The Critical Role of Risk Communication And Emotional/Psychological Knowledge In Disaster Response for Engineers: A Tale from the Mexico Earthquake of 19th September 2017.

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Mexico City is Mexico's capital, a city rich in history and color that has extraordinarily unique characteristics as a result of its historical development and changing terrain, posing challenges for infrastructure, disaster risk managers, and citizens.

On the city's foundations, myth and reality are entwined. According to sources from the XVI century, several tribes migrated from Aztlan in search of a designed event announced by Huitzilopochtli (one of the main deities in prehispanic mythology), an eagle eating a snake on top of a nopal (type of cactus) would be the location for the city to be built. Thus, they migrated from Aztlan until the signal was finally discovered on an island in the middle of Texcoco lake (**Error! Reference source not found.**).

Figure 1

Reconstruction of Tenochtitlan, the capital of Aztecs – the center of modern Mexico city.

Note. This figure shows the lands surrounded by lakes on which Mexico city was constructed. Retrieved from commons.wikimedia.org, by rosemanios, 2008, https://commons.wikimedia.org/wiki/File:Reconstruction_of_Tenochtitlan2006.jpg, CC 2.0 [rosemanios, 2008]

Later on, as a result of the Mexicas' economic activities and military might, the city grew to become the great city of Tenochtitlan, the head state of the Mexican empire, and one of the largest cities in the world at the time, dominating a large portion of what is now Mexico, until its eventual fall to Cortez and the Spanish conquest, primarily due to the spread of diseases brought by Spanish people and used during the siege (Figure 2).

Figure 2

The Conquest of Tenochtitlan

Note. This image illustrates the fall of Tenochtitlan during the Spanish conquest. Author unknown, second half of 17 century, Wikimedia commons, https://commons.wikimedia.org/wiki/File:The_Conquest_of_Tenochtitlan.jpg, Public domain. [Unknown, 2009]

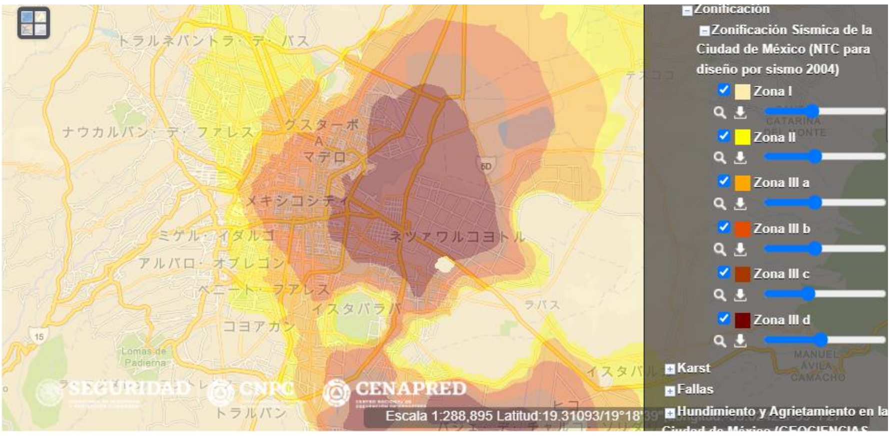
Following the conquest, Mexico City was rebuilt over the ruins of the great Tenochtitlan, using the same rocks for their structures and burying their temples in the ground, transforming the city into the capital of the Viceroyalty of New Spain, the center of the Spanish government in America, until 1810, when it gained Independence.

From its founding, this city has been a vital cultural and economic hub for the region and the country, eventually becoming the capital of the country as a free and independent state and growing to become one of the world's largest cities with over 27 million inhabitants.

According to its geography, the city is located within a valley that extends over a variety of soil types, ranging from dried lakebeds to rocky areas covered in volcanic material caused by the eruption of Xitle volcano (a nearby volcano) and transition soils in between. As a result, the city's soil map varies throughout the city, which means that in the event of an earthquake, the ground will experience varying accelerations depending on the type of soil in which the building is located (**Error! Reference source not found.**).

Figure 3

Types of soil at Mexico city.



Note: Adapted from the National Risk Atlas, 2022, http://www.atlasnacionalderiesgos.gob.mx/, Public domain. [Atlas, 2022]

Mexico City's seismic behaviour is also quite unique; due to the extraction of underground fan and sediments from its ground, a sinking effect is visible in the city's center, as well as an amplification effect on the terrain accelerations caused by earthquakes, even if the movement occurs far away from the city. In order to prepare for those possible scenarios, the city has had an early warning system in place since 1989. This system allows the city to receive alerts up to 50 seconds or more in advance of fan incoming movement, triggering a public message that is broadcast over 12,826 public speakers throughout the city.

The earthquake that altered the course of Mexico's history

On 19th September 1985, one of the most dramatic events in the country's history occurred in the form of an 8.1 magnitude earthquake with an epicenter in the Pacific, where the Cocos tectonic plate collides with the North American plate, the location of the majority of the country's earthquakes.

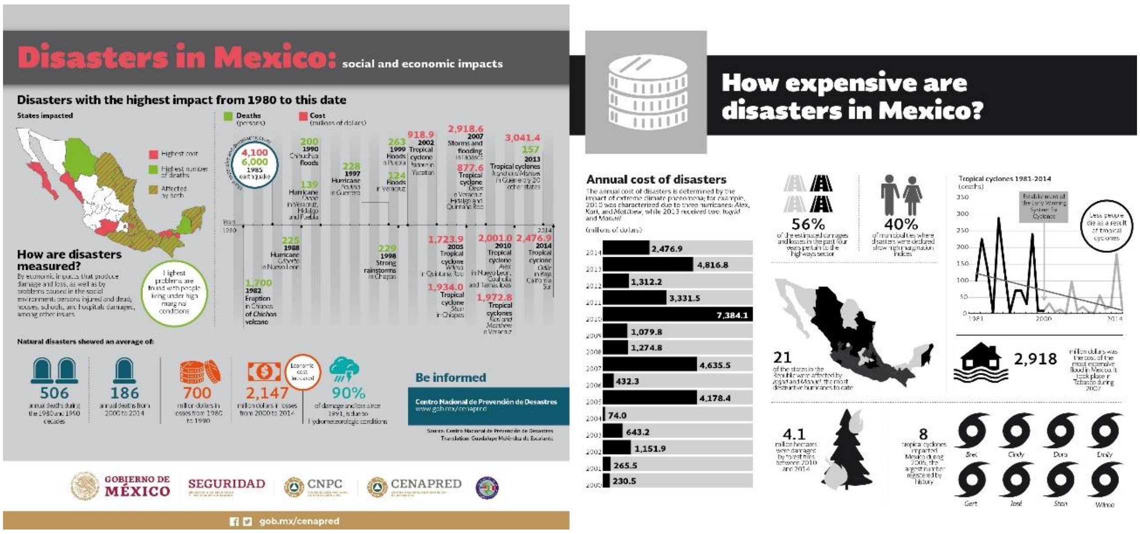
That morning, without an early warning system and with people commuting to work (7:19 a.m.), the wave that hit the city resulted in the collapse of over 400 buildings and the death of over 6,000 people, according to official estimates. The event and its subsequent aftershocks wreaked havoc on the city's basic infrastructure, affecting millions of people. At the time, the event's total cost was estimated to be around 4,100 million dollars (**Error! Reference source not found.**).

A fascinating fact about the seashore where the Cocos and North American plaques collide, near the estimated epicentre of the 1985 earthquake, is that a 200-kilometer stretch of that seashore has not experienced significant movement in the last century. This space is known as the "Guerrero Gap," and scientists believe that due to the long period of silence and the seismic behaviour of the rest of the seashore, it could be a potential location for the next major earthquake (**Error! Reference source not found.**). The SATREPS project is currently being conducted in collaboration with the Japanese government.

Models estimating the accelerations that could occur in the city as a result of that event indicate that some locations within the city could experience between 451 and 550 gals, as indicated on the map (Figure 5).

Figure 4

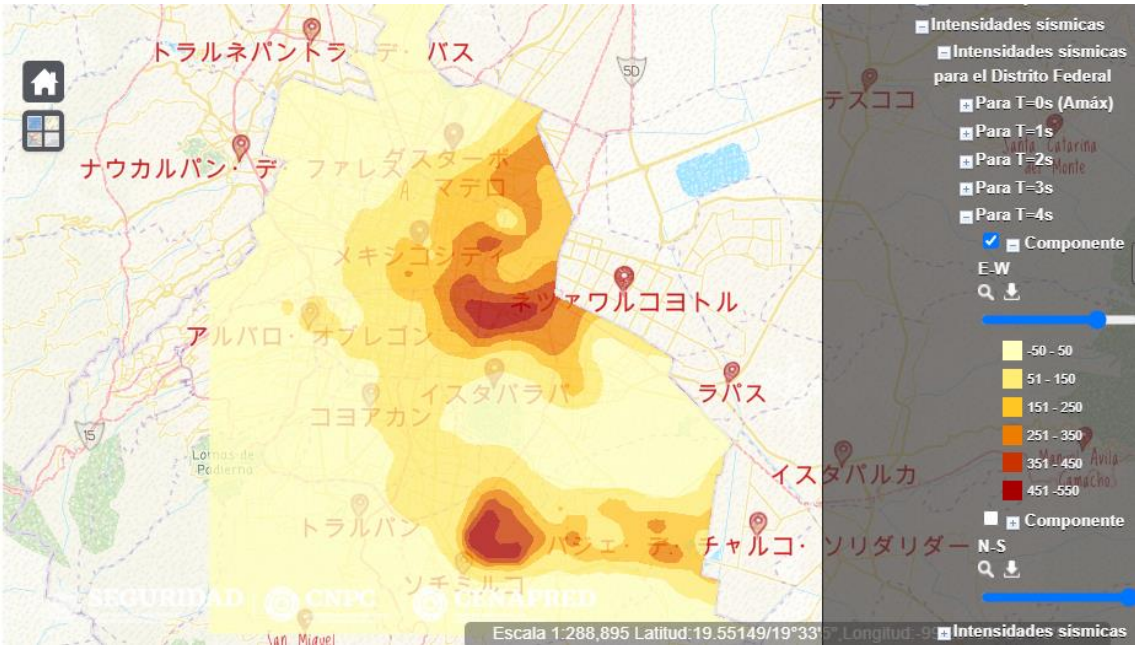
The cost of disasters in Mexico



Note: This infography shows the cots of recent disasters at Mexico, CENAPRED, 2014, http://www.cenapred.unam.mx/es/Publicaciones/images/318-INFOGRAFADESASTRESENMXICO-IMPACTOSOCIALYECONMICO(ENINGLS).JPG, Public Domain. [CENAPRED, 2014]

Figure 5

Possible accelerations in case of an 8.2 earthquake in Guerrero.



Note: The map shows the possible accelerations that Mexico city would have in case of an earthquake produced on the Guerrero gap, CENAPRED, retrieved on 2022, CENAPRED, http://www.atlasnacionalderiesgos.gob.mx/ , Public Domain, [Atlas, 2022]

For Mexico, the 1985 earthquake altered the way the Mexican government organized itself to deal with major earthquakes, resulting in the establishment of a national civil protection system (SINAPROC) a year later and, with the assistance of the Japanese government, the establishment of the National Center for Disaster Prevention (CENAPRED) three years later.

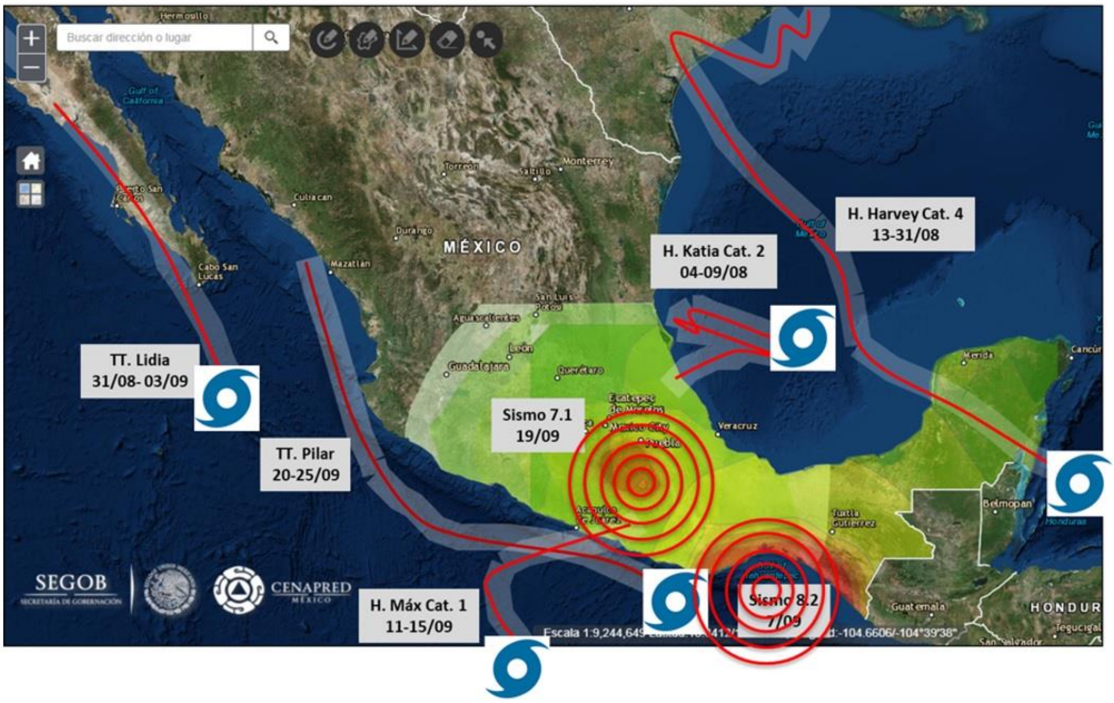
Meanwhile, reconstruction continued, and the government prepared the administrative and legal framework for the establishment of a national response system. Additionally, a new construction code for the city was being prepared to improve the city's infrastructure's resistance and was published in 1987. Naturally, it has undergone numerous modifications over the years as technology advances. While it is still considered the model for construction codes throughout the country, many buildings constructed prior to 1985 remain in the city.

Mexican situation between August and September 2017

Between August and September 2017, Mexico faced two major earthquakes (8.2 MW and 7.1 MW), two tropical storms, and three typhoons, testing its management and response systems to their limits (**Error! Reference source not found.**). Twelve days passed between two major earthquakes. The first earthquake struck on 7th September with a magnitude of 8.2MW, affecting three states in the country's south, destroying 34,000 homes and damaging another 72,000. Other sectors were also impacted; 600 historic structures, 3,000 schools, and 60 health care facilities such as clinics and hospitals were damaged or destroyed, while the second earthquake occurred on 19th September. National and subnational response teams, as well as the army, were already deployed throughout the country, assisting with disaster relief operations prior to the impact of the second earthquake, significantly reducing the pool of specialists available to deal with the second earthquake.

Image 6

August and September 2017 events at Mexico



Note: Adapted from August and September 2017 events at Mexico, CENAPRED, 2017, National Risk Atlas, http://www.atlasnacionalderiesgos.gob.mx/, public domain. [Atlas, 2022]

On 19th September 2017, the earthquake occurred exactly 32 years after the massive 1985 quake and was only a few hours apart. Its magnitude was 7.1 MW, causing accelerations of up to 182 gals, and it was registered as coming from inland (intra plaque), leaving the early warning system with only a few seconds before it struck Mexico City, collapsing 38 structures, including houses and schools and killing 228 people according to official records (**Error! Reference source not found.**). Later reports indicated that approximately 12 million people were impacted by both earthquakes, with reconstruction costs expected to exceed $2 billion. One interesting fact was that the majority of collapsing structures occurred in transition soil areas (**Error! Reference source not found.**).

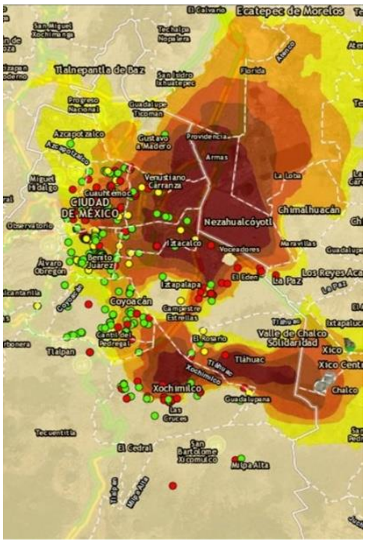
Figure 7

Damage inside a 6 level building right after the 19 September earthquake

*Note: St*ructural damages in Del Valle neighborhood, 2017.

Figure 8

Collapsed buildings in Mexico city



Note: The map shows that most of collapses are in transition soil, SGIRPC, 2019, Mexico city risk atlas, https://www.atlas.cdmx.gob.mx/, Public information. [Civil, 2022]

On 19th September, following the earthquake, government emergency response plans resumed. However, it quickly became apparent that local government capabilities had been exceeded, and citizens, businesses, and agencies required infrastructure assessments of their buildings prior to resuming operations or returning to their homes.

Days after the earthquake, the number of requests to the government in Mexico City alone exceeded 18,500; thus, the National University of Mexico's (UNAM) offer of assistance through the Faculty of Architecture as a focal point was accepted by the national government. In collaboration with the National Center for Disaster Prevention, professors and students from the previous semesters joined the efforts for the rapid damage assessment required for strategic decision-making (Figure 9).

Figure 9

Volunteer students arriving at the National Center for Disaster Prevention

Note: Students arriving on late afternoon at CENAPRED September 19, 2017.

As a result, the following questions arose: "What briefing information and tools are required before this group of volunteer architects and engineers deploys to damaged zones to conduct rapid damage assessments?" and "Are engineers capable of dealing with fearful and nervous families in their homes?" Furthermore, what additional information do they require?"

An emergency situation puts both those directly affected and those later interacting with the aftermath, such as response teams and other personnel, under duress. Around 86 percent of people involved in a stressful event, such as a large earthquake, may experience some type of reaction in one or more of the CASIC spheres over the next 24 hours (behavioural, affective, somatic, interpersonal, and cognitive). This is natural given the abnormal circumstances they are in, and at the very least, some general understanding of the challenges teams will face at households is required.

It was determined that four fundamental components would need to be taught during a two-hour mandatory session prior to deployment in order to perform the rapid damage assessment:

1. Knowledge is necessary for proper use of the evaluation form (Civil engineering knowledge).
2. Utilization of the App for Uploading Information (Information management knowledge)
3. Psychological and emotional fundamental management tools (knowledge of psychological first aid) and printed recommendations for households visited.
4. Information about the event, available shelters, useful facilities, and official sources of information (Risk communication knowledge)

Psychological first aid is a method for fostering empathic contact and ensuring the safety of those who are afflicted. It presupposes that each of us possesses a natural capacity for resilience, which acts as a catalyst for recovery in all areas. It makes use of our understanding of normal human responses in order to assist another human being who is suffering and may require assistance.

Its objective is to disseminate a basic understanding of the likely emotional responses and to facilitate the generation of alternative ways to deal with the event through simple practical techniques and assistance that enable those affected to be supported without the assistance of specialized mental health professionals, thereby reducing the incidence of pathologies such as disorders associated with acute or post-traumatic stress.

Five fundamental components were established as part of the strategy:

1. Knowledge of the event and its aftermaths
2. Observing the situation in order to detect insecure or dangerous situations
3. Assist individuals in safeguarding their physical and emotional well-being
4. Hearing the victims' expressed needs and concentrating on their perceived concerns
5. Practical assistance, such as connecting victims with agencies that can meet their immediate needs

These five steps promote a sense of security, calmness, hope, bonding, and self-efficacy, all of which help alleviate anxiety and are critical for psychological and emotional recovery.

On the other hand, risk communication refers to purposeful information exchanges between parties committed to veracity and accuracy. Information is a fundamental human need on a par with shelter and food.

Thus, in order for engineers to deal with fearful and nervous families in their households whose emotional state would change rapidly over time, not only psychological and risk communication fundamentals were required, but also simple things such as printed complementary information with key messages needed to be prepared in advance.

Typically, risk communication strategies and basic emotional and psychological response training for disasters are not included in the common curriculum of architects and civil engineers, but they are critical when communicating messages such as "**you must evacuate, your home is no longer secure due to structural damage**" or "**further assessment is required, please wait until someone else arrives.**" As previously stated, these types of messages impose a significant burden on not only the families receiving the message, but also on the professional transmitting the information. In order to mitigate these issues, these topics were included in the pre-deployment mandatory briefing.

Appropriate actions during early interactions prevent victims from developing a sense of hopelessness, are beneficial in real-world situations, and were appreciated by volunteers. Within two weeks of the event, over 13,000 students received this training as a means of increasing self-awareness and preparing for future needs.

While we typically associate mental health and well-being with psychological care and cognitive subjects, some of the most important emotional measures aimed at reducing anxiety and assisting people in coping with the aftermath of a disaster are inextricably linked to infrastructure fundamental knowledge and civil engineering statements.

Some parts of the infrastructure may sustain severe damage during a large earthquake while others sustain moderate to minor damage, but how does the general public learn about this? The majority of people are unaware of the distinction between structural and nonstructural damage. Homes are a significant affective issue in the lives of the average person; they provide them with a sense of security and also a symbolic bond to their spaces, so, naturally, they want to know how they are doing and return as soon as possible.

People look for what might be called "the OK statement," which is the belief that results from an expert's assessment of the house (which could take weeks) or, in the case of light damage, from the self-awareness that the damage is light and non-dangerous.

In the case of Mexico, CENAPRED had prepared two small massive online open courses in advance, one on basic infrastructure damage recognition (CBEE, 10 hours) and another on disasters and their psychological effects (LDEP, 25 hours), which were quickly opened to the public following the earthquake. In the weeks following the event, the CBEE course grew 360.71 percent (from 3,614 to 13,036 students) in comparison to previous editions, while the LDEP course grew 227.22 percent (from 3,130 to 7,112 students).

The data gathered from those courses revealed that people would actively seek ways to fill in gaps in their fundamental knowledge in order to alleviate the anxiety associated with not knowing whether their homes are "safe," as well as what are the common and normal reactions on their feelings and minds following the experience they encountered.

Conclusion

Due to the effects of properly transmitting infrastructure knowledge, its dissemination was deemed one of the most critical issues in promoting mental health and emotional well-being. Thus, in order for engineers to be more useful in disaster response scenarios, civil engineering technical knowledge alone is insufficient to be a member of rapid damage assessment teams. Instead, basic risk communication strategies paired with basic emotional understanding are required.

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