

# **The Tremorlator - Responsibilities of Civil Engineering Technologists to Society**

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## **ABSTRACT**

This paper describes how some technical aspects of structural engineering can be redesigned, modified and transferred for operation by civil engineering students for emergency preparedness training by the community. The Singapore Civil Defence Force (SCDF) officers and SP faculty members from the Civil Engineering Division of its School of Architecture & the Built Environment (ABE) collaborated and conceived the Mobile Tremorlator. The Tremorlator is a room fitted with home appliances and is mounted on an Earthquake Simulator to simulate earthquake ground motion accelerations. This simulator is in turn mounted on a truck to bring the Tremorlator to the community. The Tremorlator has been deployed on weekends at various grass-root communities to help them learn emergency preparedness and other civil defence skills.

## **KEYWORDS**

Technologists, societal context, civil defence, tremorlator.

## **INTRODUCTION**

Graduates in civil engineering have made contributions to the quality of life for communities by providing efficient transportation system, safe homes, proper sanitation and clean water utilities. These civil engineering infrastructures are taken for granted until natural disasters disrupt them. Earthquakes and earthquake-induced secondary disasters can cause great distress to the affected communities. In such situations, civil defence teams will have to come in to rescue people who are trapped in collapsed buildings. Civil engineers will eventually be involved in restoring the damaged public buildings and infrastructure. However before such disasters occur, the community needs to be prepared for emergencies. This is where civil engineers and technologists can chip in to help the civil defence equip the community with basic skills to respond to possible disastrous events.

The four phases of the product or system cycle are Concept, Design, Implement, and Operate (CDIO) [1]. Civil engineering infrastructures are conceived, designed, built and maintained so as to meet the design specifications and occupiers requirements. In earthquake prone areas engineers have to consider seismic loads from earthquakes. These phases of work flow are primary responsibilities of civil engineers and civil engineering technologists.

## **TREMORS IN SINGAPORE**

Geologically, Singapore is located on the stable Indo-Chinese Plate. Some 600 kilometres to the southwest of Singapore is the active Alpide Belt along the Indo-Australian tectonic plate [2]. The so-called "Pacific Ring of Fire" and the "Alpide Belt" are the first and second most active seismic regions in the world respectively. The earthquake that triggered the December 2004 tsunami in Aceh was due to movements in the Alpide Belt. Earthquakes that

hit parts of west of Sumatra can send weak tremors to certain parts of Singapore. Some people living on the higher floors of tall buildings in these areas can feel these tremors. The Meteorological Services Division (MSD) has set up a network of seismic sensors around the island to monitor the effects of these earthquakes. The data can be accessed by engineers to help them evaluate the tremor effects on civil infrastructures. The network of stations automatically and continuously monitor seismic activities around that area [3]. Historically, Singapore is not known to have experienced any earthquakes. However it remains relevant to civil engineering students in Singapore Polytechnic to appreciate the effects of earthquakes on structures that are built in regions which have earthquakes. Although structural dynamics is outside of the scope of the technologists' structural design modules, the experience of building a structural model to withstand simulated seismic loads have given them deeper and experiential knowledge of structural fundamentals. The design, implementation and testing of their models on the earthquake shaking table is one of the students capstone projects.

### **SINGAPORE CIVIL DEFENCE FORCE AND ITS PUBLIC EDUCATION EFFORTS ON TREMOR ADVISORY**

Tremors in Singapore in recent years have occurred on 26 Dec 2004, 29 Mar 2005, 18 Dec 2006, 12, 13, 14 and 20 Sept 2007, 4 Jan 2008, 20 Feb 2008 and 24 Feb 2008. These tremors are due to earthquakes in neighbouring countries, measuring 6 to 8 magnitude on the Richter Scale [4].

The Singapore Civil Defence Force (SCDF) is a uniformed organisation under the purview of the Ministry of Home Affairs. In addition to providing fire fighting, rescue and emergency ambulance services, SCDF formulate, implement and enforce regulations on fire safety and emergency preparedness matters [5]. SCDF as the lead agency for emergency services has also adopted an active approach at developing capacities in communities to cope with disasters such as tremors. To invoke greater community ownership and self-help when dealing with crisis, SCDF has introduced a wide range of community involvement programmes such as Community Emergency Preparedness Programme (CEPP) and Emergency Preparedness (EP) Day. These activities are initiated to introduce systematic yet convenient platforms for public to pick up knowledge and skills to prepare for emergencies [6].

To prepare the community to respond to unknown fears caused by tremors, SCDF has come up with the Tremor Emergency Plan (TEP). The Tremor Emergency Plan (TEP) was activated in November 2007 and a PDF version of the TEP has been made available on the SCDF internet website. Additional public education materials on Tremor Advisory are distributed to educate the public on the procedures to adopt when a tremor occurs at their premises. However, it is imperative that SCDF should also focus on an experiential learning approach through the involvement of residents as active participants rather than passive audiences. Therefore, SCDF collaborated with the Singapore Polytechnic to design a simulated setting which will facilitate a realistic training environment whereby participants will be adequately trained in the precautionary measures to adopt in the aftermath of an earthquake when a tremor is felt.

### **RESPONSIBILITIES OF CIVIL ENGINEERING TECHNOLOGISTS**

Civil engineering technologists in Singapore support civil engineers, operation managers and government agencies in a wide array of duties. Under each of the four phases of product life-cycle, the technologists are responsible for accurate collection of field data necessary for

preliminary and detailed design by engineers. Diligent data collection, processing and translation of engineering design into detailed working drawings constitute some of their professional responsibilities. As ground personnel in the day-to-day implementation and operation of the infrastructure system, they have the duty of care to ensure that the infrastructure system is successfully implemented. The system has to be structurally sound and safe for the occupiers and users. The students learn content of structural engineering in the polytechnic. Besides technical knowledge, they need to be aware of how the system fits in the external and societal context. Students need to engage with the community so as to prepare to themselves to work in the real world. The civil engineering faculty members scanned the environment to look for an external context that is also sustainable for the students' civil engineering education.

## FROM AN EARTHQUAKE SHAKING TABLE TO A MOBILE TREMORLATOR

Civil engineering students studying structural engineering have been making models that are resistant to vibration loads. The making of models is a capstone project for their module "Structural Steel Design and CAD." The project-based approach gives them the opportunity to work as a team and benefit from the experiential learning [7]. However this still lacks the external and societal context which will help the students see the direct impact of the application of engineering knowledge on the community.



Figure 1. Students in their capstone projects



Figure 2. Models ready for testing

The civil engineering faculty contacted the Singapore Civil Defence Force (SCDF) and learned that SCDF was looking for a system that can give the community hands-on experience in emergency preparedness when there is a tremor. This mutual need led to collaboration between SCDF and SP.

As pace setters, SCDF officers and SP's civil engineering faculty embarked on the CDIO phases of the product cycle. The Concept: A room that can respond under simulated earthquake tremors and be mobilized to different constituencies in Singapore. SCDF has the truck and SP has the shaking table. The Design: Meet SCDF's specifications for tremors and for emergency preparedness training. The Implementation: Detailed design and drawings, and fabrication in the workshop at SP. The Operation: SCDF plans the contacts with the community in their emergency preparedness routines, and mobilizes the mobile Tremorlator accordingly. SP staff and civil engineering students operate the tremorlator when members of the public enter the room in the tremorlator. This gives the external and societal context for the community involvement by civil engineering students that is both relevant to their learning and sustainable.

## OPERATION OF THE MOBILE TREMORLATOR IN THE SOCIETAL CONTEXT

The “Mobile Tremorlator” is deployed at Emergency Preparedness (EP) Days and other community outreach programmes organized by SCDF. About ten civil engineering students are rostered to operate the Tremorlator on some weekends. The participation in the community outreach programmes to educate the public regarding earthquake tremors will certainly benefit civil engineering students. By participating actively in these outreach programmes, these students have gained invaluable knowledge and skills on emergency preparedness. Hence, they serve as a useful change agent by leading others in tremor procedures and imparting useful emergency preparedness knowledge and skills to their school community.

In addition, they will be able to appreciate why sound structural engineering design and construction, and regular structural appraisals of buildings are important. As the tremorlator is deployed regularly in the community by SCDF, most civil engineering students will have the opportunity to educate the public on how to prepare for tremors. This would give all of them the opportunity to meet people outside the campus and develop other personal, professional skills and attributes that are difficult to impart within the campus environment. Since the Mobile Tremorlator can simulate earthquake tremors that originate from neighbouring countries, the experience in the Tremorlator room is realistic.



Figure 3 The Mobile Tremorlator

## MUTUAL BENEFITS OF OPERATING THE TREMORLATOR

A few anecdotes and speeches will illustrate this.

On Saturday, 6 September 2008, SCDF officially launched the 6th edition of the CD Emergency Handbook. The launch took place at Chong Pang Community Club at 11:00am. Mr K Shanmugam, Minister for Law and 2nd Minister for Home Affairs officiated the event. A highlight of the event was the SCDF's latest Public Education simulator known as the “Mobile Tremorlator” [8]. The Tremorlator simulates tremors within a residential setting.

Here is part of a speech by Mr Shanmugam:

*“For example, even though Singapore is far away from earthquake zones, we do experience tremors occasionally. So the SCDF, together with Singapore Polytechnic developed a “Mobile Tremorlator” to simulate earthquake tremors. This innovative project involves simulating tremors in a home setting complete with dining table, chairs, stoves and fittings such as hanging lamps and cupboards. The “Mobile Tremorlator” is a useful tool as it*

*replicates the experience of tremors. It allows residents to learn the correct measures to adopt when a tremor is felt. We will launch this innovative creation today. I am also pleased to note that students from the Civil Engineering and Management course of the Singapore Polytechnic will also partner SCDF as "Singapore Polytechnic-Civil Defence or SP-CD Ambassadors" to help educate residents in the tremor response procedure. I commend this partnership between the two organisations as it not only helps to raise the EP awareness of the community, it also helps us to anchor our Community Engagement Programme" [9].*

The Principal of Singapore Polytechnic, Mr Tan Hang Cheong, explained the origins of the Tremorlator:

*"We've always been working very closely with the Singapore Civil Defence Force. And I think through all our interactions we then conceived this idea, that perhaps it's need now for us to educate Singaporeans about all the tremors that we've been feeling so frequently nowadays. To get them to feel that at this particular level of the Richter Scale, what is it like at home and what you should do should a tremor like that occur" [10].*

For a start civil engineering students from SP are partnering with SCDF as ambassadors to conduct demonstrations and help the public respond to tremors. Gary Wong, a year one civil engineering student has gone through several rounds of public education. He said, "The buildings in Singapore are built to withstand quite strong tremors. And by running out while the building is still moving, you have a higher chance of injuring yourself in that process, as opposed to hiding under a table and waiting till the tremors stop."



Figure 4 The Prime Minister and Grassroot Organisation Leaders At the Tremorlator

Figure 4 shows the Prime Minister and grassroots organisation leaders being briefed by SCDF officers. The mobile tremorlator was moved by SCDF to Ang Mo Kio Avenue 3 as part of the Teck Ghee Constituency's Emergency Preparedness Day on 18 October 2008. Scott Wong, a year 3 civil engineering student, prepares to give a demonstration on how to respond in a room when tremors occur. Residents were able to experience hands-on how to respond before and after the tremors hit the room.

## CONCLUSION

Singapore Polytechnic is one of the early partners in the adoption of the CDIO approach in engineering education. The collaboration by its School of Architecture & the Built Environment with the SCDF to jointly develop the Mobile Tremorlator using the Conceive-Design-Implement-Operate approach benefits both the civil engineering students and the community at large through the community events organised by the SCDF. Students are able to learn actively, experientially and at the same time make direct contribution to the welfare and education of the community. A students' club has been formed to include students from other courses to partner SCDF as "Singapore Polytechnic-Civil Defence or SP-CD Ambassadors." This new initiative has helped other polytechnic students to connect meaningfully with the community. The mobile tremorlator has become an important vehicle to prepare civil engineering technologists connect their peers to SCDF, a strategic partner and exercise responsibilities to the society.

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