*16th World Conference on Earthquake Engineering, 16WCEE 2017*
*Santiago Chile, January 9th to 13th 2017*
*Paper N° 3924*
*Registration Code: S-F1464727381*

# PREPARING RESCUE AND EMERGENCY PERSONNEL TO AMELIORATE THE RESPONSE TO EARTHQUAKES (PREPARE)

F. Lanning [1], K. Miyamoto [2], A. Gilani [3], T. Nifuku [4], S. Kast [5], D. Ubico Durán [6]

[1] *PREPARE Program Director / Associate, Miyamoto International, Inc, flanning@miyamotointernational.com*
[2] *CEO and President, Miyamoto International, Inc, kmiyamoto@miyamotointernational.com*
[3] *Manager, Earthquake Engineering, Miyamoto International, Inc, agilani@miyamotointernational.com*
[4] *Project Engineer, Miyamoto International, Inc, tnifuku@miyamotointernational.com*
[5] *International Program Manager, Miyamoto International, Inc, skast@miyamotointernational.com*
[6] *PREPARE National Program Manager – Costa Rica, Miyamoto International, Inc, dubico@miyamotointernational.com*
…

## *Abstract*

The United States Agency for International Development / Office of U.S. Foreign Disaster Assistance (USAID/OFDA) Preparing Rescue and Emergency Personnel to Ameliorate the Response to Earthquakes (PREPARE) Program is a Disaster Risk Reduction (DRR) program aimed at strengthening the ability of Urban Search and Rescue (USAR) teams and key local institutions to respond to urban earthquakes by helping these teams better understand the probable impacts of earthquakes on urban areas and plan accordingly. The primary goal of PREPARE is to provide city officials and first responders with a clearer picture of the probable impact of an earthquake, build their USAR response skills and help them improve their risk management capacity. The program is taking place in two high risk cities in Latin America: San José, Costa Rica and Pasto, Colombia.

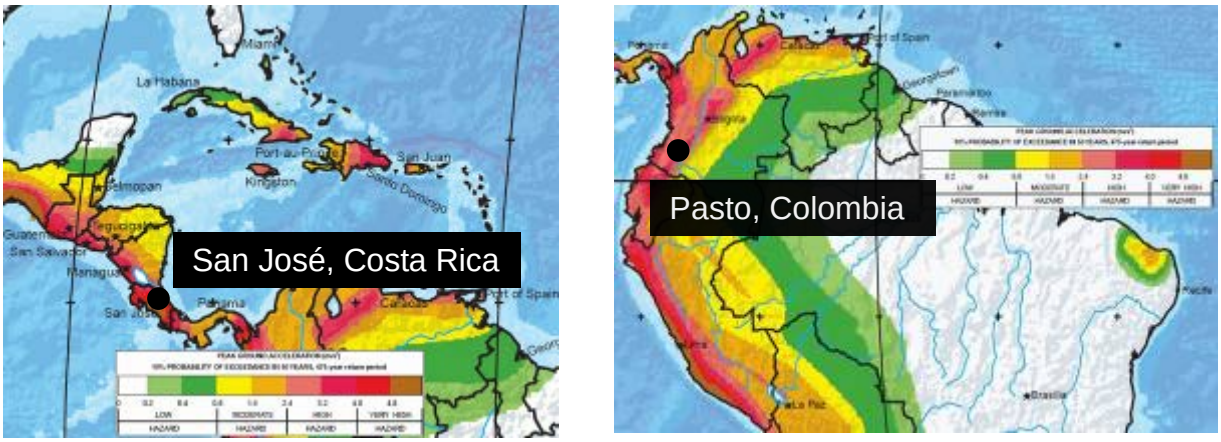
The PREPARE program has three principal components. The first phase of the program is identification of earthquake risk. This is done by studying the seismic hazards and building types to determine the probabilistic damage for each city and then will work with local structural engineers, city officials and USAR teams to identify key buildings likely to require special attention after an earthquake. This analysis also will provide critical information about the probable impact of earthquakes on the overall building stock, which can guide response planning.

The second and third phases are planning for the response, damage assessment and capacity building. In the immediate aftermath of an earthquake, local USAR teams need to know which buildings they can and cannot enter. In the days and weeks that follow, the local population needs to know if their homes are safe for occupation. City officials will need to know how to estimate volume to create a Post-Disaster Debris Management Plan to deal with the rubble a disaster generates. Based on the results of risk assessment, structural engineers and earthquake disaster specialists will work with city officials, USAR teams and professional organizations to determine how emergency responders are supported and how best to implement damage assessments. And lastly, USAR specialists will work with the local USAR teams to help them to understand and assess probable building collapse scenarios.

*Keywords: USAID; USAR; Risk; Prepare; Planning*

# 1. Introduction

San José, Costa Rica and Pasto, Colombia both are within the "Ring of Fire" area that is at extremely high risk for severe earthquakes (Figures 1-1). Urban populations have become especially vulnerable to earthquakes due to rapid and poorly controlled growth, as well as poor construction practices. While the number and severity of earthquakes has not changed, the number of people living in crowded structures not built to proper standards has dramatically increased in recent decades. As a result, earthquakes have resulted in more than 780,000 deaths in the last decade – almost 60 percent of all disaster-related deaths. (UNISDR, 2009)




Figures 1-1

The Latin American region is exposed to a particularly high level of seismic risk physically and is socio-economically vulnerable due to limited government and community capacity for risk management. Between 1970 and 2012, earthquakes in South America alone led to 77,000 fatalities. Fifteen million people were affected and economic losses amounted to $37 billion. (Global Earthquake Model, 2013) Central America is a headland serving as a fragile union between the continental landmasses of South and North America and is subject to high-magnitude earthquakes.

Not all buildings respond the same to earthquake-induced motion. In most earthquakes, the collapse of a small number of buildings causes the greatest number of casualties. Although larger buildings are the most vulnerable to seismic motion, these tend to be the best engineered and best constructed buildings. The buildings with the highest risk are multi-story buildings that were poorly engineered or built. Additionally, the overall impact of the earthquake depends on a wide range of factors including the force and frequency of the ground shaking, soil conditions and construction practices

# 2. Program Description

## 2.1. Overview

The primary goal of PREPARE is to provide government officials and first responders with a clearer picture of the probable impact of an earthquake, build their USAR response plan and help them improve their risk-management capacity.

PREPARE supports the USAID/OFDA/LAC mandate to save lives, alleviate suffering and reduce the social and economic impact of future earthquakes, especially upon the poorest and most vulnerable segments of the population who are most likely living in unsafe structures.

Through this PREPARE program, municipalities, USAR teams and other first responders can prioritize reaching populations most at risk first in the event of a major disaster. Data from past earthquakes have shown that on average 50 percent of building stock will be yellow (limited entry due to falling or other hazard) or red-tagged (unsafe to enter) following a major disaster. The loss of life and injury from building collapse or damage

thus affects 50 percent of the population. A better-coordinated and prioritized USAR response, as well as the efficient and rapid implementation of a building damage-assessment program or post-earthquake building occupancy plan, as explained above, will benefit San Juan de Pasto and San José, both defined as "high-risk." These key post-earthquake activities will also better inform disaster response, early recovery and reconstruction strategies that will benefit the entire population of the two cities.

Other direct beneficiaries include the USAR teams who will be better equipped to lead their search and rescue efforts in damaged and collapsed buildings through the training and planning tools provided.

## 2.2. Critical Assumption

The success of this project is contingent upon the following critical assumptions:

- USAR teams, and by extension the national and regional level DRR institutions and the municipalities of Pasto and San José, are eager to improve on their first-response capabilities and capacity, and will participate in and support the PREPARE initiative.
- USAR teams will dedicate time and basic resources, such as their staff time, meeting space and transport, to participate in the program.
- Critical improvements in key technical response and damage assessment capacities will result in the municipalities being better equipped to provide critical disaster support and recovery.
- Initial impact of the PREPARE program will result in long-term improvements to the capacity of government DRR agencies and the other stakeholders to effectively respond to disasters by effectively implementing knowledge transfer to key institutions and sustainable recommendations to the national, municipal, and local disaster response teams.

## 2.3. Strategy

When engineers are deployed to assist in the immediate aftermath of an earthquake, they often find local government officials and first responders who are overwhelmed by the scope of the disaster and are therefore receptive to support and technical assistance. PREPARE is designed to increase DRR capacity and help speed the initial response by USAR teams, resulting in more lives saved and more injured people rescued.

The following methodology has been employed in San José and in Pasto, with adjustments to fit local circumstances:

- Situational analysis and determination of the probable earthquake scenarios
- Planning sessions and coordination meetings with local institutions
- Training and technical assistance for the USAR teams and other stakeholders

The PREPARE program began in San José, Costa Rica in November 2015 and, six months later, in May of 2016 commenced in Pasto, Colombia. Program activities ran or will run for at least 12 months in each location, implemented in three phases in each location. The phases roughly correspond to each of the program components.

# 3. Program Phases

The PREPARE Program is broken into three phases.

## 3.1. Phase 1: City-wide Earthquake Risk Assessment

Phase One of the program was to determine the earthquake risk to both cities. This is done by first dividing the city (in San José's case, the city limits are bounded by rivers) into homogenous zones of similar building types (Figure 3-1). For example, one zone could be mostly one or two story residential homes, then another could be 3-7 story commercial buildings.

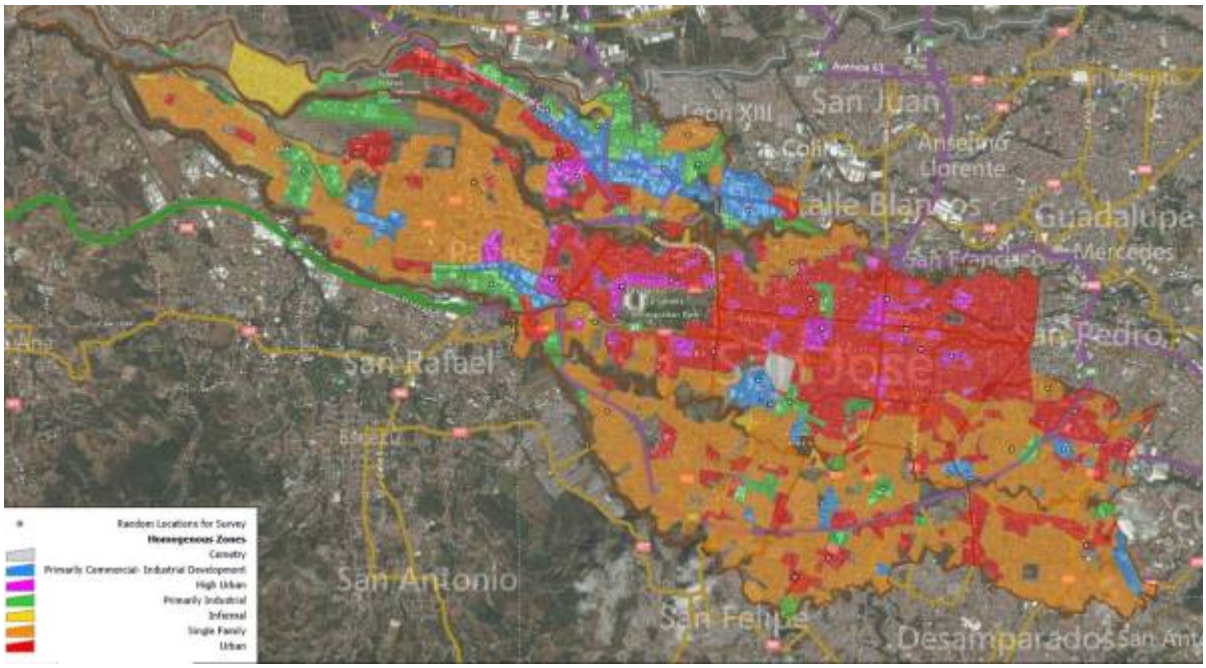



*Figure 3-1, Homogenous zones of the City of San Jose, by building type.*

Once the city was divided into these homogenous zones, field surveys were then conducted to sample the type of buildings in each zone (Figure 3-2). In other words, teams would randomly select 15 to 20 buildings in each zone and input what type of construction the building is (masonry, RC frame, steel, etc.), number of stories, era of construction, the occupancy type (est. number of people), etc. All of this is done using Android tablets that also record the GPS coordinates and photos for archiving (in case back-checking is required).

*Figure 3-2, Costa Rica Firefighters and students conducting building sampling surveys.*

Once all of the sampling is completed, fragility curves that estimate the seismic performance of the different types of buildings for the region (Central and South America), combined with the seismic hazard and micro-zonation maps, we then were able to estimate the performance of the city's building stock.

Figure 3-3 is an example of a fragility curve. Based on the curve, if we were to have 'Strong Shaking' on this type of building, then we would expect about 20 percent of the buildings to be completely collapsed, about 50 percent with 'extensive damage' and the rest with moderate damage. If we were to have weak shaking, then we would only expect slight damage to 99 percent of the buildings.

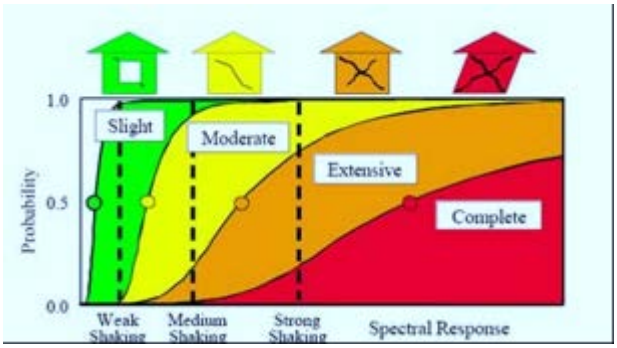



*Figure 3-3, A typical fragility curve*

On top of the building damage estimates, we overlay census data. So for example, if we knew 40% of the buildings in one zone will be completely collapsed, and know the population in that zone, then we know about how many people will probably be dead or critically injured. This more or less gives us a casualty distribution of the city and estimate numbers.

At the completion of the risk assessment and thinking on a macro-scale, we will know which neighborhoods will have more casualties and building debris than others. Figure 3-4 shows the fatalities if the earthquake were to happen at 12pm (noon) on a weekday. TL is the Total Loss in the Canton of San José.

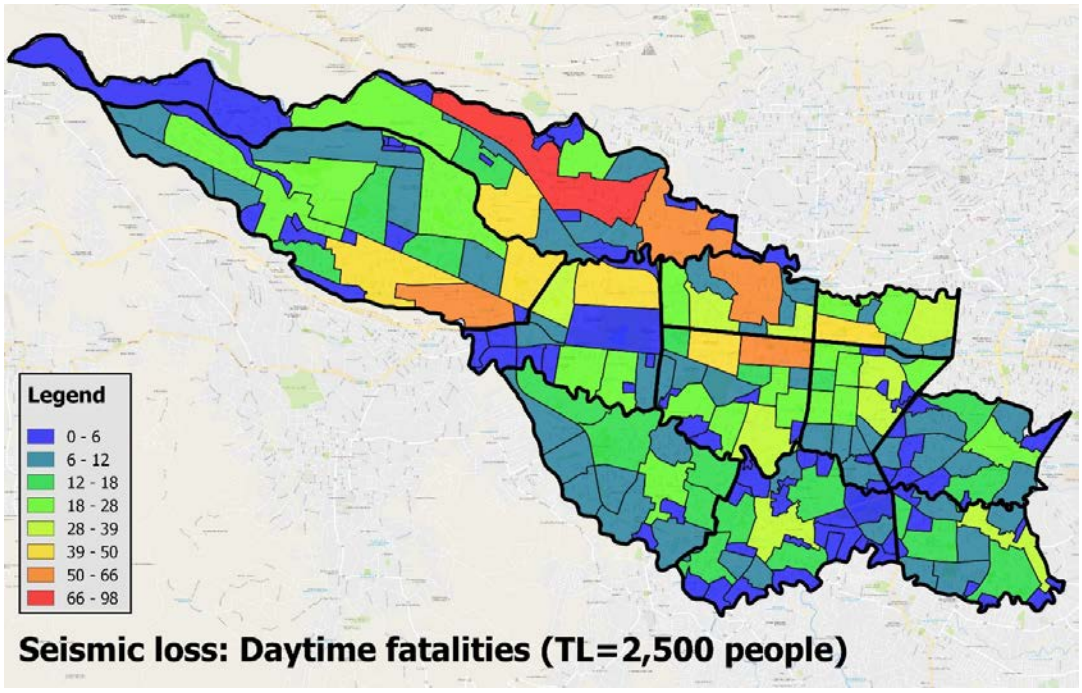



*Figure 3-4, Example of a Casualty Distribution map (Canton of San José, Costa Rica)*

Using these casualty distribution maps, we were able to work with the both the Costa Rican and Colombian governments on developing a response plan for USAR, debris management and post-earthquake rapid assessments.

## 3.2. Phase 2: Analysis of Earthquake Scenarios and Planning for Response

As part of Phase Two, the program team and partner organizations will jointly analyze several earthquake scenarios based upon the Phase One risk assessments and then review plans, policies and practices for the response including rapid damage assessments and debris management. This analysis will contribute to efforts to help partner organizations understand the probable impact of the next earthquake depending upon the time of day of the event, the day of the week and other factors. These potential risks can then be taken into consideration when reviewing and revising their Disaster Risk Reduction (DRR) policies and practices.

The development and analysis of earthquake scenarios is common practice in the United States and in many other countries. This activity can be useful as part of the review process of existing DRR policies and procedures and may result in modifications and improvements in preparedness and response for future earthquakes. Earthquake scenario results may justify reallocating some financial resources to retrofit high priority existing structures, make revisions in building code enforcement procedures and promote an increase in public awareness of the potential impact of future earthquakes. Experience in many countries that have experienced strong, destructive earthquake indicates that the cost of retrofitting structures and other preventative measures is often much less than waiting until after an earthquake takes place and then dealing with the immense costs of major reconstruction work.

Appropriate uses of a well prepared earthquake scenario include:

- Revisions in post-disaster first response plans.
- Revisions in rapid building damage assessment procedures.
- Establishing a post-earthquake debris management plan.
- Identification of vulnerabilities to building structures and critical infrastructure.
- Prioritization of preparedness efforts.
- Understanding potential impact on financial and social systems.
- Development of retrofitting strategy for high priority structures including airports, bridges, schools and hospitals.

## 3.3. Phase 3: Capacity Building and Training

Phase 3 included training on probable behaviors of buildings in seismic events (based on the probabilistic earthquake scenarios) with a special focus on expected structural damages. This was done by allowing partner organizations understand where in the city high concentration of structural damage may occur and how to plan accordingly. Presentations to first responders and local USAR teams focused on how to differentiate significant structural damage from architectural damage and what type of collapsed building they will most likely face. Training, round-table discussions, workshops and planning sessions with key partners and USAR teams were conducted to understand what the current capacity the first responders and USAR teams had and assist with revisions to improve policies and procedures for more effective earthquake response. The focus of the policies and procedures improvement workshops was to get the first responders and USAR teams closer to having the capacity to affectively deal with the magnitude of destruction in the days before international emergency response teams arrive.

New techniques for very rapid preliminary building damage assessments based upon recent experiences in Haiti, New Zealand and Nepal and other countries was also presented. Training was also provided on how to estimate the quantity of debris from damaged and destroyed buildings. Training modules prepared for the stakeholder workshops for the damage-assessment phase covered: lessons learned from damage assessment surveys in other countries and the logistics for organizing damage-assessment surveys, and tools and methods for damage and debris-volume assessment. One of the most important outcomes of Phase 3 was to allow the host government an

understanding of where its response plans and capacity currently stands at in light of the possible post-earthquake scenarios.

## 4. Conclusion, Exit Strategy and Future Steps

PREPARE is designed to strengthen the local government's current capacity of responding to a major urban earthquake. By knowing the likely post-earthquake scenarios the city will face ahead of time, the partner organizations will be stronger as a result of the training and technical assistance received that was based on these scenarios. The new knowledge gained by all stakeholders, USAR teams, central government, municipal officials and staff, existing DRR institutions, university staff and students will be passed on to a larger number of stakeholders in the future. It is anticipated after completion of the program that the knowledge gained by the municipal officials the program worked with will be passed on to adjacent municipalities. Recommendations provided through PREPARE upon completion of the 18-month implementation will forge a clear path to stronger DRR institutions in the future.

A future step may consist of partnering with the host government on forming a training and certification system for engineers to conduct post-earthquake rapid assessments as a system does not currently exist. Another possible future step is expanding the scope area to include adjacent Cantons to completely cover the greater San José Metropolitan Area.

## 5. References

Global Earthquake Model. (2013). *Global Earthquake Model - Publications*. Obtained from Global Earthquake Model: https://www.globalquakemodel.org/

UNISDR (2009). *Earthquakes caused the deadliest disasters in the past decade*. Obtained from UNISDR and Centre for Research on Epidemiology of Disasters: https://www.unisdr.org/archive/12470