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摘　要

1948 年，在美国田纳西州橡树岭（Oak Ridge）的 X-10 石墨反应堆中，由核电厂发电是有史以来第一次。从那以后，经过几十年的迅速发展，核工业逐年蓬勃发展，因此最终工程和技术实用性达到了先进水平。多数国家/地区要求采用第三代和第四代 NPP 技术，以在自己的祖国建造 NPP，以通过可靠的能源满足其能源需求。

安全程序对核电厂至关重要，为了避免可能的放射性物质释放到大气中，核电行业已经发展了几种安全标准，核电站的设计、分析、制造和安装都必须严格遵守这些程序。自从现代世界首次遇到建造了核电站以来，依然还发生过了严重的核事故。因此，关于核电是否安全也引发了一些争议。在这方面，只要遵循并安全应用安全程序，所有技术改进和工程改进都可以防止这些风险。对于由于人为失误或建筑设计上的缺陷而发生的事故风险，都已经过计算和估算，然而地震是无法预估的一种事故风险。在这种情况下，需要特定的设计分析方法和质保程序来防止地震的破坏。地震鉴定方法是其中之一，其目的是增强地震期间/之后的设备耐久性，。这种方法的目的是使设备满足其性能要求。该标准的基本目的是在可能发生的地震之后/之后模拟和分析/测试设备的强度和耐久性。

隔震技术是在土木和机械行业中常用的减小地震风险的一种设计方法，虽然在核电领域的应用较为有限，然后这种方法可以显著减小地震风险，有助于提高核电站的安全性。本文详细调研了各种类型的隔振技术，分析了其优缺点，特别指出了在核电站适用这些技术的难点和局限性，可为该技术在核电行业的应用提供基础。此外，有限元工具是设备结构抗震分析技术的重要方法，本文针对一个典型的结构支承部件，建立了详细的有限元分析模型并完成了分析，讨论了有限元分析中各种参数设置对结果的影响。

最后，论文对土耳其地震条件进行了调研，并以此介绍的土耳其抗震设计要求，并给出了结构设计与土建设计中需要着重考虑的事项。

关键词：机柜；核电站；安全性；地震质量；地震

Abstract

Generating electricity by nuclear power plants first ever took place in world history in 1948 at X-10 Graphite Reactor in Oak Ridge, Tennessee in the United States. Since then Nuclear Industry thrived dramatically year by year. After the several decades of sharply improvement so finally engineering and technological utilities are reached the advance level. With the development of generation-3 and generation-4 Nuclear Power Plant (NPP) technologies most of the countries are demanding to build NPPs in their homelands to meet their energy demands with the reliable energy resources.

Safety evaluation procedures are essential for NPPs. In order to avoid the release of possible radiation materials to the atmosphere, several safety standards were developed. The design and construction of NPPs have to follow up those procedures strictly. Since the time when modern world first met nuclear power plants some severe nuclear accidents happened as well. Therefore some controversies were also started about whether nuclear is safe or not. In this regard, all the technological improvements and engineering enhancements prevent those risks as long as the safety procedures are followed and applied smoothly . When we look into those accidents all of them occurred because of either personal mistakes or constructional design flaws. Currently, every single possible risks are already calculated and estimated . Even though there is no human mistakes earthquake is other possibility that cannot be predicted. In such circumstances, several methodology and procedures are also developed to prevent damages of the earthquake. Seismic Qualification Method is one of them and aiming to strengthen equipment durability in during/after earthquake. In this method, it is aimed to make equipment to meet their performance requirements. Basic purpose of this standard is to simulate and analyse/test equipment's strengths and durability during/after the possible earthquake.

Seismic isolation is a widely adopted method for the design of component or building in mechanical or civil engineering. Although its application in nuclear power plant is limited, the method itself can greatly reduce the risk due to earthquake. Different seismic isolation tools are investigated in the present paper. The limitations and difficulties of applications of these tools are discussed.

Finite Element Method (FEM), which is an important tool for the structural design, analysis and evaluation, is also discussed in the paper. An example of the analysis of a supporting structure using commercial FE software ANSYS is provided. The results are discussed and the factors which will affect the accuracy of the FEA are investigated, especially the quality of the mesh.

Finally, the seismic reliability of NPP in Turkey is introduced and discussed. The seismotectonic map of Turkey is provided and investigated. Based on the seismotectonic map, the Seismic Qualification Method in Turkey is discussed, including the definition of the Design Ground Movement Level and safety classification of the components. Moreover, the factors that need to be considered during the design and analysis for mechanical components and buildings were studied.

Keywords: Seismic Quality; Earthquake; Safety; Cabinet; Nuclear Power Plant

Contents

Chapter1 Introduction

1.1 Introduction

Within an industrial, chemical-handling or manufacturing workplace, safety cabinets are very useful. Not just paneling and metal frame, the cabinets are designed so as to hold specific types of chemicals or other important documents be it for later use, storage or disposal. Specifically in the nuclear power plants cabinet system is playing such a crucial role, by containing monitoring system . Therefore, in the case of earthquake cabinet is one of the critical structures which should be kept strong and durable against seismic loads. For that reason, from equipment choosing stage until the seismic analysis of cabinet structure every steps should be examined and calculated very carefully.

In such industrial and manufacturing units, it is not only cabinets that are required for the safety of the structural integration. There are various types of doors such as motorised doors, air seal doors that are installed so as to protect the units from any damage. The different types of doors come with unique features and apart from protecting the unit they have some specific qualities too.

Earthquakes are a kind of natural disasters that cannot be controlled and predicted sufficiently. This uncertainty, during the project design phase, triggered the studying of evaluation of foundation features in order to prevent collapsing of structures. Moreover, minimizing the damages on materials which are bearing to earthquake loads is another important subject in the seismic qualification procedure. The basic principle of traditional design methodology is amplifying the endurance features of materials by predetermined ductility tests. This method reveals two important problems during design stages . First; increasing in some structures the necessity to increase the capacities of the elements in proportion to the earthquake loads it is both very expensive. The second is that in this method based on the ductile element detailing by limiting the strength, certain level of damage of the structure is allowed from the beginning. This causes huge economic consequences for the places like hospital, nuclear power plants, firefighting stations which are supposed to keep running right after the earthquake immediately. Besides if precautions methods are not applied that might cause severe accident and loss of lives.

Seismic isolation method, unlikely capacity design principle, commensurate with increasing earthquake loads it envisages to decrease the earthquake demand rather than increasing the capacity. We cannot control the earthquake, but by preventing the earthquake transmitting from the ground to the structure we can reduce the earthquake demand. It is possible with the presence of flexible layer that allows us to increase the endurance of materials between the superstructure and ground according to natural periods of the earthquake.

1.2 Purpose of this study

The main purpose of this study is general discussion of earthquake including:

1. How does it happen?
2. What are the critical issues in seismic movement?
3. An example of severe accident due to earthquake Fukushima accident is investigated in detail. Simulation using ANSYS software are studied.
4. How can we reduce the risk by strengthening the material endurance?

Chapter2 General Discussion of Earthquake and Importance

2.1 What is Earthquake

"EARTHQUAKE" is the phenomenon where the vibrations that occur suddenly due to the breaks in the earth's crust spread in waves and shake the surface and the environment they pass through. Earthquake is a natural event that shows that the soil that people regarded as immobile and safely stepped on would also play, and that all their structures could be destroyed in a way that could be damaged and lost their lives. The branch of science that examines how the earthquake occurred, how earthquake waves spread across the earth, measuring instruments and methods, evaluation of records, and other issues related to earthquakes is called "SEISMOLOGY".

2.2 Reasons of Earthquake Occur and Types of Earthquake

Regarding the internal structure of the world, there is a ground model supported by the data obtained as a result of geological and geophysical studies. According to this model, there is a lithosphere formed around 70-100 km thick on the outer part of the earth.

The continents and oceans are located in this rock. The belt between the lithosphere and the core, which is 2.900 km thick, is called Mantle. The core under the mantle is considered to be composed of a Nickel-Iron mixture. The place is known to increase the temperature as you go deeper from the surface. From the fact that the transverse earthquake waves cannot propagate in the core of the earth, it is concluded that the core should be a liquid medium.

Although the mantle is generally solid, it contains local liquid environments as it descends from the surface.

There is a soft Upper Mantle called Asthenosphere under lithosphere. The forces formed here, especially due to convection currents, break the stone crust and divide it into many "plates". Convection currents formed in the upper mantle are connected to the high temperature caused by radioactivity. As the convection currents rise upwards, they cause stresses in the rock and then the formation of plates by breaking weak zones. There are still about 10 large plates and many small plates. Together with the continents standing on these plates, they float like an raft on the astenosphere and move at a speed that people cannot feel relative to each other.

In places where convection currents rise, the plates move away from each other and form the mid-ocean ridges in the hot magma emerging from there. In the regions where the plates touch each other, there are frictions and jams, one of the rubbing plates sinks down to the Mantle and melts to form the loss zones. This sequential event caused by convection currents continues and goes under the lithosphere.

Here, the boundaries of these plates, where the plates forming the earth's crust are rubbed against each other, compressed each other, climbed over each other or entered below, as the places of earthquakes in the world. The vast majority of earthquakes in the world occur on narrow belts at the plate boundaries where these plates force each other.

Above, we have said that the "plates" that make up the earth's crust are in motion due to the convection currents in the Asthenosphere and therefore they push each other or open from each other, and the zones where these events occur also form earthquake zones.

There is a frictional force between the two plates that push each other or go under the other, which prevents movement. In order for a plate to move, this friction force must be removed. A movement occurs when the friction force is exceeded between one sheet being pushed and another plate. This movement takes place in a very short time unit and is in shock nature. Eventually, earthquake (shaking) waves emerge that can spread far away. These waves propagate by shaking the environments they pass through and decreasing their energy as they move away from the direction of the earthquake. Meanwhile, land fractures called fault line can occur on the earth, sometimes visible, extending for kilometers. These fractures are sometimes not observed on earth, they may be hidden by surface layers. Sometimes, a fault that was formed from an old earthquake and reached to the surface, but covered in time, can play again. The description of the occurrence of earthquakes in this way and under the name of "Elastic Rebound Theory" was made by American Reid in 1911 and it has been proved by being tested in laboratories.

According to this theory, at any point, when the energy that is gradually formed by the elastic deformation accumulation gradually, reaches a critical value, it overcomes the frictional force along the fault plane and creates relative movements of rock blocks on both sides of the fault line. This event is a sudden displacement movement. These sudden displacements, on the other hand, occur when the unit deformation energy accumulated at one point is released, discharged, in other words, it turns into mechanical energy and as a result, the breaking and tearing motion of the ground layers.

In fact, it is impossible for the rocks to break without prior accumulation of a unit. This unit creates the movement of displacement, convection currents formed in the upper crust in the earth crust seen, rocks can resist until a certain deformation and then break. As a result of these breaks earthquakes occur. After this event, some or all of the stresses and energy that have accumulated since the rocks have been removed. In the faults mostly formed during this earthquake event, elastic rebounds are formed on both sides of the fault and in the opposite direction.

2.3 Tsunami and Fukushima Accident

In this part Fukushima Nuclear accident is mentioned to point out the importance of material strength and endurance during the earthquake especially for the nuclear power plants to prevent such potential severe accidents . Moreover the criticality of material strength against seismic movements and vibrations is vital, otherwise if we do not pay attention and take necessary precautions its likely to see similar accidents in the future . Therefore, Fukushima accident is explained in detail in this section regarding to earthquake and tsunami affects.

The Fukushima Nuclear Power Plant is located on the seaside near Fukushima, Japan. The second biggest accident in the history of the nuclear power plant occurred as a result of the 9.0 magnitude earthquake that occurred 130 km from the city of Sendai on 11 March 2011 and the following tsunami. Seismic information recorded at the Fukushima plant, located 180 km from the epicenter, shows acceleration of 0.56 g for the plant. The tsunami height, originally designed for the Daiichi power plant, was 3.1 meters. This value was determined by considering the tsunami in Chile in 1960. The power plant was built at a height of 10 meters above sea level, and seawater pumps are at a height of 4 meters above sea level. In 2002, the design was developed for a 5.7 meter tsunami. When the 23-meter high tsunami, which occurred during the earthquake, hit the beach, its height dropped to 15 meters and left the turbine building 5 meters under water.

When the earthquake occurred, the reactors were closed successfully and cooling continued using diesel generators. Since the earthquake damaged 6 external power supplies, cooling was continued with diesel generators. Diesel generators are located at the base of the turbine building. After 41 minutes, the first tsunami wave hit the plant, and after 8 minutes the second wave arrived. These waves submerged and damaged the seawater pumps of the main concentrator circuit and backup cooling circuits. The waves also put the diesel generators on the floor of the turbine building under water and covered the main switches and batteries with water. As a result, power plant darkening occurred and the reactors were deprived of the main cooling system. Tsunami also disrupted the roads around the power plant and made interference from the outside difficult. As a result of the emergency created by this situation, an emergency was declared on March 11 at 19.03 and the Fukushima region started to be evacuated around 2 km of the power plant at 20.50. At 21.23, this area was increased to 3 km and the next day was increased to 10 km at 5.44. Later, this area was increased to 20 km on 12 March.

The first three units continued to produce 1.5% power due to degradation of fission products, although they were turned off. As a result of not being able to absorb this heat with the external system, steam started to form in the pressure vessel of the power plant. In addition, Hydrogen started to form as a result of steam-Zirconium interaction. The increase in temperature and pressure and the hydrogen explosions caused a serious accident. Fuel dissolution occurred in all the first three units but remained in the fuel protection container. However, some volatile fission products and water-soluble soluble fission products that escaped at the first moment have escaped out of the protection container. Cooling was provided by external sources and the heat of the reactor could be removed stably.

Radiation released from the Fukushima Power Plant and released into the environment by water leakage is mainly emitted by the volatile Iodine-131 isotope. Other important isotope is the Cesium-137 isotope. On March 12, the evacuation area was increased to 20 km. The base value for evacuation is determined as 20 mSv / year. According to the flight measurements made by the French Institute for Radiological Protection and Nuclear Safety between 30 March and 4 April, the dose taken by people living around the plant will not exceed 30 mSv / year. Considering the Iodine-131 equivalence of the cesium-137 isotope, the Iodine-131 equivalence activity released from the plant was estimated at 770 PBq. The radiation released between 12-31 March 2011 in the estimation made by the owner of the plant Tepco in May 2012 is equal to 940 PBq Iodine-131 equivalence activity.

On 31 December 2011, Tepco conducted radiation exposure examinations on 19,594 people working on the field on 11 March. According to the report, 167 employees received doses over 100 mSv. Of these 167 people, 135 people received doses between 100-150 mSv, 23 people between 150-200 mSv, 3 people between 200-250 mSv and 6 people over 250 mSv. According to the numbers determined in January 2014, 173 employees received doses between 100 mSv and 1578 employees between 50-100 mSv. There is no loss of life due to radiation in this accident. 6 employees received doses above 250 mSv, but these values did not cause acute radiation sickness.

With the tsunami following the 8.9 magnitude earthquake on the Riechter scale, systems providing power to three of the light water boiling water reactors in the Fukushima Nuclear Power Plant were disabled. There are six nuclear reactors in the power plant. Reactors 1, 2 and 3 shut down automatically. During the earthquake, there is no fuel 12 in the 4th unit, and the 5th and 6th units are in cold shutdown due to routine maintenance.

The accident has become worse by the release of radioactive materials into the environment due to the loss of water in the used fuel storage pools and the explosion due to hydrogen formation due to metal water reaction and the accumulation of hydrogen gas more than 4%.This accident was classified as 7 on the INES scale due to its high radioactive emissions.

Units 1, 2, and 3 are currently stationary, but still not fully cooled. On March 11, 2011, an 8.9 magnitude earthquake occurred in Tohoku-Chihou-Taiheiyo-Oki at 14.46 hours local time, causing serious damage to the area, but the tsunami that occurred about an hour after the earthquake caused much greater damage. With the earthquake, a total of 11 reactors operating in 4 different nuclear power plants in the region were shut down automatically. Immediately after the earthquake, problems started to occur in the 1.2 and 3. units of the Fukushima Nuclear Power Plant, and some problems occurred in the 4th unit five days after the earthquake.

Nuclear power plants in Japan are designed to react quickly during an earthquake. In case of ground movements, there are automatic systems that are activated to shut down the system safely. The design value of ground movements is maximum 550 Gal (0.56g) for Dai-ichi Nuclear Power Plant. The tsunami height determined in the design for Dai-ichi Nuclear Santali is 5.7 meters. The height of this power plant above sea level is 10 13 meters.In this disaster, 14-15 m and larger tsunamis took place. Reactors were closed automatically as ground movements reached 500Gal with the earthquake. After the automatic shutdown of the reactors, auxiliary waste heat removal (RHR) cooling system was activated. The RHR system is operated with electric pumps. When the main power in the reactors was lost due to the earthquake, the emergency diesel generators in the turbine building came into operation and worked for 56 minutes, but were damaged by flooding after the tsunami that came 56 minutes after the earthquake. Mobile power supplies were delivered to the power plant and connected to the power plant within nine hours. The capacity of these resources is much lower than the main diesel system.

It is believed that in the first three hours of the accident, fuel melting in the first three units. It is estimated by TEPCO that 75% of the fuel melts and leaks into the lower sections of the reactor. This can happen when the fuel temperature reaches 2500 ° C. When melting occurs, the "corium" begins to move towards the bottom of the reactor vessel. If very hot fuel or material comes into contact with coolant, it can dissolve and break and move towards the bottom of the reactor vessel. Cracks occur in the material at 1200 ° C, oxidation starts at 1300 ° C and the envelope begins to melt at about 1850 ° C. After 1 hour after the reactors shut down automatically after the earthquake, when the power was cut off due to the tsunami, the reactors continued to produce approximately one-half (1.5%) of their nominal power output. This production is due to fission product decay. Calculations with the models with the best verification have shown that currently there is approximately 22 MW in unit 1 and 33 MW in units 2 and 3 . The reactor, which hosts the heart, caused the production of a large amount of steam in the pressure vessel, since heat cannot be drawn through the water circulation. This generated steam could be condensed in the pressure relief pool under the reactor. However, the internal temperature and pressure of the steam increased rapidly. Although it is tried to make water injection with the Emergency Central Cooling System (ECCS) at 16.36 hours, ECCS could not be activated in the first and second units half an hour after the power loss in the system.

After the first 12 hours, the pressure in the secondary protection vessels increased rapidly and reached 12 times the design value on March 12, 2011. This may have damaged the pumps leak system. On March 12 at 15.36, a hydrogen-related explosion occurred in the secondary protection container of the first unit. Most of the roof was blown up. On Sunday, March 13, sea water injection started in the main protection vessel of the first unit.

These complications continued to occur sequently and finally authorities were not able to control the system. This is all happened due to miscalculations and unpredictable consequences of earthquake. For that reason the importance of seismic qualification methodologies are understood better . If equipment qualities and strengths are managed and adjusted accurately ,the possibility of facing such severe accidents in the future is quite low .

Chapter3 Seismic Isolation Method

3.1 Definition of Seismic Isolation

Seismic Isolation is a such building design methodology which can be takes place in several positions on, under or in between the structures. Main function of this method is to increase period of superstructure by absorbing the vibration of the earthquake to the infrastructure. Thus, the impact of the earthquake against super structure is reduced. In classical structures displacements are distributed to the height of the building and increase on the upper floors. Base insulated in buildings, displacement is concentrated in insulators and relative acceleration is interconnected on each floor and the magnitude is close each other. Isolation system with low horizontal rigidity it separates the structure from ground horizontal movements. This situation helps the embedded frequency of the building much smaller than its current frequency. Higher modes that cause damage to the structure are first mode and it is orthogonal to ground motion. These higher modes are not involved in the movement, so large energy of high frequency ground motion is not transmitted to the structure. Isolation the system does not absorb earthquake energy, but reflects it to the system's dynamics. This damping not related, but having a certain damping to prevent resonance would be useful. If the superstructure is rigid, the behavior of the insulated structure is of one degree of freedom. very similar to the behavior of the building. Force of typical elastomeric insulators displacement relation, linear due to its inherent damping properties It is not linear. Therefore, in order to determine the seismic behavior of the structure with seismic isolation, nonlinear properties of isolators' mathematical models should be applied accurately.

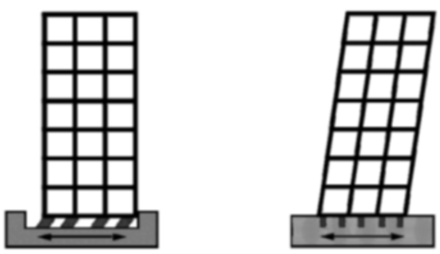

Figure 3.1 Embedded system and basement isolation system

3.2 Fundamentals of Seismic Isolation System

The main purpose of the seismic isolation method which applied in building is reducing the vibration period of the structure which comes from possible earthquake scenario. To understand why it is so important , Figure 3.2 and Figure 3.3 demonstrated properly. As can be seen from these figures, the increase of the structure's period decreases the spectral acceleration values on the structure. Increasing demand for displacement with the growth of the building period when it is met, the building is significantly protected from earthquake.

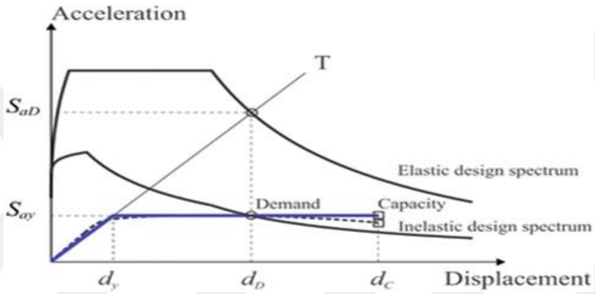

Figure 3.2 Elastic vs Inelastic (accelaration)

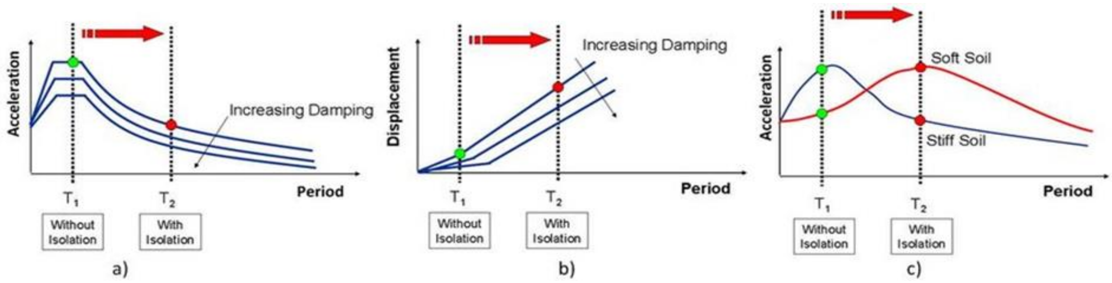

Figure 3.3 Effects of base isolation: a) on spectral acceleration, b) on lateral displacement, c) for different soil conditions

The elements that make up the insulation system are called insulating units. These units generally are Elastomeric Insulators (LRB- Lead Rubber Bearings , HDRB – High Damping Rubber Bearings) or Friction Base ısolator . Earthquake insulation used in buildings units usually include the following features:

- High Vertical Rigidity
- Low Horizontal Rigidity
- Ability to carry vertical load
- Energy Absorption

- Re-centering after the earthquake
- High horizontal rigidity against horizontal loads outside the earthquake (like wind).

In addition, the insulation units are under the largest displacement and vertical load combinations it must be stable, with increased lateral displacements, increased resistance and repeated changes in physical properties under loads , should be limited .

• Design Earthquake (Strong earthquake with a 10% probability of over 50 years ground motion) will not cause any damage to the structural system and at least "Immediate Use" performance after design earthquake criterion will be provided.

• Large Scale Earthquake (Earth-dependent earthquake with a probability of 2% over 50 years ground motion) any damage to the earthquake insulation system under its influence will not occur and at least “Life Safety” performance criterion in the structural system will be provided.

3.3 Difficulties in the Applications of Seismic Isolation Method

• Large relative displacements between superstructure and insulation level the structure must be provided for the entire duration of use.

• For flexible structures whose period is outside the range with a risk of resonance not applicable ; because the main purpose of isolation is to prevent resonance and flexible Isolation has no effect on structures.

• Sensitivity of the structure with increasing slender (height / width) ratio Increasing the moment increases the likelihood that the structure will rise up. This situation is very makes it difficult to use insulation in high-rise buildings .

3.4 Limitations in Seismic Isolation Systems Applications

3.4.1 Structure Weight

The most practical isolation methods give the best results on heavy masses. The building period should be large in order to create an effective insulation system. The period is proportional to the building mass and inversely proportional to the structure rigidity. There is no unlimited rigidity range for the tools which used for the isolation . For example, for the elastomeric rubber insulators to stay stable under seismic loads. There is a minimum diameter value that they must have in order to remain. There is no such restriction for systems with sliding insulators and therefore light structures can be used with sliding insulators. Apart from structure weight, displacement values for any given period and at the same time expenses for both heavier and lighter structures are almost same. There are very few isolation methods that can be applied successfully in places such as detached houses in light structures.

3.4.2 Structure Period

The most suitable structures are the short-period structures in 1 second period. This value less than ten times for buildings, less than 5 times for rigid steel framed structures valid for those. The most useful isolation techniques 1.5-3.5 building period It shifts to the seconds interval. If the period of the building is already in this range, isolation implementing the system will not yield any benefits.

3.4.3 Ground condition

Insulation process can best be applied on rock or hard ground. Soft floors increased effect of earthquake waves and resonance in isolation period 7 causes large displacements like this. Spectral acceleration in Figure 3.4 value changes on soft grounds.

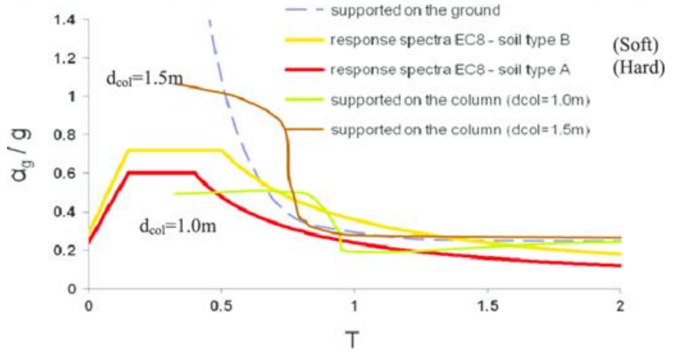

Figure 3.4 Change of spectral acceleration value on soft grounds

3.4.4 Near Fault Ground Motion

The near fault effect makes the applicability of the isolation method the most controversial . Because the isolation method is operable for structures up to 5 km at most as the distance to the winning increases, the so-called enterprise takes place. Although isolation can be applied in places where near fault condition is observed, it is generally the cost of construction increases and the design becomes very complicated.

3.4.5 Location

If dynamic characteristics and ground conditions are suitable for seismic isolation the most important parameter to consider is the location of the building. The applicability of the base isolation method is a distinction that separates the superstructure and the infrastructure. depends on the presence of the plane. The swing gap should be at least 10 cm and the seismicity of the area should be increased up to 100 cm depending on the situation . If there is no enough oscillation and swing gap, isolation will not work as desired. On the other hand, since isolation plane is horizontal it helps to method to be more applicable in this regard. Otherwise, as seen in Figure 3.6, on sloping lands not only horizontal but also vertical isolation by cascading planes also need to be created.

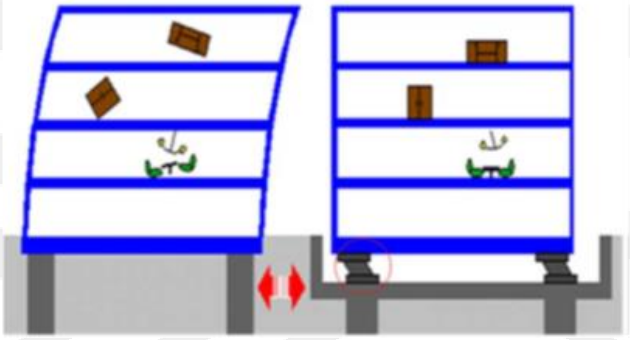

Figure 3.5 Damage comparison of insulated and non-insulated structures

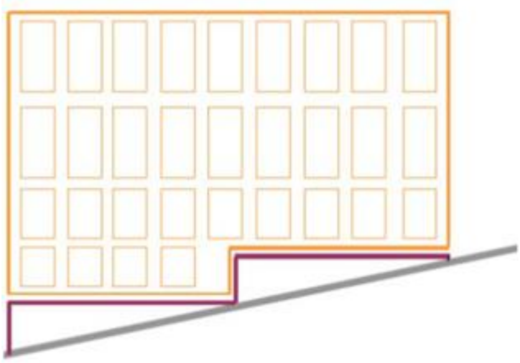

Figure 3.6 Insulation application on sloping terrain

3.4.6 Selection of carrier system

The most practical isolation methods work better under pressure. In sliding systems isolation can be separated while vertical loads are drawn. In pulling circumstances where relatively low strain points , cavitation situation occurs which affects the rigidity of the insulator negatively. For these reasons, in terms of meeting the horizontal loads of the insulation system it is not practical to base it on structural members. As a sample long centile curtains or frames that transmit cross steel moment can be given. As a general rule, a significant tensile stress at the design earthquake level it is not allowed to occur , tensile stresses are accepted at the highest earthquake level but this makes the design very complicated.

3.4.7 Benefits of Seismic Isolation Method

a-) Technical Benefits

Between floors in a structure designed according to traditional seismic design methods damage to column and beam joints due to different displacements might occur. However, displacements between floors in a seismically isolated structure, 9 bending deformations, cracks and plastic deformations will be avoided. Forces in columns and beams will be minimum. It will be seen from Figure 3.7 superstructure part of a structure with seismic insulation applied as a single rigid element to act .

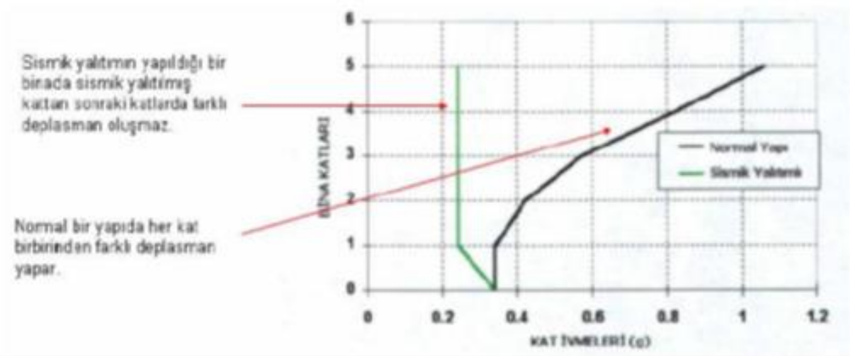

Figure 3.7 Graph of floor displacement request in an insulated structure

- A building prepared according to traditional seismic design methods, difficulties in the elaboration of the system, as well as the implementation of the structure and it contains many difficulties in terms of construction cost. Seismic isolation and a structure where the method is applied behave like a rigid mass of the superstructure and due to its feature, both the earthquake and ground conditions of the superstructure elements and the design and detailing phases of the building gets simplified.
- Traditional earthquake design methods characteristic of ground motion, ground content, material quality, structural behavior and mathematical modeling it contains many uncertainties. These uncertainties in design with seismic isolation there is, but since the sensitivity of the structure is reduced in terms of earthquake effects the degree of security of the schematic isolation method is higher.

b-) Economical Benefits

Non-structural but use with the use of seismic isolation method damage to the elements that fall into the required or valuable building class immediately by preventing the transition of the earthquake acceleration acting on the structure from the infrastructure to the upper structure superstructure damage level is reduced and minimized.

3.5 Seismic Isolation Tools

Base isolation systems can be examined under 3 main headings:

a-) Elastomer-based mechanical parts

Low Damping Rubber Bearings (LDRB)

Damping Rubber Bearings (LRB)

High Damping Natural Rubber (HDRB)

b-) Roller Bearing Isolation System

Friction pendulum system (FPS)

Cross Linear Bearing (CLB)

Earthquake Engineering Research Center (EERC)

Elastic Frictional Basement Isolator System (RFBS)

Electricite – de France system (EDF)

TASS System (Taisei Shake Suspension System)

c-) Helical Spring Separated Systems

Gerb Helical Spring System

3.5.1 Low Damping Rubber Bearings (LDRB)

Natural rubber is the first elastomer used in seismic isolation technology. This support type was created by placing steel plates between rubber layers. These bearings have a very high vertical rigidity due to steel plates, at the same time relatively low lateral rigidity . Lateral rigidity depends on thickness and numbers of rubber plates . Usually the desired rigidity is provided by , by keeping the layer thickness constant and the number of layers provided by replacement. Increasing the height creates the risk of buckling, so the diameter of the height is half of the support diameter. Effective damping, usually 0.07 is less than. its mechanical behavior is viscoelastic and hysteretic and the combination of two behaviors. They are easy to manufacture and their mechanical properties is limited by temperature, loading and aging effects. Most important their disadvantage is that they need an additional damper. With the development of low damped bearing type high-damped and lead-core rubber 12 types are obtained . Low damping rubber insulators are shown in Figure 3.8 and low damped rubber insulators in columns application places are shown in Figure 3.9.

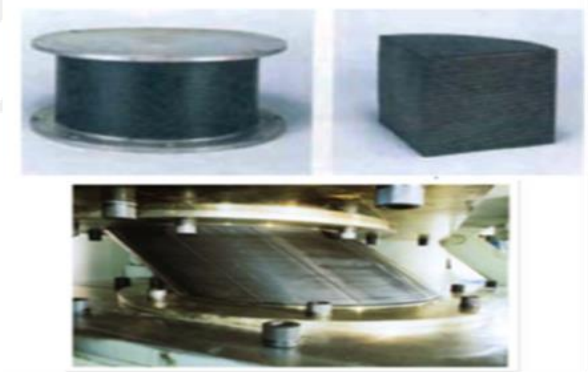

Figure 3.8 Low damping rubber insulators

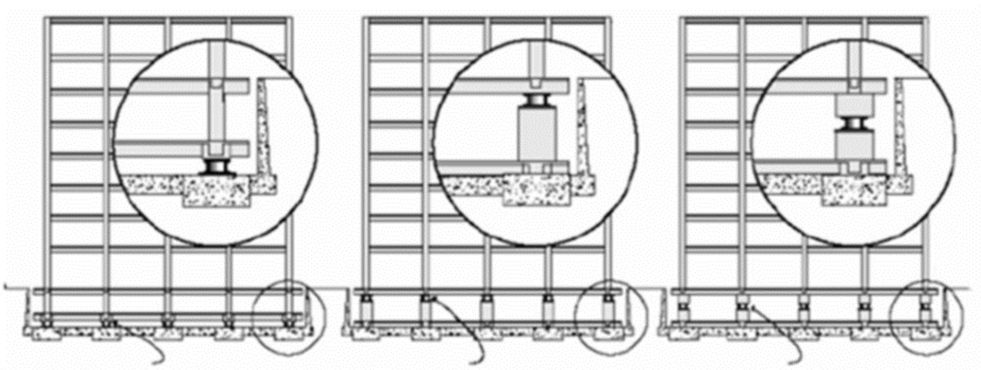

Figure 3.9 Seismic isolator bottom- upper – middle respectively

Rubber insulators can be applied to the structure in where column bottom level, column top level and column middle level. When we consider the effect of bending moment to upper and bottom level of column, applying this system to middle level can yield more effective outcomes.

3.5.2 Damping Rubber Bearings (LRB)

Lead core insulators were produced and developed in New Zealand in 1975. These isolators, which have been widely used in New Zealand, Japan and USA, model is similar to low damped rubber insulators. In this isolator there is lead core in the middle of the support. This prevents the rubber from high slip displacement . The lead core is firmly supported by the elastomer layer and is approximately provides a yield stress of 10 MPa. We see that lead core insulators and low damping natural rubbing bearing insulators are frequently used together. In such applications, lead core isolators are used in inner bearing as a damper ;on the other hands low-damping natural rubbers are use in outer systems as a stabilizer. Rubber observes the energy in case of the low or medium range earthquake scenarios by doing core plastic deformation . Damping rate achieved as a function of displacement and is usually at the level of 15% and 30%. The most important benefit of lead core insulators is their rigidity in service condition. It can be combined with the flexibility of the case and work like a single element. This situation lead-core especially when high damping requirement occurs makes the insulator the most common type of insulator .

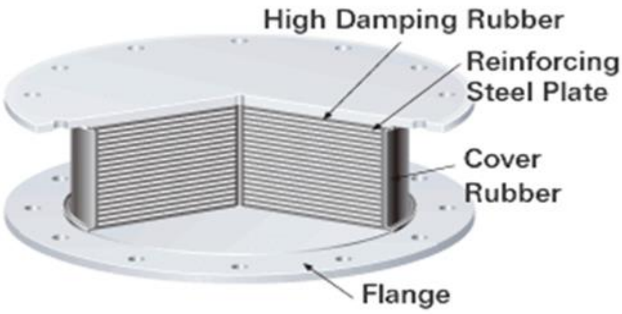

Figure 3.10 Damping Rubber Bearings

3.5.3 High Damping Natural Rubber (HDRB)

High damped natural rubber insulators was developed in 1982 at Malaysia Rubber Manufacturers Association (MRPRA). This eliminated the need for additional dampers for low-dampening rubber insulators. In this insulator damping is amplified with additional carbon blocks ,oils , resins or other additional fillers. This damping is increased by 10-20% under shear deformations. damping in insulators, it is neither viscous nor cyclical. This damping has a behavior between both. The experimental results showed that the behavior of these elements is the combination of linear viscous and elastoplastic elements' behavior. Another advantage of these kind of isolator bearing tools is the ability of damping to vibrations of railways before it reaches the main structure. A typical example of high damped natural rubber bearings is show in figure. It can be seen from the figure steel plates and the top and bottom layers of the insulator are both under protection and the axial load resistance of the insulator is increased. Rubber plate horizontal rigidity has provided horizontal isolation to the insulator by keeping it at a low level . The damping requirement of the isolator is met with filled material which added to the insulator.

Figure 3.11 High Damping Natural Rubber (HDRB)

The use of high-damping natural rubber has many advantages. It meets the necessary flexibility and energy damping need as a single element , easy to design and manufacture . Moreover, the feature of compressing when they place to any position makes them unique and adjustable to many structures.

3.5.4 Friction pendulum system (FPS)

It is a support element that can slide on concave spherical surface using special metals . This material has a vertical movement feature that also raises the building during horizontal movement. Thus , it can damp the earthquake energy by 80%, also it can provide structure turn back its original position in a short amount of time. In Figure 3.12 friction pendulum type insulator section can be seen. Earthquake energy is damped by using building weight . The frictional force depends on the radius of curvature of the insulating surface and the normal force. Moreover it limits the upper shear force which occurs during earthquake. Figure 3.13, friction based seismic isolator underweight operation the principle is simply expressed. The geometry of friction pendulum systems and the weight it carries are important parameters. Because the behavior of this system is a simple pendulum based on the basic principles of the movement.

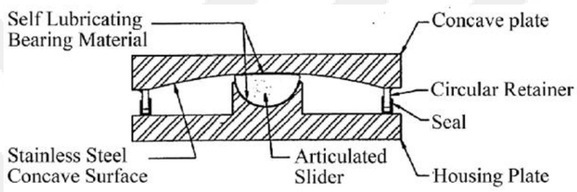

Figure 3.12 Friction pendulum system (FPS)

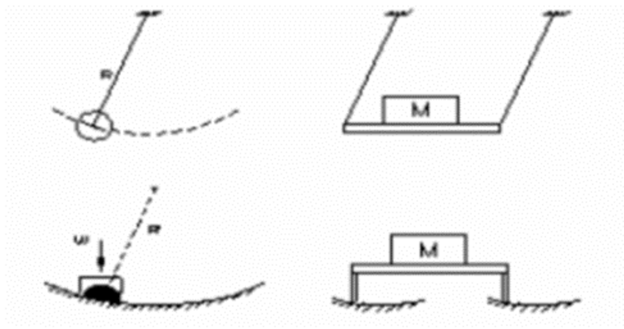

Figure 3.13 Friction based seismic isolator underweight operation the principle is simply expressed

The protective cylinder which locates in friction pendulum system not only prevent lateral displacement but also protects the inner element external mess. Effective rigidity of the insulator and insulation of the structure period is controlled by the curvature radius of the concave surface.

3.5.5 Cross Linear Bearing (CLB)

These systems are designed to eliminate such cases arise in the use of elastomer based insulation systems and problems such as buckling or rupture of insulators . CLB is compared with many experimental data , earthquake records , theory and results of several analysis. All experimental and application has shown a superior performance in its works and its applicability the system met the necessary criteria properly. The purpose of this method is applying the seismic isolation to light structures (wooden or steel houses) , high structures and structures which shapes like tower . This type of insulator consists of planes which perpendicular to each other and objects on a sliding steel body that moves diagonally in the direction. There are steel balls that allow the rail to roll and move. Body moves with a small friction force. The diameter of the steel balls ,the number of effective balls and the number of rails determines bearing capacity of the insulator. In Figure 3.14, cross-rail bearings carrying two and four units of linear mass are exemplified.

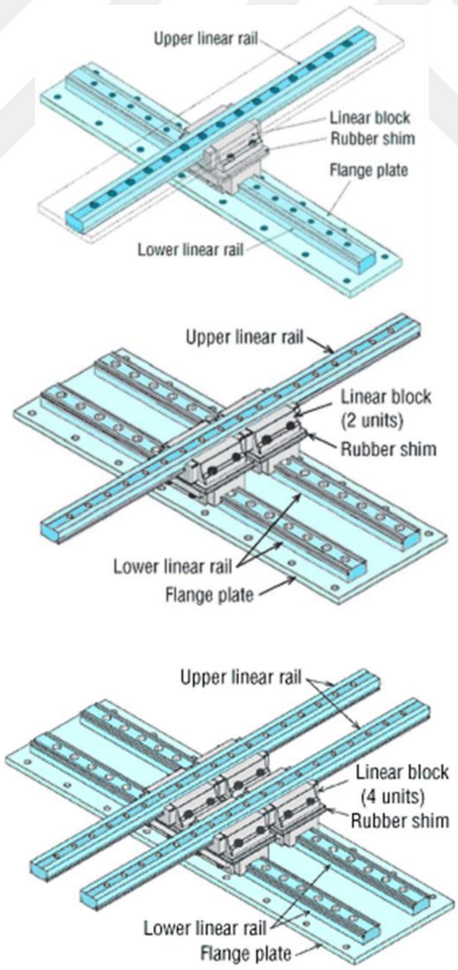

Figure 3.14 Cross rail bearings carrying 1, 2 and 4 units of linear mass

The vertical load bearing capacity of this isolation system in the range of 10 tons to 30 tons. Also in the plane of the structural system, 35 cm to 100 cm in both directions allows horizontal displacement .

3.5.6 Earthquake Engineering Research Centre(EERC)

It is a system formed by combining rubber based and sliding systems. In this system , inner columns are covered by sliding elements which made up by stainless steel materials. On the other hand outer columns are damped by low damped natural rubber insulators. Rubber insulators, re-centering of the structure and controls the torsional behavior of the structure.

3.5.7 Elastic Frictional Basement Isolator System (RFBS)

In this system base insulators , consists of rubber core and circular shape plates which are in contact with each other with frictional forces. The most important reason for the regulation of this system is its sliding lack of force to return the bearings to their initial balanced position . By adding the flexible core to the system , the system can be centralized in this way. As a result of the experiments, the rubber core alone could not prevent displacements. For this reason, a steel rod is placed in the rubber core that distributes displacements through the layers . Some important benefits of this system can be listed as follows:

- This system is also can be used to arrange asymmetrical structures as well because in elastic frictional systems rigidity and central mass contradicts with each other at the level of isolation .
- Friction in the system prevents horizontal displacements .
- The elastic supports in the system is only affected by horizontal loads caused by earthquake . Vertical loads are carried by sliding sections that are more rigid. This situation reduces creep problems under vertical loads and increases the capacity and stability of replacement.

3.5.8 Electricite－de France System(EDF)

This system is for application to nuclear power plant facilities, It was developed in the early 1970s. This organization had developed a nuclear power plant which is based on 0.2 g acceleration. The system is designed for the power plants to be placed which has higher seismicity . System; layered artificial rubber (neoprene) insulators with lead-bronze alloy in contact with stainless steel combines. The sliding surface of the system is fitted on top of the elastomeric insulator. Service life of friction coefficient of sliding surface, taking into consideration of insulator, it should be 0.2 . Artificial rubber pad, very low it has displacement capacity and it is not more than about ± 5cm. If incoming displacements exceed this limit value, the sliding element can be provides sufficient movement. The system does not have any mechanism that is correcting the bearing. Therefore, permanent displacements in the system may occur. System was only once used in the South Africa , the city of Koeberg in where a large power plant station.

3.5.9 Electricite TASS System (Taisei Shake Suspension System)

This system was developed by a company called “TAISEI” in Japan. All vertical loads in this system are carried by stainless steel teflon elements with a flat surface. By using neoprene layer insulators in the system, the system is centralized

3.5.10 Gerb Helical Spring System

GERB system for base isolation, initially belonging to the power station turbine It was developed for the vibration isolation of their devices. In this system, both horizontal and large spiral steel springs that behave flexibly vertically are used . Its vertical frequency is about 3-5 times its horizontal frequency. Steel springs are completely damped and the system is always used with GERB visco dampers. As with all three-dimensional systems, there is a very strong relationship between the horizontal movement of the system and the swing movement. Because the center of gravity of the insulated structure is above the stiffness center of the insulation system. The GERB system was tested in the city of Skopje, the capital of Macedonia, with a shaking test. It was also implemented in two steel-framed buildings in Santa Monica, California. A typical spiral spring base insulator is exemplified in Figure 3.15.

Figure 3.15 Spiral spring base insulator

Chapter4 Finite Element Method modeling on ANSYS

4.1 Introduction

Box section profiles have high performance level under axial load thanks to their cross section geometry. However, local buckling, especially on the profile body and head under the influence of bending, prevents the profile to reflect the strength values that are the result of the cross section geometry to the combination or the structure it is part of. In particular, in a combination of wide headed column narrow headed beam exposed to bending effect; Since the load transferred from the beam to the column is indirectly transferred to the body via the column head, possible local deformations are opened. For this reason, the deformations are not on the beam, they are damped on the column, and the combination moves away from the strong column weak beam principle. The recent earthquakes have shown that the local buckling effects occurring in the profiles in structures designed using box section profiles are effective on the mechanism states. This has led designers and scientists to work on the evaluation and prevention of deformations in box section profiles.

Duff (1963), Kanatani (1980), Mang (1983), Davies and PanjehShahi (1984), Szlendak and Brodka (1985, 1986a, 1986b), Szlendak (for square and rectangular box cross-sectional junction, whose plane inclination is also considered within the scope of the Design Guide. 1986,1991), Kanatani (1986), and Yeomans and Giddings (1988) worked on welded box section joints. The researchers tried to determine the node rigidity according to the state of the welded joints of the box-section profiles exposed to moment effect and the coefficient β (b1 / b0) determined by the dimensions between the profiles forming the joint. Design Guide (2009), Korol (1982), Korol and Mirza (1982) focused on the algorithm of local buckling on the column and beam under bending effect. However, each combination behaves differently according to the cross-sectional effects of the structural elements that make up that combination.

4.2 Material and Method

In this study, it is tried to prevent the deformations that may occur in the column or beam in such a combination with the rigidizing plate added to the combination. With the rigid plate added to the node, the deformations occurring in the column under the influence of bending were tried to be kept within linear limits. On the other hand, the deformations on the beam are tried to be formed in the desired place and shape. By using different mesh techniques on the numerical model calibrated according to the experimental model created for this purpose, the effect of mesh quality on node behavior was examined. As a result of the analyzes, the most appropriate finite element model was tried to be created for real behavior.

In the numerical analysis of the sample, the experimental analysis of which was completed, ANSYS computer program was used. In the program, the models have been subjected to nonlinear analysis by dividing them into finite elements, and in order to analyze the model whose experimental analysis has been completed, within the same conditions, it is necessary to divide (Meshing) the finite elements in the appropriate number and geometry. In the program, mesh can be done automatically or manually by considering a specified algorithm. In both cases, the model to be meshed should take into account the geometry of each element and the interaction when they come together. Because in the program that makes analysis using finite element solution technique, loads are distributed to finite parts through node points. If the finite pieces are not formed in the appropriate size and in the appropriate lower geometry, the joints that provide the connection within themselves will not catch each other. For this reason, either the program will give convergence problems and will not be able to offer the solution of real behavior. In Figure 4.1, the finite parts used in the ANSYS program are given, and in Figure 4.2, an example of an example arranged using the automatic and manual mesh technique is given.

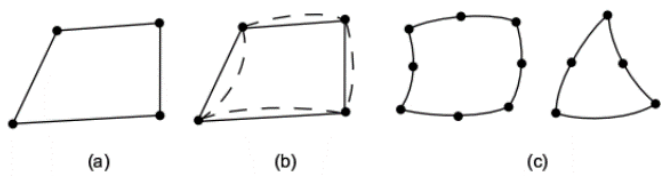

Figure 4.1 Examples of finite elements that can be defined in the Ansys program

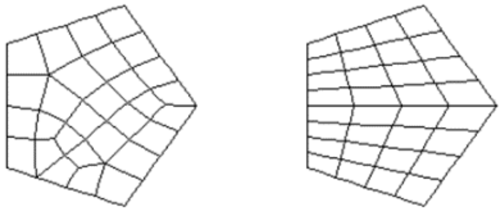

Figure 4.2 Automatic mesh and manual mesh geometry

Mesh technique to be used in numerical modeling affects mesh quality and is calculated by the program as a coefficient. The results obtained for each case where this coefficient is 90% or more gives the closest approach to the line. However, it would not be very accurate to consider mesh quality as a numerical value only. Because the results obtained from the analysis are also related to our expectations. The part where the stresses or deformations are concentrated should be determined by designer and increase the number of elements by reducing the finite element size in those regions. In this way, the analysis will be concentrated in the desired region, and the results will be closer to reality. In Figure 4.3, a sample is presented to explain this situation. As can be seen in the figure, the mesh formation in the model on the left is controlled by program, and in the model on the right, the mesh quality is concentrated in the desired region with a mapping technique made in the desired regions.

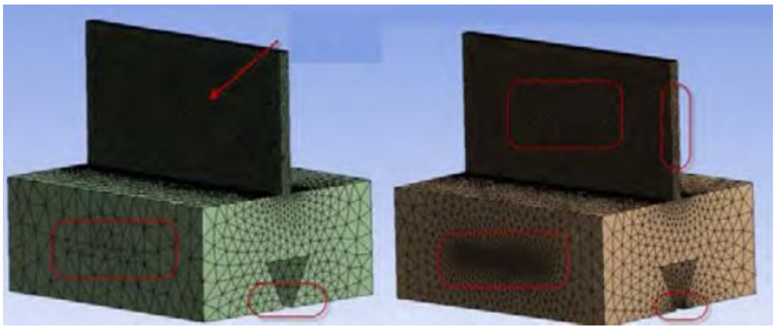

Figure 4.3 The differences between automatic and manual mesh application.

In this study, experimental and numerical model of circular column combined with rectangular cross section beam and its behavior under horizontal load acting cyclically were investigated. In the model, a steel profile with a circular cross section of Ø219.1 x 5mm is used for the column, while a 150x200x4mm rectangular box profile is selected on the beam. In Figure 4, the experimental model general condition, support conditions and loading arm views are given. Accordingly, the horizontally located element column, vertical element beam is taken as 1960 mm and 980 mm respectively. Experimental model bearing conditions are given the freedom to rotate in one direction, and their ability to rotate and displace in all other directions is prevented. The load was applied to the sample using a loading arm, which was designed to be double-hinged and acted reversibly. The length of the rigidizing plate, which is detailed on the column, is Vb = 300 mm., The width is Hb = 344 mm. The wall thickness is 8 mm, which is twice the thickness of the beam wall.

The sample was digitized using the Ansys Work Bench V14.0 finite element analysis program using the experimental analysis results and the model was calibrated. The Ansys Workbench program can perform nonlinear analysis, both geometric nonlinearity and material nonlinearity due to its technical features. Therefore, all the elements that make up the sample (profile, weld, support plates) are introduced to the program using nonlinear material properties. Using these material properties, column, beam, loading arm parts and support plates are modeled as shell elements, butt plate and welds are modeled as solid elements.

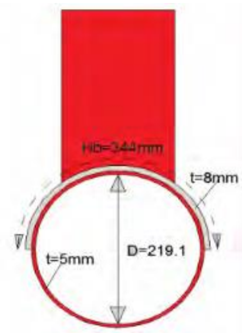

Figure 4.4 Loading Arm

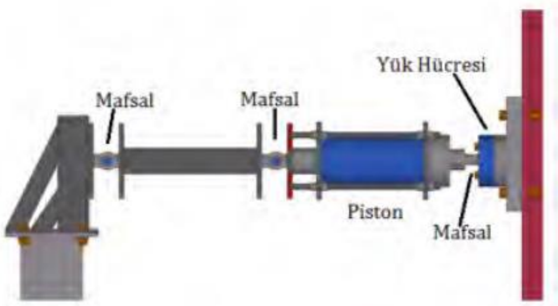

Figure 4.5 Cross section View

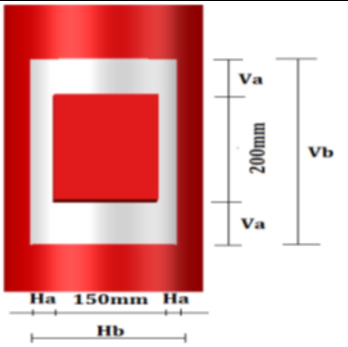

Figure 4.6 Upper View

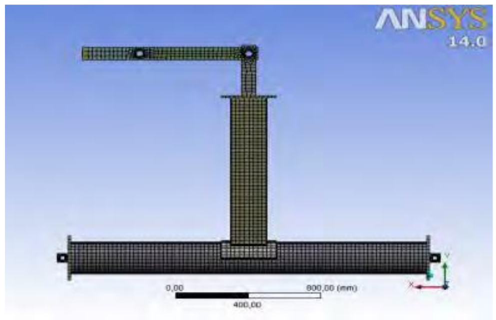

Figure 4.7 Numerical study mesh view

In Figure 4.6 and Figure 4.7, the views of the model, which is the subject of the study and created using two different mesh techniques, are divided into finite elements. The model used in the study consists of two elements with rectangular and circular sections. The rectangular section beam fit into the circle form using the dovetail cutting method. In this case, the transition from rectangular form to circular form in dividing into finite elements makes the dimensions and shapes of finite parts from being standard. It makes it difficult for the finite pieces of different forms and sizes to catch each other in the program, which will enable load transfer to each other. For this reason, the parts lose their form in order to connect together and the transitions become irregular. This situation causes the mesh quality to not be at the desired level in the parts where the rectangle fits into a circular form if automatic meshing is performed. However, in the model, which is divided into finite pieces manually, there is a harmony between the pieces realized in the desired form. All the models analyzed in the study were based on this comparison. In models created using these two techniques, the friction and stiffness coefficients in the combinations have been changed and the number of models has been increased, and the contribution of mesh quality to behavior in different interaction situations has been examined.

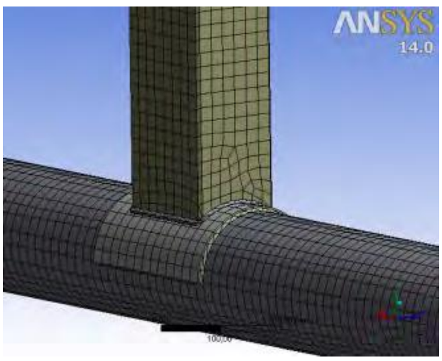

Figure 4.8 Automatic Mesh

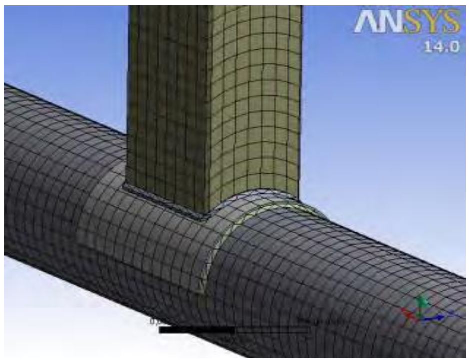

Figure 4.9 Manuel Mesh

4.3 Research Findings and Evaluation

In experimental analysis, it was observed that local deformations on the column were prevented with the forehead plate attached to the joint. The column exhibited a rigid behavior, and in line with the strong column weak beam design, a mechanism was formed in the beam. The node has lost capacity due to the mechanism. No tearing has occurred on the profiles, butt plate and weld in the joint. Deformations occurring at the junction are observed under the influence of bending. The beam head is concave and its body is convexly twisted and the deformation in the body and head has increased in each cycle. The jointing state that occurred on the beam occurred approximately 6 cm above the rigidizing plate.

Stress and deformation graphs of the results obtained for models created using two different mesh techniques in numerical analysis are shown in Figure 4.8-4.13. When the figures are examined, the joint condition is caught at the same point on the beam in both cases.

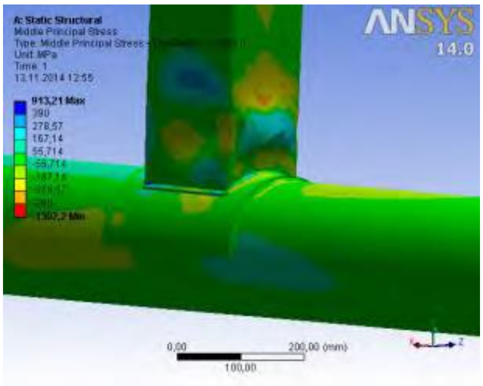

Figure 4.8 MAFIX

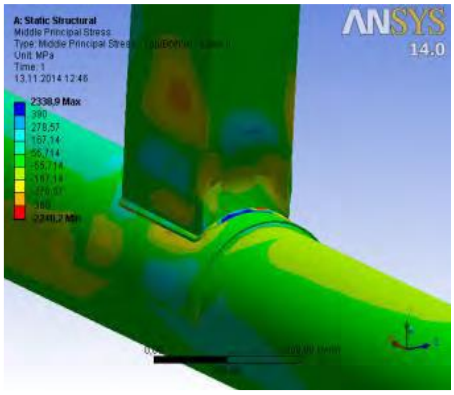

Figure 4.9 MMFIX

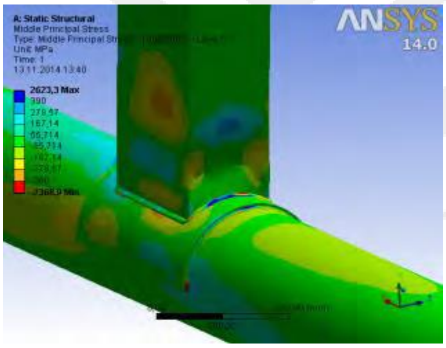

Figure 4.10 MAFRC

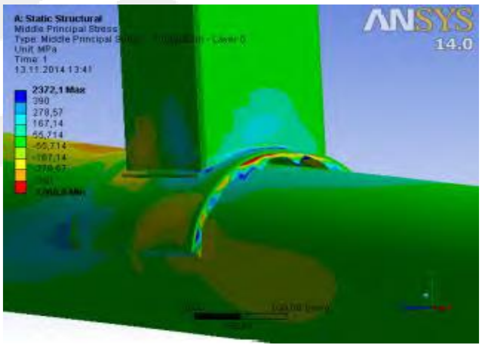

Figure 4.11 MMFRC

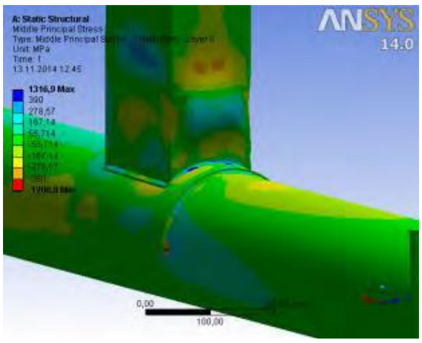

Figure 4.12 MA30-5

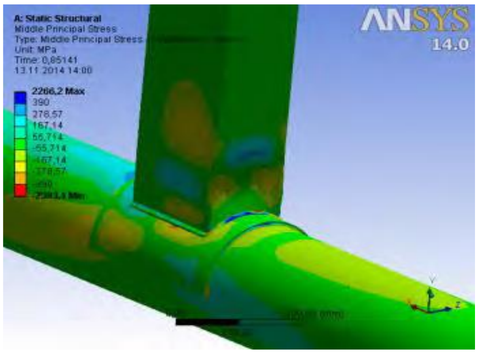

Figure 4.13 MM30-5

4.4 Conclusion and Suggestions

It is a known fact that in the models to be created for the analyzes made with finite element programs, material properties and geometric dimensions can be digitized accurately as well as results that are close to real behavior. However, if the models to be analyzed consist of box-sectional profiles where local deformations depending on the section features come to the fore, the finite algorithm should be intensified and the interaction of the finite parts should be modeled most accurately. The analyzes made within the scope of the study showed that; The negative effect of geometric differences on the interaction of the finite parts to be formed should be avoided, especially when the parts with different cross-sectional geometries are evaluated together. Otherwise, as the deformation increases as in the model created by using the automatic mesh technique, the interaction of the finite parts will be interrupted, the program will either give convergence error and terminate the analysis or tear the source seam, which should behave as rigidly as in the analysis. For this reason, it was seen that the mesh technique used in the analyzes, in which parts with different cross-sectional geometry were evaluated together, affected the solution results. In such cases, it would be correct to do the final disassembly work manually, not according to the program, and decide the size, shape and density of the finite parts by the designer. However, it is not a problem to use finite element programs in models with automatic mesh application, fixed geometry and unpredictable deformations such as local buckling.

CHAPTER5 Seismic Reliability of Nuclear Power Plants in Turkey

Earthquake is a very important factor in nuclear power plant design. One of the Turkey earthquake safety due to frequent earthquakes exposed the country has attracted many people's attention. all regions of Turkey's 780,000-km area does not have the same degree of seismic activity. The location, time, magnitude and other characteristics of earthquakes that may occur in a seismically active region cannot be fully predicted. The most important issue in earthquake engineering is to determine the effects that earthquakes that may occur in a certain time interval can create on the construction site, especially the maximum values that can be expected for ground motion parameters such as acceleration, velocity and displacement. Due to the similarities of earthquakes in terms of time, location and severity, an approach based on probability and statistical methods is used to determine the parameters of ground motion to be used in the design of the structures. Despite deterministic approaches, the probability approach is to determine a set of values and a probability distribution defined on this set instead of a single value for ground motion variables.

The purpose of the seismic risk analysis is to identify certain probability values for future seismic activities at the construction site by regularly combining the available data of previous earthquake events with geological, seismological, statistical and other information. The result of the seismic risk analysis is usually in the form of a curve that indicates the probability of overcoming a particular ground motion parameter or earthquake intensity in the construction site in one year or the average repetition period.

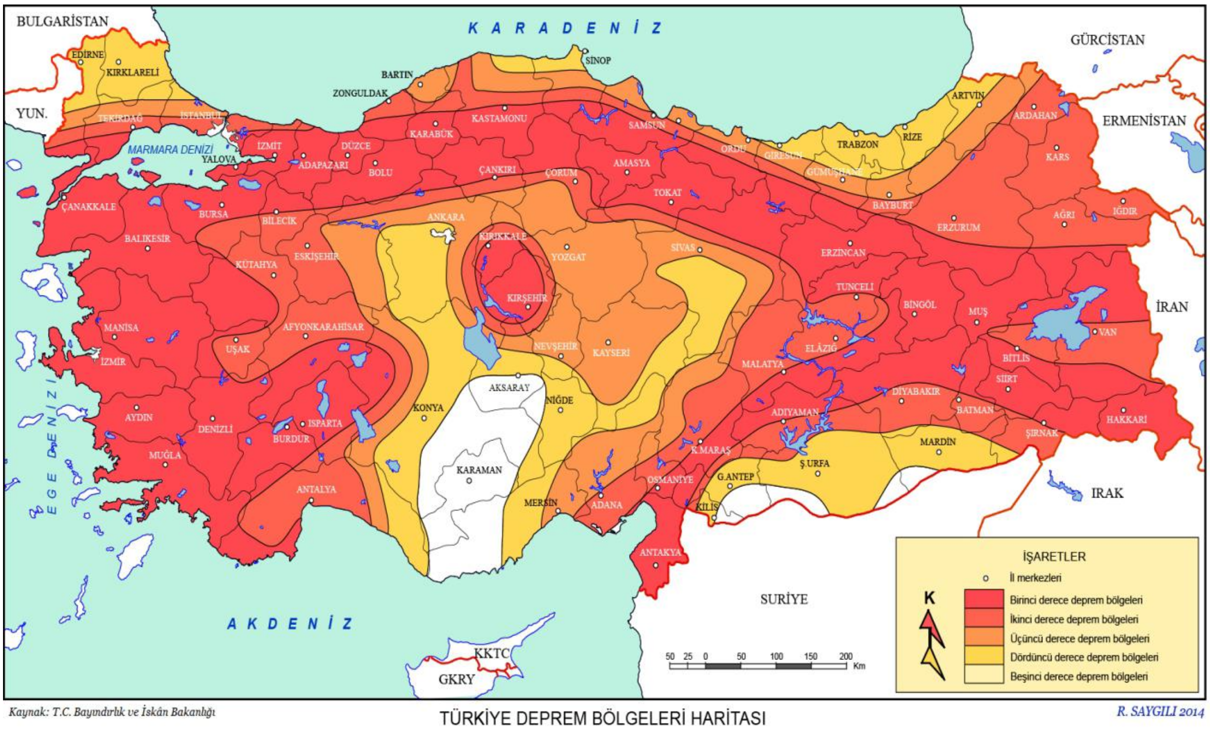

Figure 6.1 The map of the Turkey earthquake

In many countries, the life of nuclear power plants is considered to be 50 years. During this 50-year period, it is considered that the probability of an earthquake that constitutes the basis of the design is very low. If the earthquake that is expected to be repeated every 5000 years on average is taken into consideration, the probability of this earthquake to occur during the operation period is 1%, and if 10,000 years are taken, it will be 0.5%. Countries usually consider earthquakes, which are expected to occur every 5000 or 10,000 years, in the design of the power plant. This approach is considered sufficient in the world in terms of power plant security.

In statistical analyzes or probability calculations, the more and frequently the data is obtained, the closer the results to the calculation. In this case, there is an obligation to go to old earthquakes, namely historical and instrumental earthquake records. In instrumental records, the parameters are more precise. The records belonging to the old years are used to find the greatest value that can be expected. In the studies to determine the earthquake hazard, seismotectonic maps are made by studying the earthquake activity of the region together with the tectonic structure. All historical and instrumental earthquake data and regional geological surveys are evaluated according to international standards and safety criteria. An area with a radius of at least 150 km from the center where the power plant will be installed is subject to inspections. The purpose of seismotectonic zoning is to reveal areas with a homogeneous earthquake potential. Seismotectonic regions are defined according to the similarity between the geological structure and seismicity. The use of seismotectonic approach in determining earthquake parameters in nuclear power plants is compulsory in Turkey as in many countries.

The ultimate aim of these studies is to determine “Design Ground Movement Level”. These levels are;

Operation Based Earthquake S1: It refers to the highest ground motion level expected to be on site during the life of the nuclear facility and where the facility can maintain normal operation.

Safe Shutdown Earthquake S2: It directly refers to safety boundary conditions and ground motion level corresponding to the highest earthquake potential that can affect the site.

In determining the (S1) and (S2) ground motion levels, the following steps are specified in the USA and International Atomic Energy Agency (IAEA) safety standards:

- For a seismically active structure, the maximum earthquake potential (magnitude and intensity) is assessed by moving it to a suitable location on the building closest to the site.
- The maximum earthquake potential in the seismotectonic area of the site is considered to be on site.
- A reduction function is used to determine the earthquake ground motion level that will cause maximum earthquake potential in this field.

All elements in the nuclear power plant are classified into classes as seismic category 1, seismic category 2, and out of category, in order to ensure safety in an earthquake event and to test some elements after an earthquake exceeding a specified level. All structures, systems and components that fall under seismic category 1 are identified. These elements are designed to withstand the S2 earthquake level ground motion results or are shown to be able to withstand an earthquake force at this level. Category 1 includes the following elements:

- Elements that may cause an accident to be dysfunctional, directly or indirectly,
- Necessary elements for stopping the power plant, monitoring critical parameters, keeping it in a stopped state and withdrawing residual heat in the long term,

- Elements required to prevent radioactive leakage in accident conditions or to ensure leakage is kept below specified limits

As a safety precaution, elements designed to alleviate the consequences of design accidents are also included in category 1.

Then, all structures, systems and components that fall under Seismic category 2 are identified. The elements in Category 2 are designed to resist the S1 earthquake level ground motion results. Category 2 covers the following elements:

- Elements not included in Category 1, to prevent the escape of radioactivity beyond normal operating limits
- Necessary elements to alleviate accident conditions in long-term situations not included in Category 1

The following issues are taken into consideration in terms of civil engineering structures in earthquake design:

- Carrier ground adequacy,
- Suitability of interconnected building foundations
- To ensure optimum rigidity, load and weight distribution and minimum torsional effects, structural frames and curtain walls are balanced in the plan and placed symmetrically,
- Collision possibilities of neighboring buildings due to dynamic displacement,
- Adequacy of the connections of additional protrusions and sections to the main structure
- The adequacy of the strength of the required structural elements, especially against horizontal cutting forces,
- To provide sufficient ductility and to prevent sudden collapse due to shearing and pressure effects, the required amount of reinforcement
- Proper placement and distribution of the reinforcement,
- Correct design of structural joints,
- In cases where extreme deformations are predicted, P-D effect caused by vertical loads and lateral lapses on the structures due to earthquakes,
- Groundwater removal effect on the foundation,

The issues related to the nuclear plant structure, systems and components' dynamic behavior and the earthquake behavior and stability of all ground structures (natural and human structure slopes, dams, dams, etc.) and ground structures (natural and human structure slopes, dams, dams, etc.) that may affect seismic security are certain. somehow it is taken into account. When the water-saturated granular floor layers are exposed to earthquake ground motion of S1 or S2, liquefaction potentials are determined and safety limits against liquefaction are shown to be sufficient. In cases where adequate security limits cannot be provided, the location of the site or facility is changed. Possible settlements (especially different settlements) that may occur due to earthquake are taken into account, especially when the ground differs. The potential of the soil to lose its predicted bearing strength during and after the earthquake is investigated.

Chapter6 Conclusion

In conclusion, earthquakes are part of the nature of mankind and instead of escaping and ignoring that fact, we should face it and get well prepared in such scenario. As technology advances we started to build up gigantic structures such as huge trade centers, dams, hydroelectric power plants and Nuclear Power Plants. In this regard their strengths and endurance has vital importance. We experience Fukushima accident lastly and we are still struggling its grand consequences since precautions were not applied properly. Especially for nuclear power plants, everything should be calculated and implemented based on procedures and official standards.

Seismic isolator is such invented methodology and carried out lately for most of the buildings and structures. Isolator types varies base on the ground movement or seismic conditions. By embedding the seismic isolator to materials, the effect of earthquake always would be significantly low.

In this regard, ANSYS software enables us to build up the model and evaluate the any magnitude of earthquake scenario and see the results before experience any severe accident.

In seismic studies, as we mentioned before there are many critical conditions. Therefore, understanding of territories' seismic parameters are critical. In our study we consider the Turkey as an example and we briefly explained seismic studies in Turkey for NPPs and we shared earthquake distribution zone map .In the same way , before applying seismic isolation methodology , side studying should be done as well .

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Declaration

本人郑重声明：所呈交的学位论文，是本人在导师指导下，独立进行研究工作所取得的成果。尽我所知，除文中已经注明引用的内容外，本学位论文的研究成果不包含任何他人享有著作权的内容。对本论文所涉及的研究工作做出贡献的其他个人和集体，均已在文中以明确方式标明。

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