

University of Houston GK12 Program: Earthquake and Structural Engineering and the Science Behind Harry Potter



R. Howser, S. Khatri, H. Dhonde Y.L. Mo
and the University of Houston GK12 Team



Abstract

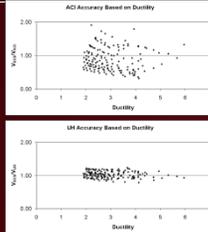
There is a critical need for improving infrastructure materials in regions of high seismic activity. In these regions, increased concrete confinement is required in traditionally reinforced concrete (RC) columns resulting in closely spaced hoops. These hoops produce highly congested, difficult to construct columns. The use of self-consolidating fiber-reinforced concrete (SCFRC) in columns in these regions permits the elimination of hoops, allowing greatly improved constructability. Steel fiber-reinforced concrete (SFRC) is a composite material consisting of traditional concrete and a dispersion of randomly oriented steel fibers. Research has shown that introducing steel fibers can improve many properties of traditional RC including shear resistance, ductility and crack control. However, steel fibers in concrete cause the mixture to stiffen causing difficulty while placing it in complex formworks. A solution is to use self-consolidating concrete (SCC) designed to self-consolidate and flow under its own weight. Mixing steel fibers into SCC creates SCFRC. In this project, the GK12 fellow is comparing the behavior of flexural- and shear-critical RC and SCFRC columns. The columns will be tested by applying an axial load and then applying a cyclic lateral load at the top of the column until failure. While participating in the GK12 program, the fellow has published one journal paper, one conference paper, one conference presentation, and three poster presentations.

The fellow has introduced structural and earthquake engineering research in addition to incorporating the University of Houston (UH) GK12 theme of *The Science Behind Harry Potter*. Some examples include: (i.) While studying plate earthquakes, the students were shown pictures of earthquake induced building collapses. The students learned how earthquake engineers design buildings to withstand earthquakes and were able to correctly identify where structural elements of buildings should be placed for maximum earthquake damage prevention. (ii.) While studying geology, the students learned about the unique characteristics of pumice. The students were shown how structural engineers in ancient Rome drew inspiration from pumice to create the lightweight concrete used to construct the Pantheon. The students learned how civil engineering students use the same concepts today to build concrete canoes for the American Society of Civil Engineers (ASCE) concrete canoe competition. (iii.) As part of a unit on the scientific method, the students learned how engineers use the scientific method every day. This was coupled with learning how to design a bridge. The collapse of the Millennium Bridge in Harry Potter was also studied.

Research Activities Completed While Participating in GK12

Ductility and Shear Capacity in RC Columns

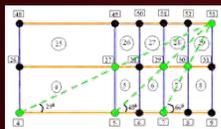
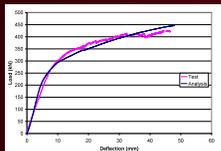
- Modeled more than 100 columns using finite element analysis
- Studied relationship between ductility and shear capacity in reinforced concrete columns and proposed a model to predict the shear capacity
- Resulted in the publishing of one journal paper



Modeling of PC Bridge Girders



- Previously tested five prestressed concrete bridge girders
- Observed a 45° failure plane when an approximately 30° failure plane was expected according to current codes
- Created finite element program "Simulation of Concrete Structures" (SCS) to predict structural behavior
- Confirmed accuracy of SCS
- Used SCS to validate observed 45° failure plane
- Resulted in two conference presentations and a conference paper



Failure Plane	Failure Planes		
	29-Degree	48-Degree	66-Degree
Failure Plane	2.36	1	1.24

Cyclic Testing of Self-Consolidating Steel Fiber Reinforced Concrete Columns



- Noted that traditional concrete reinforcement in seismic areas results in closely spaced hoops
- Determined that self-consolidating steel-fiber reinforced concrete could be an answer

- Studied steel fiber reinforced concrete beams with no transverse reinforcement tested at UH
- Mixed approximately 40 concrete mixes to determine optimal mix design
- Cast columns
- Column testing will begin this month



GK12 Classroom Activities

Structural and Earthquake Engineering

- While studying plate tectonics and earthquakes, the students were shown pictures of earthquake induced building collapses. The students learned how earthquake engineers design buildings to withstand earthquakes and were able to correctly identify where structural elements of buildings should be placed for maximum earthquake damage prevention.



- During their scientific method unit, students used the scientific method to design and build paper bridges. The students tested and improved their bridges to reinforce their skills.

- While studying geology, the students learned about the unique characteristics of pumice. The students were shown how structural engineers in ancient Rome drew inspiration from pumice to create the lightweight concrete used to construct the Pantheon. The students learned how civil engineering students use the same concepts today to build concrete canoes for the American Society of Civil Engineers concrete canoe competition.



The Science Behind Harry Potter



- As part of the scientific method unit, the students learned how engineers use the scientific method everyday. This was coupled with learning about how to design a bridge. The collapse of the Millennium Bridge in *Harry Potter and the Half-Blood Prince* was studied.

- As the students were studying acids and bases, the students were shown a clip from *Harry Potter* showing the marauder's map, a map that exhibits disappearing and reappearing ink. The students created their own ink through the use of acids, bases and indicators.
- The Latin roots present in the magical spells spoken in *Harry Potter* were identified. These same roots were recognized in biology and chemistry vocabulary words.



- While studying owls, the students were given a picture of the owl character in *Harry Potter*. The students were asked to identify what type of owl she is, her gender, why she has spots, etc.

Acknowledgements/Sponsors

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