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PROPERTY TEST OF CONCRETE ISOLATORS

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Abstract

There was a specific type of isolator that was used in a pervious NSF research project. Therefore due to the past research the isolator was then created out of concrete. The isolator consisted of a total of four concrete blocks with two concave plates in each of the blocks. Then two of the blocks were connected with a steel bar. Then a rubber ball was used as a bearing between the two concrete blocks to dissipate energy during seismic loading. After the concrete isolator was fabricated it was then subjected to a series of different tests within the SEESL Lab at University at Buffalo.

Introduction

Within this NSF research project an isolator was created out of concrete which would ultimately be used in an isolated floor system. The design of the isolator had two concave plates in the concrete specimen. In the isolators was rubber balls that sat in the concave plates and another plate was then placed on top of the rubber ball. When the isolators experienced a force, the energy in the system would be dissipated due to the unique properties of the concrete and the rubber balls. The isolator was constructed which and would be tested in order to determine the properties of the isolator.

Background

The type of isolator that is being used within the research project is called ISO-Base. This type of isolator was designed by WorkSafe Technologies and the entire isolator and the spherical balls are steel. This isolator was used due to the previous research that was done by Ramiro E. Varga1s and Michel Bruneau in the investigation of the Structural Fuse Concept.

Figure 1 shows the isolator being active. When a force, P, is applied to the top plate of the isolator the balls roll in the concave sections of the isolator. The maximum displacement in one direction is dependent on how large the diameter of the plate, the maximum displacement in one direction is half of the diameter of the plate. Therefore the total displacement would equal to the diameter of the plate. The isolator works by dissipating energy through the compression of the balls and the coefficient of friction between the plate and the balls. Therefore; if there is an increase in the friction between the plate and the isolator, the dampening in the isolator would increase too.

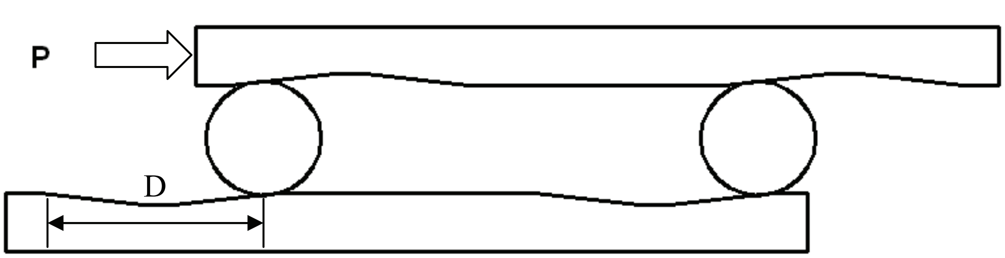


Figure 1: Concrete Isolator in Action

The only difference with the concrete isolator and the ISO-Base isolator is the different materials are being used. The spherical balls are composed of polyurethane rubber or polyurethane. The advantage of using a concrete isolator is that economic value of the isolator is significantly smaller than the isolators that are composed entirely of steel. Another advantage of the isolator is different hardness of the rubber balls can be used in order to vary the dampening of the isolator. By varying the hardness of the rubber balls there would be a difference in the contact area between the two plates would affect the dampening ratio of the isolator.

Methods

In order to create the concave plates within the isolator an AutoCAD drawing was created of the concrete specimen. Figure 2 shows the top view of the concrete specimen. This shows the two plates that are within the isolator, and in the middle of one of the plates is a 1 inch diameter; a rubber ball would then sit in the middle of the 1" diameter. The diameter of the plate is 8 3/8", which this would be the total displacement allowed by the isolator. Within figure 2 are 1/4" anchor bolts, there is where flat bar pieces of steel would connect another isolator plate. Then there would be a total of four plates along with four rubber balls within the complete assembly of the isolator.

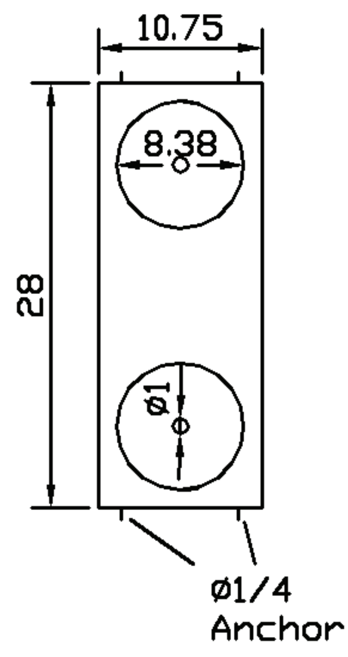


Figure 2: Top view of the Concrete Isolator

Figure 3 shows the front view of a top plate of the isolator. The plate has an incline of 6 degrees and along with the 1 inch diameter seat the 5 inch spherical radius where a 2" diameter rubber ball would sit. There is also an 1/4" anchor that is fixed in the middle of the top plate in order to fix steel plates as dead load on the isolator.

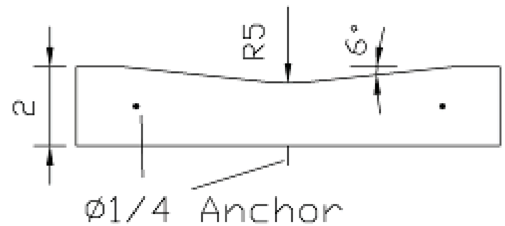


Figure 3: Front View of the top plate of Concrete Isolator

Figure 4 shows the ¼" anchor is located within the middle of the concrete isolator; this anchor is where the steel plates would be fixed to the specimen.

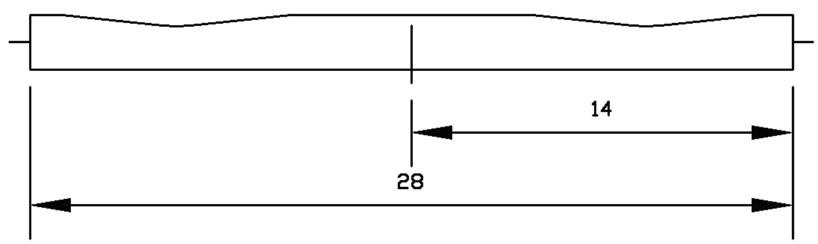


Figure 4: Side View of the top plate of Concrete Isolator

After the series of AutoCAD drawings were created of the specimen, the formwork was able to be created. In order to create the concave plates in the isolator a foam mold was created in order to cure the isolator. The series of AutoCAD drawings were sent to Thermal Foam and the mold was fabricated. Within the mold were bolt holes drilled into the sides of the mold in order to fix the ¼" anchors during the pouring of the concrete. A lubricant was used to coat the foam mold so concrete would not stick to the mold. This would also allow the mold to be reusable.

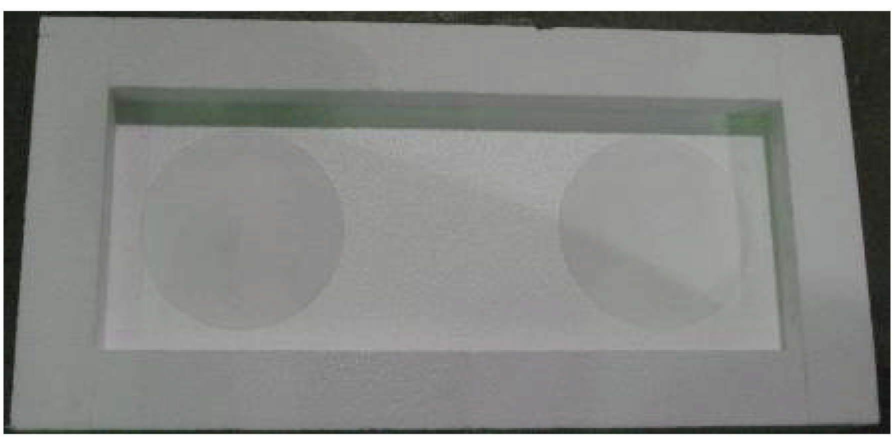


Figure 5: Foam Mold for Isolator

Figure 6 displays the rebar reinforcement within the concrete isolator. The rebar used in the design of the isolator is D2 bars. The rebar cage has total dimension of 10 1/4" by 27 1/4" with 2" openings. The reinforcement was tied down with 1/8" wire ties. One piece of rebar had two 90° angles in order to make an attachment to the other pieces of rebar within the cage. The reinforcement was placed 1" vertically from the bottom of the foam mold. This was done with the use of two normal 1" height rebar chairs that were placed on the bottom of the foam mold. While other rebar chairs were made from bent pieces of rebar which were placed around the dome areas of the foam mold. The use of the rebar chairs was to fix the reinforcement vertically during the pour of the concrete. Pieces of “stay stills” were placed at the corners of the rebar cage in order to prevent it from moving horizontally during the pour of the concrete.

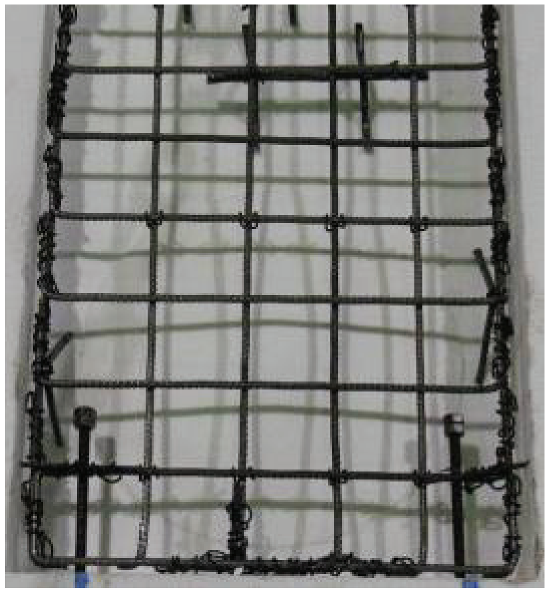


Figure 6: Reinforcement of Concrete Isolator

Bagged concrete with strength of 4,000 psi was used for the creation of the isolator. Quikrete was selected for the bag mix due to the size of the aggregate of the mix, the aggregate size ranged from 3/8” to 1/4”. The sizes of the aggregate allowed it to settle through the 2” by 2” rebar spacing. Super plasticizer was used in the mix of the concrete in order to increase the workability of the concrete due to the specimen size. The normal slump of concrete mix was 2” while with the use of the super plasticizer the slump increased to 6”. With the use of the super plasticizer the normal 7 day strength of the concrete was tested in order to see the affect of the super plasticizer on the strength of the mix. Three compression test cylinders were made that where 6” in diameter by 12” tall and then tested. The cylinders followed ASTM standards C31 and C39 for the curing and compression testing of the concrete cylinders. The normal strength of concrete for a 4000 psi mix after 7 days would be 2,500 psi. With the addition of the super plasticizer the 7 day strength of the concrete was 2,600. With this verification of the strength of the concrete then the mix of the concrete was started for the isolators.

Figure 7: Cylinder after Compression Testing

The total amount of concrete specimens created was 8 pieces. Then 2 bags of concrete were used in order to create 2 molds and 3 tests cylinders for compression testing. With the mold created out of foam, during the pour of the concrete the rebar could not be vibrated. Otherwise the rebar cage would sink further into the foam mold. Therefore the foam mold was vibrated, shown in figure 7. The purpose of using vibration during the pour of the concrete is to reduce air pockets within the specimen.

Figure 8: Vibration of Foam Mold

After the concrete pour the molds were allowed to cure for 24 hours. The concrete isolators were then removed from the molds. At the points where there where anchor bolts were, the foam mold was cut to allow the concrete specimen to be removed from the molds. When the concrete specimens were taken out of the molds, they were placed in plastic bags that were filled with water which is shown in figure 9. The purpose of curing concrete in water is because of hydration. Hydration is a special chemical reaction that cement has with water. During hydration a node forms on the surface of the cement particles. Each node grows and is connected to other cement particles which then attach to the aggregates in the concrete. This is what gives concrete its strength is this process (Portland Cement Association).

Figure 9: Hydration of Concrete Isolator

Results

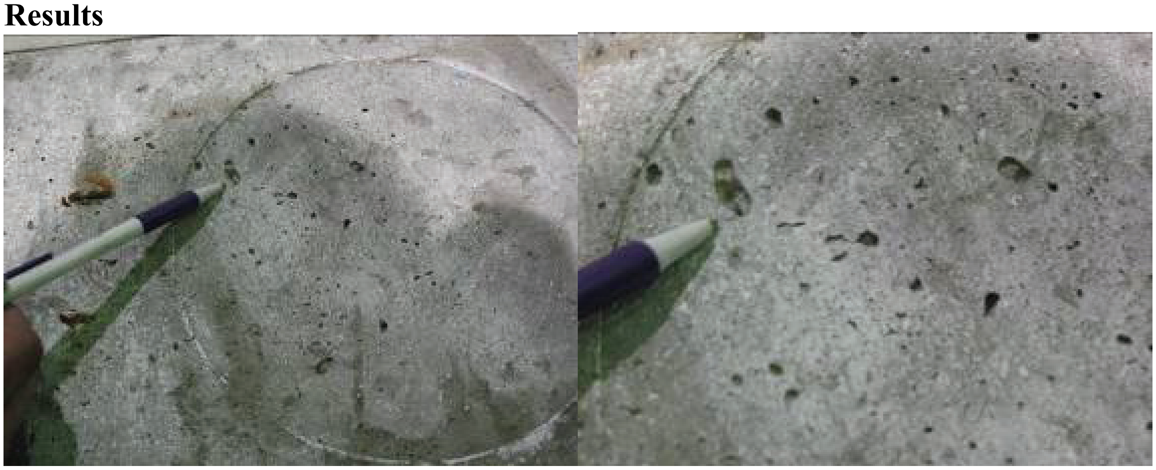
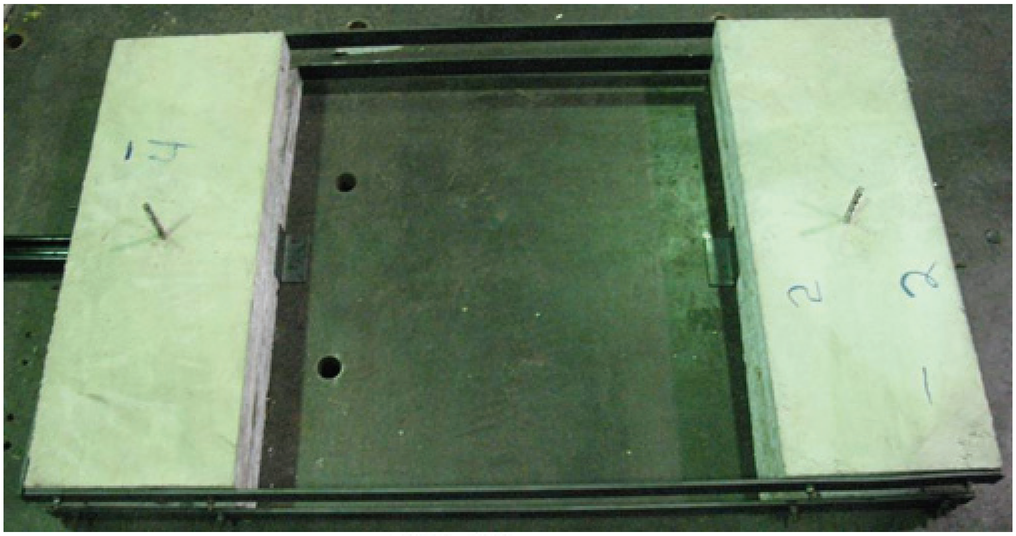


Figure 10: Air Pockets within the Plate of the Concrete Isolator



a.) Top View

b.) View of rubber balls

Figure 11: Final Product of Concrete

Figure 12: Concrete Isolator in maximum Displacement

Within table 1 shows the various compression of different types of balls that were used in the concrete isolator.

Table 1: Various Compressions of Different Balls due to maximum loading

Material	Hardness	Compressed (in)
Neoprene Rubber	**55A**	**1 1/8**
Neoprene Rubber	**70A**	**5/8**
Polyurethane	**95A**	**1/4**

Discussion

Figure 10 shows the inner surface of the concave plates within one of the concrete specimen. This specimen has many air pockets at the surface of the concave plate. During the pour of the concrete if there was not enough vibration to the mold then the air pockets formed. As a result several of these air pockets were filled in with an epoxy mix with a 4,000 psi tensile strength. The reason for the filling of these holes is that as the isolator was in action the ball become caught onto these holes. Therefore the rubber ball could deteriorate and not perform properly. This concrete specimen was not selected as the final four for the isolator.

Figure 11 shows the completed concrete isolator. Steel bars connected the two concrete boxes with the concave plates. In figure 11 a it is visible that the anchor bolts would be used to attach the maximum load on top of the plate. The maximum load on the isolator was 1400lbs. While within 11 b it the rubber balls are shown within the concave plate. Figure 12 shows the isolator in action when there is a force pushing the top plate of the isolator.

There were two different types of materials that were used for the balls. One was using neoprene rubber which had two different hardness on the durometer scale. While polyurethane was used later in the project due to its properties. The desired result is to have the balls compress only a small amount compared to the diameter of the balls. The polyurethane only compressed 12.5% compared to its diameter under maximum loading. Compared to the neoprene balls as shown in table 1 the polyurethane compressed the least. Therefore this ball was chosen for its properties.

Conclusion

Due to time constraints of the summer NSF research there was no information on the testing on the concrete specimen within the lab. The tests that are going to be conducted are free vibration test, hysteretic test, and a frequency sweet test. However there are several suggestions in the creation of the concrete specimens.

- Increase the concrete cover when designing the rebar.
- Account for the inaccuracies within the foam when placing the rebar into the mold.
- Importance of using a different type of vibration system for the pouring of the concrete.
- A better way to cure the concrete in total hydration.
- The use of different ball bearings within the isolator itself for different dampening ratios.

References

ASTM C 31, C 39. Annual Book of ASTM Standards, Volume 04.02, ASTM, West Conshohocken, PA, Website http://www.astm.org

Portland Cement Association. (2007). Concrete Basics. Retrieved from July 27, 2007, from Portland Cement Association. Web Site: http://www.cement.org/basics/concretebasics_concretebasics.asp.