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A study of seismic isolators used in buildings and their properties

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Abstract

The differences in soil properties, inadequacy in inspections and workmanship errors negatively affect the earthquake performance of the structures. Similarly, the complexity of earthquake forces that cannot be formulated adequately makes structural engineering solutions difficult. One of the solutions that will reduce the loss of life and property during an earthquake is the use of seismic isolators. In this study, the types of insulators used today and their properties were examined.

Introduction

Earthquakes are a natural disaster that does not show any symptoms before and can cause great loss of life and property due to the lack of an early warning system [1]. Alpid Belt, one of the two important earthquake belts in the world; It extends from Spain, Italy and Greece to Northern India and Afghanistan, and Turkey is located in the so-called Mediterranean Earthquake Belt on this belt. There are two major fault zones in Turkey, 92% of which is on this seismic belt. These are East Anatolian and North Anatolian faults. Turkey can be divided into the following four seismotechnical regions [2]

1. North Anatolian Fault Zone
2. East Anatolian Fault Zone
3. Bitlis Thrust Zone and East Anatolian Compression Zone
4. Aegean (Western Anatolia) Grabens Zone.

The fact that most of the existing building stock in Turkey is not built in accordance with the current earthquake regulations, workmanship-material defects, the inhomogeneity of the soil properties and the lack of public awareness about earthquakes increase the loss of life and property in earthquakes. Reasons such as increasing urban population, unplanned construction considering today's facilities and technology, it is not acceptable to experience loss of life in a possible earthquake. This situation causes the concept of earthquake resistant building design to gain importance. Contemporary regulations prepared to meet current needs allow for quality building design and production, and our latest earthquake regulation [3], which came into force in 2018, is a good example of this. However, the fact that the earthquake has a complex structure limits its deterministic features to be used in engineering solutions. For this reason, it is necessary to use approximate data in engineering calculations and to stay on the safe side at the highest degree in proportion to these. This undoubtedly increases the cost. Earthquake resistant building design can be roughly summarized for two purposes and these are; The structure is of sufficient quality and the cross-sectional forces that will occur during the earthquake are calculated in such a way that they can be met at a sufficient rate [4]. In the traditional design approach; It is expected that the seismic energy coming into the structure will be damped by the inelastic deformations that the structure will exhibit before it collapses. It is expected that the structure designed for this purpose will be damaged at a level that can be repaired in a moderate earthquake, and that collapses that will cause loss of life in a severe earthquake will not occur [5]. In summary, the traditional approach aims to meet the seismic loads that will affect the structure with damage that will occur at a level that will not collapse. Increasing the rigidity of the structure for less damage; It will also increase the earthquake forces that will affect it. This situation creates the need for a different way to design earthquake resistant structures. Today, this need has been met by means of special elements that absorb the energy that affects the structure in the event of an earthquake. The techniques for protecting the structure from seismic loads acting on it can be divided into active and passive protection systems. Active control methods, in general terms, are systems in which an energy source is used to keep the displacement of the structure at the desired level. Passive control methods mentioned above; It provides the energy acting on the structure with special elements that absorb and absorb it [6]. In this study, seismic isolation systems, which are one of the passive protection methods, are emphasized and an example image of them is presented in Figure 1 [7].

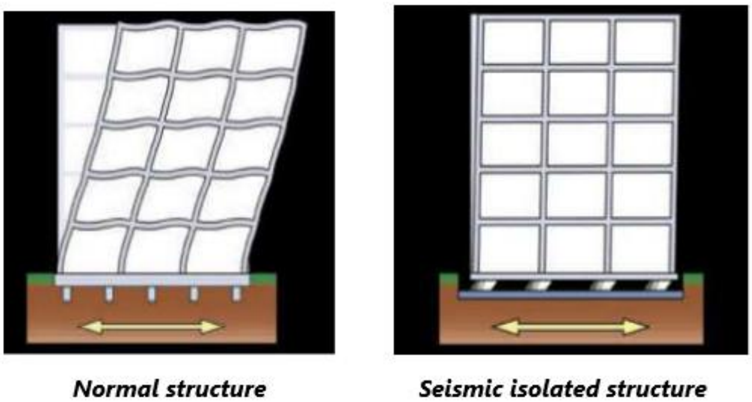

Figure 1. Behavior of normal and seismically isolated structures during an earthquake

Protecting from the devastating effects of earthquakes has been a problem that all civilizations established in earthquake regions wanted to solve, and they sought a solution to this issue. The seismic isolation provided by today's special elements has tried to be applied in different ways in historical buildings. Considering that the working principle of the seismic isolator in the building is to roughly separate the ground and the building, reducing the effect of the shaking on the building, it is possible to see an application in this logic in the Dikili Taş monument in Istanbul. The granite stones under the pedestal can be considered as a historical isolation system made in order to reduce the shaking that will occur on the monument during earthquake shaking. [8]. Today, in parallel with the development of the properties of insulators, the number of structures using isolators against earthquakes is increasing rapidly. If the advantages of seismic isolators are examined; minimizing the damage to the structure, protecting the goods-equipment inside the building and reducing the relative floor acceleration. Also, as disadvantages; high cost, the presence of nearby buildings, and the difficulties encountered in the design of water and natural gas installations in a structure where insulators are used [9]

Types of Seismic Isolation

Seismic isolators can generally be grouped under three headings. These;

1. Elastomeric base isolation tools,
2. Insulation tools designed on slip
3. They are spring type systems.

The insulator types under general headings can be briefly explained as follows [10].

Low damping natural and artificial rubber insulators; It gives high vertical rigidity to the rubber structure between two steel plates and is highly resistant to the effects of temperature and time.

Lead core rubber insulators; It is similar to low damping rubber insulators and can be thought of as several layers of this, and horizontal flexibility is provided by rubber. The elastic behavior of lead up to 11 MPa also contributes to this flexibility.

Highly damped rubber insulators; similar to lead core insulators, the difference between them is that they exhibit high damping properties.

Figure 2. Highly damped rubber insulator

Neoprene insulators with steel plate layer; It consists of rubber between steel and a lead-bronze alloy. It is generally used in nuclear power plants and bridges.

Friction pendulum system; This system, which exhibits pendulum movement on spherical stainless steel, protects the structure from earthquake forces.

Flexible-friction sole insulation system; It reduces the friction problem with many sliding interfaces and provides isolation with the rubber in the center.

The GERB system is; it is generally used in nuclear turbines and provides insulation in three dimensions.

Conclusion

Minimizing the damage to the structure against earthquake effects is an important issue in the field of structural engineering. With the help of today's advanced technology, the use of insulators related to this subject has been developed and started to be applied. The use of seismic isolators, especially in special structures such as bridges and hospitals, which reduce the damage to the structure during an earthquake and which should be used during and immediately after the earthquake, is an effective solution that is becoming increasingly common.

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