UNDERSTANDING THE CONCEPT OF BASE ISOLATION

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INTRODUCTION

Base isolation is one of the most important concepts for earthquake engineering which can be defined as separating or decoupling the structure from its foundation. In other words, base isolation is a technique developed to prevent or minimise damage to buildings during an earthquake. In this essay, the concept of base isolation will be explained by giving some examples from other engineering and sport branches. These examples are automobile suspension systems and some defence techniques in boxing. Additionally, some experiments and analytic graphs will be demonstrated to provide better understanding of the concept of base isolation.

USING THIS CONCEPT FOR EARTHQUAKE ENGINEERING " BASE ISOLATION"

It might be thought that structures can be protected from the destructive forces of earthquakes by increasing the strength of the structures so that they do not collapse during such events. In other words, more rigid attachment of a building to its foundation will result in less damage in an earthquake (the principle of strengthen to resist damage). However, if the foundation is rigidly attached to the building or any other structure, all of the earthquake forces will be transferred directly and without a change in frequency to the rest of the building. Providing a base isolation device between the building and the ground can minimize the level of earthquake force transmitted to the buildings.

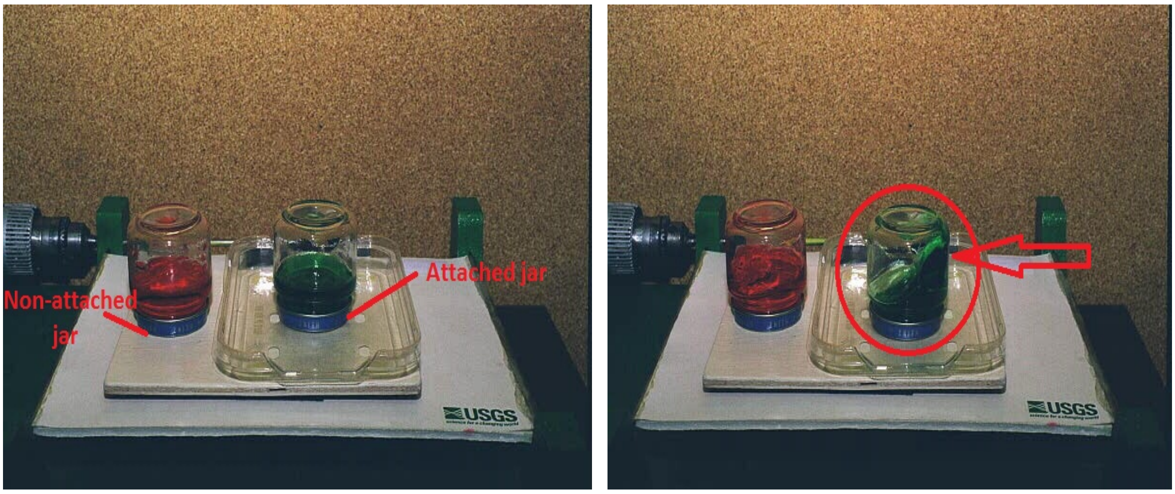

Figure 1 (The effect of vibration to attached and non-attached jar)

Figure 1 shows the effect of vibration to the attached and non-attached jars which are filled with coloured water. As can be seen from the Figure 1, since the green water is attached the ground, all the vibrations are transmitted to the jar directly and causes the water slosh up much higher than the non-attached one. This principle is exactly the same to the structures which have base isolation systems (non-attached jar) and the conventional ones (attached jar) (Figure 2)

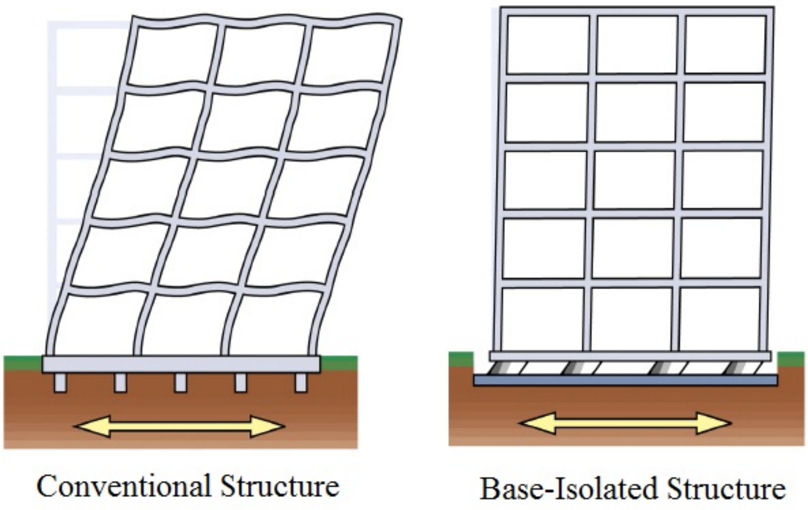

Figure 2

As an earthquake shakes the soil laterally, the foundation moves with the soil and the seismic waves are transferred throughout the structure over time as the seismic wave travels up to the structure (Figure 2).

"If the earthquake has natural frequencies with high energy that match the natural frequencies of the building, it will cause the building to oscillate violently in harmony with the earthquake frequency. However, if the natural frequency of the building can be changed to a frequency that does not coincide with that of earthquakes, the building is less likely to fail". [1]

This is exactly what a base isolator does. The base isolator reduces the stiffness of the structure and thereby lowers its natural frequency. In this condition, the building's superstructure will respond to the vibrations as a rigid unit instead of resonating with the vibrations. Simply put the building's foundation moves with the ground and the base isolator flexes to reduce the ground motion from affecting the superstructure" (superstructure is demonstrated in Figure 4).

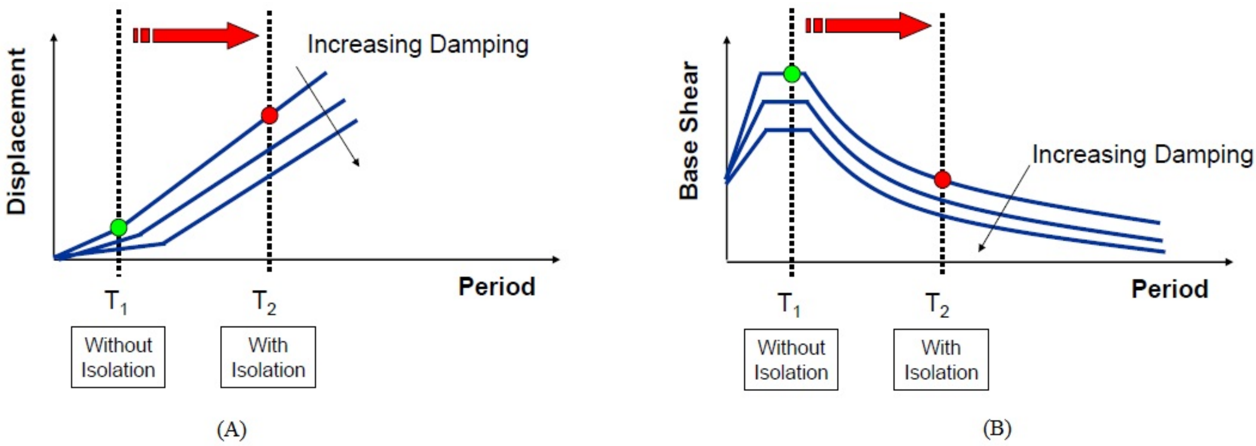

Figure 3

Figure 3 illustrates how the base isolation system affects structures in a positive way. Base isolated structures are likely to have larger displacement, as they are separated from the ground. In other words, base isolation lets buildings to move over the ground so that they have less frequency (Figure 3-A). Similarly, the graph B shows that non-isolated structures are subjected to much higher shear forces than the isolated ones which mean that structures are much more vulnerable to earthquake forces without a base isolation system.

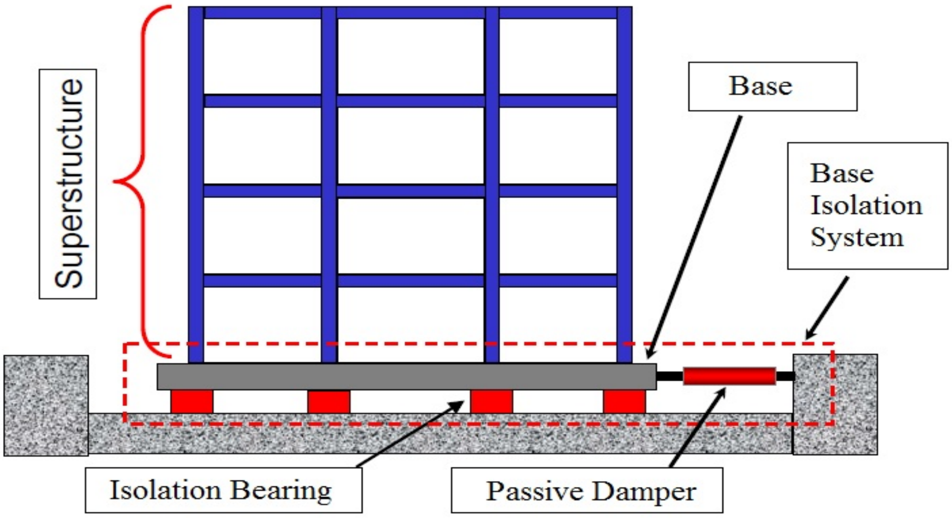

Figure 4

As can be seen in Figure 4, a simple base isolation system consists of two basic components which are isolation bearings and damper. The former protects the superstructure from collapse because of lateral movements based on earthquake forces, whereas the latter absorbs or dissipates the energy that base obtains during an earthquake.

APPLICATIONS OF THIS CONCEPT IN OTHER BRANCHES

Automotive Suspension

The isolators (damping and elastomeric bearings) work in a similar way to car suspension, which allows a car to travel over rough ground without the occupants of the car getting thrown around. In other words, a vehicle with no suspension system would transmit shocks from every bump and pothole in the road directly to the occupants. The suspension system has springs and dampers which modify the forces so the occupants feel very little of the motion as the wheels move over an uneven surface. As demonstrated in Figure 6, shock absorbers in automotives work exactly the same principle with the dampers in base isolation system.

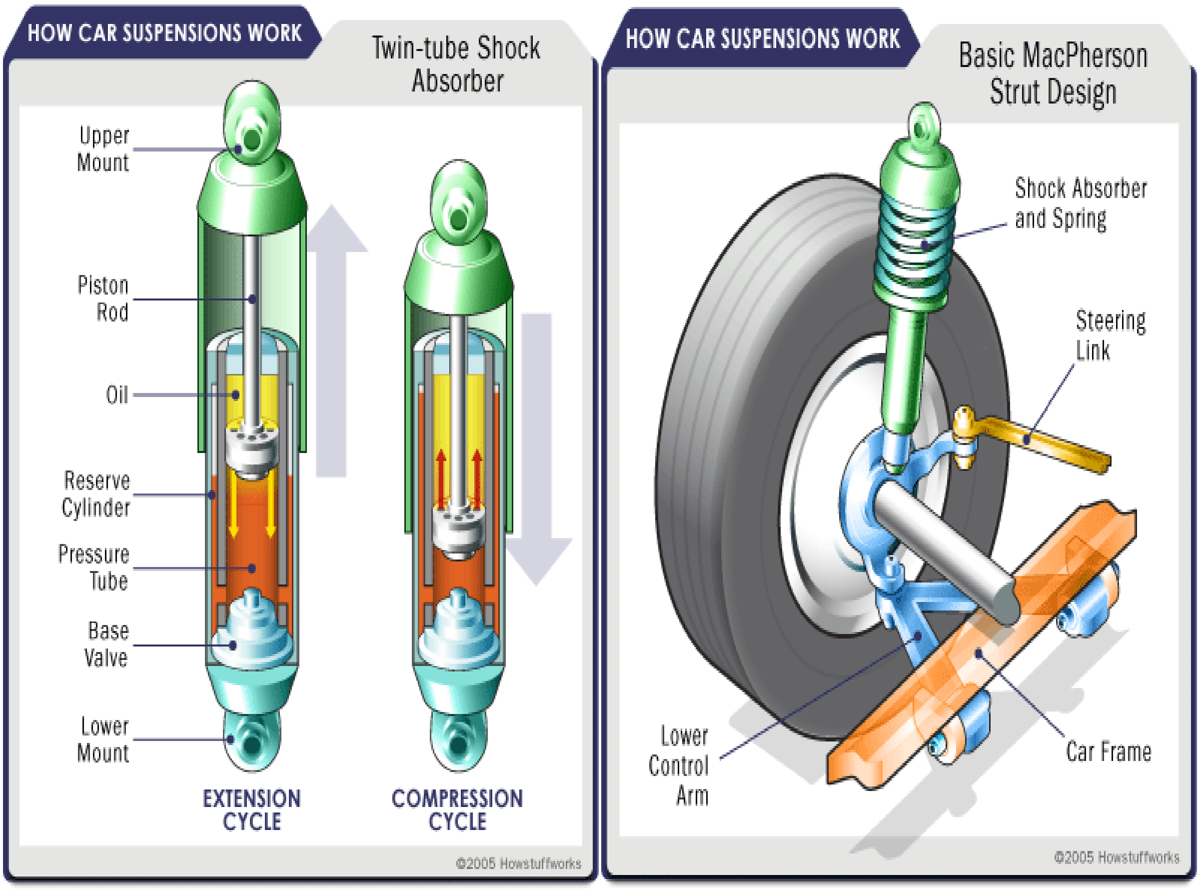

Figure 6 (Car suspension system- shock absorber)

Rolling with the punch

A boxer can stand still and take the full force of a punch but a boxer with any sense will roll back so that the power of the punch is dissipated before it reaches its target (Figure 8). A structure without isolation is almost the same with the upright boxer (Figure 7), taking the full force of the earthquake; the isolated building rolls back to reduce the impact of the earthquake.

Figure 7

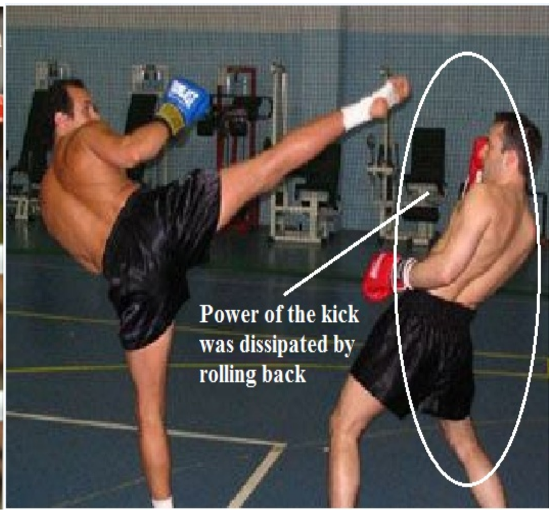

Figure 8

If the structures are designed the same principle of rolling back instead of increasing its strength and stiffness, earthquake forces will be dissipated by damper and elastomeric bearings. By using elastomeric bearings, it is provided that the structure will not be subjected to earthquake forces directly; all the forces will be transmitted to base isolation system.

The party trick with the tablecloth

The concept of base isolation is almost the same with party trick where the table cloth on a fully laden table is pulled out sideways very fast. If it is done right, everything on the table will remain in place and even unstable objects such as full glasses will not overturn (Figure 9a, 9b, 9c). The cloth forms a sliding isolation system so that the motion of the cloth is not transmitted into the objects above which are clearly similar earthquake forces are not transmitted to the structure above by the help of elastomeric bearings in base isolation system.


Figure 9a


Figure 9b


Figure 9c

CONCLUSION

Base isolation has developed into a deep field requiring the work of many engineers and affecting the lives of people across the world, whether they are aware of it or not. By observing and analyzing the physical phenomena that cause buildings to crumble, engineers have devised an effective strategy to sidestep this problem. Besides, once the concept is understood, it is highly possible to use this concept for solving other engineering problems. As it is illustrated in this essay, a technique that has very effective solution to an engineering problem may help even a boxer to win a box match. This is called as seeing and touching the engineering concepts which aims to provide a better understanding of engineering principles through using simple physical models and appropriate practical examples.

REFERENCES

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