

# Evacuation of institutional buildings during a disaster in developing countries: From planning to implementation phase

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**ABSTRACT:** Disasters (e.g. earthquakes or fire) cannot be avoided in life time of buildings. These can lead to human loss if preparedness is not planned. Developed countries have procedures and policies about how to prepare themselves before any unwanted event, how to respond during the event and how to recover after the event. These measures are good guidelines for developing countries. But these strategies cannot be easily implemented because of the prevailing situations i.e. resources and literacy rate are different. The overall goal of the social research program is to bring the awareness level of all stakeholders (i.e. ‘policy makers’, ‘rescue organizations’ and the most important ‘public’) of developing countries up to the international standards so as to have full preparedness. The specific goal of this work is to analyse the effect of health and safety trainings on students i.e. how to respond during a disaster? The whole exercise is conducted in Capital University of Science and Technology, Islamabad, Pakistan. The task is divided into five phases: modifications in existing infrastructure, training of staff, educating the engineering students only, monitored drill and student feedback. It may be noted that non-engineering students are not trained. Two months after the training, a mock monitored drill is conducted through CCTV cameras to check the behaviour of trained students. Based on limited feedback, a marginal difference between the behaviours of trained and non-trained students is observed. The analysis of student feedback is also presented. At the end, recommendations are made in order to further improve the preparedness.

## 1 INTRODUCTION

Buildings can suffer due to disasters (e.g. earthquakes or fire) during its life time. This can result in human loss if proper measures are not taken timely. Advanced nations have defined rules and strategies about how to prepare themselves before any annoying occasion, how to react during the occasion and how to recuperate after the occasion. These procedures are virtuous guidelines for developing nations. But these approaches cannot be easily executed because of the predominant circumstances i.e. capitals and literacy rate are different. Abulnour (2014) investigated the ways to make the disaster management more efficient in Egypt. There are three factors, i.e. scope, time and cost, which usually device the program of disaster management. The concept of disaster management mainly consists of three phases i.e. pre-disaster, warning and post-disaster phases. The typological classifications of disasters are natural and man-made. Natural disasters include earthquakes, wild fire, landslides, droughts, floods, storms, cyclones, desertification, environmental degradation, and volcanic eruptions. Man-made disasters include armed conflict, civil strife, technological disasters, human settlement disasters, and severe accidents. The effective execution of both disaster risk reduction and disaster risk management systems is dependent on thorough institutional capacities by key performers at various levels of government, the private sector and civil society as well as effective coordination between these performers and levels (Bass et al. 2008). Caymaz et al. (2013) proposed an effective disaster management model at the tactical level in order to manage with the all categories of disasters in Turkey. There should be a single principal establishment, which is directly associated with the Prime Ministry and manages all types of disaster preparedness, rescue and relief efforts if the affected area is widespread. This is so because it is significant to make quick decisions in times of crisis, it must be designed and authorized as an independent structure similar to development agencies. Koo et al. (2013) conducted a comparative study of evacuation strategies for people with disabilities in high-rise building evacuation. It was concluded that evacuation tactics that permits populations with wheelchairs to use elevators are efficient. Koo et al. (2014) estimated the effects of

psychological confusion and physical exhaustion in a semi panic situations during evacuation. It was reported that the psychological confusion due to unexpected sentiment escalation from the acknowledgment of unforeseen dangers increases the average evacuation periods up to 25% depending on the complication of evacuation directions of the buildings. The accumulated physical exhaustion of people during the evacuation progression could also significantly delay the evacuation time. Cronstedt (2002) reported PPRR (Prevention, Preparedness, Response and Recovery) approach as a too constraining perception in modern emergency management. This is due to change and developments in risk management standards and not showing beneficial to emergency managers. Niu et al. (2015) suggested to consider the influence of safety signs and information sharing on the behaviour of pedestrians for evacuation planning. Noh et al. (2016) presented a new strategy for evacuation of a high-rise building. According to them, separate pathways should be provided for disabled peoples. The main factor in this plan is determining the precise percentage of persons without disabilities at each floor to each route. It was concluded that the anticipated evacuation plan can decrease the average evacuation time of the entire residents by ten percent. Pearce (2003) studied the Australian and American research findings of disaster management planning and recommended to shift its focus from response and recovery to sustainable hazard mitigation because of necessity to integrate disaster management and community planning. It was concluded that if mitigative plans are to be effectively executed, then the disaster management process must incorporate public participation at the local decision making level. Rahman (2012) determined factors of disaster management preparedness involving many departments in Kedah, Malaysia. These factors included the level of understanding (knowledge) and practice of Directive No. 20 (the Policy and Mechanism related to the national disaster management and relief activities). The core aim of the directive was to make methodical synchronization among departments involved in disaster management as well as relief and rehabilitation activities. A total of 15 departments covering nine districts in which 120 respondents were selected based on proportionate stratified sampling. It was concluded that both the independent variables (knowledge and practice) explained 86% of the variance in disaster preparedness. All departments at district level in Kedah had good knowledge of the Directive 20 and also had good practice of it.

The main aim of the societal research program is to bring the responsiveness level of all participants (i.e. ‘policy makers’, ‘rescue departments’ and the utmost significant ‘public’) of developing nations up to the worldwide standards so as to have complete awareness. The precise purpose of this study is to analyse the consequence of health and safety trainings on students i.e. how to react during a disaster? The entire execution is done in Capital University of Science and Technology, Islamabad, Pakistan. The task is divided into five stages: modifications in existing infrastructure, training of staff, educating the engineering students only, monitored drill and student feedback.

## **2 ADOPTED PROCEDURE**

Health and safety of students, faculty and staff is an important aspect and is given the prime priority by the university. Certain steps (described in coming sub-sections) need to be ensured for which information of university infrastructure and its people are important. University consists of ten blocks (A to J), one generator room and two canteens. Only one block, generator room and two canteens consist of ground floor (G) only. Out of eight blocks, five blocks consist of four stories (G+3), two blocks consist of three stories (G+2) and two blocks consist of two stories (G+1). This makes a total of 34 floors which need to be evacuated in a systematic manner considering the nature of the disaster. University has total student strength of 3713 and employees (faculty and staff) of 301. During peak hours (i.e. 8 am to 4 pm), around 2500-3000 students, faculty and staff are present in the university campus.

### **2.1 Modifications in Existing Infrastructure**

#### **2.1.1 Building Evacuation Planning and Identification of Assembly Areas**

In emergency situations, people have to be moved from dangerous place to safer places in a hurry (Saadatseresht et al. 2009). Figure 1 shows the layout of all buildings within the university campus and designated assembly areas. As it can be seen in left picture of Figure 1, the buildings can be separated in three clusters: 1. Four blocks A to D and one canteen, 2. six blocks E to J and generator room, and 3. One canteen and parking area. It may be noted, from right picture of Figure 1, that the

assembly area – 1 is in the play-ground and the assembly area – 2 is in the two green areas keeping the passage clear to access the four blocks A to D for rescuing injured people. Figure 2 shows the overall evacuation plan of a typical floor designated for classrooms. Such kind of evacuation plans are pasted in all rooms and corridors, particularly the indicating only the current position and the direction to follow.

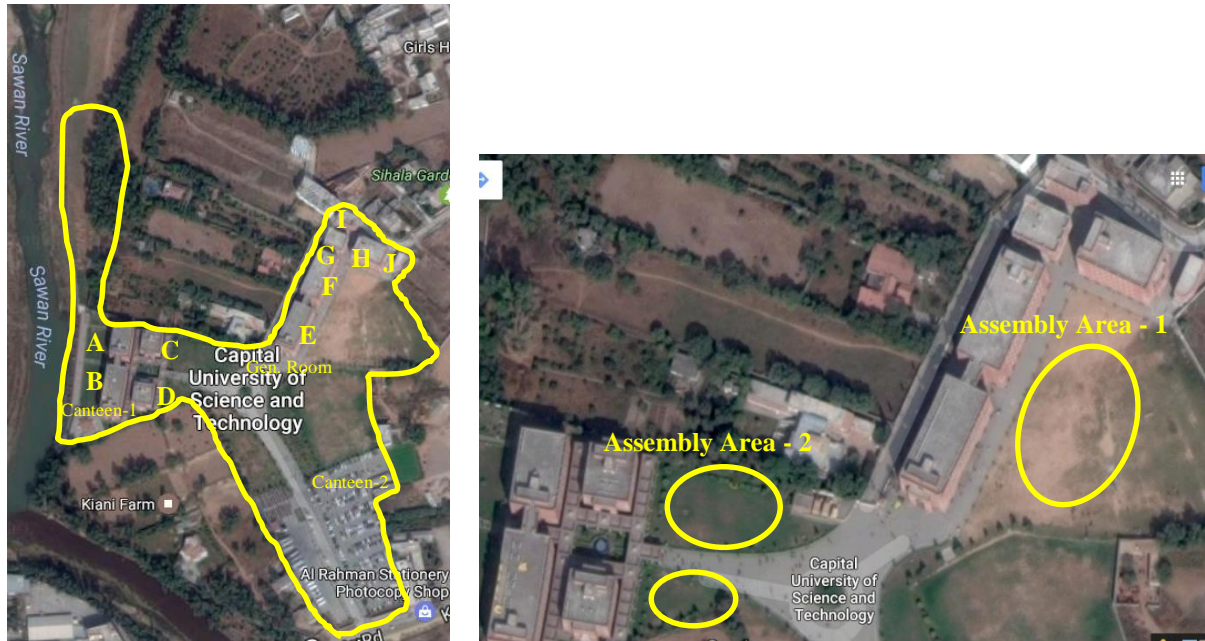


Figure 1: University campus (left picture) and assembly areas (circles in right picture)

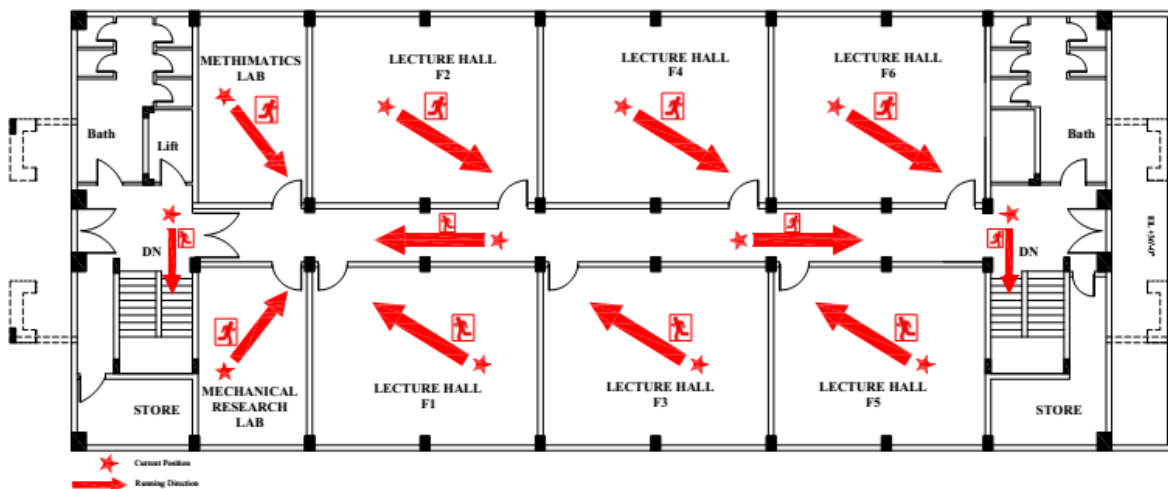


Figure 2: Evacuation plan of a building floor having classrooms

### 2.1.2 Testing of bells and alarms

The nature of the disaster is different, so evacuation should be done accordingly. One thing is common, i.e. to alert the occupants of the buildings. This can be done with the help of emergency bells and alarms. For this purpose, all blocks of the university are equipped accordingly. But it may be noted that the alarm system is not centralized. For testing of bells and alarms, following procedure was adopted:

- 1- An email was sent to all employees of the university about the testing of bells and alarms on the specified date and time so that faculty and students can observe the intensities and tone of bells and alarms. They were also requested to evacuate the building if they would hear these bells and alarms in future.

- 2- All bells and alarms of the university buildings were on for 15 minutes to check their status, intensities and tone. This also helped to identify the faulty bells and alarms.

## 2.2 Training of Staff

Disasters include fire accidents, earthquake, flood or any terrorist activity. For this, evacuation of the buildings needs to be done as per their respective demands. Social behaviour for building occupants is also necessary (Sagun et al. 2011). Selfish and selfless behaviours are two main factors that should be considered in evacuation (Song et al. 2016). Accordingly, floor volunteers (i.e. faculty, lab engineers, attendants and guards) were trained for the effective response during any disaster.

## 2.3 Training of Engineering Students

Health and safety trainings of engineering students were conducted at the start of each semester in two directions: (1) Safety measures during the lab work (for every lab course), and (2) Safety measures during any disaster. Health and safety coordinators visited the lab classes regularly to monitor the health and safety measures and discipline.

## 2.4 Drill Execution

For the drill, students and faculty were not informed at the time of ringing bells and alarms. Only few employs (10-15) knew about the drill who were monitoring it. A total of 47 theory classes and 04 lab classes were in progress. Bells and alarms were on at around 10:25 am.

## 2.5 Student Feedback

Two weeks after the drill, a feedback was collected from 437 engineering and 169 non-engineering students. It may be noted that it was a difficult task to take feedback from all students especially in last teaching week. The sample of non-engineering students is relatively small compared to that of engineering students. The feedback performa is given in Figure 3.

A. Please provide the following information:			
<i>Your Department</i>	<i>Your Semester</i>	<i>Your Auditorium at Time of Safety Drill</i>	
B. Please answer the following (Please tick any one “Yes” or “No”):			
Sr. No.	Question	Answer	
		Yes	No
1	Were you given safety training “how to behave during any natural disaster”?		
2	Had you observed discipline during the safety drill?		
3	Was your response quick in evacuating the building?		
4	Had you observed CUST ambulance rescuing the injured?		
5	Had you attended the next class at 11 a.m. after safety drill?		
6	Were the volunteers guiding during the safety drill?		
7	Was the conduct of safety drill a good step?		
8	Had you seen the fire brigade during the safety drill?		
9	Will you behave in a discipline manner during real earthquake in future?		
10	Do you recommend conducting safety awareness trainings/seminars?		
C. Any suggestion.			

Figure 3: Student Feedback Performa

## 3 RESULTS AND ANALYSIS

### 3.1 Response of students

The response of students and faculty was observed through CCTV cameras and live observations. The evacuation of the building (auditorium F1 in Block-F) and return to building are shown in Figure 4. This can be regarded as a good example of response. The photographs of three cameras are shown,

one in class room, one in the corridor and one for the assembly area – 1. Around 10:24 am, all classes were in progress. After the ringing of the bells, students and faculty reacted and started evacuating. Around two minutes after the ringing of bells, auditorium F1 was empty and some of the students started gathering in assembly area – 1. But still, only few students were in the corridor. It may be noted that the auditorium F1 is on the fourth floor in Block F. Most of the classes were evacuated by the teachers. Some were informed by the floor volunteers in order to evacuate buildings. But still, there were few classes in which students gathered around teacher (Figure 5). Around 7 minutes after the ringing of bells, block F was evacuated and all students, staff and faculty was gathered in assembly area – 1.

Ten minutes after all blocks were evacuated, students and faculty were directed to go back and resume classes. The overall response of engineering students was better than non-engineering students. Generally, floor volunteers reacted in an effective manner for evacuating the building; controlling crowd towards assembly areas and sending them back to classrooms. All buildings were evacuated in 6-8 minutes. It may be noted that the response time was 1-2 minutes and the exit time was 5-6 minutes. After the evacuation of building, rescue team approached block B twice and block H once for rescuing any mocked injured in CUST.

Time	Class room	Corridor	Assembly Area – 1
10:24 AM	 12-30-2016 Fri 10:24:32 F 1 Camera 01	 12-30-2016 Fri 10:24:09 F-Block 3rd Floor Front Side	
10:25 AM	 12-30-2016 Fri 10:25:22 F 1 Camera 01	 12-30-2016 Fri 10:25:14 F-Block 3rd Floor Front Side	
10:26 AM	 12-30-2016 Fri 10:26:00 F 1 Camera 01	 12-30-2016 Fri 10:26:16 F-Block 3rd Floor Front Side	
10:42 AM	 12-30-2016 Fri 10:42:22 F 1 Camera 01	 12-30-2016 Fri 10:42:49 F-Block 3rd Floor Front Side	
10:50 AM	 12-30-2016 Fri 10:50:15 F 1 Camera 01	 12-30-2016 Fri 10:50:27 F-Block 3rd Floor Front Side	

Figure 4: Response of students, staff and faculty (a good example)





Figure 5: Response of students, staff and faculty (a bad example): CCTV footage from classroom at 10:26 am

### 3.2 Analysis of student feedback

The year-wise, overall and combined analysis of feedback taken from trained and un-trained students is given in Figure 6. According to the feedback from students, following is noted:

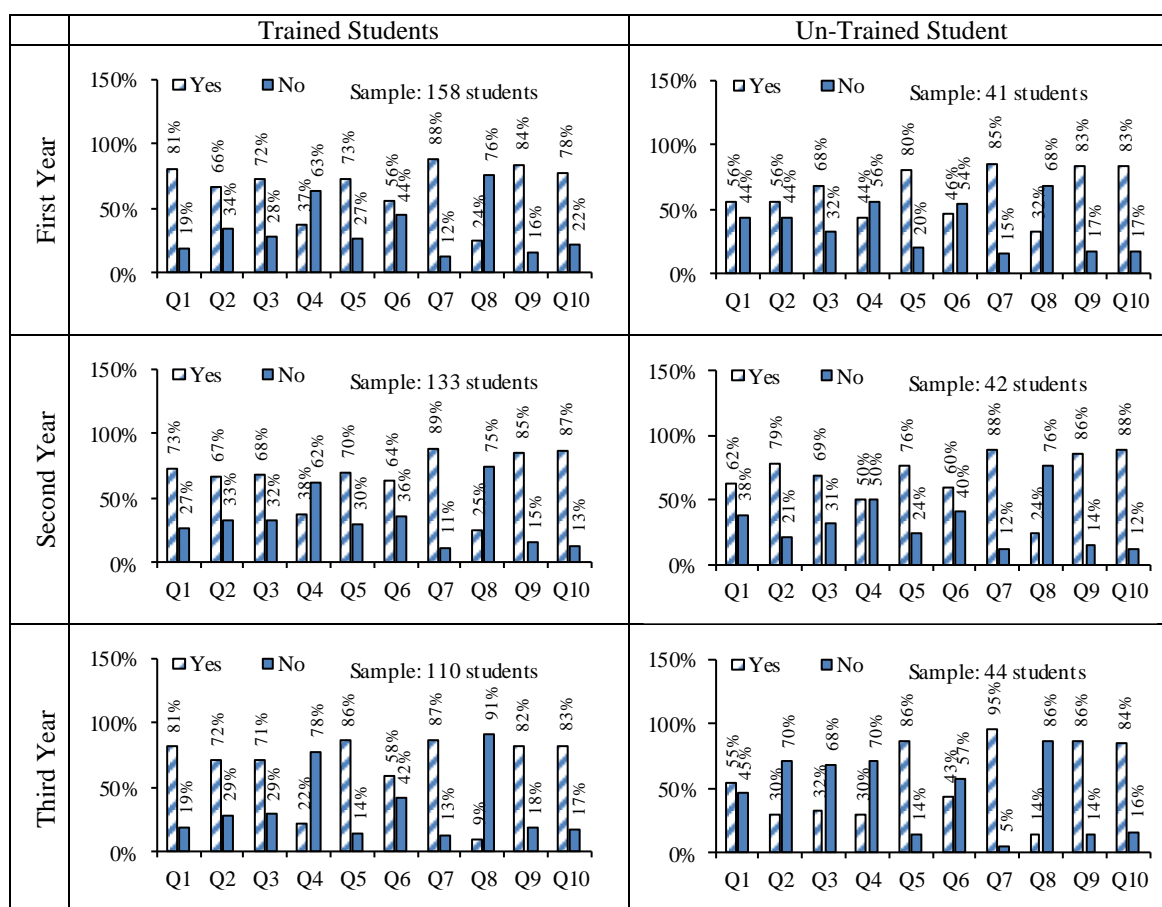
- 1) Majority of engineering students remembered their training, but there were students who claimed that they were not given training. It may be noted that no engineering student was allowed to attend the lab course without the health and safety training. Health and safety training also guides a student that how to behave in such situations i.e. earthquake, flood, etc. This shows that there is a need to emphasize more on such awareness during health and safety trainings. On the other hand, a good number of non-engineering students also showed that they got training for such situations. As a whole, 72% of engineering students and 56% of non-engineering students accepted that they attended safety trainings. On combined basis, 68% answered “Yes” for training about how to behave?
- 2) A mix reply is given regarding discipline by both engineering and non-engineering students. However, a good discipline was observed through CCTV cameras and live observation from the top of Block E. As a whole, 61% of engineering students and 52% of non-engineering students observed discipline. On combined basis, 59% answered “Yes” for observing discipline.
- 3) Majority of students showed quick response. This was also observed through CCTV cameras and live observations by the coordinators. All buildings were evacuated and gathered in assembly areas in just 6-8 minutes. As a whole, 73% of engineering students and 57% of non-engineering students showed quick response. On combined basis, 69% answered “Yes” for showing quick response.
- 4) Majority of the students standing in assembly areas did not observe CUST ambulance. It may be noted that CUST ambulance reached Block B three times and reached Block F only once. Therefore, CUST ambulances should be increased in numbers so that more students can be rescued. As a whole, 42% of engineering students and 41% of non-engineering students saw CUST ambulance. On combined basis, 42% answered “Yes” for seeing CUST ambulance.
- 5) Majority of the students took their classes after the drill. As a whole, 74% of engineering students and 78% of non-engineering students took their classes. On combined basis, 75% answered “Yes” for taking classes after the drill.
- 6) Students answered that volunteers were guiding them. As a whole, 56% of engineering students and 49% of non-engineering students got guidance from volunteers. On combined basis, 54% answered “Yes” for receiving guidance from volunteers.
- 7) Majority of the students replied that the conduct of such drill was a good step. As a whole, 87% of engineering students and 89% of non-engineering students marked drill as a good step. On combined basis, 88% answered “Yes” for saying drill a good step.

- 8) Majority of the student's response on the presence of fire brigade vehicle was realistic. However, there is a need to emphasize on increasing the observational behaviour during such events. As a whole, 84% of engineering students and 79% of non-engineering students did not see fire brigade vehicle as it was not called. On combined basis, 82% answered "No" for seeing fire brigade vehicle.
- 9) Majority of the students replied that they would behave in a disciplined manner in future during any disaster. As a whole, 83% of engineering students and 80% of non-engineering students claimed for disciplined behaviour in future. On combined basis, 82% answered "Yes" for showing disciplined behaviour in future.
- 10) Majority of the students recommended safety awareness trainings to be conducted in future. As a whole, 84% of engineering students and 86% of non-engineering students recommended awareness trainings in future. On combined basis, 84% answered "Yes" for conducting awareness trainings.

### 3.3 Observed Flaws

Overall it was a good exercise. But following flaws were observed:

- I. Intensity and tone of the bells and alarms were not so good in terms of siren, tone and loudness. The alarm system is not centralized.
- II. Training of non-engineering students was not conducted.
- III. Number of ambulances of CUST is only one. The ambulance siren and word "Ambulance" are not there on CUST vehicle.
- IV. Few faculty and staff were still not observant to alarms and evacuation guidelines in spite of the steps mentioned in section 2.1.2.



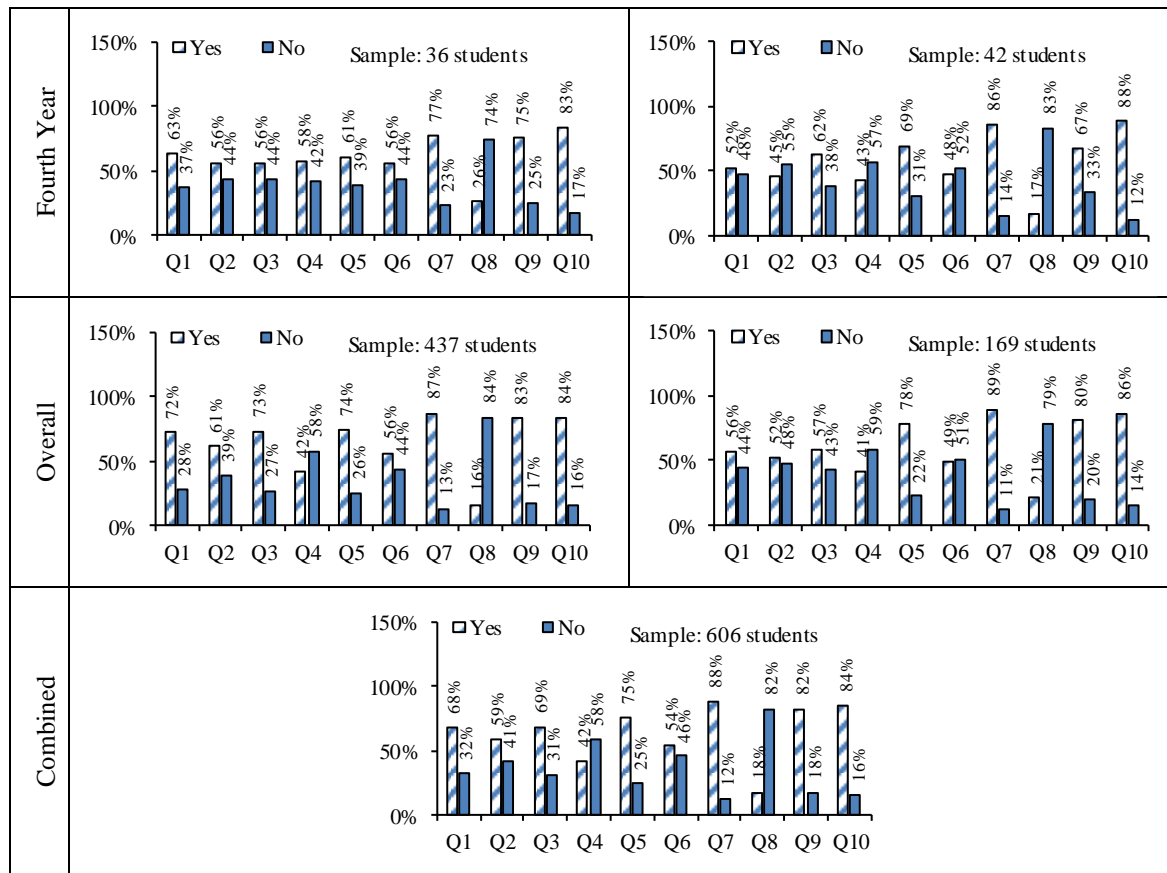


Figure 6: Analysis of feedback

#### 4 CONCLUSION AND RECOMMENDATIONS

This work is conducted to analyze the consequence of health and safety trainings on students i.e. how to react during a disaster? The entire execution is done in Capital University of Science and Technology, Islamabad, Pakistan. The task is divided into five stages: modifications in existing infrastructure, training of staff, educating the engineering students only, monitored drill and student feedback. Such kind of drills can help in identifying the flaws and for further improvement. Lessons from other major earthquake/disaster response drill can also be studied and adopted if similarity exists. However, based on analysis of uninformed drill (monitored through CCTV cameras) in current study, following are the recommendations:

- I. Intensity and tone of the bells and alarms need further improvement in terms of siren, tone and loudness. The alarm system should be made centralized.
- II. Training of all students, faculty and staff (not only the engineering students, faculty and staff) should be done. The tradition of regular awareness and training should be maintained.
- III. Ambulances of CUST should be increased. The ambulance siren and word “Ambulance” should also be there on CUST vehicle. Furthermore, medical staff is also beneficial.

#### 5 ACKNOWLEDGEMENTS

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