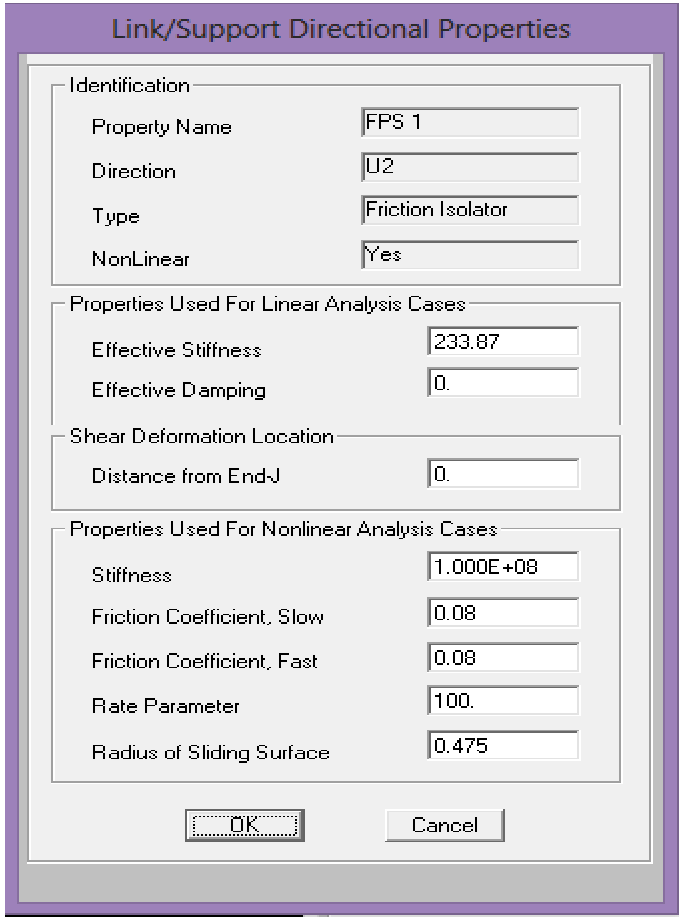


Properties of Base Isolation

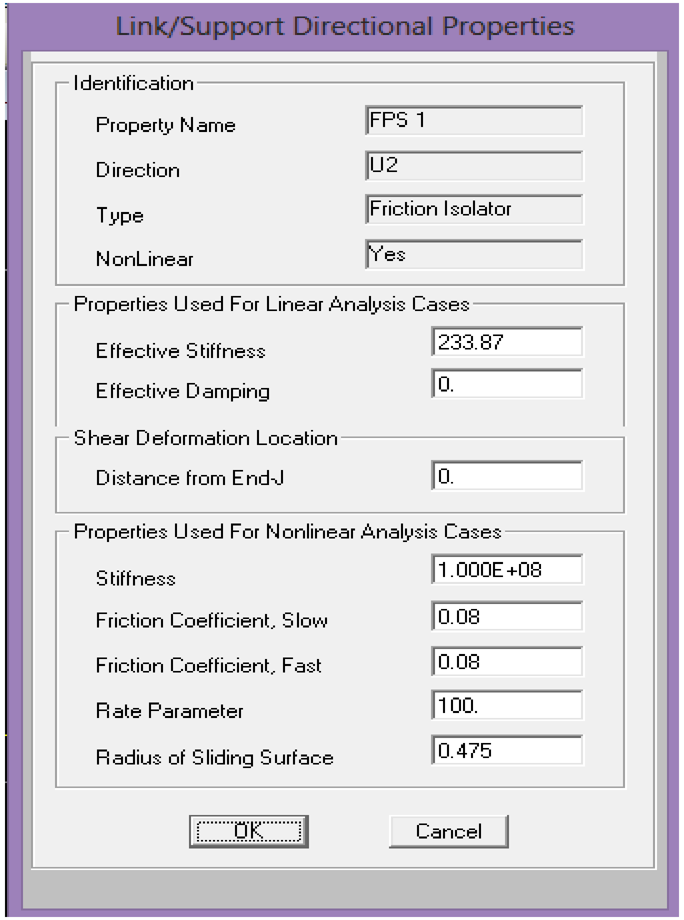
U1 Direction



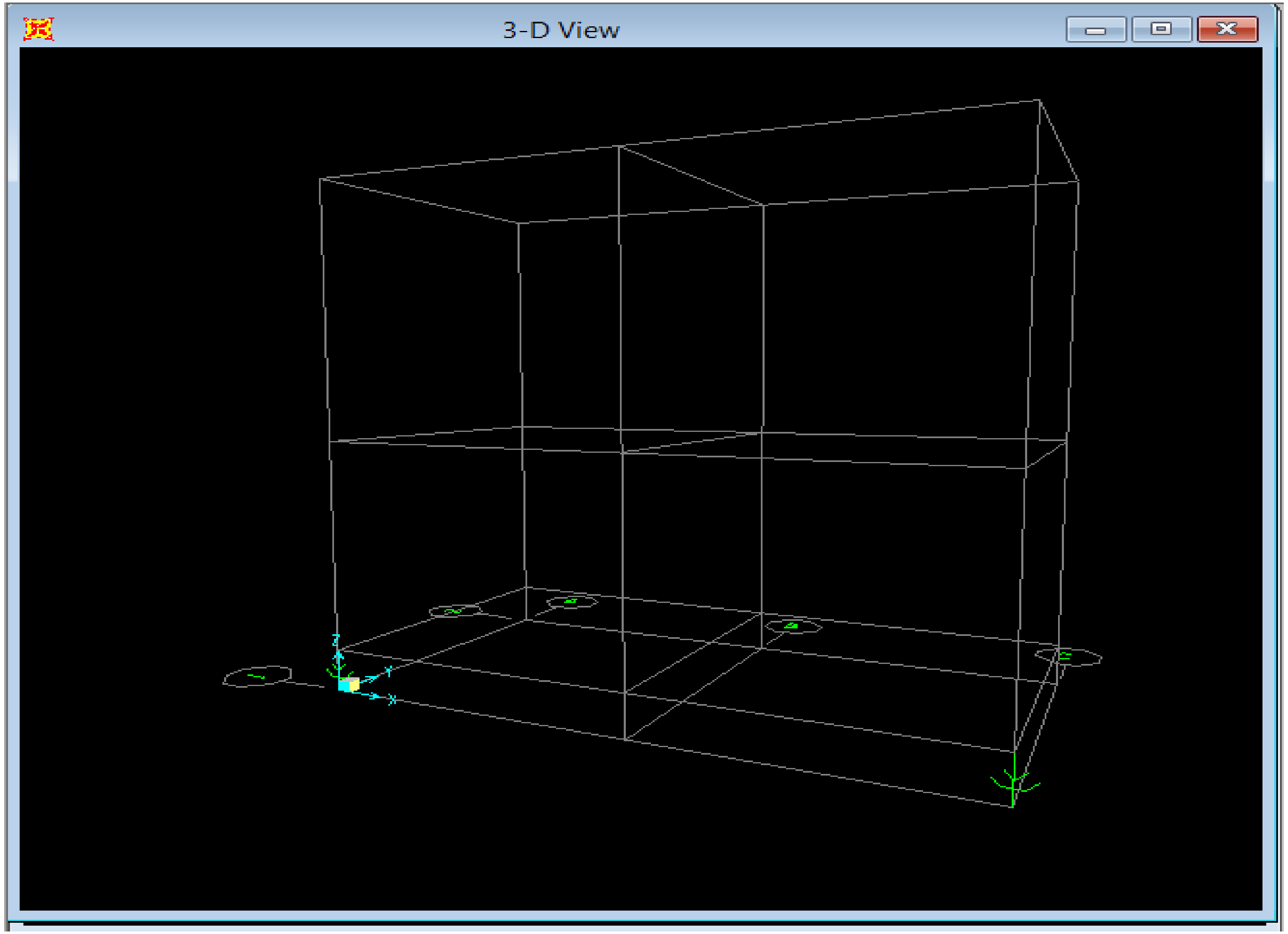
U2 Direction



U3 Direction



3-D view of Base isolation



Create fix foundation of Water Tank

- Figure-6 shown that the fix the foundation at the bottom of the water tank structure. For absorb the ground vibration and earthquake moment.

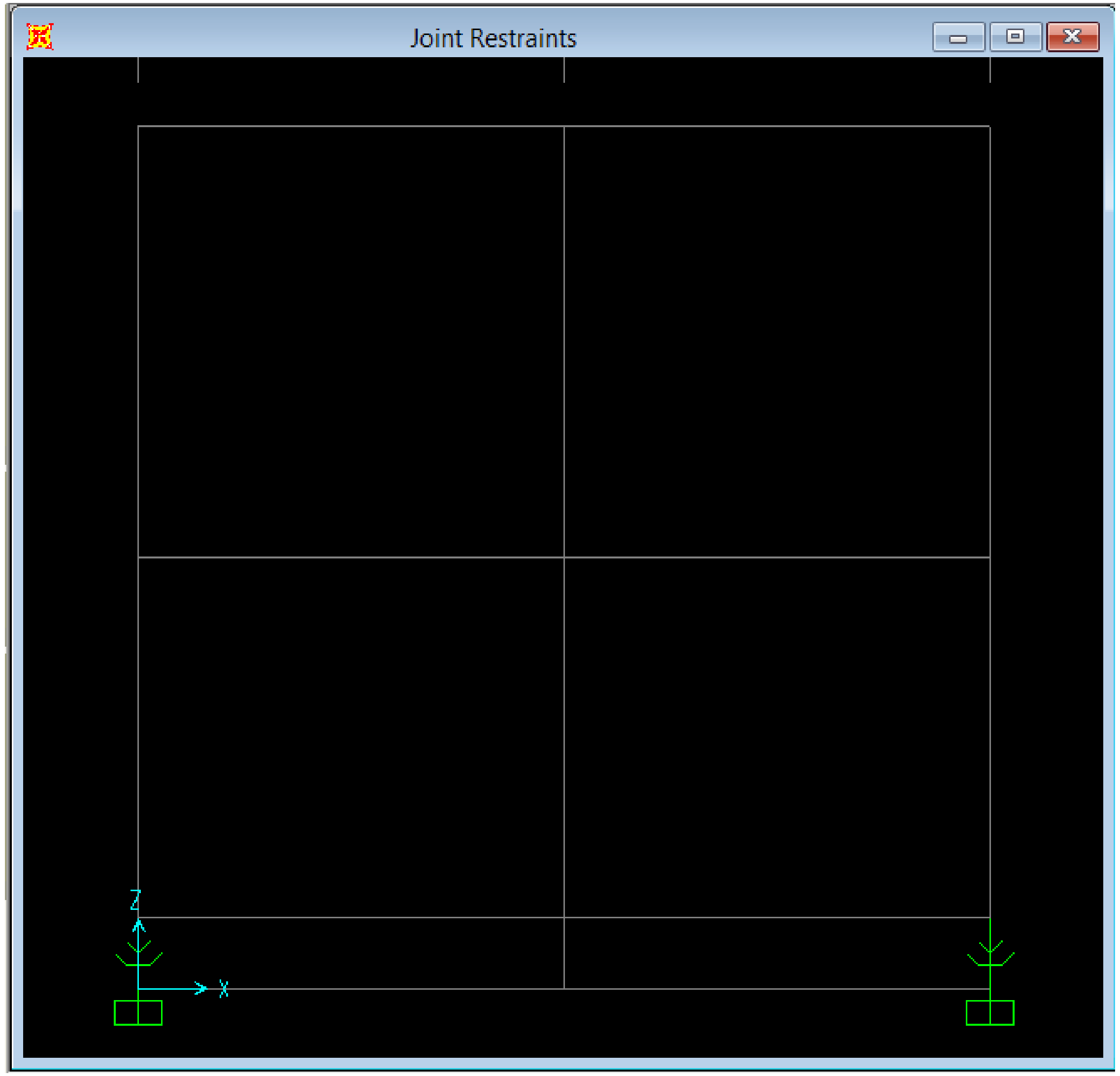
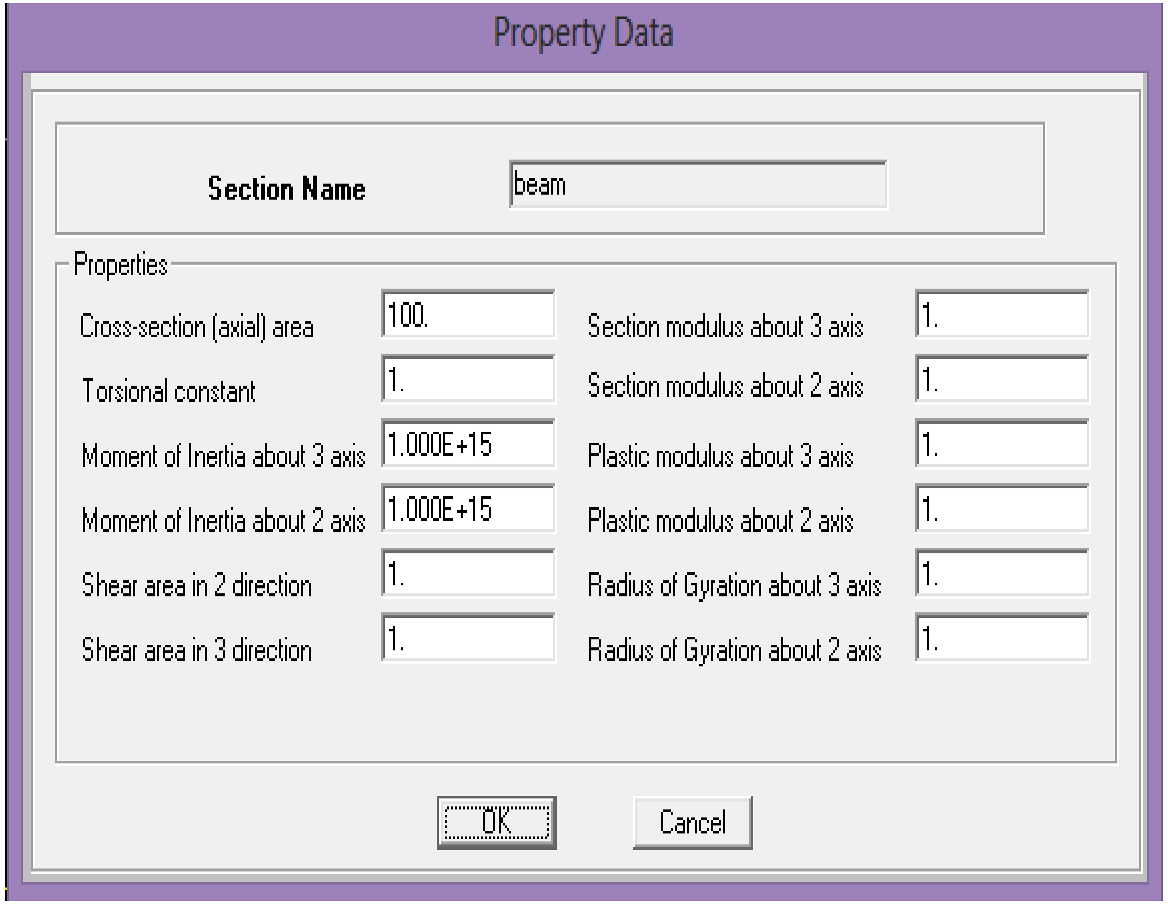
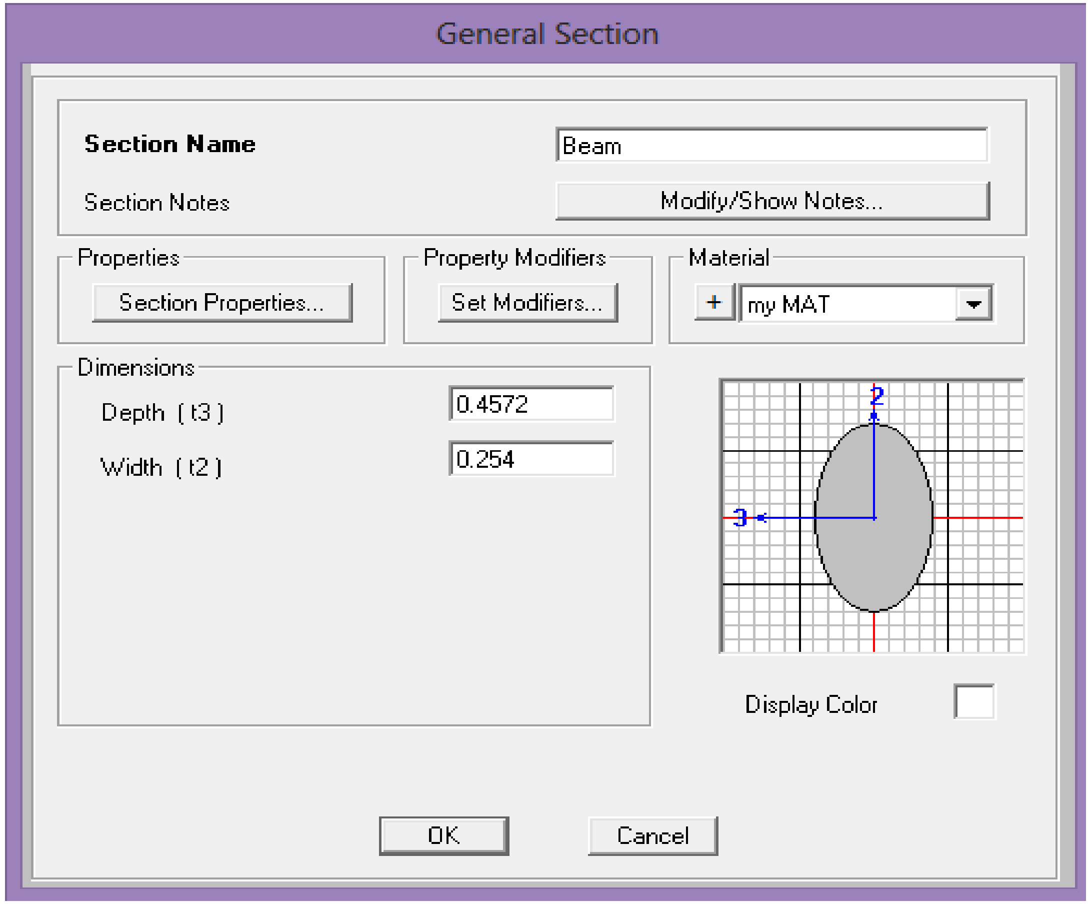


Figure-6

Define frame section

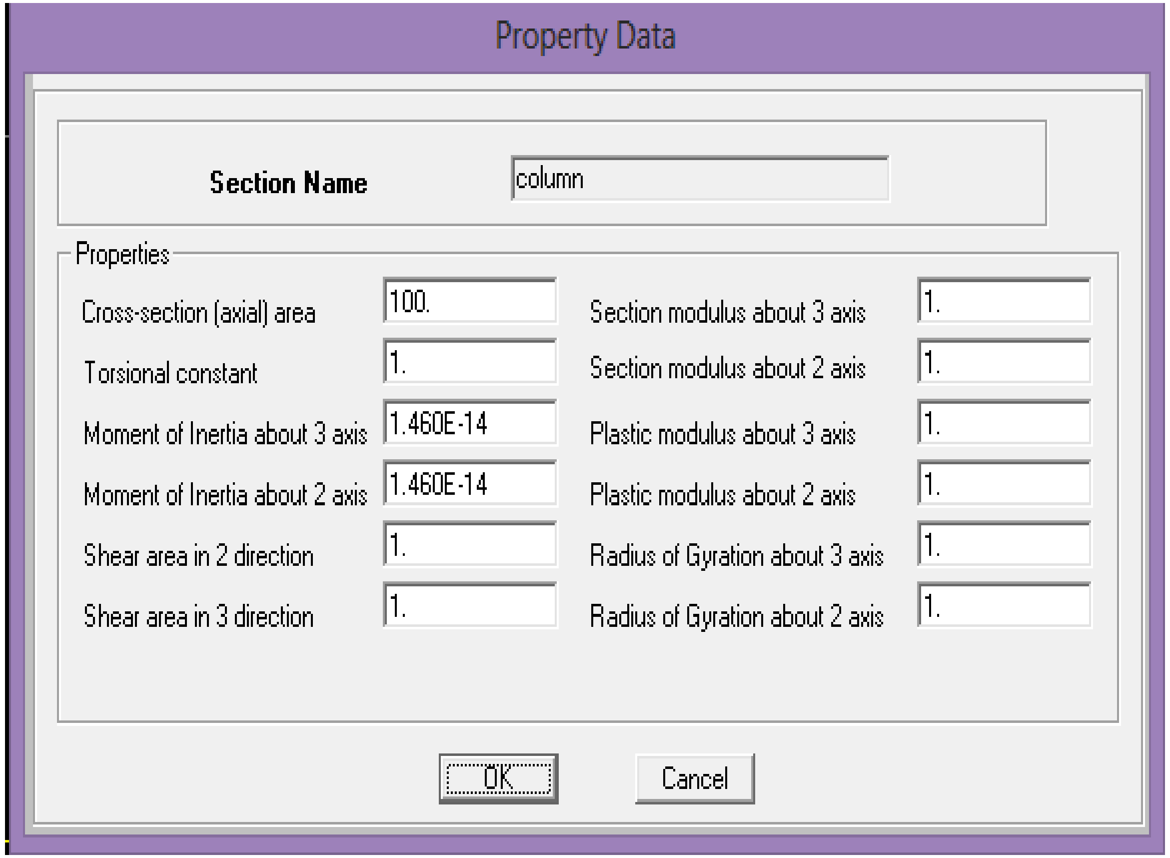
- Beam

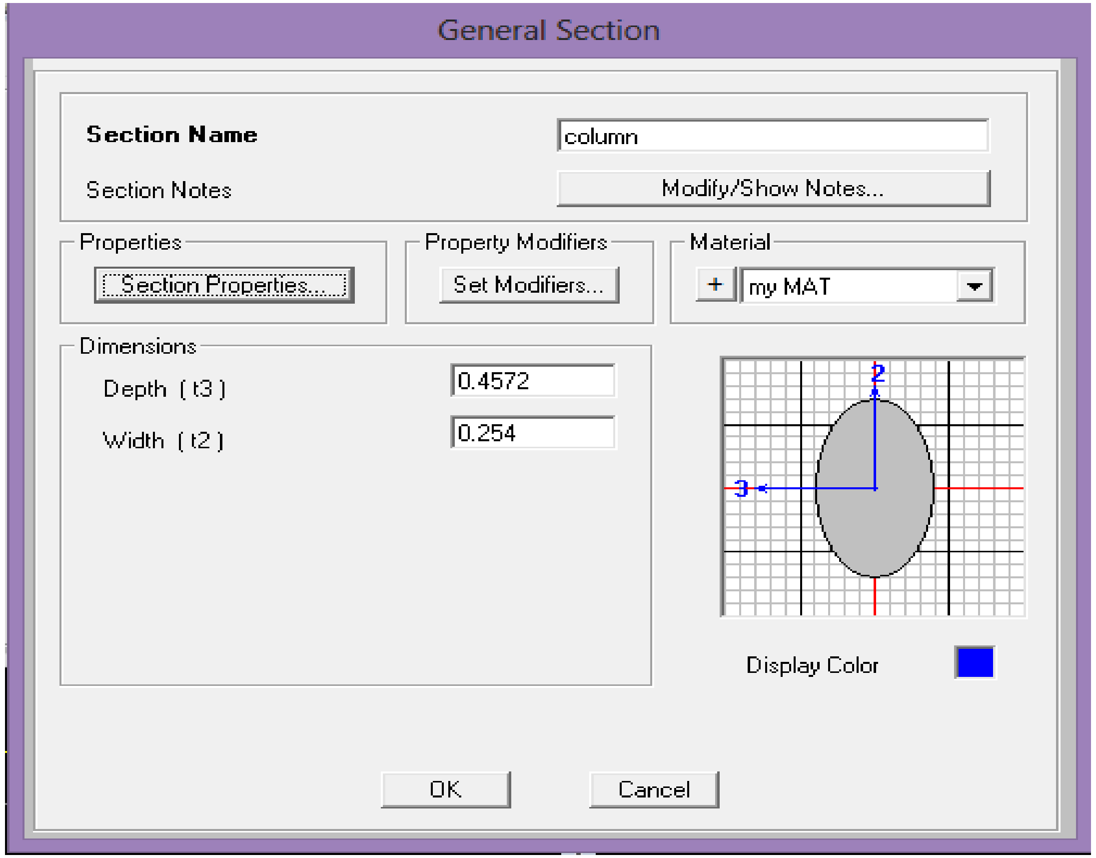




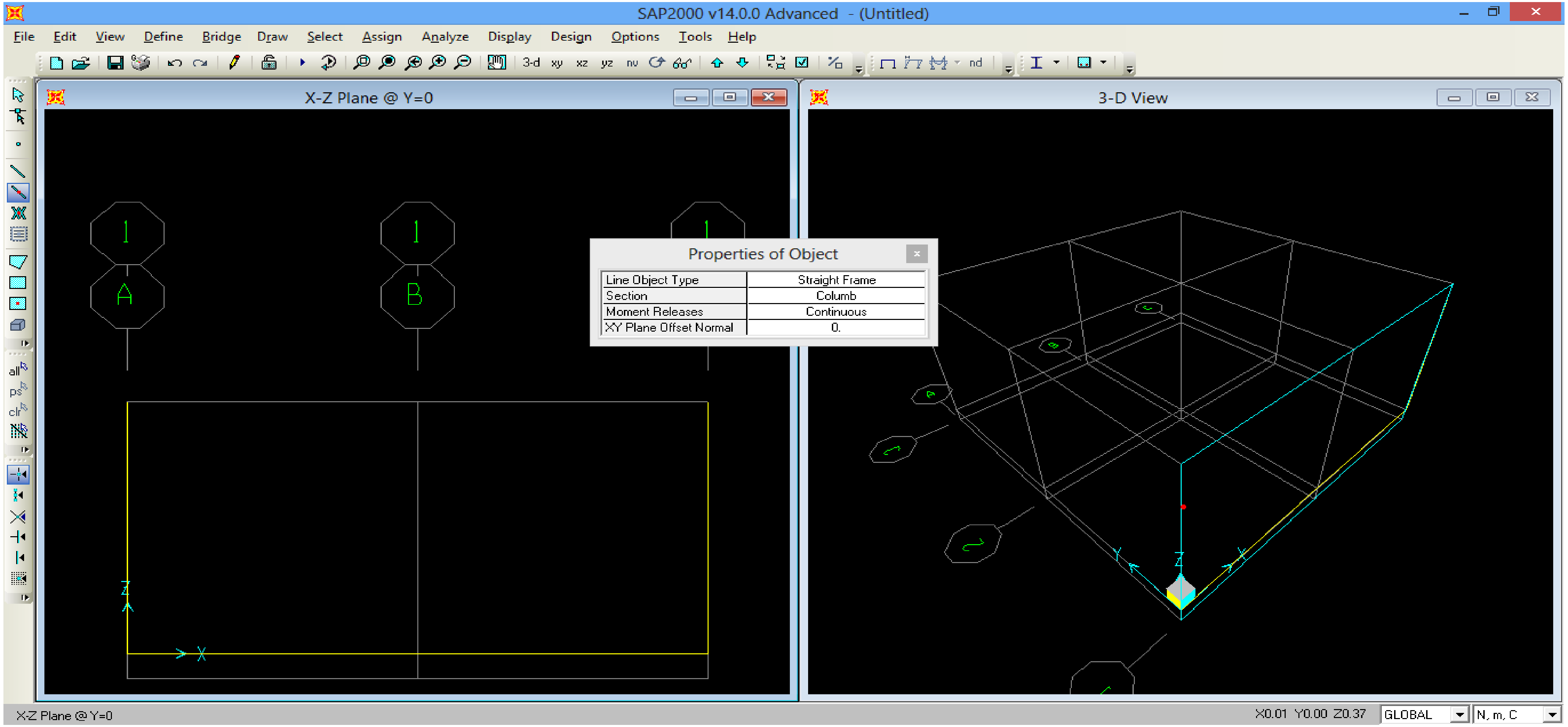
Define frame section

- Column



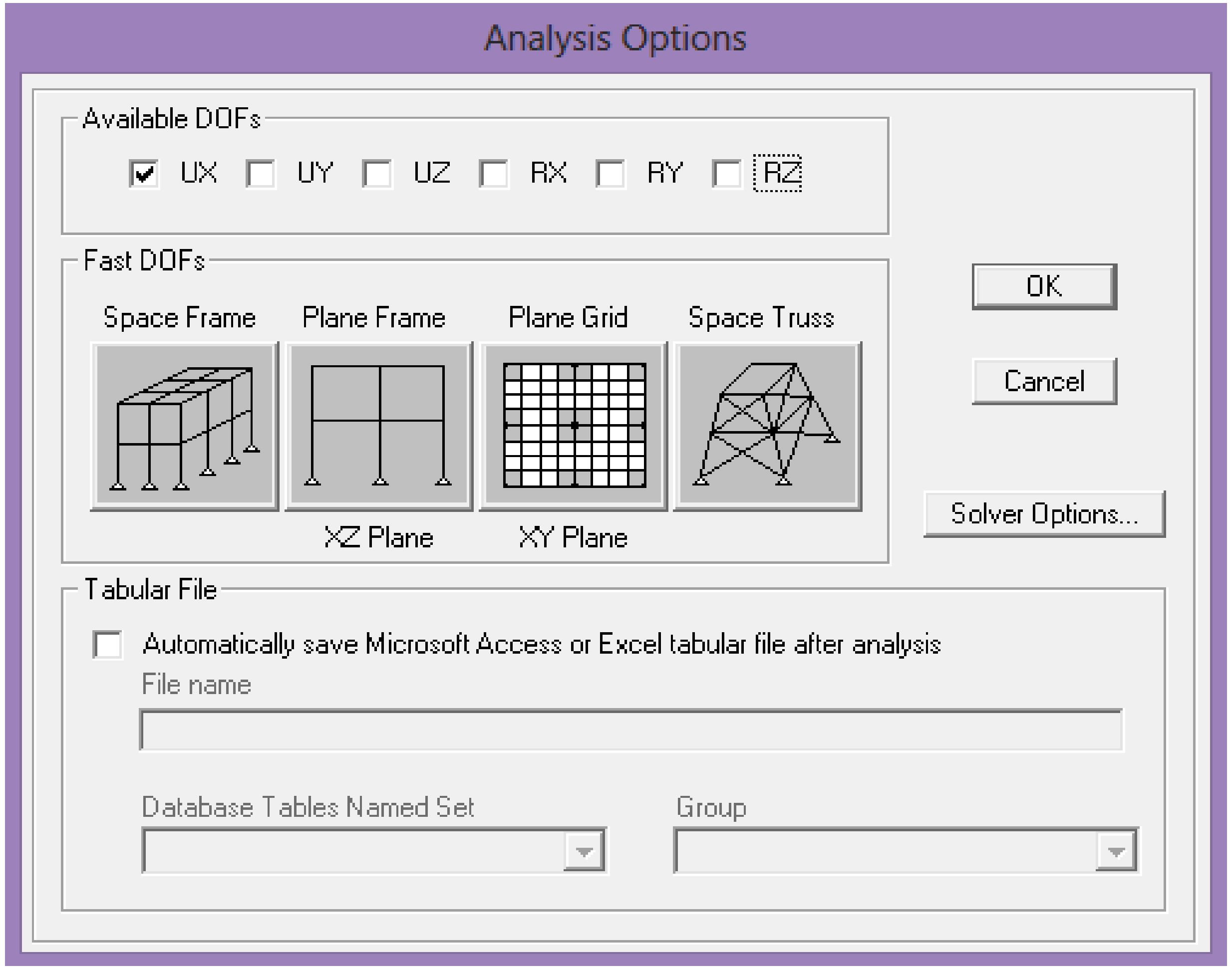


Screen Shot of Beam & Column



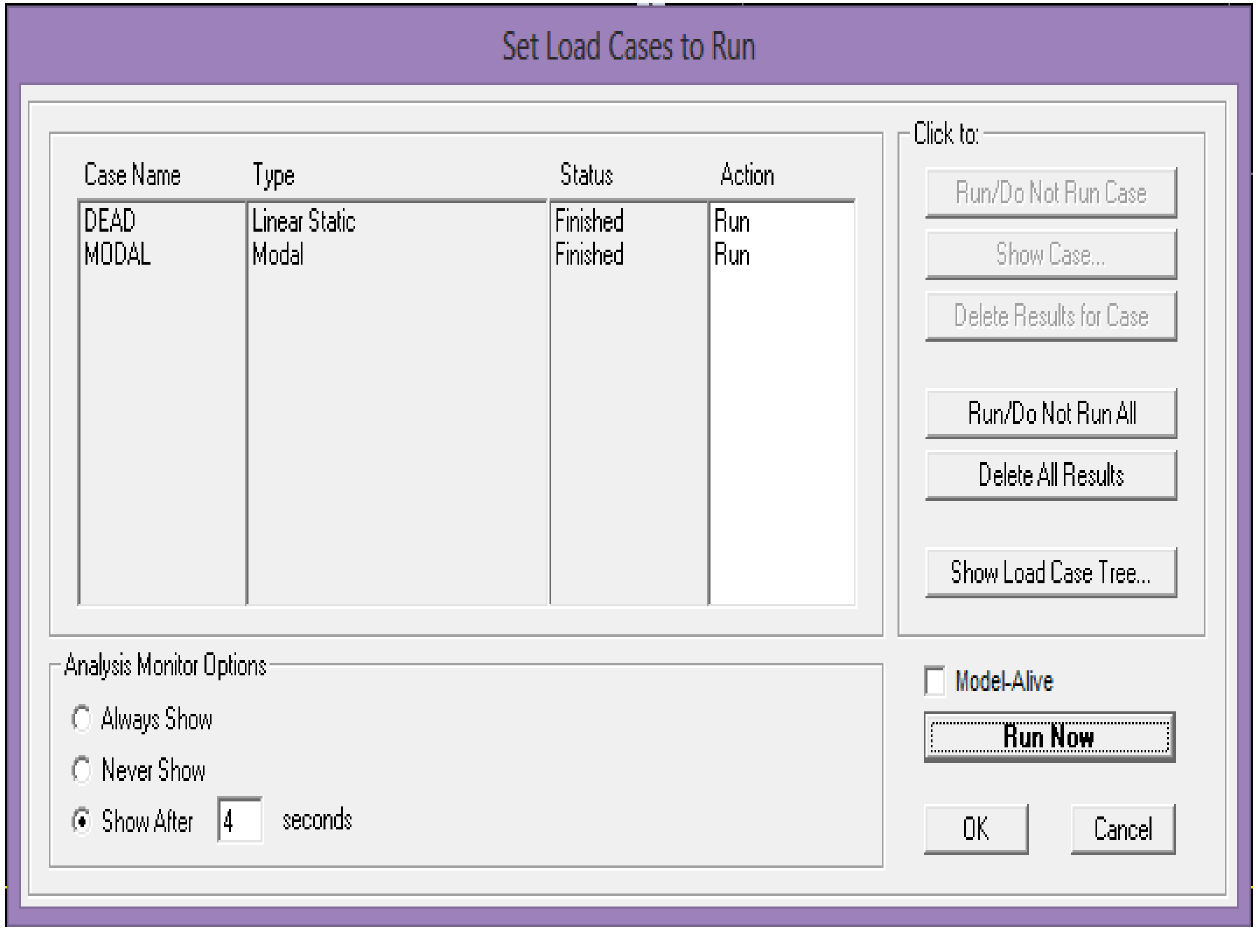
Analyze of the water tank

- In this step for choose model for analyze the structure of the water tank and choose the set analyze option from software for analyze of water tank model.
- For analyze select in software UX.



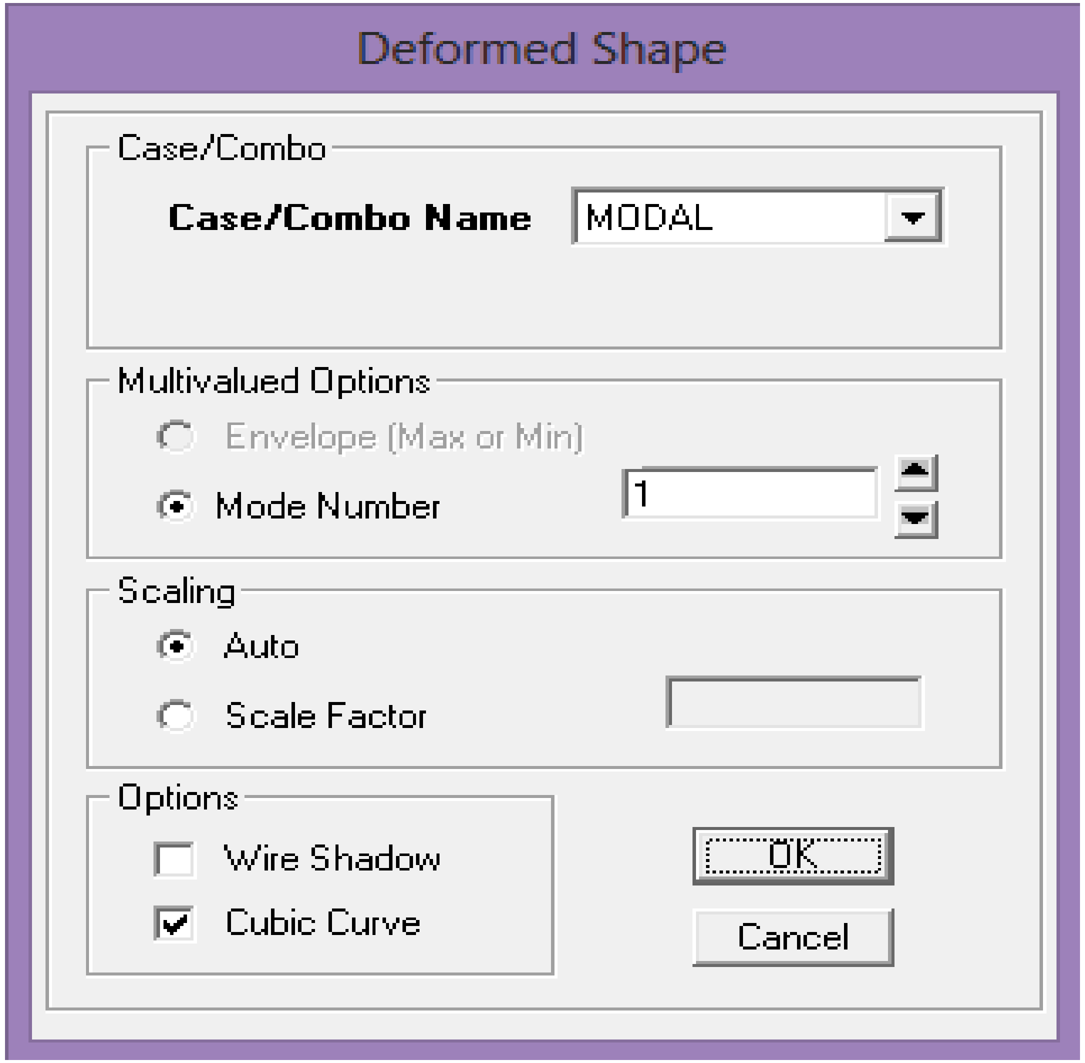
Run Analysis

- In this step whole input data is run and give the results. All analysis and input data of the base isolated water tank is completed here.
- Open the run analysis and select the run analysis and select the run now option for the run the program.

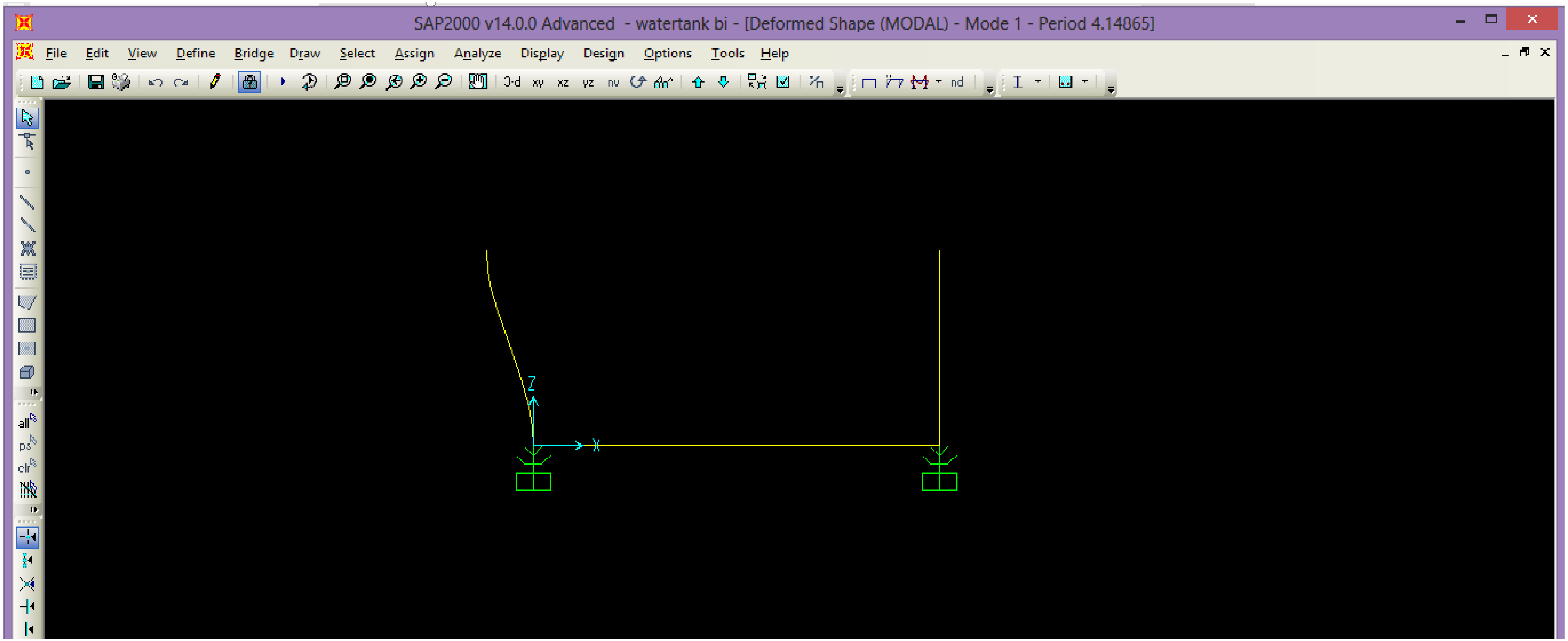


For Show Deform Shape

- for show the mode shapes of the water tank structure select deformed shape option and give the mode number and run the program.



Screen shot of deform shape of water tank model



Conclusion

- From result concludes that the performance of base isolated structure is good compare with non-base isolated structure.
- For all three conditions tank full, tank partially full and tank empty case, friction type of bearing giving good performance in base isolation. The shear transmitted to the superstructure across the isolation interface is limited by the static friction force, which is equal to the product of the coefficient of friction and the weight of the superstructure.
- From result of the experiment on shake table conclude that the response of the earthquake is in with base isolation is less than the without base isolation water tank structure.
- By providing friction pendulum bearing at the foundation of the water tank structure and any kind of structure we reduce down the earthquake at higher frequency and also reduce response of the earthquake.

Expected Outcome

- The safety of a water tank will depend upon the use of seismic protection system and initial architectural and structural configuration of the water tank and design and their ductile performance under seismic loading.so in our study we use friction pendulum system which is the one type of base isolation and which is the one of the seismic protection system for protect water tank and any kind of structure.
- The application of friction pendulum bearings (FPB) can optimize structure force, extend service life and prevent destructive damage caused by earthquake, gale and other natural disasters.
- From project conclusion, application of friction pendulum bearing at the foundation of the water tank structure and any kind of structure is give good performance during earthquake. By providing this bearing we can reduce down the earthquake effect on the water tank structure and any kind of structure. And construct structure earthquake resistance.

Patent Search & Analysis Report (PSAR)

- Ueda Sakae, Taguchi Wakao ,Kawai Toshinao (2007)” Seismic isolation sliding support bearing system” Us patent invention relates to a seismic isolation sliding support bearing system with low friction.
- Kawata Masayoshi, Izumo Yoji, Fukumoto Yosuke (2004)” Sliding pendulum seismic isolation system” Us patent invention main object is to provide abase isolation structure capable of securing stable operation since there is no such a possibility that micro-vibration usually produced does not exceed a requested allowable vibration value, and in earthquake, preventing heavy damages from occurring by developing base isolating effects, and thereby effectively isolating a structure in which vibration-sensitive equipment are disposed such as a semiconductor manufacturing plant from earthquake.
- Chuang Hsun-Jen (2009) ”Seismic Isolation Bearing” Us patent The present invention relates to a seismic isolation bearing, and more particularly to a seismic isolation bearing which employs a shock absorbing pad to increase its ability to isolate seismic energy.
- Zayas Victo,Low Stanley(2001)” Sliding pendulum seismic isolation system” Us patent The invention claimed herein is a method of configuring sliding pendulum bearing components in such a manner that the seismic forces transmitted to the supported structure are reduced, and costs of the isolation bearings, seismic gaps, and supported structural frame are reduced, as compared to the prior-art systems.
- Ishimaru Shinj ,Ishigaki Hidenori ,Hata Ippei (2002)” Base isolation device for structure” Us patent the object of this invention is to provide a base isolation device for a structure that is capable of effectively suppressing vibration in the out-of-plane direction of the structural members of a structure.

- Huber Peter, Roos Rainer(2005)” sliding pendulum bearing” Us patent The invention relates to a bearing for the protection of buildings, said bearing being formed as a sliding pendulum bearing with a low friction material, and having a first sliding plate with a first concave sliding face and a sliding shoe in sliding contact with the first sliding face of the plate, said first sliding face of the first sliding plate having a stable equilibrium position in at least one dimension for the sliding face into which the sliding shoe returns of its own accord following a displacement caused by the action of an external force.
- Moreno Gil, Hubbard Don(2005) ”composite isolation bearing” Us patent invention relates, generally, to isolation bearings, such as seismic and isolation bearings utilizing a rolling sphere or hardened ball on a bearing surface. In one specific embodiment, the invention relates to an isolation bearing in which the load or a portion thereof is concentrated on one or more rolling sphere or hardened ball placed between bearing surfaces, at least one of which is indented and has a cross-section comprising at least one of an arc, a constant slope, or a parabola and at least one additional shape.
- Watson Ronald, Bradford Paul(2010)” sliding pendulum bearing” the invention has numerous advantages over previously known isolation bearings. In particular the unitary compound isolation bearing of the invention is simpler to install than any prior compound bearing system thus reducing costs of installation and risks of improper installation.
- Marioni Agostino (2009)” sliding pendulum seismic isolator” invention comprises a lower sliding element and an upper sliding element with opposed concave surfaces between which there are arranged two intermediate elements slidable along the concave surfaces of the lower and upper sliding elements and coupled to each other through a contact between a spherical-surface and a plane.

- Takenoshita Yukinori, Hosono Yukihiro(2007)” Seismic isolation device” Us patent The present invention relates to a seismic isolation device, and more particularly to a seismic isolation device mounted between an upper structure of a bridge constructed by engineering work and a building etc. and a subtraction or a lower structure thereof, to suppress shake of the upper structure against an earthquake.
- Mualla Imad(2009)” Bearing for structures” Us patent The present invention relates to a bearing for structures of the type including a block of flexible material, such as rubber, to be arranged between structural elements of the structure.
- Sato Takanori (2007)” Seismic isolation device” Us patent mic isolation device includes a tabular base board having curved convex protrusions and a smooth sliding plate placed in such a way that a sliding contact surface thereof is made to abut the curved convex protrusions of the base board.
- Yamada; Takao, Kurabe Katsun ,Tagawa Kengo ,Shibata Koichi(2004)” Seismic isolator ” Us patent An object of the present invention is to provide a seismic isolator which not only reduces a response acceleration, transferred to a structure or equipment therein, arising from an earthquake but also restrains a response displacement and a residual displacement under a desired value, and which has a stable operating characteristic in the response acceleration, regardless of the acceleration arising from the earthquake being large or small.

WORK PLAN

Work	Aug	Sep	Oct	Jan	Feb	Mar	Apr	
Literature review								
Design bearing								7th SEM
Making water tank model								
Write up project								
Analysis on shake table								
Analysis on software (SAP 2000)								8th SEM
Compare the results								
Write up project								

References

- Abali, E. and Uçkan, E. (2010). “Parametric analysis of liquid storage tanks base isolated by curved surface sliding bearings.” Soil Dynamics and Earthquake Engineering, Vol. 30, pp. 21-31.
- Jadhav, M. B. and Jangid, R. S. (2006). “Response of base-isolated liquid storage tanks to near-fault motions.” Structural Engineering and Mechanics, Vol. 23, pp. 615-634
- Shenton III, H. W. and Hampton, F .P. (1999). “Seismic response of isolated elevated water tanks.” Journal of Structural Engineering, ASCE., Vol. 125, pp. 965-976.
- Shrimali, M. K. and Jangid, R. S. (2002). “Non-linear seismic response of base-isolated liquid storage tanks to bi-directional excitation.” Nuclear Engineering and Design, Vol. 217, pp. 1-20.
- Shrimali, M. K. and Jangid, R. S. (2003). “Earthquake response of isolated elevated liquid storage steel tanks.” Journal of Constructional Steel Research, Vol. 59, pp. 1267-1288.

THANK YOU…

We shape our buildings, thereafter they shape us.

– Winston Churchill