Integrating Earthquake Preparedness at IIT-Mandi

Christopher Brainard - Abhay Kumar - Davis Ladd - Prabhakar Prasad - Jake Tappen - Chirag Vashist

Sponsors: Dr. Kala Uday & Dr. Maheshreddy Gade
Advisors: Dr. Ingrid Shockey & Dr. Gbetonmasse Somasse

April 28th, 2019

Integrating Earthquake Preparedness at IIT-Mandi

An Interactive Qualifying Project
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
degree of Bachelor of Science

by
Christopher Brainard
Abhay Kumar
Davis Ladd
Prabhakar Prasad
Jake Tappen
Chirag Vashist

Date:

28 April 2019

Report Submitted to:

Dr. Maheshreddy Gade and Dr. Kala V. Uday and

IIT-Mandi

Dr. Ingrid K. Shockey and Dr. Gbetonmasse B. Somasse

Worcester Polytechnic Institute

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Abstract

The goal of our project was to create a Resource for Emergency Planning (REP) for the Indian Institute of Technology, Mandi. We conducted an online survey and coordinated in-person interviews with family members, staff and security guards to gauge the level of awareness concerning seismic risk on campus. We evaluated the campus terrain with regard to earthquake vulnerability. Lastly, we met with officials in Mandi District to understand the government's policies toward preparing communities for a quake. In completing these tasks, we identified gaps in preparedness on campus and were able to provide recommendations in the REP manual for the institute, including evacuation maps for residents to follow in the event of an earthquake.

Executive Summary

Introduction

Earthquake preparedness protocols are a crucial safety practice in areas of high seismic activity. They serve multiple purposes that can protect communities where earthquakes are most prominent. Firstly, they can limit injury by encouraging residents to adhere to immediate guidelines in the event of an earthquake. Secondly, they standardize actions and expectations in an emergency situation, ensuring the entire community can manage disaster relief following the event. Finally, they encourage regular assessments and coordinated drills. Providing a state, province, or community with an earthquake preparedness guide is an extremely important security step to conserve human life as well as mitigate the long-term effects of a disaster.

The goal of our project was to create a Resource for Emergency Planning (REP) for the Indian Institute of Technology-Mandi (IIT-Mandi), located in the Kamand Valley of Himachal Pradesh. To meet this goal, we identified three objectives. First, we measured the awareness of the IIT-Mandi community on seismic risk to their person. By doing this, we were able to better understand the current knowledge, awareness, and training the community has in the event of an earthquake. Second, we evaluated natural and structural hazards of the IIT-Mandi campus in terms of seismic activity. This objective was implemented into an evacuation map to highlight areas to avoid during the disaster. Finally, we appraised current earthquake risk and safety practices of Mandi district and IIT-Mandi. This ensured that our REP complied with these resources. Achieving these objectives allowed our team to develop an effective resource for the community of IIT-Mandi to keep the residents safe, provide clear protocols, and establish safe zones on campus.

Background

The development of an effective risk mitigation plan for IIT-Mandi requires understanding of the seismic hazard potential of the area, and needs to build from existing local and government protocols. IIT-Mandi is located in the state of Himachal Pradesh, which has experienced over 300 earthquakes in the past 90 years that were identified as 4.0 or greater on the Richter Scale. Sixty of these have been identified as 5.0 or greater resulting in lasting damage on communities (Himachal Pradesh State Government, n.d.). The state is one of the most dangerous with respect to seismic activity in the country, due to its proximity to fault lines in the western Himalayas. In the figure to the right, Himachal Pradesh can be found in the northwestern region of India. The institute's location in Himachal Pradesh is an active seismic zone, indicating a very high risk for damage.

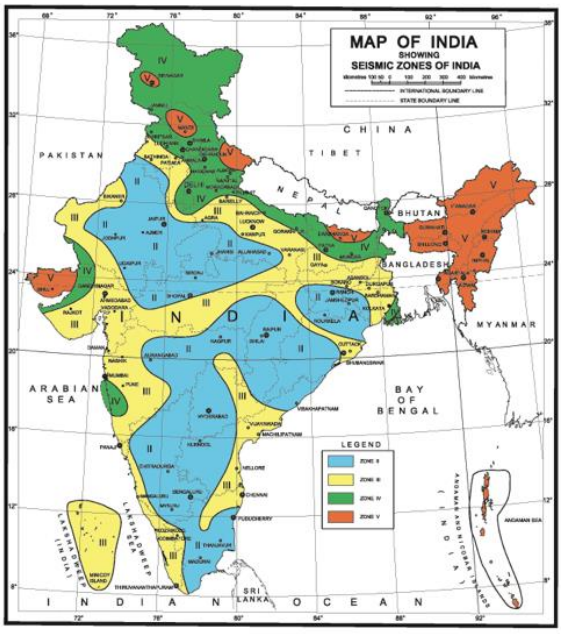

Figure A: Seismic zones of India (Government of India, 2016).

The area around the campus is labeled as a level V danger zone with respect to seismic activity (Charak, 1978). This rating is established by the government as a way of acknowledging potential hazards. What has been observed is that the hazards that typically cause loss of life during earthquakes are not the seismic disturbance itself, but rather the secondary damage from the terrain. This includes danger from landslides, liquefaction, and building collapse (Ammon, 2011). With the IIT-Mandi campus 14 miles northeast of Mandi Town, through winding narrow mountainous roads, the institute may be required to operate in isolation with help from outside resources in the days following a significant quake.

Methodology

Here, we provide an overview of the data and methods used to conduct our study and to prepare a guide. The guide includes evacuation maps and community safety procedures with the intent of mitigating risk during the event. Toward that goal, we developed three objectives:

1. Measure the awareness of IIT-Mandi community on seismic risk to their person.
2. Evaluate natural and structural hazards of the IIT-Mandi campus in terms of seismic activity.
3. Appraise current earthquake risk and safety practices of Mandi and IIT-Mandi.

These objectives were accomplished by interviewing families and staff on campus, sending out an online survey for faculty and students, and conducting rapid vulnerability assessments (RVAs) of the campuses to design the appropriate evacuation maps. We also observed an earthquake mock drill in a nearby village. The photos below illustrate the methods use during our fieldwork.

Figure B: Chirag interviewing a campus guard (Photo Courtesy: Brainard, 2019).

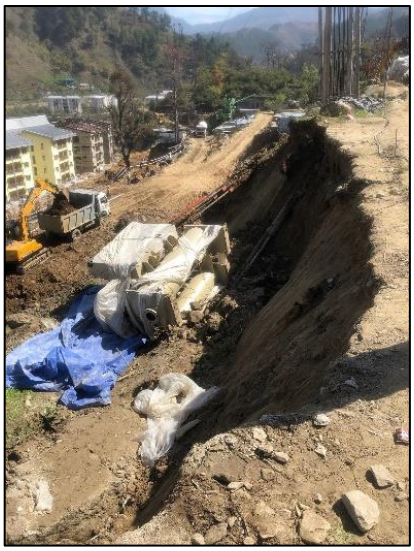

Figure C: Rapid vulnerability assessment on campus (Photo Courtesy: Brainard, 2019).

Figure D: Local government officials conducting an earthquake mock drill (Photo Courtesy: Brainard, 2019).

Results & Discussion

Our survey of the IIT-Mandi community generated 117 responses that helped us gauge the perceptions of earthquake preparedness across the campus. The majority of these surveys were answered online, with twenty-eight conducted as in-person interviews. Our survey demonstrated that only 39% of participants knew the correct answer to which earthquake zone Mandi falls in as defined by India's Ministry of Science, while 38% admitted they did not know. The variance in answer shows a general lack of the technical knowledge of the area that they live, which too indicates a shortcoming of the subject matter in the classroom. In regards to the knowledge IIT community members have on earthquakes there too was a deviation in responses. As depicted in Chart 1, on average we saw that a little over 25% of respondents learned of an earthquake preparedness guide from an academic textbook, and 20.5% read of one in a newspaper or magazine. This being said, another 24%, have never received any form of education on earthquakes. With this large spectrum of answers there exists a variety of responses in how people would react during a seismic event. As a result, the difference in understanding of priorities during an earthquake could lead to miscommunications and poor decisions that result in loss of life.

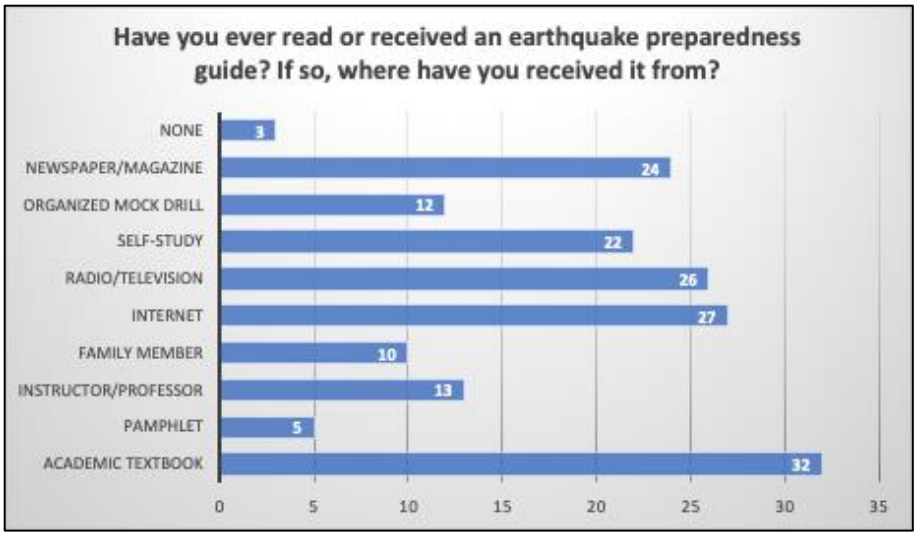

Chart A: Prior knowledge of earthquake preparedness guides by source.

With regard to our site assessments of North and South Campus, the RVAs revealed a number of locations that show promise as safe zones or evacuation sites on both campuses. Through this assessment we found that there are ten main evacuation sites on South campus and three safe zones on North campus.

We also attended a mock earthquake drill of a local government secondary school, Netaji Subhash Chandra Bose Memorial Government Senior Secondary School in the Padhar region of Himachal Pradesh. Unfortunately, IIT-Mandi has no formal drills or regular recurring educational practices at the institute. Therefore, the earthquake mock drill at the secondary school, held by the local government officials of Padhar, including police officers,

fire safety personnel, and the Sub-Divisional Magistrate (SDM), helped us to gauge how the local villages prepare for earthquake activity as well as perceive seismic events.

Following the drill, we interviewed the SDM of Mandi, Avneesh Sharma, who coordinates the emergency guide planning to natural disasters in the small villages of Mandi district. Our discussion focused on local villages "disaster management plans with resources specific to their community" that aim to ensure the safety of each villager. As Sharma explained, nearly all villagers have experienced at least one consequential disaster in their lifetime. In discussing the protocols for community level engagement, his advice aided us in formatting our REP manual for IIT-Mandi.

Project Outcomes

To provide the campus of IIT-Mandi with the essential knowledge for an earthquake preparedness guide, our team designed a Resource for Emergency Planning (REP) manual. This REP has four recommended steps to guide the campus on how to create an earthquake preparedness guide in the future. Within these steps, there are a series of recommendations that include procedures for the community in earthquake preparedness.

Step 1: Preemptive Planning

Preemptive actions should be taken before the seismic event. For instance, suggestions on securing objects within a building, implementing a chain of command as well as response team, coordinating personnel to teach the campus about earthquake awareness and safety, establishing an auditory alarm and SMS communication systems, setting in place preparedness kits for personal and school use, and lastly performing routine mock drills.

Step 2: "Drop, Cover, & Hold On"

The "Drop, Cover, & Hold On" procedure that should be the immediate response of the IIT community at the first feeling of tremors. This includes how to react both inside, outside, and in a vehicle.

Step 3: Evacuation Protocol

The evacuation protocol details the key actions following an earthquake for all persons, including injured and those with disabilities. Evacuation maps for both North and South campus are also presented in Step 3 of the REP, and the map of North Campus is displayed in Figure E, below.

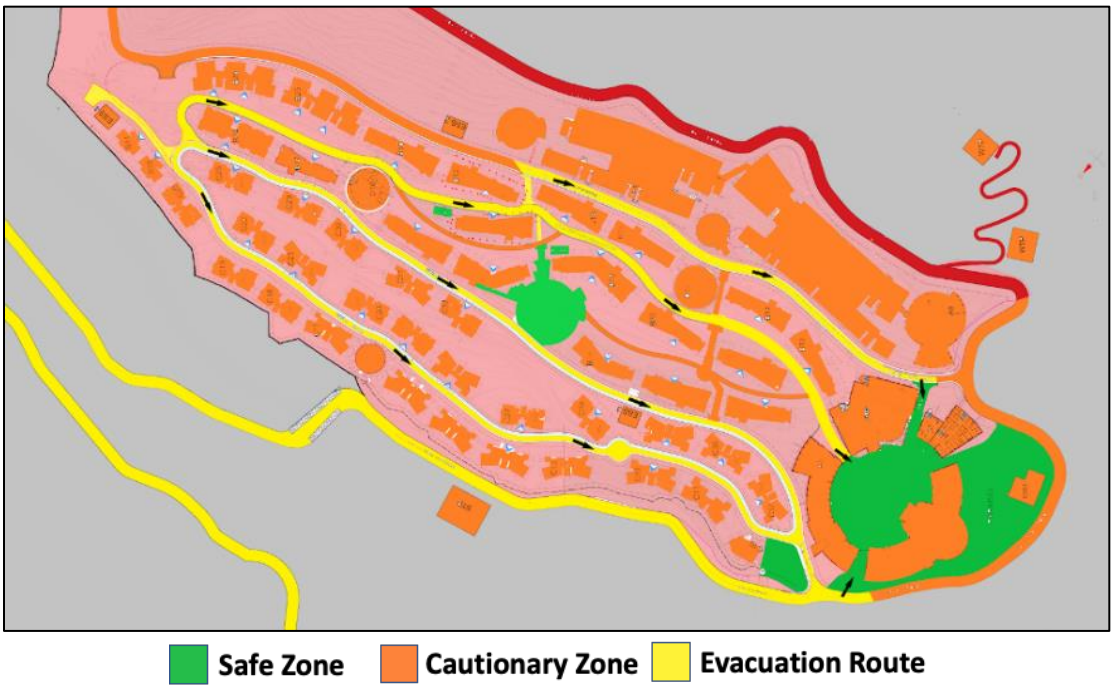

Figure E: North Campus evacuation map.

Step 4: Campus Recovery

Finally, Step 4 highlights how the campus should assemble once residents and staff have evacuated to the specified safe zones on the maps. We recommend the disaster management administration on campus coordinate some form of attendance system to account for any missing persons, therefore, allowing proper authorities to be notified and then handled in a timely fashion.

In sum, the importance of this project cannot be overstated after learning the status of the IIT-Mandi community's risk and vulnerability with regard to earthquakes. It is clear that while there is some basis of understanding about the potential hazards caused by an earthquake, the uniformity and organization that can prevent unnecessary injury does not exist. The greatest preventive measure that can be made is education of the community so that actions taken during the disaster mitigate damages that can ultimately be avoided. We were able to identify best practices that prepare an individual for a disaster, however sustainability of an education system will be a crucial step in the future. Vulnerability assessments will need to be conducted again as incoming students arrive and as the campus expands. New residents will need to be educated on what they can do to protect themselves from hazards. In addition, the policies and protocols will need to be practiced by all administrative personnel so that the precious moments during and after a seismic event are not wasted in regaining control of the campus. Earthquakes are inevitable in the area, and as we have seen, the IIT community is receptive to preparedness and open to incorporating a guideline that seeks to create a more resilient campus.

Acknowledgments

We would like to thank the following individuals who assisted us and guided us throughout our project:

- Our mentors, Dr. Kala V. Uday, Dr. Maheshreddy Gade, Dr. Ingrid K. Shockey, and Professor Gbetonmasse B. Somasse for their contributions and thoughtful critiques towards the development of our project.
- Dr. Devika Sethi for accommodating our team with the necessary resources for the successful conclusion of the ISTP/IQP.
- We would like to extend gratitude towards everyone who took the time to participate in our study.
- Sub-Divisional Magistrate of Padhar, Avneesh Sharma, for his guidance in breaking down the government strategies for community-based disaster management.
- The Indian Institute of Technology Mandi and Worcester Polytechnic Institute for providing us with the opportunity to complete this study.

Authorship

This report, and the work done during the project, was split up into even parts amongst the WPI and IIT students. All members worked together on creating our final posters, presentations, and surveys.

The primary authors and editors of this report:

Christopher Brainard, Davis Ladd, Jake Tappen

The primary translators and conductors of the interviews:

Abhay Kumar, Prabhakar Prasad, Chirag Vashist.

Figure F: The earthquake preparedness team.
From right to left on the top: Prabhakar, Christopher, Jake.
From right to left on the bottom: Davis, Chirag, Abhay.
Photo Courtesy: Dr. Gbetonmasse B. Somasse

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List of Acronyms

DC	Deputy Commissioner
DDMA	District Disaster Management Authority
DEOC	District Emergency Operations Center
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
GoI	Government of India
GPS	The Global Positioning System
HP	Himachal Pradesh
HPSDMP	Himachal Pradesh State Disaster Management Plan
IIT-Mandi	Indian Institute of Technology Mandi
IMD	India Meteorological Department
NDMA	National Disaster Management Authority
NEC	National Executive Committee
NPDM	National Policy on Disaster Management
REP	Resource for Emergency Planning
RVA	Rapid Vulnerability Assessments
SDMA	State Disaster Management Authority
SEC	State Executive Committee
SEOC	State Emergency Operations Center
UNDP	UN Development Programme
USGS	United States Geological Survey

Chapter 1: Preparing for seismic risk in Himachal Pradesh

Earthquake preparedness protocols are a crucial safety practice in areas of high seismic activity. They serve multiple purposes that can protect communities where earthquakes are most prominent. First, they can limit injury by encouraging residents to adhere to immediate guidelines in the event of an earthquake. Secondly, they standardize actions and expectations in an emergency situation, ensuring the entire community can manage disaster relief following the event. Finally, they encourage regular assessments and coordinated drills. This project is in accordance with the eleventh goal of the United Nations Development Programme (UNDP) on promoting sustainable development in cities and communities. One of the goal's main targets is to "increase the number of cities and human settlements implementing integrated plans and policies towards resilience to disasters and holistic disaster risk management" (United Nations Development Programme, 2019). Providing a state, province, or community with an earthquake preparedness guide is an extremely important security step to conserve human life as well as mitigate the long-term effects of a disaster.

Each year, millions of people are at risk around the world and are vulnerable to loss and destabilization in the aftermath of seismic activity. On April 25th, 2015, a 7.8 earthquake was recorded on the Richter scale in Kathmandu, Nepal. The sheer force of the earthquake reportedly caused "8,700 deaths and destroy[ed] 299,600 buildings and 90% of medical facilities in the region", resulting in increased difficulties to aid those in need of medical attention (Zhao, 2016). Following the disaster, it was learned that earthquake preparedness training had likely reduced the casualty rate and destruction, as compared with other major disasters, such as the 2010 Haiti earthquake. The destructive aftermath recorded in each country, show that "preparedness is essential" (Auberach, 2015, p. 1).

Northwest India, and more specifically the state of Himachal Pradesh, is due for a major earthquake. The Minister of State for Science, Technology and Earth Sciences, Yalamanchili Satyanarayana Chowdary, developed seismic zones for the country of India, keeping in mind the countries elevated risk for seismic activity (Bhawan & Road, 2017). As depicted in Figure 1 to the right, the northern border of India falls within severe earthquake zones due to its close proximity to the Indian and Eurasian tectonic plates.

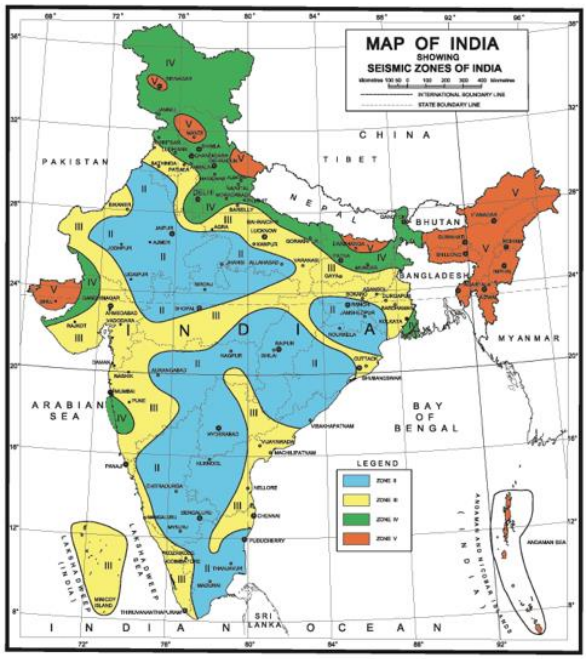

Figure 1: Seismic zones of India (Government of India, 2016).

More specifically, the area surrounding Mandi and its Kamand Valley is located in a Zone V Seismic Zone, the highest earthquake risk level possible. Though there has not been significant earthquake activity in Himachal Pradesh recently, a "seismic swarm of activity" recently shook the city of Rampur, located in neighboring Uttar Pradesh (Singh, 2016, p. 44).

In late August of 2016, 58 earthquakes struck in one day, demonstrating the high frequency of tectonic plate movement in the region. India's northern regions need protocols in place to prepare for natural hazards such as these.

The State Disaster Management Authority of Himachal Pradesh designed a template for disaster management. The plan, entitled, *Preparation of Disaster Management Plans by Various Departments of Government of Himachal Pradesh,* outlines the state's vision on disaster management. The plan specifically aims to "build a safe and disaster resilient Himachal Pradesh...through a culture of prevention, mitigation, preparedness and response" (Government of Himachal Pradesh, 2016, p. 1). Yet, despite this initiative from government agencies, less has been done to prepare specific protocols in communities vulnerable to a natural disaster.

The goal of our project was to create a Resource for Emergency Planning (REP) manual for the Indian Institute of Technology-Mandi (IIT-Mandi), located in the Kamand Valley of Himachal Pradesh. To meet this goal, we identified three objectives. First, we measured the awareness of the IIT-Mandi community on seismic risk to their person. By doing this, we were able to better understand the current knowledge, awareness, and training the community has in the event of an earthquake. Second, we evaluated natural and structural hazards of the IIT-Mandi campus in terms of seismic activity. This objective was implemented into an evacuation map to highlight areas to avoid during the disaster. Finally, we appraised current earthquake risk and safety practices of Mandi district and IIT-Mandi. This ensured that our REP manual complied with these resources. Achieving these objectives allowed our team to develop an effective REP manual for the community of IIT-Mandi to keep the residents safe, provide clear protocols, and establish safe zones on campus.

We begin this report by providing an overview of seismic activity in the state of Himachal Pradesh, as well as highlighting key terms and best practices used in the event of a natural disaster.

Chapter 2: Understanding the context for vulnerability

The development of an effective risk mitigation plan for IIT-Mandi requires understanding of the seismic hazard potential of the area, and needs to build from existing local and government protocols. In this section, we explore the vulnerabilities of earthquake activity, how to predict risk, and how to think about readiness to confront the hazards presented by natural disasters. In preparation towards further risk mitigation and hazard preparedness, our overview includes geographical and seismic frequency summaries of the area, profiles of our stakeholders, and consideration of current government policies.

Seismic activity in Himachal Pradesh

Himachal Pradesh has experienced over 300 earthquakes in the past 90 years that were identified as 4.0 or greater on the Richter Scale. Sixty of these have been identified as 5.0 or greater resulting in lasting damage on communities (Himachal Pradesh State Government, n.d.). The state is one of the most dangerous with respect to seismic activity in the country, due to its proximity to fault lines in the western Himalayas. The institute's location in Himachal Pradesh is an active seismic zone, indicating a very high risk for damage, as illustrated in Figure 2 (*Earthquake hazard map,* 2002). The area around the campus is labeled as a level V danger zone with respect to seismic activity (Charak, 1978). This rating is established by the government as a way of acknowledging potential hazards. What has been observed is that the hazards that typically cause loss of life during earthquakes are not the seismic disturbance itself, but rather the secondary damage from the terrain. This includes danger from landslides, liquefaction, and building collapse (Ammon, 2011). With the IIT-Mandi campus 14 miles northeast of Mandi Town, through winding narrow mountainous roads, the institute may be required to operate in isolation with help from outside resources in the days following a significant quake.

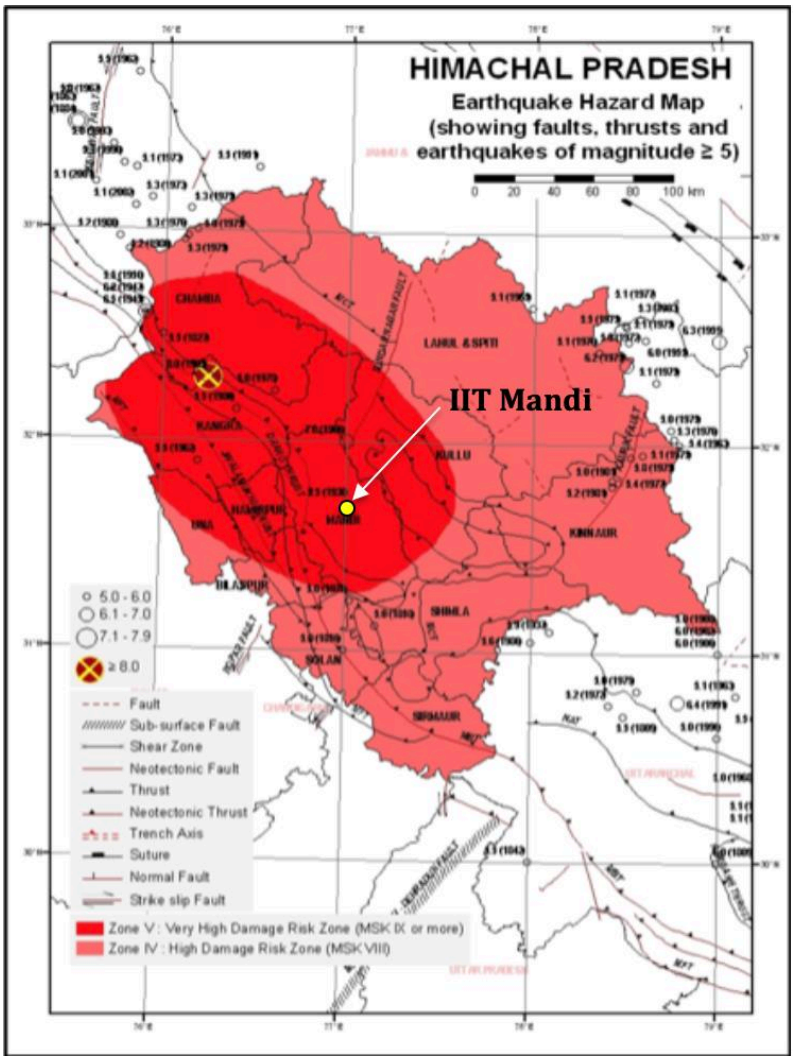

Figure 2: Hazard map of Himachal Pradesh (*Earthquake hazard map*, 2002).

Risk assessment and community emergency guide planning

Terms such as risk assessment, vulnerability, hazard management, and risk mitigation are all used to describe the concepts behind the response to disasters (human or natural). The Government of India (GoI) has defined in their *National Disaster Management Guidelines* the definitions of these terms, carefully stating their purpose and specific meaning when it comes to natural disasters. The terms risk assessment and risk mitigation are significant in the context of earthquake preparedness and disaster control (for definitions specified by the federal government, see Appendix A). However, due to the wide variety of opinions and variables, risk assessment is an imperfect science. The Federal Emergency Management Authority (FEMA) provides one framework for risk as measuring the "expected casualties, direct economic losses and displaced households" (Your earthquake risk, 2019). In order to create a sufficient REP manual for the community of IIT-Mandi, these risks must be identified and evaluated.

When assessing risk and disaster control, it is vital to analyze how efficiently preparedness plans translate into community action. Though there may be current preparedness and risk mitigation plans in place, there are still factors that affect the actual implementation of these procedures. The government may set the "standard" for preparedness from certain disasters, but how well are these protocols followed at the micro level in a community is a question to keep in mind. For instance, the Community for Accredited Online Schools outlines the important aspects of earthquake preparedness for schools across the United States. Highlighting the national earthquake preparedness guidelines from the American Red Cross and other organizations, schools get prepared by "considering the buildings, securing furniture, gathering emergency supplies, and holding earthquake drills and evacuation practices" (Russell, n.d.). Below, Figure 3 provides an example of those guidelines and their descriptions.

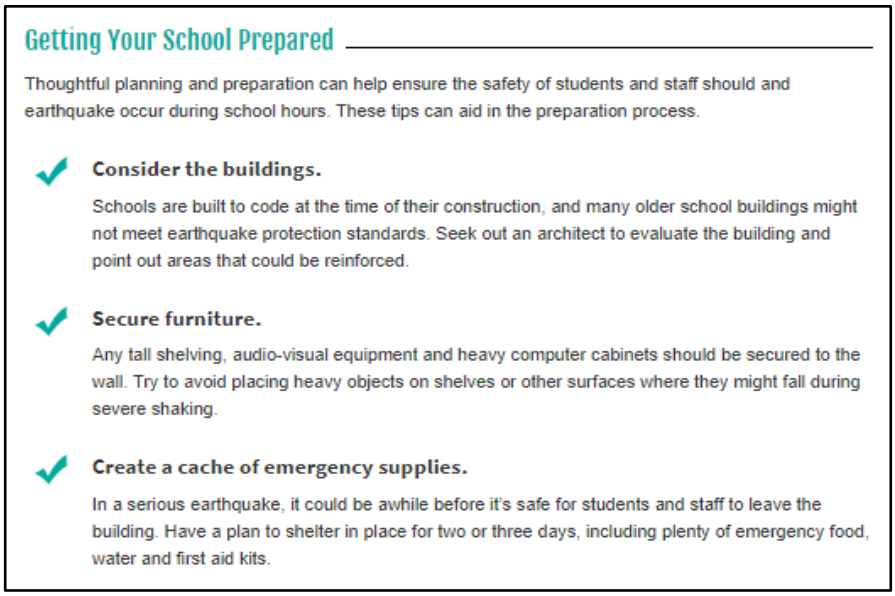

Figure 3: Getting your school prepared (Russell, n.d.).

Though organizations such as the American Red Cross and FEMA have disaster protocols on the national and community level, guidelines can be established in schools, homes, businesses, and other organizations. Local communities, schools, and households need to coordinate their own disaster management activities to ensure that their communities are responding correctly to reduce and mitigate risks. IIT-Mandi is located within an extremely high-risk zone for seismic activity, leaving the university community subject to a catastrophic event with little to no warning. Furthermore, developing a safety guide for a community encompasses more than just earthquake preparedness. Past case studies have been analyzed to gauge seismic activities effects on similar areas and one is analyzed in the next section. A serious focus has to include the local perceptions of risk and vulnerability, as well as streamlining response for initiating coordinated protocols. At this time the national, state, and district plans for disaster management are quite comprehensive in writing, however, in terms of the campus and surrounding villages there is little information known about how well these plans transition to a citizen accountability level.

Best preparedness practices

In 1905, Himachal Pradesh was hit by a magnitude 8.4 earthquake close to Kangra, in northern India. Occurring over a century ago, it remains one of the most devastating earthquakes to affect the country of India and caused critical damage to the region and more than 15,000 casualties. IIT-Mandi is located in a very similar terrain compared to Kangra, and the effects of an earthquake at this magnitude could reap the same results even with building adaptations over the past century.

In order to better understand risk assessment and hazards in a natural disaster such as an earthquake, we evaluate a case study that serves as important lessons for future disasters. Our case study is a risk assessment on seismic activity in Nepal, which demonstrates the benefits of earthquake preparedness (Chaulagain, 2014).

Seismic risk assessment in Nepal

Research in a study entitled *Seismic Risk Assessment and Hazard Mapping in Nepal* has a similar goal to our own in assessing hazards related to seismic activity. Nepal's history of severe earthquakes dates back to the early 13th century (Chaulagain, 2014). Due to the number of seismic events in Nepal, multiple studies have been conducted to estimate the damage, death toll, and injuries expected if a large magnitude earthquake were to occur. This team successfully used "combining probabilistic seismic hazard, structure vulnerability, and exposure data" to create hazard maps and building models across Nepal (Chaulagain, 2014).

To get a better understanding of the severity of earthquakes in Nepal, the researchers examined ground motion in the region by using prediction equations to classify the tectonic makeup of the country. In doing so, the researchers were able to accurately represent the levels of building collapse, destruction, and damage in each region. This was significant in their study because the "level of building damage depends on the intensity of ground shaking" (Chaulagain, 2014). By gathering data and making methodical predictions using ground motion equations and previous data from other experts, this study was effective in mapping probabilistic seismic hazards in Nepal. The creation of these geographical hazard maps proved its significance to the reconstruction of the country of Nepal. Prior to the earthquake of 2015, "the lack of information of the physical geography of the affected areas"

suggested that it was not possible to know which places would be safe for development (Hall, 2017, p. 41). Moreover, those agencies that did provide geographical hazard maps of particular regions in Nepal stated that "reconstruction had run more smoothly as a result" (Hall, 2017, p. 41). This shows evidence that geographical hazard maps provide regions of seismic activity with safety not only prior to an earthquake, but also afterwards. Evaluating the ground motion in a particular region is an essential part of hazard map design, however, this could prove a difficult or impossible task to achieve when creating a hazard map of the Kamand Valley for IIT-Mandi since these technologies may not be available.

Chapter 3: Strategies to achieve our goal

Here we provide an overview of the data and methods used to create a Resource for Emergency Planning for IIT-Mandi. The guide includes hazard maps and community safety procedures with the intent of mitigating risk during the event. Toward that goal, we developed three objectives:

1. Measure the awareness of the IIT-Mandi community on seismic risk to their person.
2. Evaluate natural and structural hazards of the IIT-Mandi campus in terms of seismic activity.
3. Appraise current earthquake risk and safety practices of Mandi and IIT-Mandi.

These objectives were accomplished from a combination of interviews, rapid vulnerability assessments, and hazard mapping as summarized in the chart below (see Figure 4).

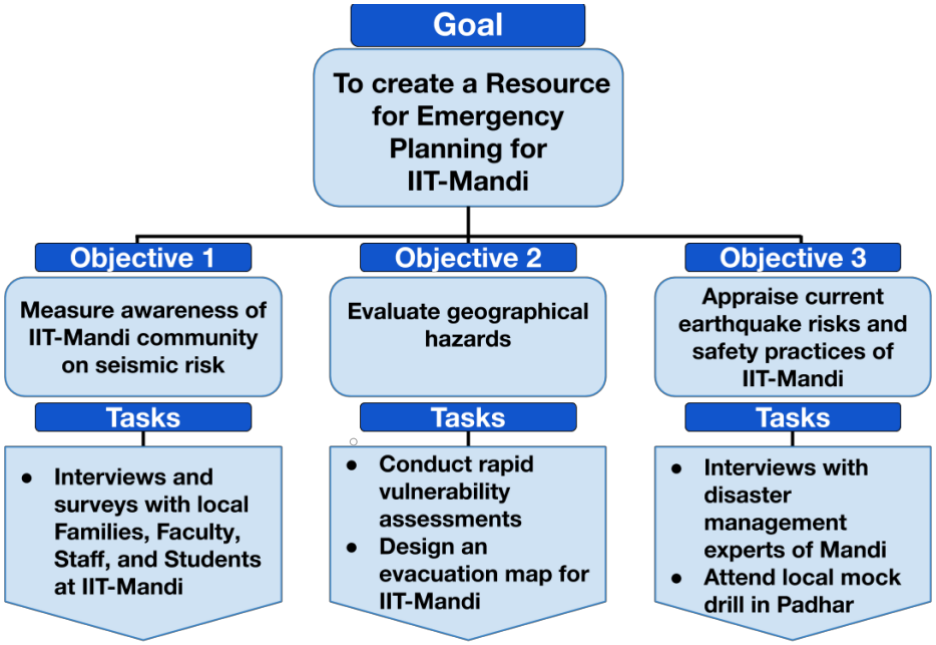

Figure 4: Methodology and objectives flow chart.

1. Measuring awareness of IIT-Mandi community on seismic risk

Our first objective assessed the awareness of the IIT-Mandi campus and extended campus communities on the risks associated with seismic activity. We measured the level of preparedness of the campus in case of earthquakes. This data was used as a starting point towards understanding the baseline of knowledge and practices.

A combination of surveys and interviews with faculty, staff, students and families living on campus helped to assess the current level of preparedness against hazards based on a sample of convenience. Interviews were conducted in a semi-standardized format (Berg, 2007). The survey questions are in Appendix B of this report. These information gathering techniques also served as a way to estimate the current safety standards known by the IIT-

Mandi community. The surveys were presented in English and distributed online using the school's email to students and faculty. The student population's sample size was larger in proportion to any other body. Therefore, their answers' were most representative out of all other responses. Staff and construction workers hired by the school were interviewed in-person using a semi-standardized format in Hindi or English using a convenience sample. We also interviewed family members living on campus using a snowball sample derived from faculty contacts or by convenience (Berg, 2007).

2. Evaluating geographical hazards

The second objective was to evaluate the potential hazards of the terrain surrounding IIT-Mandi in the event of seismic activity. The geographical composition of the land surrounding IIT-Mandi, while being a risk itself, played a direct role in planning the best safety strategies. Understanding the terrain of IIT-Mandi, where construction was most prominent, and what areas were most traffic prone allowed us to identify regions where there was greater risk of damage or compromises to evacuation zones. By conducting Rapid Vulnerability Assessments (RVA) and creating evacuation maps, we worked to identify key areas of geographical risk if an earthquake were to occur in the IIT-Mandi region. We also looked at non-geographical hazards in the urban environment of the campus such as the collapse of nonstructural building components and power lines that could fall in the roads.

Using RVA's and hazard maps was the best approach to evaluate the land surrounding IIT-Mandi because it presented immediate assessments of which areas should be avoided and how they will affect accessibility if seismic activity were to occur. Some questions that this assessment addressed:

1. Which areas are the most susceptible to destruction due to an earthquake?
2. How will the location of the campus affect accessibility and emergency response?
3. Which areas will prove to be the best safe zones during and in the aftermath of an earthquake?

We walked the entire campus taking over 300 pictures to assess which of the three zones each area depicted: safe zone, cautionary zone or evacuation route. Green zones represent safe gathering points that could serve as a bases for operation during and after the disaster, such as managing wounded. Yellow zones are approved evacuation routes that serve as the safest way to reach the green zones. While orange zones represent areas of caution were people should avoid if possible and largely encompass the locations that are being evacuated from. Through discussion at each site and referencing pictures after the fact we were able to justify areas that could be considered safe and those that had the potential for causing hazards.

The assessment included the collection of data for an evacuation map, with areas marked to serve as muster points for the people on campus (i.e. places they will evacuate to for safety). Similarly, we evaluated the vulnerability of residents with regard to structural material of buildings as well as potential danger from landslides and flooding. Finally, we assessed road and civil access routes in and out of campus in order to locate areas where evacuation can affect emergency response. The results from the RVA's were collected to note

vulnerable locations and create a map that highlighted key areas of risk. This map used a color-coded system as defined above to illustrate the levels of risk on the campus.

3. Appraisal of the current earthquake risk and safety practices of Mandi and IIT-Mandi

The final objective was to appraise the current risk mitigation practices by the local management of IIT-Mandi and surrounding villages. We visited a community emergency planning drill in the village of Padhar, to observe the strengths and weaknesses of how the local school conducted a mock drill. We took note of the seriousness with which the children took the drill and the length of the drill. Further, we watched how and by whom the majority of the drill was managed, as well as comparisons between how well the information presented in the drill held up against other sources we had investigated.

We conducted interviews with Mandi district planning officials at the Padhar village office to assess current hazard mitigation practices in and around the IIT-Mandi community. Our method of sampling for interviews was a snowball sample to gather expert opinions. These interviews were designed to aid in furthering our research on how the experts of Mandi district structure their disaster management plans as well as how we applied these policies into the recommended evacuation map and REP manual for IIT-Mandi. Therefore, we used semi standardized interview formats (Berg, 2007). After completing these interviews, the data collected was analyzed for similarities and differences in response. Furthermore, the results were also used to investigate correlations to the surveys conducted in Objective 1.

Chapter 4: Risks and capacities at IIT-Mandi

The results of our study confirmed considerable risk on campus and also provided some interesting findings in terms of local capacity. Key responses to our survey are highlighted below. For a full list of the results from our survey, refer to Appendix C.

Limited awareness of seismic risk in the community

Our survey of the Mandi community generated 117 responses that helped us gauge the perceptions of earthquake preparedness across the campus. The majority of these surveys were answered online, with twenty-eight conducted as in-person interviews.

As depicted below in Chart 1, only 39% of participants knew the correct answer to which earthquake zone Mandi falls in as defined by India's Ministry of Science, while 38% admitted they did not know.

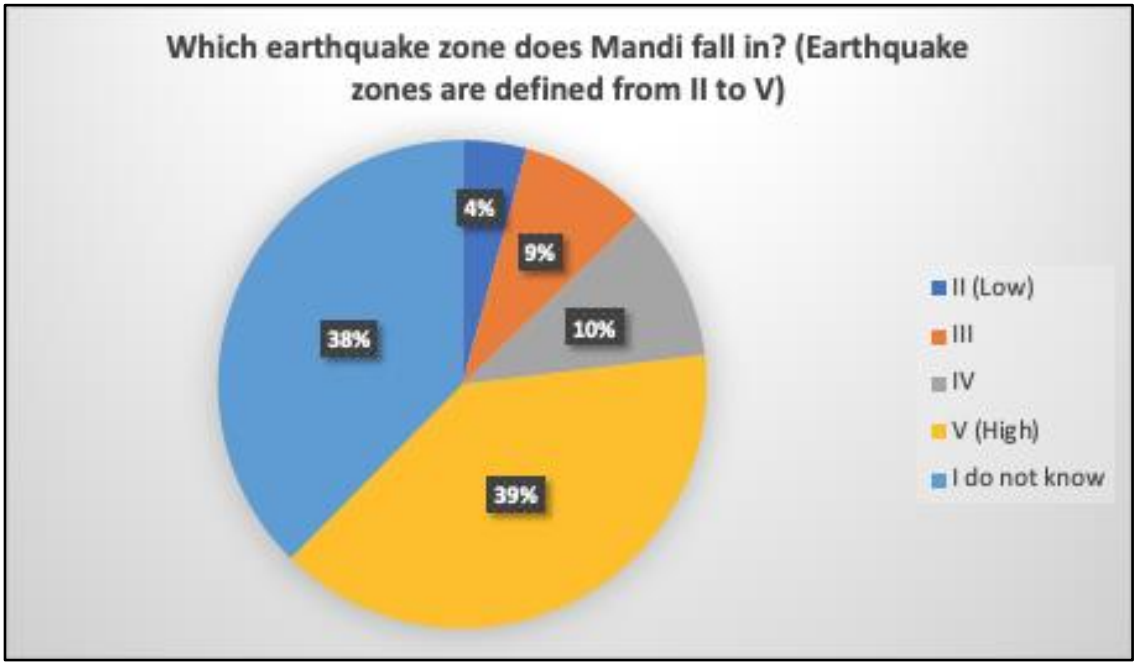

Chart 1: Responses to Mandi's earthquake zone.

Chart 2 summarizes the current state of earthquake preparedness knowledge gap. This chart depicts that on average roughly 25% of respondents learned of an earthquake preparedness guide from an academic textbook, and 21% read of one in a newspaper or magazine. Surprisingly, 24% have never received any form of education on earthquakes.

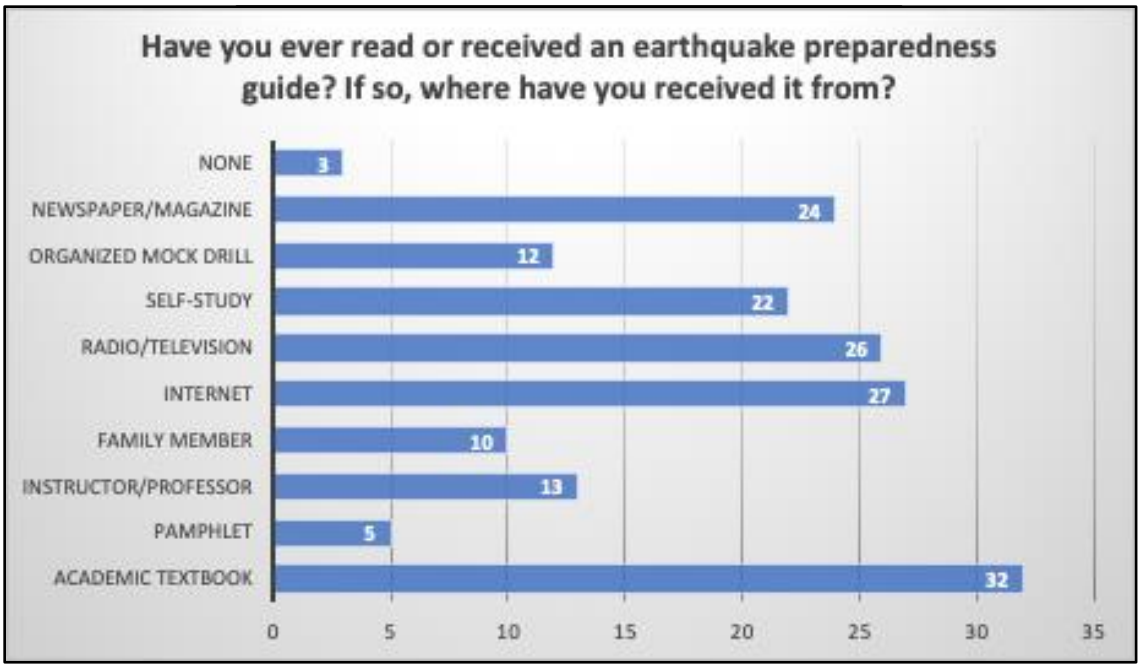

Chart 2: Prior knowledge of earthquake preparedness guides by source.

The remaining survey questions asked respondents what they would pack in a disaster bag, and about awareness regarding the immediate physical consequences in the aftermath of an earthquake. These results also indicated a wide spectrum of answers, some of which could be classified as highly inadvisable and suggesting a lack of uniform education on disasters, as shown in Chart 2. This difference in understanding of priorities during an earthquake could lead to miscommunications and poor decisions that result in loss of life.

Finally, we asked the community how often a mock drill should be held at IIT-Mandi to help gauge whether or not the residents thought participation was needed. The responses indicated that 49% of the community believed that there should be a mock drill held twice a year to simulate earthquake evacuation and safety protocols.

Rapid vulnerability assessment concerns

Below are highlights from our rapid vulnerability assessment, to identify safe and cautionary zones as well as evacuation routes. Through this assessment we found that there are ten evacuation sites on South campus and three safe zones on North campus. The evacuation routes were identified as the main walkways that connect the campus and we determined that all small paths or walkways could be blocked easily by structural decay of buildings or the surrounding terrain. A series of images from our RVA's can be seen below.

Figure 5: Safe zone on North Campus (Photo Courtesy: Tappen, 2019).

Safe Zone - This is the bus stop on North Campus, which is designated as an open space that has no or a low risk of hazards resulting from earthquakes. This location will serve as an evacuation point on the hazard map where students, faculty, staff and families will evacuate to in the event of an earthquake.

Figure 6: Cautionary zone on North Campus (Photo Courtesy: Brainard, 2019).

Cautionary Zone - This shot of the construction underway depicts an area where residents on campus are in immediate danger if an earthquake were to strike. The hillside, where this picture was captured has seen landslides on a frequent basis and therefore it is advised those in this area evacuate as swiftly as possible towards a safe zone.

Figure 7: Evacuation route on North Campus (Photo Courtesy: Brainard, 2019).

Evacuation Routes - This location shows a pathway, which serves as one of many evacuation routes towards the designated safe zone. The walkway is safe with respect to falling objects and potential landslides. Therefore, it is advised faculty, families, students, and staff proceed along these paths in order to reach safety after an earthquake strikes.

Appraisal of standard earthquake risk and safety practices

We attended an earthquake drill at a local government secondary school named, Netaji Subhash Chandra Bose Memorial Government Senior Secondary School in the Padhar region of Himachal Pradesh. The earthquake drill at the secondary school was held by the local government officials of Padhar, including police officers, fire safety personnel, and the Sub-Divisional Magistrate (SDM).

The school was preparing for an earthquake using evacuation drills from buildings in various scenarios. Figure 9 depicts a student repelling from the roof with a rope, which shows one way that safety personnel can evacuate individuals in the event of building collapse or structural failure. Figure 8 shows the appropriate emergency response vehicles recommended during a disaster. In this drill, the ambulance is tasked with transporting students who were injured to the nearby Civil Hospital. This could be similarly carried out to familiarize students with the IIT-Mandi hospital and their protocols.

Figure 8: Rope procedure from mock drill (Photo Courtesy: Brainard, 2019).

Figure 9: Ambulance procedure from mock drill (Photo Courtesy: Brainard, 2019).

A second aspect of our third objective was to interview local government officials in the Mandi district on disaster management. We interviewed the SDM of Mandi, Avneesh Sharma, who coordinates the emergency guide planning to natural disasters in the Mandi district. Our discussion focused on local villages "disaster management plans with resources specific to their community" that aim to ensure the safety of each villager (Sharma, 2019). As Sharma explained, nearly all villagers have experienced at least one consequential disaster in their lifetime. For this reason, community members are open to helping and listening to experts who want to teach the community the best practices for disaster preparedness. However, for these guidelines to work, Sharma notes that it is essential to identify those individuals at the community level who are most experienced in disasters specific to their region to gain a sense of the community's perceptions and readiness. These steps followed by the district level will be important in implementing our REP manual for IIT-Mandi. Essentially, by raising each individual's awareness we increase the safety of the school.

Discussion

The results from all three objectives suggest that preparedness for earthquake readiness has yet to take shape at IIT-Mandi. When we analyzed our RVAs and compared them with the current public perceptions, there are important gaps in how the community identifies risks during seismic activity. Our own background research, speaking with university experts, and government regulations indicated that the campuses buildings are built to withstand some seismic activity. However, we identified other concerns likely to cause damage during the disaster throughout the campus grounds. Unfortunately, the community's response towards what to do in the event of seismic activity revealed a sizable portion of people exposing themselves to possible hazards. The variation in answers shows a general lack of the technical knowledge of the risks associated with the area where they live. For example, 10% of respondents answered incorrectly for proper reactions inside buildings and 38% responded incorrectly for reactions in an automobile. These discrepancies for such notable sizes of the population show that the current preparedness at IIT-Mandi is extremely lacking. The misconceptions of the subjects from this survey allowed us to develop a cohesive plan that will be IIT-Mandi's REP. We justify our plans in the REP by using the answers of this survey to demonstrate that the community, while having some earthquake awareness, is ill prepared in some scenarios.

Our most notable finding was that IIT perceptions are not in sync with capacity shown by the emergency planning drill at the school in the Padhar region of Himachal Pradesh. This was especially valuable because of the interview with the SDM, which helped explain how education around these programs begins. He explained how to start when building a plan from an individual to a village which can be adjusted to fit the mold of the institute's community. This information can form the basis for what IIT Mandi will need in the future.

From watching the roles of students, teachers and police trainers carried out in the emergency planning drill, we can extrapolate responsibilities to IIT-Mandi individuals with confidence that the parties are capable of their assigned role in disaster preparedness. Through this method we would not start fresh, but rather update the campus to the highest standards by implementing strategies that communities with similar earthquake hazards face and have already developed plans to uphold. Toward that end, we combined the results and the best practices in a guide that can be adjusted in the future based on terrain and personnel changes to campus.

Chapter 5: Recommendations and Conclusion

To provide the campus of IIT-Mandi with an earthquake preparedness guide, our team designed a Resource for Emergency Planning (REP) for the campus to use in the event of an earthquake. This REP has four recommended steps to guide the campus on how to create an earthquake preparedness guide. A poster used to highlight these steps can be found in Appendix D, as well as the full REP manual in Appendix E. These steps are listed below.

- **Step 1: Preemptive Planning**
- **Step 2: "Drop, Cover & Hold On"**
- **Step 3: Evacuation Protocol**
- **Step 4: Campus Recovery**

Within these steps, there are a series of recommendations that include procedures for the community in earthquake preparedness. Step 1 lays out the actions that should be taken before the seismic event. For instance, suggestions on securing objects within a building, implementing a chain of command as well as response team, coordinating personnel to teach the campus about earthquake awareness and safety, establishing an auditory alarm and SMS communication systems, setting in place preparedness kits for personal and school use, and lastly performing routine mock drills. With respect to a mock drill on campus, the manual provides clear instructions and steps on the key points of a mock drill, breaking them into procedures that should be followed as an earthquake strikes. Moreover, our findings indicate the IIT community currently has no administration for handling seismic events, therefore we strongly recommend the immediate integration of one. The picture below illustrates a section of the REP in Step 1.

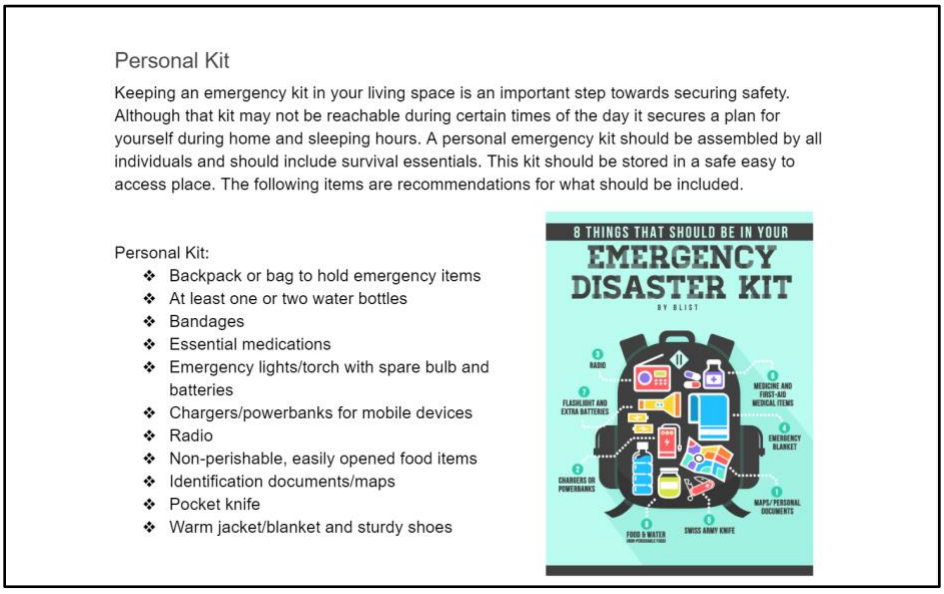

Figure 10: Snapshot of REP.

Step 2 of the manual, describes the "Drop, Cover, & Hold On" procedure that should be the immediate response of the IIT community at the first feeling of tremors. This includes how to react both inside, outside, and in a vehicle.

Step 3 covers the evacuation protocols following an earthquake for all persons, including injured and those with disabilities. Evacuation maps for both North and South campus are also presented in step 3 of the REP, and the map of North campus is displayed in Figure 11 below. The evacuation maps illustrate areas that are safe zones, areas that can be used as an evacuation route, and locations that are in the cautionary zones from an earthquake. We recommend that this map be posted in classrooms, sent out to faculty and students, and be implemented into the IIT student handbook. Furthermore, we suggest that this map be updated every two years to better reflect the development of the campus following construction periods.

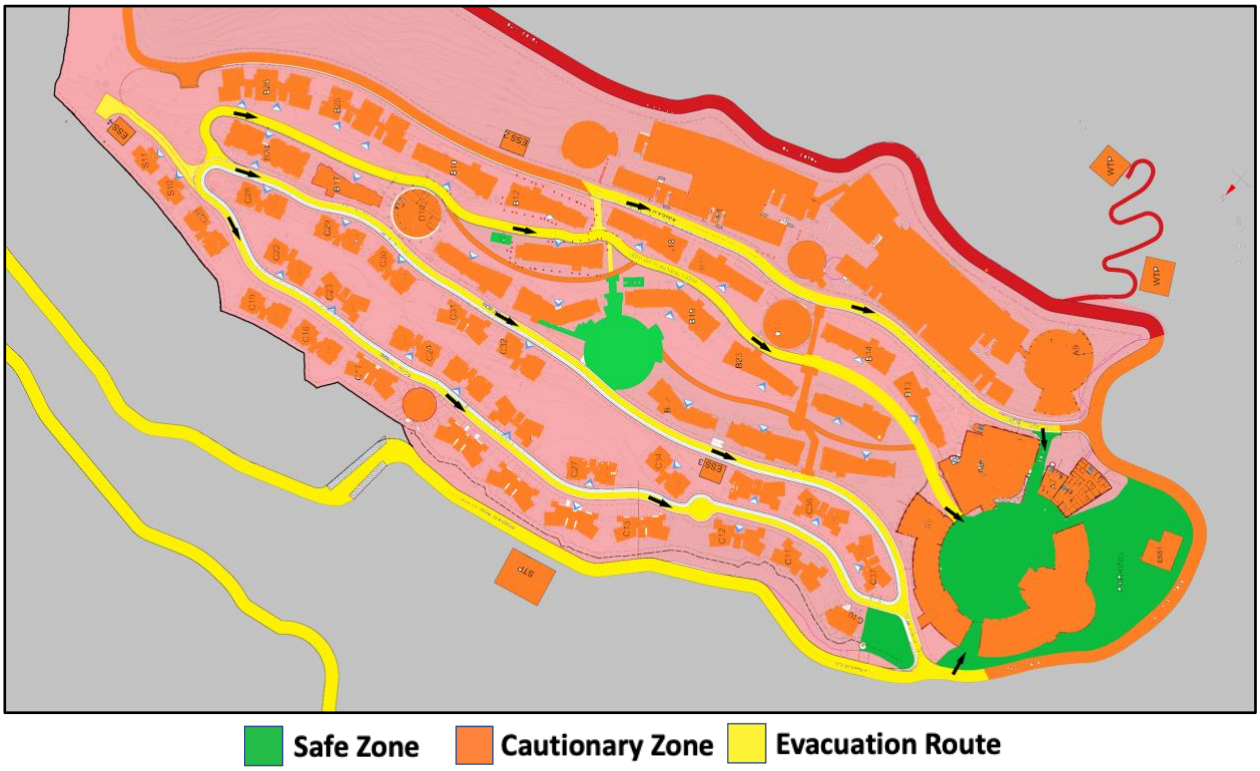

Figure 11: North Campus evacuation map.

Finally, step 4 highlights how the campus should act once people have evacuated to the specified safe zones on the maps. We recommend the disaster management administration on campus coordinate some form of attendance system to account for any missing persons, therefore, allowing proper authorities to be notified and then handled in a timely fashion. This will in the end, help the administration to maintain control during a very chaotic event.

In sum, the importance of this project cannot be overstated after learning the status of the IIT-Mandi community's risk and vulnerability with regard to earthquakes. It is clear that while there is some basis of understanding about the potential hazards caused by an earthquake, the uniformity and organization that can prevent unnecessary injury does not exist. The greatest preventive measure that can be made is education of the community so that actions taken during the disaster mitigate damages that can ultimately be avoided. We were able to identify best practices that prepare an individual for a disaster, however sustainability of an education system will be a crucial step in the future. Vulnerability

assessments will need to be conducted again as incoming students arrive and as the campus expands. New residents will need to be educated on what they can do to protect themselves from hazards. In addition, the policies and protocols will need to be practiced by all administrative personnel so that the precious moments during and after a seismic event are not wasted in regaining control of the campus. Earthquakes are inevitable in the area, and as we have seen, the IIT community is receptive to preparedness and open to incorporating a guideline that seeks to create a more resilient campus.

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Supplemental Materials

Appendix A: Literature Review

This section discusses government policies on disaster management in India and important terms related to hazard control.

Federal Disaster Management Infrastructure for Mandi District

In April of 2007, the *National Disaster Management Guidelines: Management of Earthquakes* was created by the National Disaster Management Authority (NDMA) to aid the departments of the Government of India (GoI), state governments, and other organizations in disaster management planning (National Disaster Management Authority, 2007). This guide recognizes the fact that roughly "59 per cent of India's land area could face moderate to severe earthquakes" (National Disaster Management Authority, 2007, p. 1). Following the development of the *National Disaster Management Guidelines*, the NDMA adopted the *National Policy on Disaster Management* (NPDM) in October of 2009. This policy strives to carry out the GoI's vision "to build a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response" (National Disaster Management Authority, 2009, p. 13). With respect to IIT-Mandi, it is best to analyze the state of Himachal Pradesh's (HP) plan for disaster management. In 2017, the state of HP developed the *Himachal Pradesh State Disaster Management Plan* (HPSDMP). Using the national guidelines, plan, and HP state policy on disaster management this document was formed to adhere to the *Disaster Management Act, 2005*. In the HPSDMP the state government describes the disaster preparedness protocol that was laid out in the HP State Policy on disaster management. A few of the key practices are identified below in Table 1.

In February of 2018, the Government of India, NDMA, and Ministry of Home Affairs initiated a mega mock drill in the state of HP, where 12 districts, including Mandi, participated in coordinated exercises to test readiness (HP prone to various natural, manmade hazards: Onkar Sharma, 2018). As part of the exercise, not only were educational institutions teaching "Drop, Cover, and Hold On" procedures, but discussions were conducted by Deputy Commissioners, district and state incident response teams, and army officials by video conference (HP prone to various natural, 2018; Government of Himachal Pradesh, 2018). To engage the communities in this drill, the government of HP used media outlets and educational pamphlets to promote the importance of awareness during the event of an earthquake (HP prone to various natural, 2018). In the end, while the Secretary of Revenue and Disaster Management Authority remarked that the exercises were successful in "encouraging progress...for disaster prevention and mitigation", he also suggested that there is "still a large distance to travel" (HP prone to various natural, 2018). For drills to be successful in real life scenarios, additional support is necessary to measure a community's resilience and risk with regard to hazards.

Table 1: Disaster preparedness protocols of Himachal Pradesh

Key Term	Description
Capacity development	Describes the need for "capacities across all sectors and at all levels is the most enduring, cost-effective and sustainable method for disaster preparedness" (State Disaster Management Authority, 2017, p.76). The HPSDMP recognizes the importance of discussion and communication with outside agencies or stakeholders to be better prepared for a disaster, whether it be natural or human induced.
Forecasting and early warning systems	The HP government has developed with the India Meteorological Department (IMD) "four observatories...equipped with state-of-the-art broadband sensors, high dynamic range (24-bit) digitizers, GPS time synchronization and facility to access data remotely through satellite communication and telephone mode" (State Disaster Management Authority, 2017, p. 83).
Setting up and strengthening of emergency operations centre	The State Emergency Operations Center (SEOC) will be upgraded with state of the art communication systems in order to follow guidelines set by the NDMA. As well, the emergency operations centres (EOCs) are designed to be at the core of the disaster by exchanging messages from various agencies to the correct stakeholders or authorities in charge of emergency response (State Disaster Management Authority, 2017, p. 84). In the case of districts like Mandi, the districts EOCs (DEOCs) will carry out operations similar to the SEOC, that also meet the needs specific to the district (State Disaster Management Authority, 2017).
Communications and information technology support	EOCs at all levels of government will have a fail-proof communications system in order to guarantee the transmission of information through voice, data and video (State Disaster Management Authority, 2017, p. 84).
Training, simulation and mock drills	Designed for all types of disasters and will be instituted at state and district levels. It is up to the HP SDMA to choose whether or not districts like Mandi run drills four times per year. The mock drills are expected to test "the effectiveness of the preparedness machinery including manpower and equipment" and should be conducted at areas where populations are most dense (State Disaster Management Authority, 2017, p. 87).
Community based disaster preparedness	Since community members are the "first responders" it is expected of these individuals to participate in the event of a hazard. Participation by a community safeguards "local ownership, addresses local needs, and promotes volunteerism and mutual help to prevent and minimize damage" (State Disaster Management Authority, 2017, p. 87). Thus, it is highly encouraged that women and children also take part in community planning and discussion to address the vulnerabilities of the region to specific hazards in order to best develop a district disaster management plan (State Disaster Management Authority, 2017).

Risk Assessment and Community Resilience

The Government of India (GOI) defines within its, *National Disaster Management Guidelines,* risk assessment as "the determination of the nature and extent of risk by analysing potential hazards that could pose a threat to people, property, livelihood, and the environment" (State Disaster Management Authority, 2017). Essentially, this means that the risk that is to be assessed is based on the impact to the individuals it affects. This directly leads into risk mitigation, which the GOI interprets as the "measures aimed at reducing the risk, impacts or effects of a disaster" (State Disaster Management Authority, 2017).

The question then becomes: how does one measure risk? Due to a wide variety of opinions, risk assessment is an imperfect science. There have been many studies in the field of risk assessment and it has, in its own nature, become a science that must be closely evaluated. When it comes to measuring risk, the "technical assessment typically models the impacts of an event in terms of direct harms", noting that it is important to look at the outcomes a particular event may result in (Kasperson, 1988, p. 179). Key thinkers in the field of risk assessment such as Kasperson and Slovic have highlighted the value of studying the "social amplifications" and "risk perceptions" that alter the appearance of traditional risk assessments. Slovic notes that, while risk assessments are purely evaluating actual hazards, the general public "rely on intuitive risk judgements" (Slovic, 1987, p. 280). Essentially, the human interaction with how they perceive an event as "risky" most likely will differ with what key researchers or analysts identify as risk.

Appendix B: Methodology - Survey Questionnaire

WPI-IIT Mandi Survey for ISTP/IQP Project

Survey designed for local faculty, students, and staff at IIT-Mandi to gauge their perceptions and educational level of awareness on earthquakes. It will only be seen by the online recipients at IIT-Mandi.

In the proceeding survey, please answer the questions to the best of your ability about earthquake preparedness. The survey is optional and should only take 10 minutes to complete. Any information you provide will be highly appreciated.

1. Please specify your age: _____ years old

2. Please choose the category you fall into at IIT-Mandi:

a. Student b. Employee

3. Please specify your level of education below:

a. <12 grade c. Undergraduate e. PhD

b. 12 grade d. Post graduate f. Other: _____

4. How many years have you been at IIT-Mandi?

Please specify number of years: _____

5. How many earthquakes have you felt in your lifetime?

0 ---------- 1 ---------- 2 ---------- 3 ---------- 4 ---------- 5 +

6. How many earthquakes have you felt during your time at IIT-Mandi?

0 ---------- 1 ---------- 2 ---------- 3 ---------- 4 ---------- 5 +

7. Which earthquake zone does Mandi fall in? (Earthquake zones are defined from II to V in India)

II (Low) III IV V (High) Or - I do not know

8. What items would you include in a preparedness backpack that you could assemble in advance and grab in the event of a disaster? Answer all that apply:

a. Water d. Flashlight g. Valuable possessions

b. Bandages/Medkit e. Medication h. Electronics

c. Canned food f. Fruit

Other: _____

9. Suppose you are travelling in a seated vehicle when an earthquake strikes. What should be the first thing that you do?

a. Stand and brace yourself against the seats

b. Evacuate the vehicle by using the door

c. Evacuate the vehicle by breaking the window

d. Stay seated and tuck head between legs and cover neck with hands

10. Which type of building do you live in/work in on IIT-Mandi campus? Choose multiple.

a. Concrete c. Semi-structure (Steel + Concrete) e. Stone

b. Bamboo blocks d. Steel f. I do not know

Other: _____

11. Which building is safest based on your perception?

c. Concrete c. Semi-structure (Steel + Concrete) e. Stone

d. Bamboo blocks d. Steel f. I do not know

12. Suppose you are inside a building when an earthquake strikes. What should be the first thing that you do?

a. Crouch in a doorway
b. Crouch by the window
c. Break window and escape
d. Stand in center of room
e. Hide under desk or other sturdy furniture

13. How long until after an earthquake occurs should you wait to go outside?

Immediately (No waiting) ____30 seconds____1 minute____5 minutes____30 minutes____

14. Have you ever read or received an earthquake preparedness guide?

Specify below:

a. Academic Textbook
b. Pamphlet
c. Newspaper/Magazine
d. None
e. Instructor/Professor
f. Family member
g. Organized Mock Drills
h. Other: _____
i. Internet
j. Radio/Television
k. Self-study

15. Rank the dangers associated with the immediate consequences of an earthquake in the Mandi district from 1-8, where the lower the number the higher the risk level:

Landslide	_____	Ground liquefaction	_____
Floods	_____	Chemical Corruption	_____
Building collapses	_____	Radiation Problems	_____
Electrical fires	_____	Tsunami	_____

16. Rank the dangers associated with the prolonged effects of an earthquake in the Mandi district from 1-8, where the lower the number the higher the risk level:

Food Shortage	_____	Shelter loss	_____
Medical Supply Shortage	_____	Water Shortage	_____
Critical Injuries	_____	Sanitation Control Issues	_____
Lack of Communication	_____	Wild Animal Issues	_____

17. How necessary is a disaster management module in the IIT-Mandi Handbook?

(Not Necessary) 0 -------- 1 -------- 2 -------- 3 -------- 4 -------- 5 (Very Necessary)

18. How necessary is a required mock drill session on IIT-Mandi campus?

(Not Necessary) 0 -------- 1 -------- 2 -------- 3 -------- 4 -------- 5 (Very Necessary)

19. If you answered yes to the question above, how frequent should these sessions be?

a. Once a year
b. Twice a year
c. Once in 2 years
d. Once in 3 years
e. Once in 4 years

*** Would you be willing to meet for an interview and provide us with more information? If so, please provide us your name and email and we will reach out to you at our earliest convenience. Thank you for participating in our study. If you have any questions, we can be reached at gr-earthquakesistp@wpi.edu.**

Name: _____

Email: _____

Appendix C: Results of Survey

This appendix reveals the results from the survey we used to gauge the seismic awareness of the IIT-Mandi community.

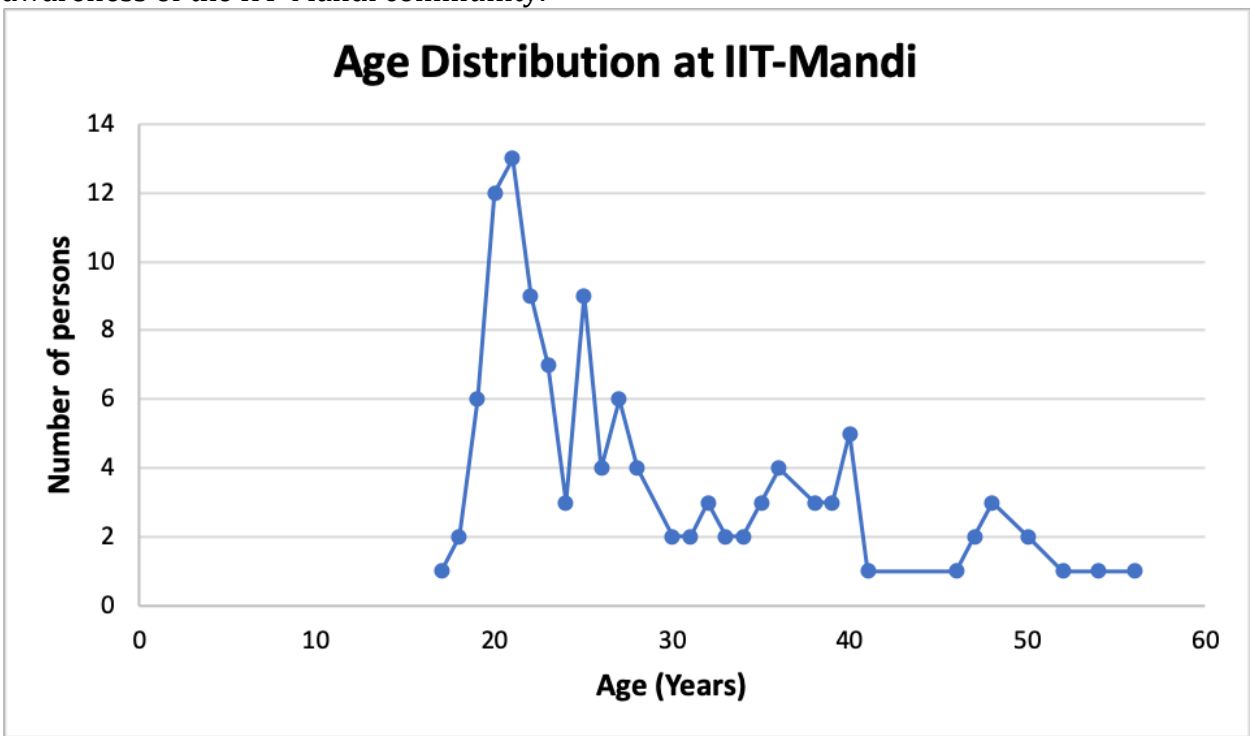

Chart 3: Age distribution of the participants in the survey.

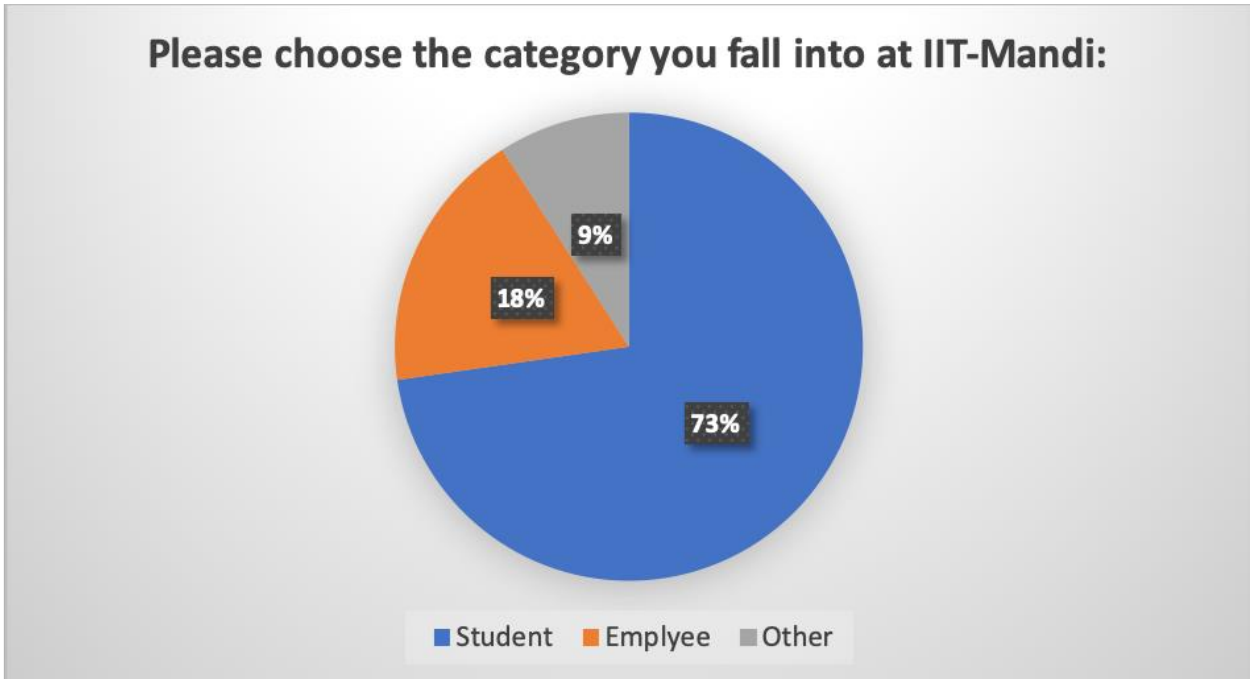

Chart 4: Position participants held at IIT-Mandi.

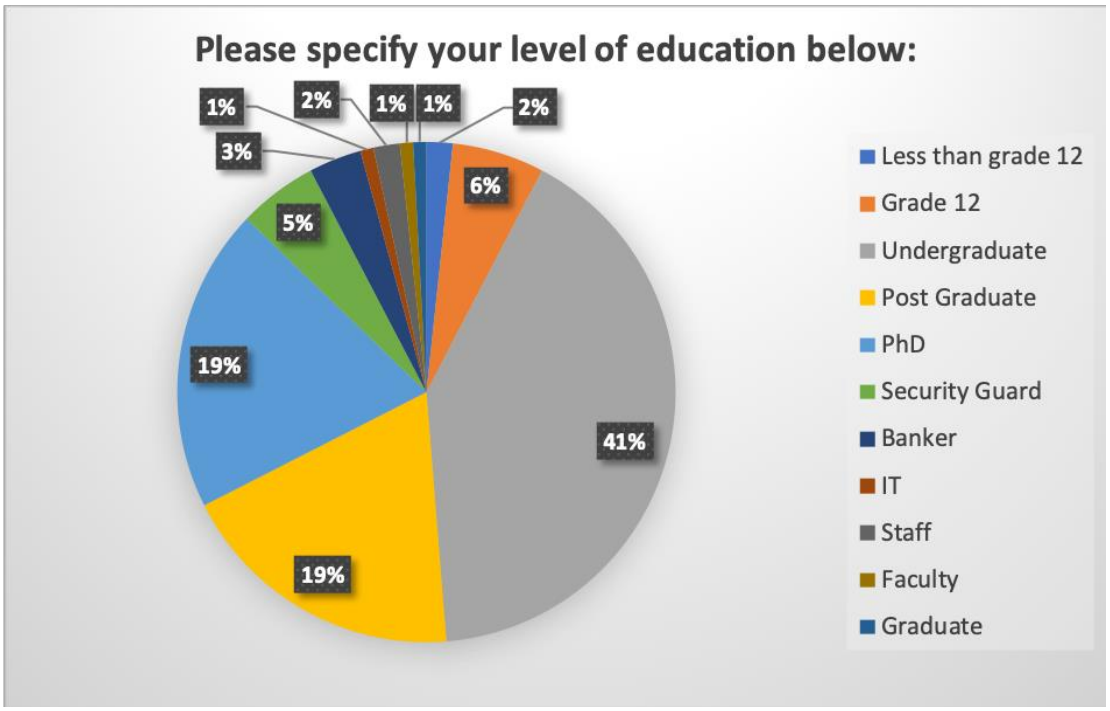

Chart 5: Education level of the participants in the survey.

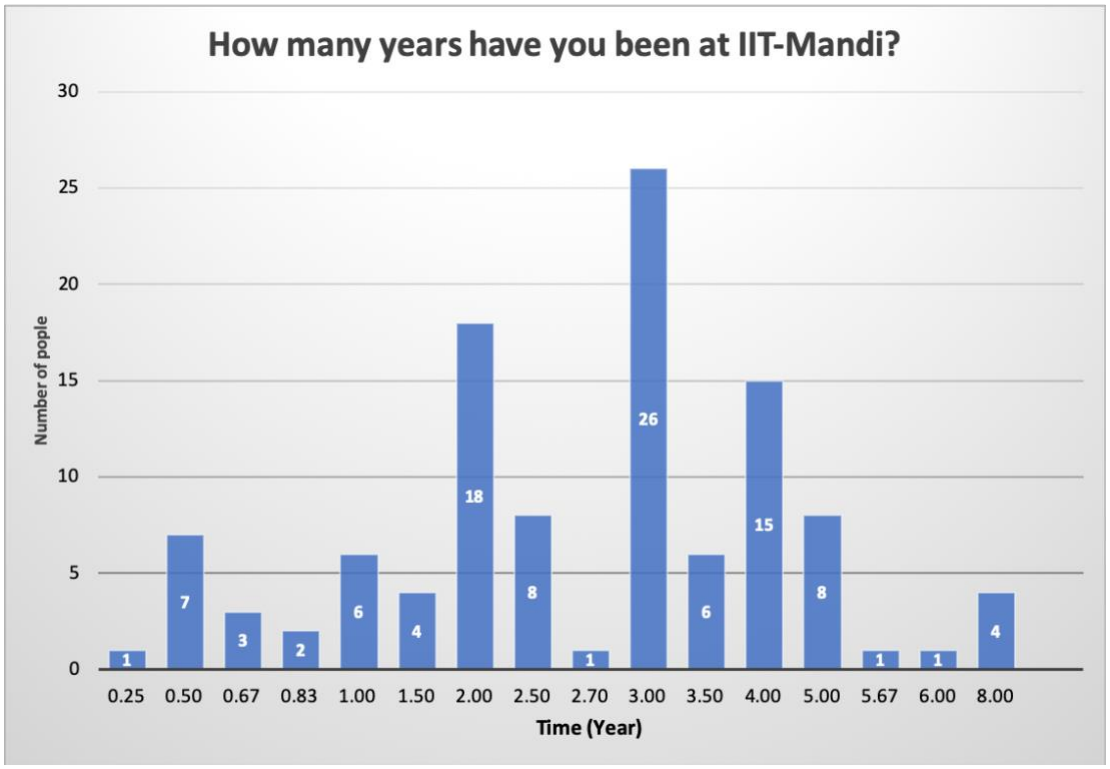

Chart 6: Number of years each participant had been at IIT-Mandi.

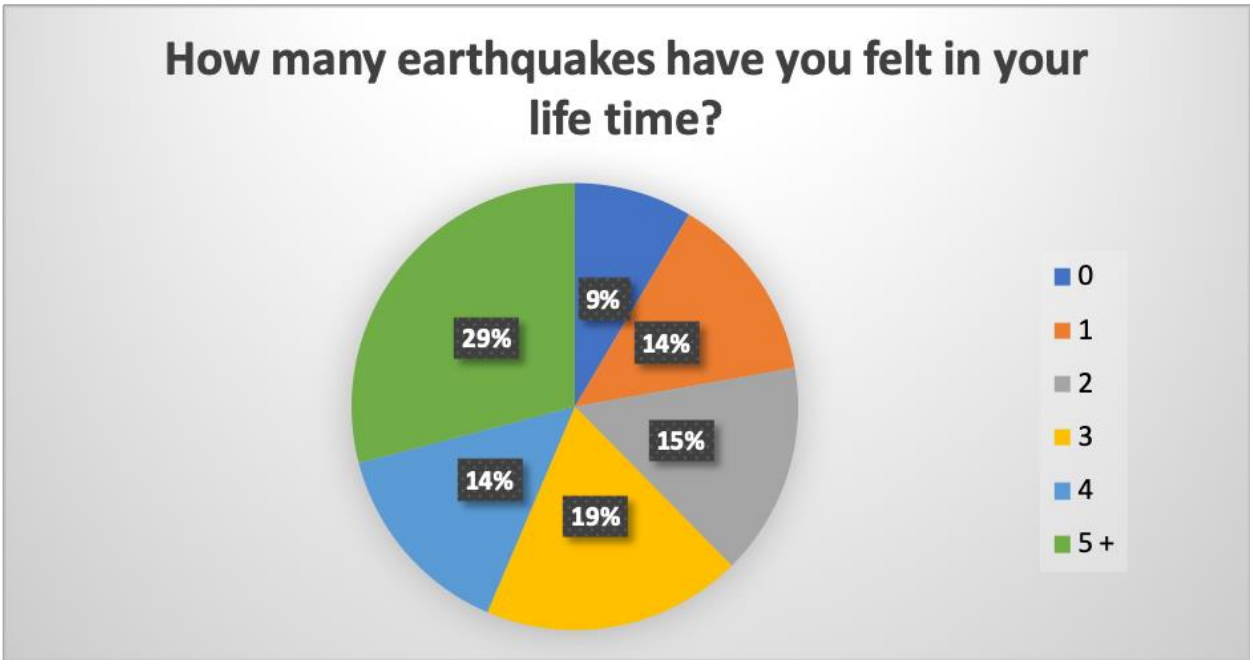

Chart 7: Number of earthquakes each participate has felt in their lifetime.

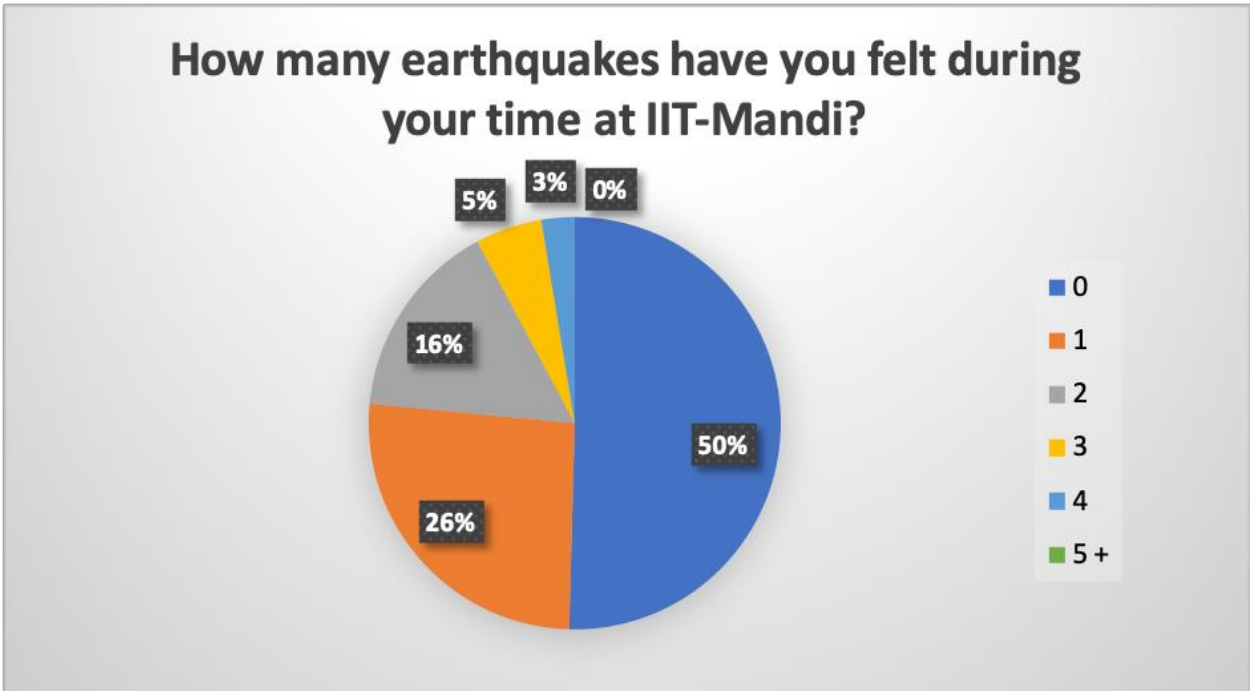

Chart 8: Number of earthquakes each participant has felt during their time at IIT-Mandi.

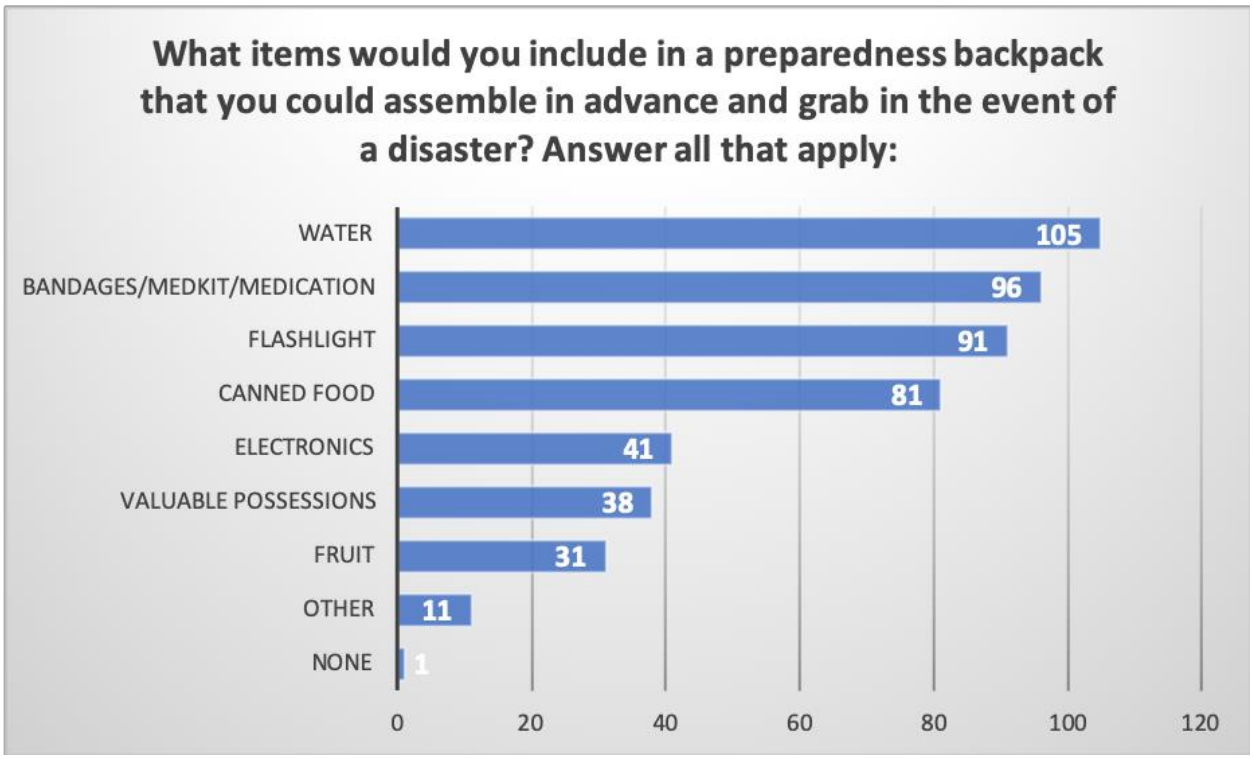

Chart 9: Items participants would include in a disaster kit.

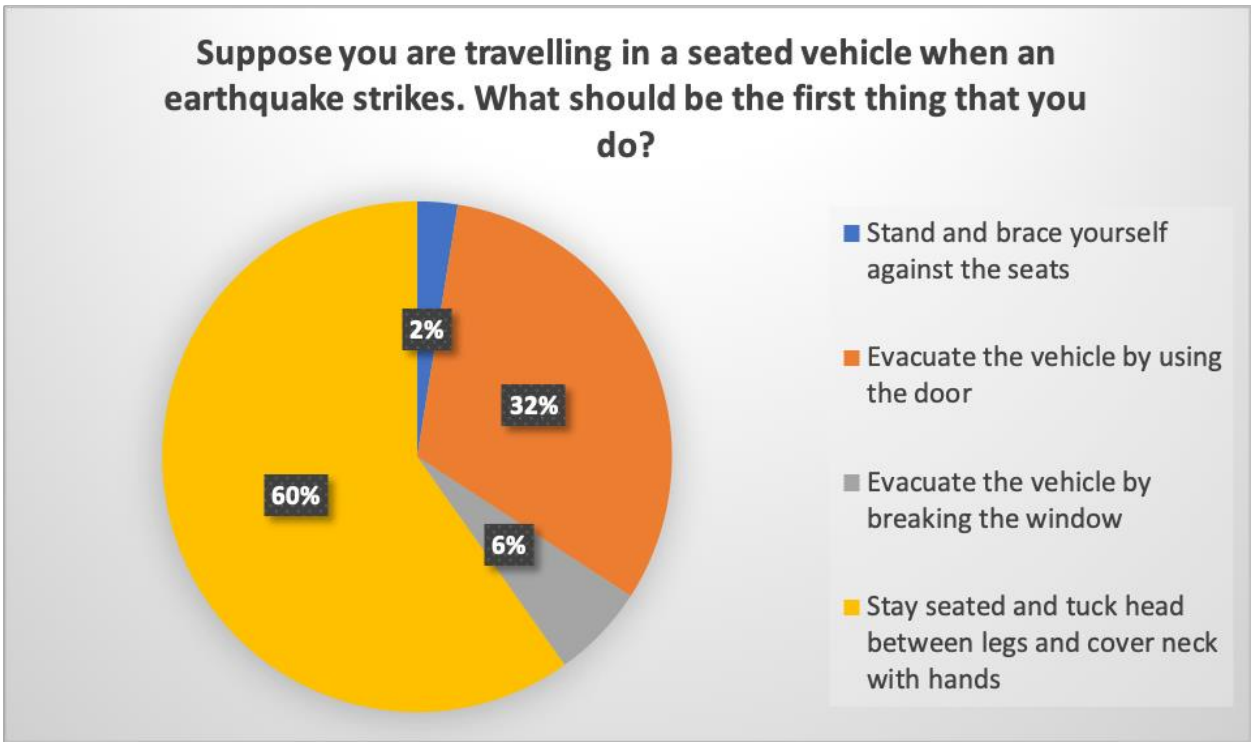

Chart 10: Response to being in a vehicle during an earthquake.

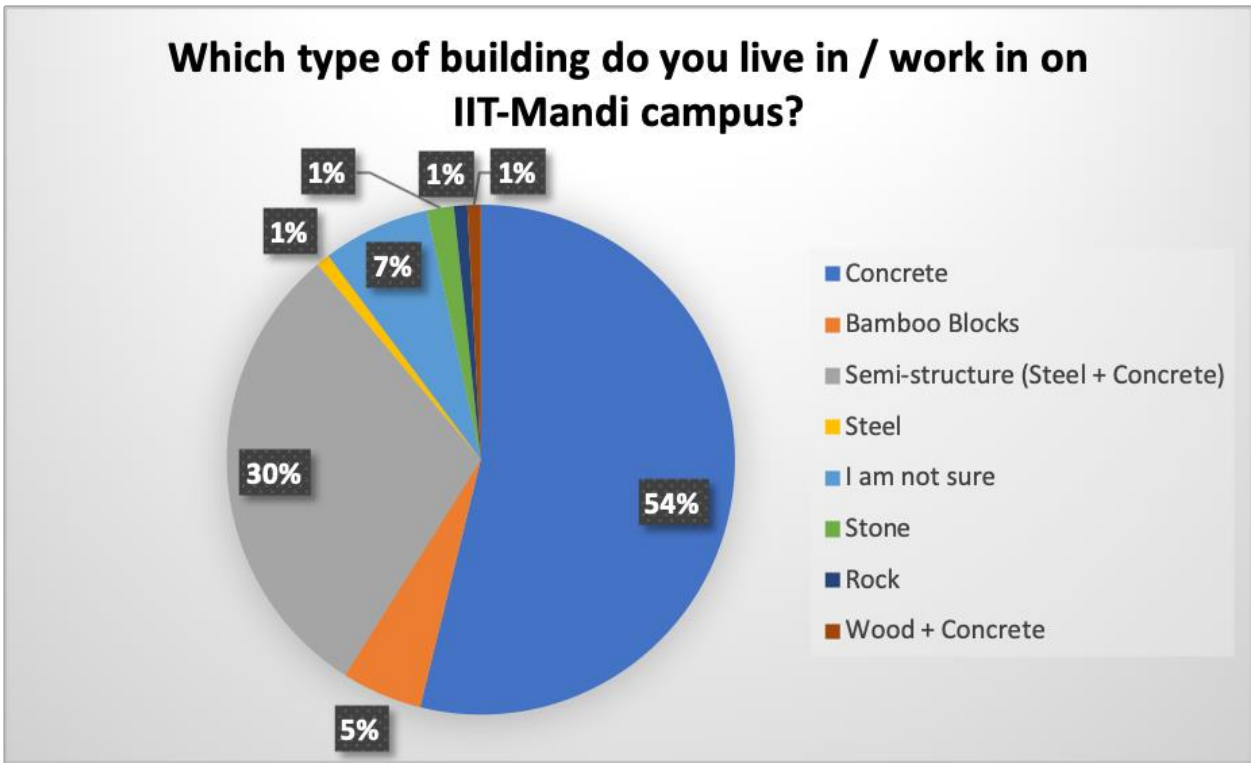

Chart 11: Type of building each participants live in on campus.

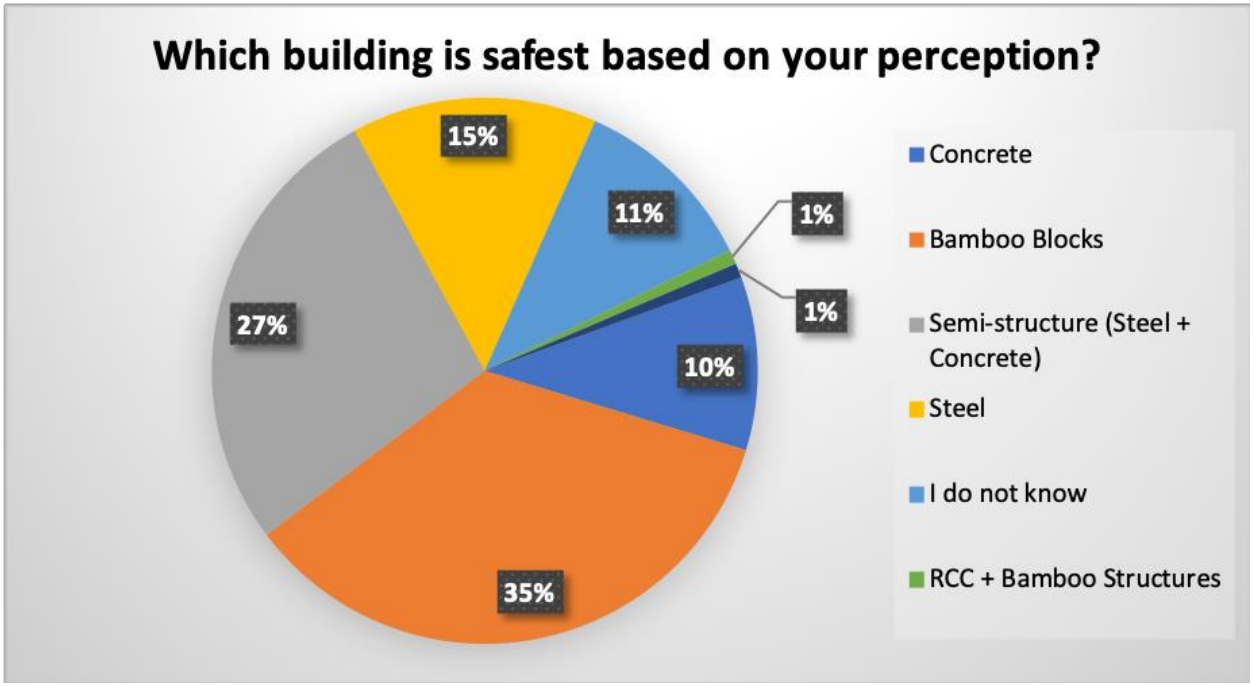

Chart 12: Perceptions of safest buildings.

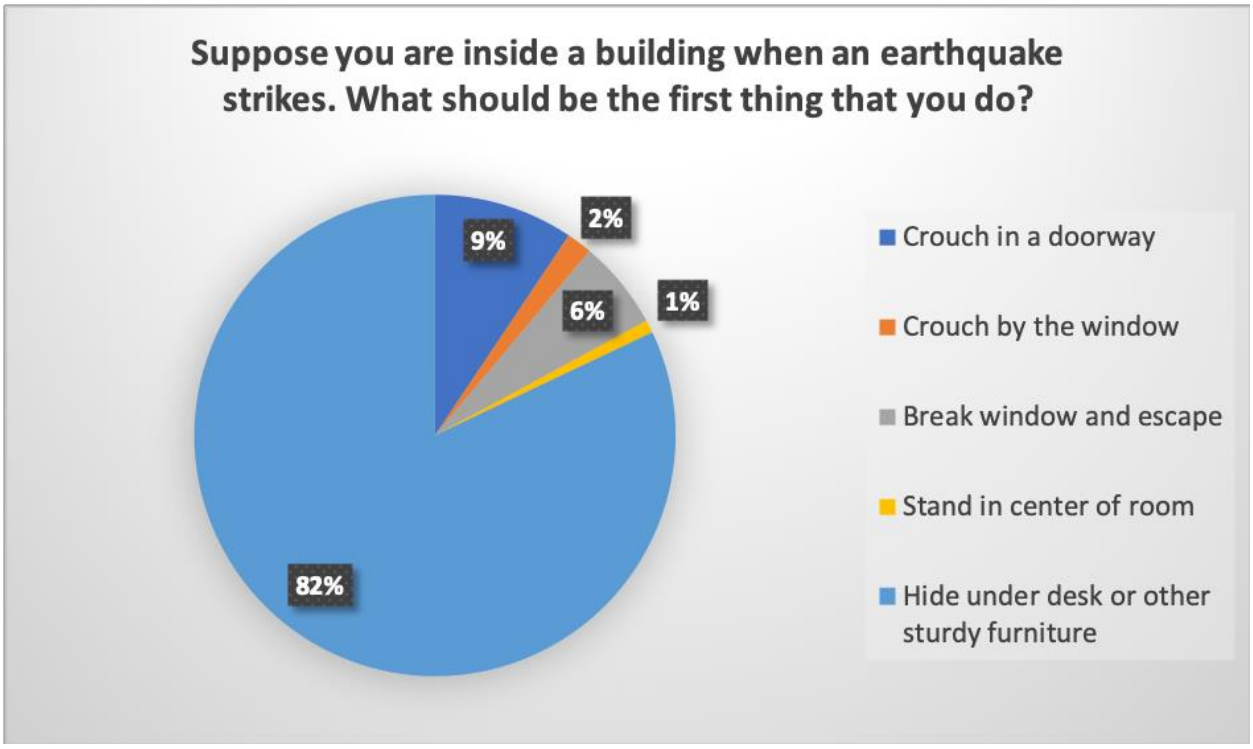

Chart 13: Response to being in a building during an earthquake.

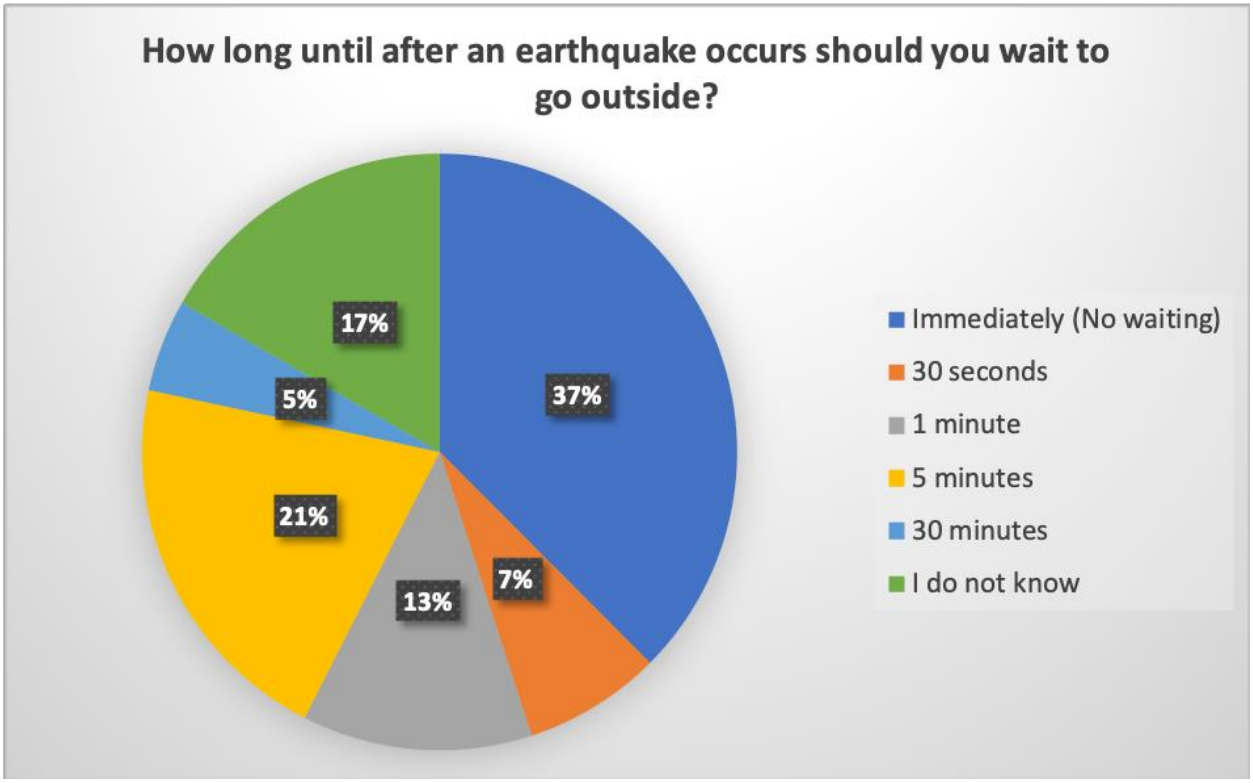

Chart 14: Responses to evacuating a building.

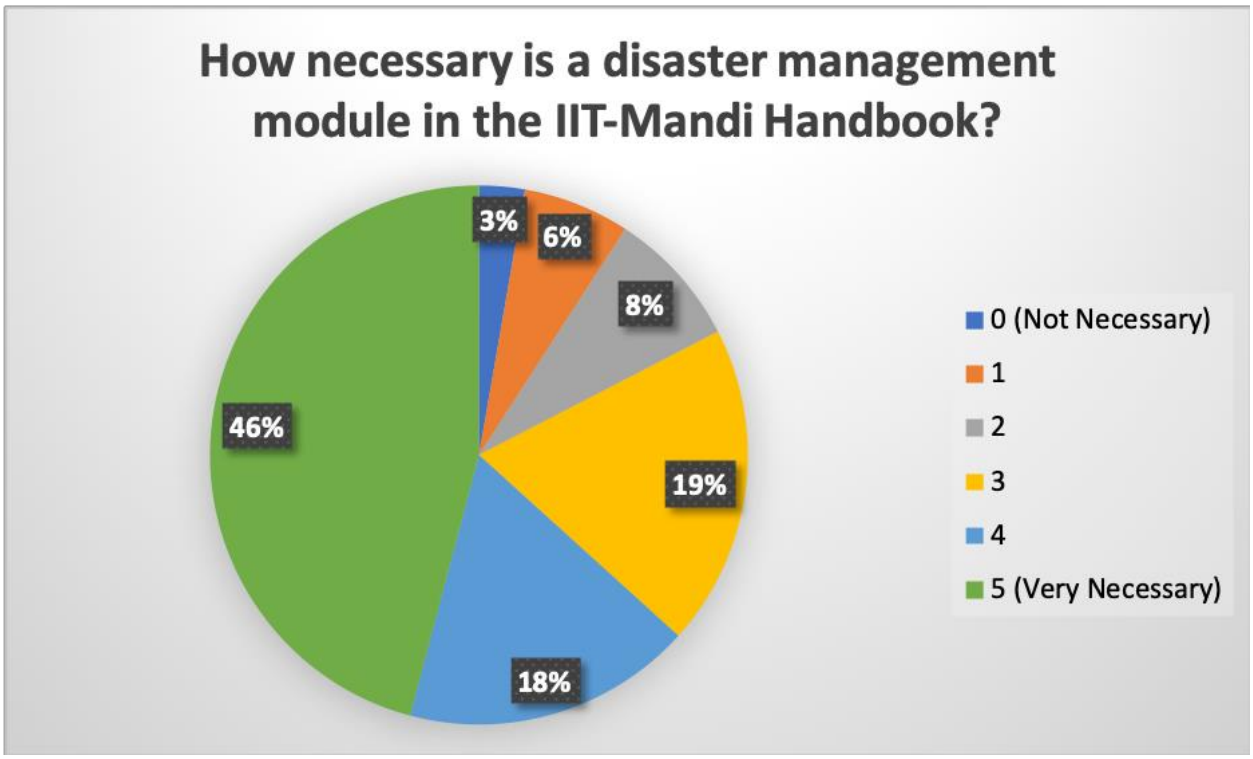

Chart 15: Necessity of disaster management module.

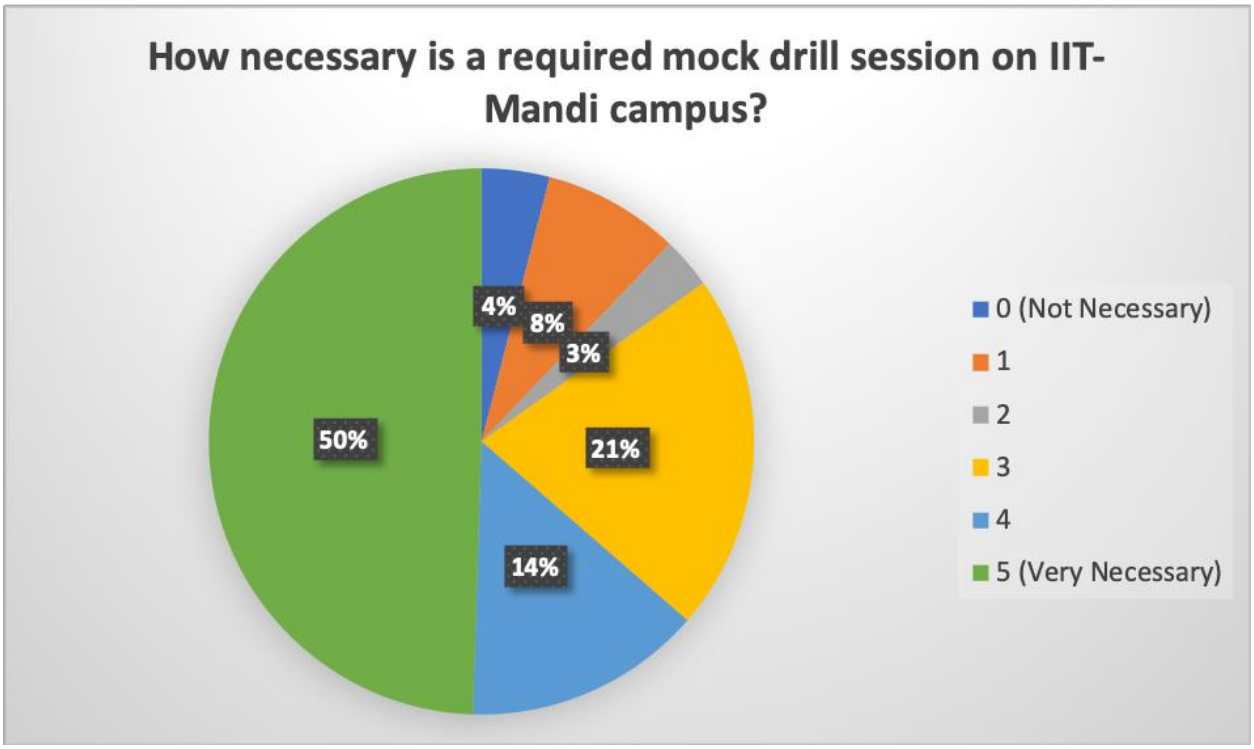

Chart 16: Necessity of a mock drill on campus.

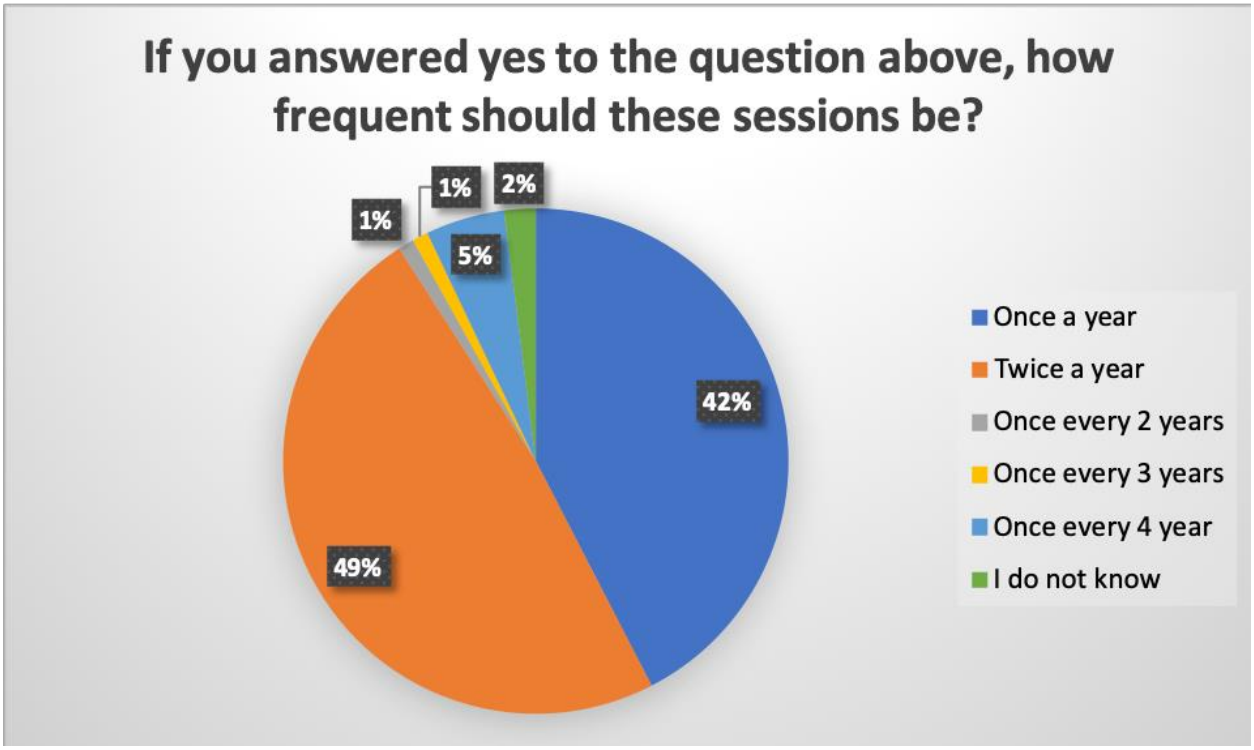

Chart 17: How often should a mock drill be implemented?

Appendix D: Poster

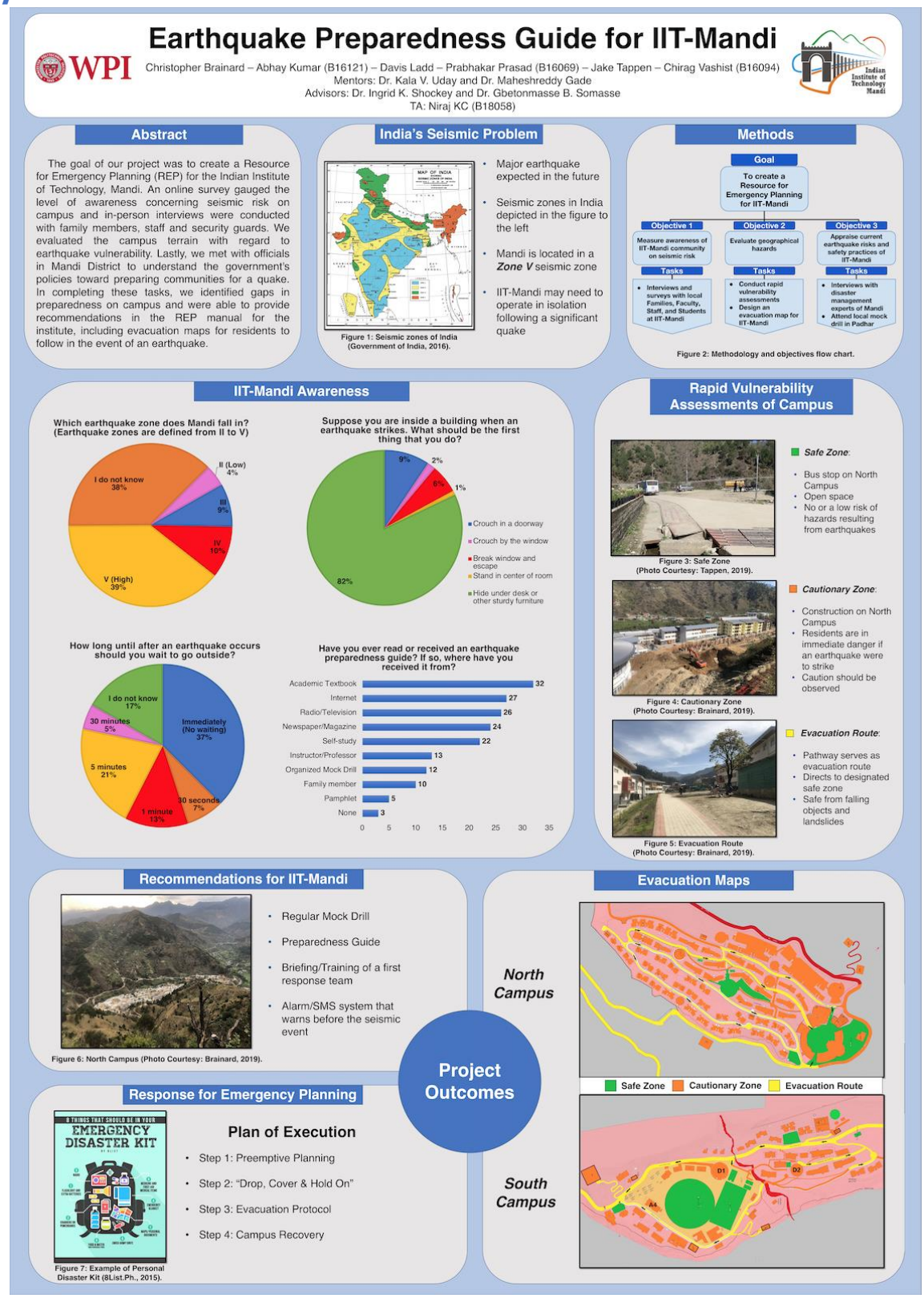

Figure 12: Open-house final poster.

Appendix E: Project Outcomes (Resource for Emergency Planning, REP)

We developed a Resource for Emergency Planning (REP) for IIT-Mandi to further aid the campus administration on implementing their own earthquake preparedness guide. In this manual, we detail key steps towards achieving this task. The manual is provided in the following pages of the appendix.

Indian Institute of Technology Mandi: Resource for Emergency Planning

Christopher Brainard – Abhay Kumar – Davis Ladd –
Prabhakar Prasad – Jake Tappen – Chirag Vashist

Table of Contents

Introduction

This document covers the recommendations that the school can adapt and develop into an earthquake preparedness guide. This Resource for Emergency Planning (REP) first covers recommended preemptive planning in Step One, including preparedness kits, mock drill requirements and school established administrative positions. Next, Step Two of the REP establishes how a school community should react to an earthquake and the necessary steps to take following the disaster. Step Three highlights evacuation procedures. The final step covers the recovery stages following an earthquake.

Step 1: Preemptive Planning

This section will largely cover how a university can prepare itself for the eventuality of destructive seismic activity on its campus. The most impactful step occurs in the preparatory stages for earthquake hazard prevention. Due to this we have outlined in detail the necessary precautions to take and begin readying an administration for an earthquake.

Securing the Building

The buildings on the IIT Mandi campus are built to withstand seismic activity, however residents can arrange furniture and non-structural components so they will not cause injury and secure items that could tip away from the wall. The best method for securing objects is using a polymer adhesive or bolting items into the walls. It is also important to be conscious of the layout of rooms so that in the event of an earthquake falling objects or breaking glass do not block your exit. Most injuries are a result of breaking glass or falling objects so separating oneself from areas where that is possible is crucial. Evacuation is only necessary if there is damage to the building or if there is a fire.

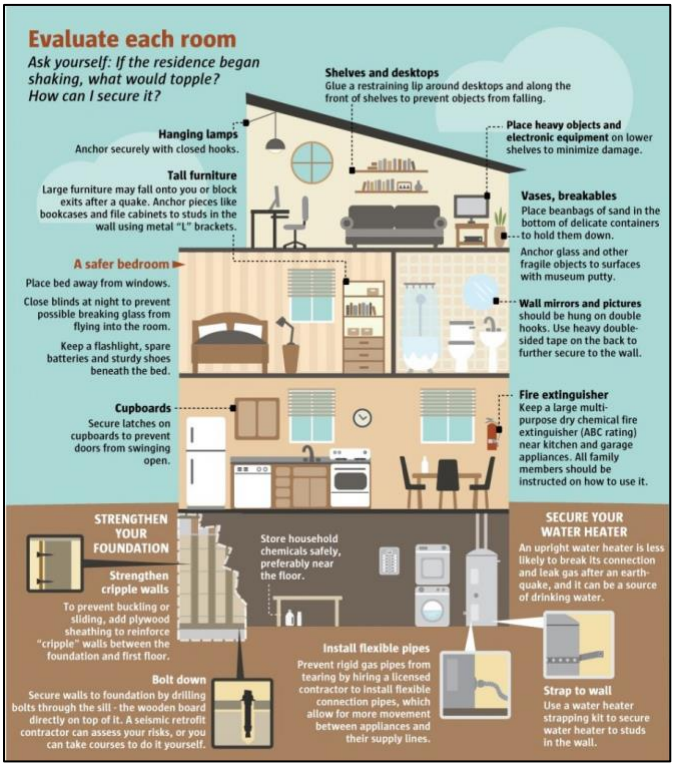

Figure 1: Hazards Identified in a Building (Emergency Essentials, 2015).

Auditory and SMS Messaging Systems

It is highly recommended that the school adopt an auditory and SMS phone messaging warning system. The Auditory alarm should be capable of being triggered by any seismic

activity automatically by detecting the non-destructive P-waves in the earth. This alarm should also be capable of being heard clearly from any part of campus even if hearing is impeded by the operation of load machinery or moderate noise cancelling headwear. This alarm should have a manual switch to be turned off by a member of the institute's administration after the event. The SMS system can be as simple as a notification message similar to the auditory message that is sent automatically at the first detection of an earthquake. This can help notify those with hearing impairments and also help bring an explanation by those disoriented by the events of the disaster.

Disaster Management Administration Recommendations

As the university develops its plan for earthquake preparedness, we recommend the development of a disaster management administration that can either be taken from the pool of current faculty and staff or hired into new positions. This hierarchy is critical because it not only helps to maintain order and allows people to feel safer, it also helps with communication to paramedic and police services and providing accurate information about the campus' condition. Below is an example of what this hierarchy may include, as well as brief descriptions of what is expected of various personnel on the IIT-Mandi campus.

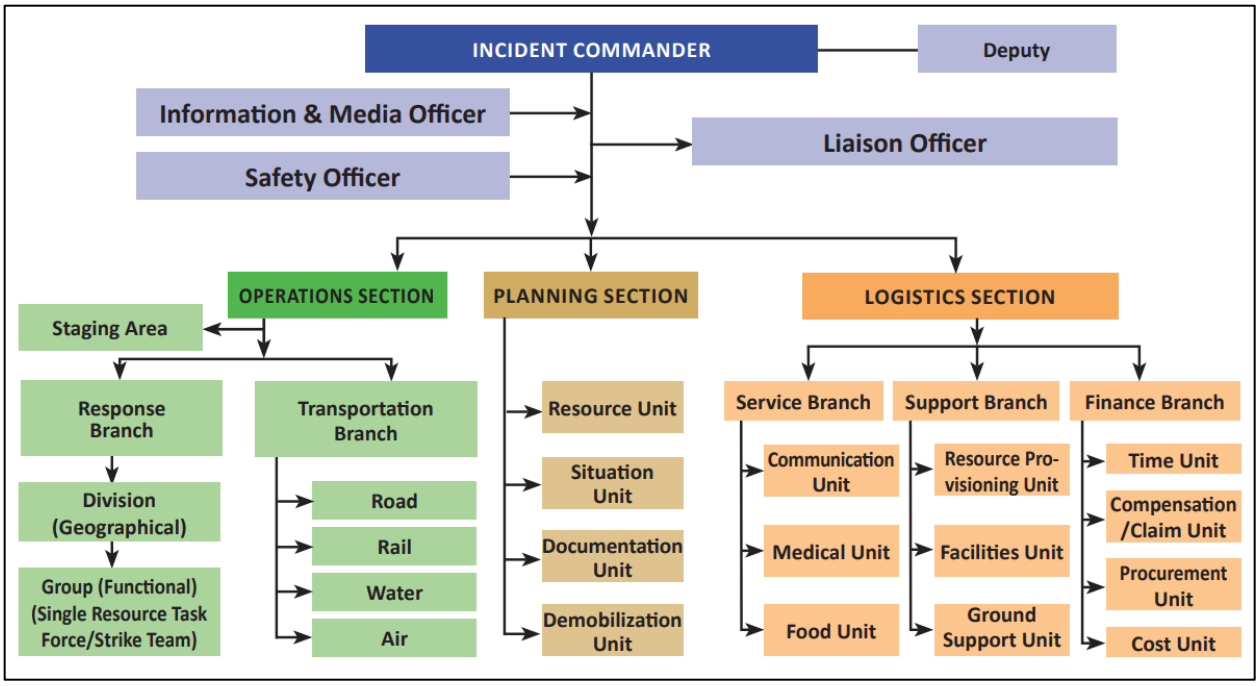

Figure 2: Example of Incident Response Teams Breakdown (National Disaster Management Authority, 2010).

Incident Commander

The role of the incident Commander is to oversee the entire operation of hazard management until command can be taken over by a government party such as the police. It will also be the Incident Commander's job to relay information to paramedics and police to

help make their job easier and oversee evacuation procedures. This position could be taken over by the director or any other administrative personnel in the school. We recommend they have experience regulating jobs and are invested in the school year-round.

First Emergency Responders (Response Branch)

As the first responders on IIT-Mandi campus, it is expected that those chosen are trained in handling hazards that occur. With this in mind, they will be responsible for directing students, families, and other community members towards the assigned evacuation routes and zones. These persons should also be educated on moderate first aid practices in case of times where medical personnel are not available. This branch should have a considerable number of operatives considering they will help oversee evacuation in all locations. This being the case, a medium for communication should be implemented that can communicate during real time events, such as a radio. One possible recommendation is that a pool of candidates from the security guard administration on campus take on a portion of this role as they are already stationed around campus. Regardless of what group takes on this role, they should meet for routine training and medical training on a regular basis. Newly hired first responders will need to be oriented by the more experienced personnel on the school's preparedness guide for earthquakes.

Educational Role

This role is not specified in the command tree above and any of the above administrative leaders, if not multiple, may inherit this responsibility. It is important that if a preparedness guide and evacuation plan are to be effective then an educational system must be in place to teach future attendants what to do in the event of an earthquake. These instructional seminars need only be taught annually or semi-annually, which can happen during times of attendant turnover like new student orientations. These educational courses should teach basic hazard safety information in order to make every community member on campus prepared for the eventuality of an earthquake.

Preparedness Kits

Implementing both personal and school emergency kits is an essential step towards efficient community planning and helps ensure that the needs of individuals can be met in the event of an earthquake. The personal kit is meant to help the individual who may have minor injuries reach the evacuation zone with minimal delay, while the school kit is meant to aid those with more serious complications.

Personal Kit

Keeping an emergency kit in your living space is an important step towards securing safety. Although that kit may not be reachable during certain times of the day it secures a plan for yourself during home and sleeping hours. A personal emergency kit should be assembled by all individuals and should include survival essentials. This kit should be stored in a safe easy to access place. The following items are recommendations for what should be included.

Personal Kit:

- Backpack or bag to hold emergency items
- At least one or two water bottles (1 to 2 Liters)
- Bandages
- Essential medications
- Emergency lights/torch with spare bulb and batteries
- Chargers/powerbanks for mobile devices
- Radio
- Non-perishable, easily opened food items
- Identification documents/maps
- Pocket knife
- Warm jacket/blanket and sturdy shoes

Figure 3: Example of Personal Disaster Kit (8List.Ph., 2015).

School Kit

The school kit should be stored near the evacuation zone or in key buildings where the hazard management administration can reach and utilize its contents during evacuation and recovery periods, that are detailed in later steps.

School Kit:

- Portable kit and cot with waterproof cover
- Colored ribbons to indicate injury level
- Blankets, sheets, pillows, and pillow cases
- First aid Bandages, scissors, and tweezers
- Plastic waste receptacles
- Disposable thermometers
- Face shields
- Assorted bandages, gauze, and adhesive tape
- Splints - long and short
- Breakable Instant Cold packs

- Emergency lights/torch with spare bulb and batteries
- Sanitary napkins and paper towels
- Washcloths and hand towels

Mock Drills

In order to best prepare a local community or district like Mandi that is prone to frequent earthquake activity, experts recommend the development of mock drills that teach not only students and children, but also adults the ideal practices for emergency situations. This is an important inclusion to the continuous education for hazard safety on campus. During these drills proper evacuation practices should be demonstrated by knowledgeable administrative parties. These drills should simulate the actions that would be carried out during an actual earthquake and it is recommended that an auditory warning system and SMS based communication system operate as they would during the actual event. The public should be notified that the event is a drill, however, there should be no deviations from actual protocols. This time can be used to teach community members safe practices that are being updated into the preparedness guide and remind people of vital information. These mock drill practices should include Steps Two and Three at the minimum.

Step 2: "Drop, Cover & Hold On"

During any seismic event, the "Drop, Cover, & Hold On" procedure should be a natural and immediate response for residents of all ages. This strategy will offer the best protection from loose or falling objects during a seismic event

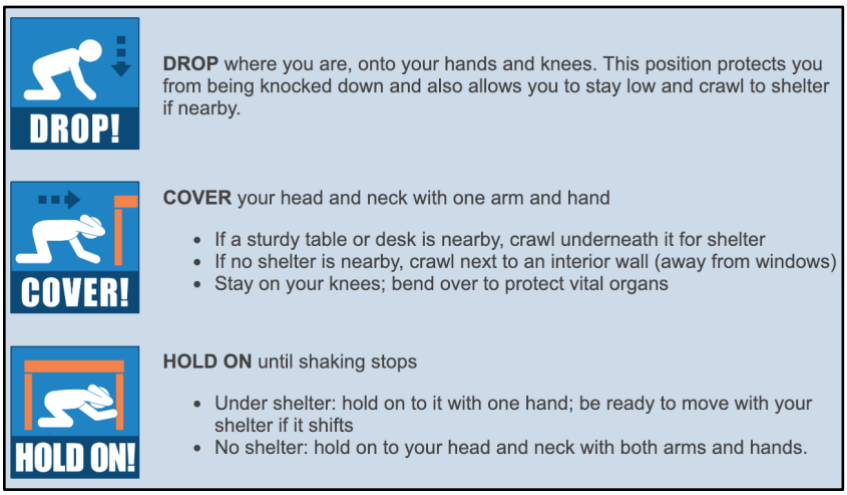

Figure 4: Drop, Cover, and Hold On Procedure (Great ShakeOut earthquake drills, n.d.).

Procedure if in a Building

- Initiate the "Drop, Cover & Hold On" procedure immediately
- Crawl to the closest piece of sturdy furniture for cover and protection from falling objects
- If in bed, cover head with a pillow to protect from injury
- If unable to proceed towards cover, grab onto a sturdy object and assume the Drop, Cover & Hold On procedure
- Wait roughly 5 minutes after an earthquake strikes to exit a building. This insures that any immediate aftershocks have passed
- Then follow the necessary procedures laid out in the Evacuation portion of this guide

Procedure if Outside

- Get low to the ground
- Check your surroundings for any electrical wires, trees, lighting poles, and attached objects from buildings that could harm you
- Initiate the Drop, Cover & Hold On procedure for the remainder of the event
- Wait roughly 5 minutes after an earthquake strikes to head towards safety. This insures that any aftershocks have passed
- Then follow the necessary procedures laid out in the Evacuation portion of this guide

Procedure if in an Automobile

- If you in an automobile during an earthquake, park the vehicle on the side of the road and wait out the duration of the event
- Resist exiting the vehicle unless there is a direct danger to your person upon remaining
- Wait roughly 5 minutes after an earthquake strikes to head towards safety. This insures that any aftershocks have passed
- Then follow the necessary procedures laid out in the Evacuation portion of this guide

Step 3: Evacuation Protocol

After the Drop, Cover and Hold On method has been carried out as the first response to an earthquake the next objective is the evacuation protocol. First assess your surroundings for nearby damage to your area. If a building is undamaged evacuation may be unnecessary. However, if there is damage to the structure proceed by following the evacuation map in a calm and orderly fashion to reach the safe zones. At these points a plan will be put in place

to recover from the hazard. Below you can find specifications for the evacuation map and recommendations for evacuating those with injuries and disabilities.

Evacuation Map

The evacuation maps below show what routes the community should take in the event of an earthquake to avoid the most potential hazards while on the North or South campus. Some important notes include that the people evacuating should stay on main pathways only and avoid alleys or moving too close to buildings. While the buildings themselves are built to code and structurally sound, the non-structural components including items moved in by residents and glass from windows are some of the leading causes of injuries during earthquakes.

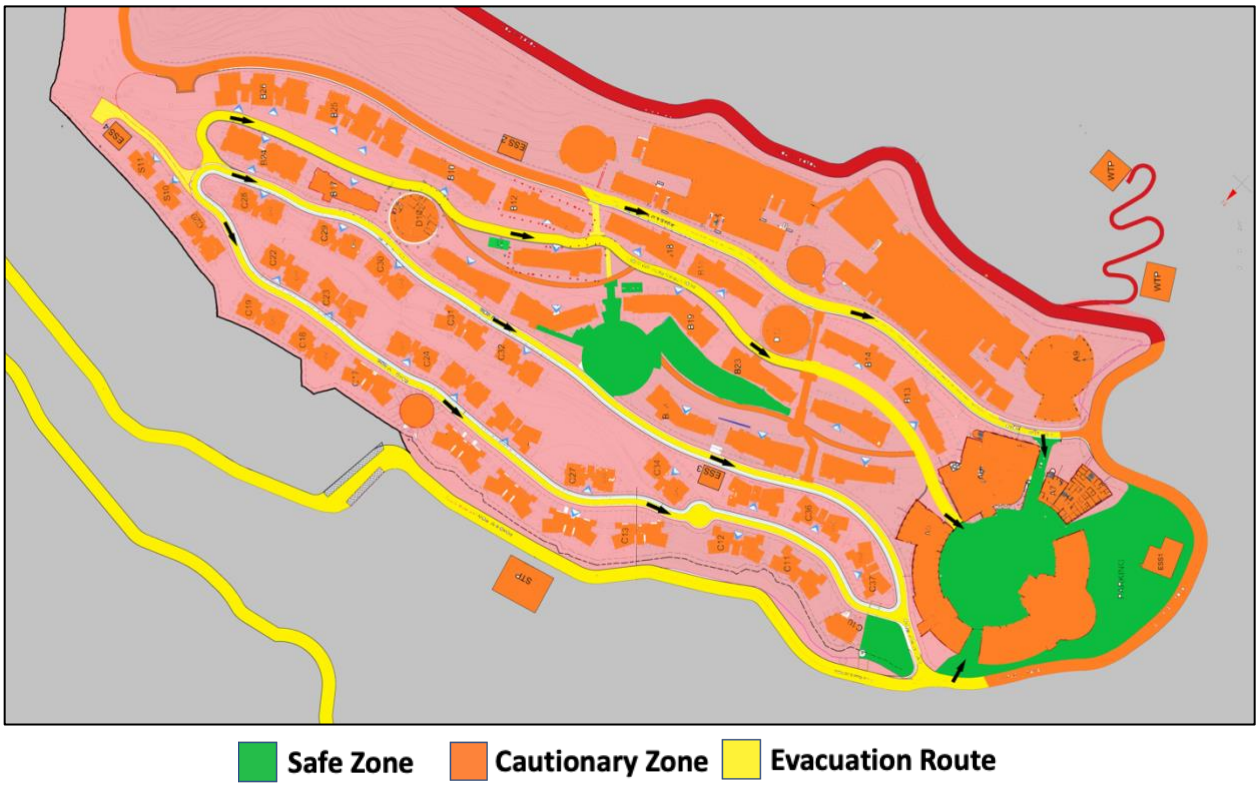

Figure 5: North Campus Evacuation Map

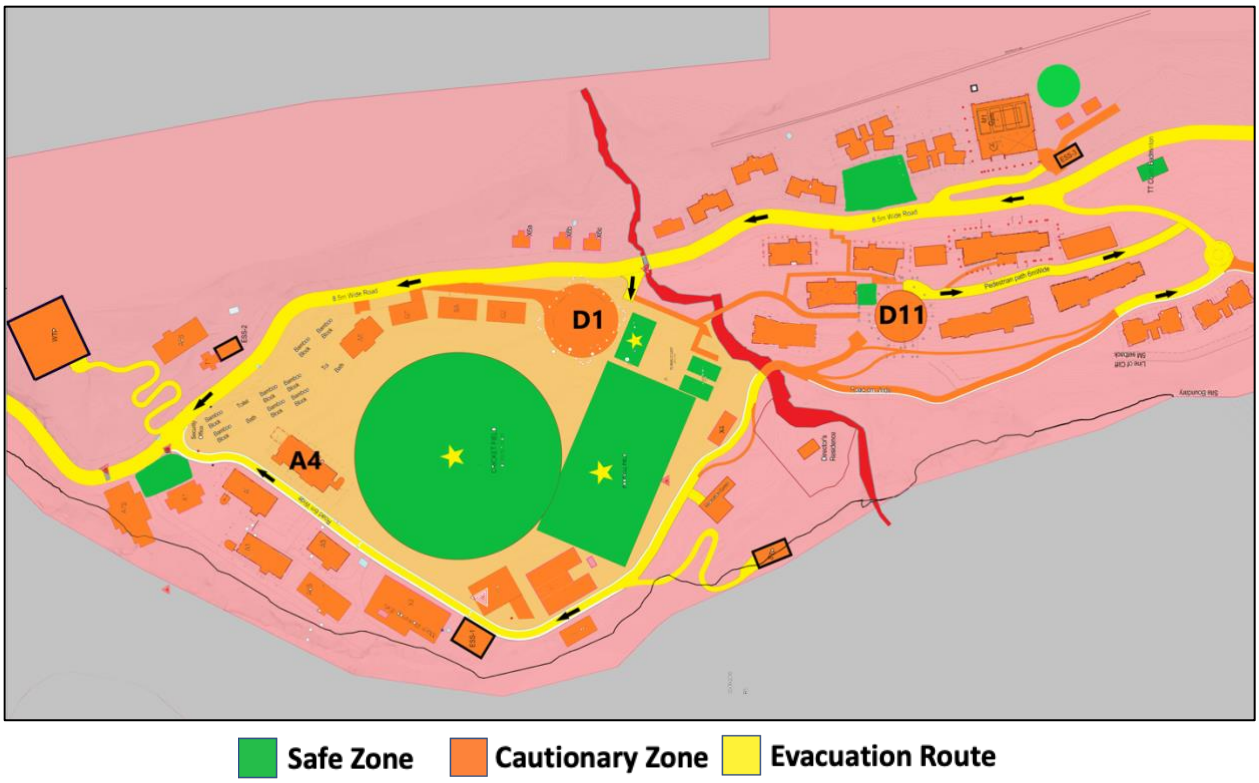

Figure 6: South Campus Evacuation Map

Evacuating Injured

Upon finding an injured person perform the basics of first aid response. First aid and medical response are an important part of any emergency plan and there should be a basic level of first aid understanding for every person on campus. This level of cooperation will aid in stabilizing those with injuries and will be very helpful when medical professionals move to treat patients. If the helping party is unable to help the injured do not risk injury to self, evacuate and get the help the injured person needs. Below we have displayed the various ways to help an injured person evacuate to the safe zones.

The Basics of First Aid Response:

- Calmly approach the injured and appraise the situation
- Ensure the approach is safe for any responder
- DO NOT move a critically injured person unless their immediate safety is in danger
- When moving an injured person, make sure to prevent any movement of the neck to minimize further injury

Proper Techniques for Carrying Those with Injuries:

- **Pack-Strap Carry** – If person is unable to walk, helper must hold both of the persons arms over the his/her shoulders. Keep a bent back to take the weight of the injured
- **Two-Handed Seat** – Two helpers form a backrest and grab each other's wrists with their other arms to make a seat
- **Two-Person Carry** – Two helpers carry an injured person by arms and legs

Figure 7: Pack-Strap Carry (Lewis & Clark College, 2012).

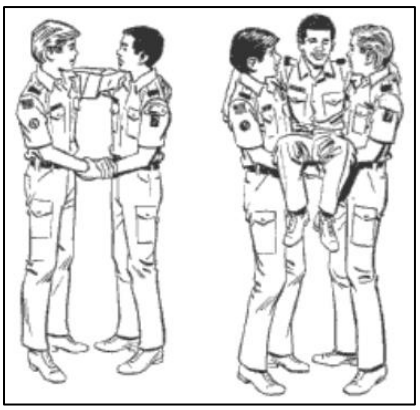

Figure 8: Two-Handed Seat (LAFD CERT, 1995).

Figure 9: Two-Person Carry (Lewis & Clark College, 2012).

Evacuating Disabled

Residents with disabilities will require additional aid during evacuation protocols. Able bodied persons can assist in this matter through the following guidelines.

- For individuals with visual impairment
  - ➢ Specify the type of disaster and offer a hand for guidance
  - ➢ Call out obstacles you encounter and when you reach the evacuation point
- For individuals with hearing impairment
  - ➢ Get their attention using hand signals or lights
  - ➢ Gesture to evacuate together or offer written instructions
- For individuals with crutches or canes
  - ➢ Can be guided or be carried out as though they are an injured person
  - ➢ Either assist and accompany them to the site or offer a chair or other furniture to carry them to a safe zone
- For individuals with wheelchairs
  - ➢ Consult with the affected person and decide whether carry them without a wheelchair is more optimal
  - ➢ Reunite the individual with the wheelchair when it is safe to do so

Step 4: Campus Recovery

The final step of our REP is a few coordination techniques once people have evacuated to the safe zones. This portion should be focused on establishing the state of the school and assessing the state of the community. This includes development of an attendance system and the drafting of a report that can be handed over to government officials once they are able to take over the hazard management on campus.

Attendance System

It is strongly recommended that an attendance system be implemented in order to help draft a missing and injured persons report. This report is extremely important and time saving for parties like incoming paramedics. Attendance can be taken from any number of ways but we recommend splitting it into subsections such as by departments or hostel numbers or even drawn up zones which are pre-coordinated with the campus administration, emergency response branch, and community members. This attendance can also be capitalized by taking down all injuries from minor to severe and can help to monitor people's conditions.

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