QUICK REPORT TO EERI, SMIS, CENAPRED AND GIIS REGARDING THE EARTHQUAKE IN COLIMA, MEXICO
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Preface

On Tuesday January 21, at 8:06 in the evening local time, the coastal region of Mexico near Manzanillo was shaken by a strong earthquake. As soon as they found out, EERI (Earthquake Engineering Research Institute), CENAPRED (National Center for Disaster Prevention), and SMIS (Mexican Society for Earthquake Engineering), individually at first and jointly afterwards, began reconnaissance efforts.

In CENAPRED on Wednesday January 22, an investigative team was formed with 4 members. It was headed by Dr. Sergio Alcocer (Director of Investigation), and also included Roberto Durán Hernández (Investigator), Leonardo Flores Corona (Investigator), and Carlos Reyes Salinas (Subdirector of Structural Engineering and Geotechnical Area). That team also represented SMIS.
On the morning of January 22, that team traveled to Colima and began its reconnaissance and evaluation of information.

In EERI on Wednesday January 22, preparations were begun to send a reconnaissance team. The team was headed by Prof. Richard E. Klingner (University of Texas at Austin, specialist in structural engineering), and made up of Paul J. Flores (ABS Consulting, Los Angeles, California, specialist in disaster mitigation), of Anna Lang (Tipping – Mar & Associates, Berkeley, California, specialist in structural engineering), and of Prof. Adrián Rodríguez-Marek (Washington State University, specialist in geotechnical engineering). Klingner, Flores and Lang arrived in Colima in the evening of Thursday January 23; Rodríguez-Marek arrived in the morning of Sunday January 26. Upon arrival, the EERI team contacted the CENAPRED / SMIS team, and they began to work together.

On Wednesday January 22, GIIS (Grupo Interuniversitario de Ingeniería Sísmica (GIIS) began its preparations, and named a team headed by Prof. Hugón Juárez (Universidad Autónoma Metropolitana de Azcapotzalco). The team arrived to Colima on Thursday, January 23. The GIIS / SMIS team visited the municipalities of Colima, Villa de Álvarez, Comala, Tecomán and Armería, in the state of Colima. In the state of Jalisco, the group visited, among others, Ciudad Guzmán, Melaque, Barra de Navidad and Cihuatlán, which were cities damaged by the 1995 Mw 8 earthquake. Results of their observations in the states of Jalisco and Michoacán will be included in the final report, to be jointly prepared by SMIS and EERI.

Upon arrival in Colima, some effects of the earthquake were immediately apparent (Figure 1).

![Figure 1 Damage to crosses, Cathedral of Colima](image)

Over the following days, the teams carried out a basic reconnaissance of the effects of the earthquake, concentrating on the response of structures and soils, and also on the functioning of response mechanisms, on different levels, of the Mexican government. The teams visited the municipalities of Colima, Manzanillo, Tecomán, Comala, Coquimatlán, Villa de Álvarez, Ixtlahuacan and Armería, whose locations are shown in Figure 2.
The storage, backup and exchange of information was facilitated by a uniform system of file organization. After comparing initial reflections on their observations, team members identified various key issues, that could serve as focal points for the subsequent dissemination of the technical significance of the earthquake. The key issues were as follows:

- the apparent contrast between the significant magnitude of the earthquake, and the general level of damage;
- local effects of soil conditions;
- an apparent hierarchy of structural vulnerability, based on construction material, structural configuration, and location;
- an apparent coherence of organized disaster response by the different levels of the Mexican government, to quantify the effects of the earthquake, and to take initial measures to mitigate its effects on the affected populations;

Upon further reflection, it occurred to the combined reconnaissance team that two other issues were important. These are presented in the form of questions:

- What is the best way to combine lessons previously learned, with the new lessons learned from the Colima earthquake, and apply them to the process of seismic reconstruction and rehabilitation of damaged structures?
- What is the best way to identify the new lessons learned from this earthquake, and transfer the underlying technology to the responsible entities in the US and in Mexico?

Figure 2 Overall map of the areas visited
The purposes of this quick report are to introduce those key issues, present preliminary reflections concerning them, and lay the groundwork for a future report of greater scope and depth, to be published in the near future. This quick report was written jointly by the members of the combined teams of CENAPRED / SMIS, GIIS / SMIS and EERI. In support of the agreement recently signed between EERI and SMIS, the report is directed to those two bodies in two identical versions, one in English, and the other in Spanish.

**Basic Data (USGS NEIC)**

Date and Time: 2003-01-22, 02:06:31 UTC  
2003-01-21, 20:06:31 local time

Magnitude: $M_w$ 7.8, $M_s$ 7.6 (SSN-UNAM)

References: 60 km SSW of Colima, Colima, México  
60 km ESE of Manzanillo, Colima, México  
110 km SSW of Ciudad Guzmán, Jalisco, México  
500 km W of México, DF, México

The epicentral locations of the main shock and principal aftershocks are shown in rough form in Figure 3. As the figure shows, the epicenter is located in a seismic gap where earthquakes had not occurred in recent years.

As of this date, it has not been possible to verify the existence of local strong-motion records. There was a seismograph network operated by specialists of the University of Colima, but it was apparently used only to monitor the Colima Volcano. As of the date of this quick report, nearby records are not available.
Overview of the Regional Effects of the Earthquake

As of January 25, 2003, the impacts of the earthquake are as follows:

- 17 confirmed dead
- 500+ injured (this a very uncertain figure since there has not been a systematic collection and confirmation of the number) of persons injured. In the municipality of Tecomán, the mayor indicated that they have specific records of the number injured by type of injury and the source of injury.
- 13,493 residential structures have been reported a suffering some level of damage. Many of these reports have come from public surveys of rapid visual inspections. These reports then serve as the basis for assigning inspectors organized and trained by the Colima College of Architects and Civil Engineers. (In Mexico, the term College is equivalent to Association).
- Of the 13,493 structures reported, 11,008 have been inspected with the following official results:
  - 2,728 total damage
  - 4,150 partial damage
  - 4,131 safe for occupancy
- 56 disaster assistance centers have been established by the military to provide food, shelter, medical assistance and public information.
- 600 structures housing medium to small business suffered some level of damage.

These figures were confirmed by State Civil Protection authorities, although they cautioned that the number of structures damaged will most likely increase as further safety inspections are made. There are several towns that have not been inspected yet.

Apparent Contrast between Magnitude and Intensity

At first glance, one might expect more damage from an earthquake of magnitude $M_w$ 7.8. Nevertheless, the attenuation relationship of Youngs et al. suggests peak accelerations between 0.10 and 0.15 g for an event with epicentral distances of about 60 km and a focal depth of about 10 km. Such a peak acceleration level is generally compatible with the level of observed damage.

Geotechnical Observations

In Manzanillo, the team observed general settlement of the soil underlying the old municipal pier (Figure 4). According to local authorities, the soil there had originally been consolidated. Reports of possible damage to the Coahuayana Bridge, to the southeast of Manzanillo, had not been confirmed as of the date of this report.
Along the toll highway between Manzanillo and Colima, landslides were evident (Figure 5).

In the exit from the toll way into Colima, an overpass had damage to seismic stops at the ends of bent caps (Figure 6).
In Villa de Álvarez, a residential area to the northwest of central Colima, large settlements and openings in the ground were visible. These could have been due to natural causes, or according to residents, to the presence of old sand mines in the area (Figure 7, Figure 13).
Hierarchy of Structural Vulnerability

In our subsequent report, damage to specific buildings will be reported. For purposes of this quick report, damage has been categorized according to construction materials: steel; reinforced concrete; confined masonry; unreinforced masonry; and adobe. In this section, the general behavior of each type of construction is described. Observations of damage are used to draw general conclusions regarding structural vulnerability.

Performance of Steel Structures

Only one steel structure was observed in Colima: a large storage area, half of which was covered by a roof supported by rolled steel shapes, and the other half, by large timber trusses. Due to an electrical short circuit after the earthquake, the timber half of the roof caught fire and collapsed. The portion supported by steel shapes appeared undamaged.

Performance of Reinforced Concrete Structures

The following observations were made regarding reinforced concrete structures in and around Colima:

- Typical reinforced concrete structures are at most four stories high, probably because of requirements for installation of elevators in buildings with more floors.
- The level of ductile detailing is unknown.
- Stucco and tile facades are most common, and are bonded to the underlying structure by mortar, without mechanical anchorage.
- The common practice is to place unreinforced masonry infills within bays of frames. Typically, the infills are neither reinforced nor connected mechanically to the surrounding frame.

Overall damage to reinforced concrete structures was minor. The most commonly observed damage was minor shear cracks in walls and columns and spalling at beam-column connections. Most of these buildings were public facilities and therefore had possibly been built with a higher level of design and construction oversight. Most of these buildings appeared to be repairable.

Performance of Masonry Structures

Most masonry structures had solid units of fired clay, although a few used solid concrete units (tabicón). Hollow concrete masonry units similar to those used in the US were not observed, nor were hollow clay units with horizontal nor vertical perforations.
Typical masonry structures were constructed as follows:

- Walls are typically one to two wythes thick, with 20-100 mm (1-4 in.) of mortar between courses.
- Walls are plastered with approximately 30 mm (1 in.) of stucco on both faces, applied directly to the masonry without mesh or mechanical anchorage.
- Typical masonry is laid in running bond with no interlocking units between wythes.
- Bond beams are generally not present at the level of the horizontal diaphragms, though wood members were occasionally used for this purpose.
- Lintels over openings are generally of wood, though sometimes masonry arches were used.
- For single story houses, Roofs are generally constructed of tree trunks and small limbs. Additional wooden limbs are used to support clay tiles or corrugated metal or cardboard sheets. Roof members are generally not attached to bond beams or the supporting walls. In larger houses, solid or prefabricated reinforced concrete slab are used.
- The foundation is typically a continuous footing with its base about 0.4 m below grade, and narrower at the top than the bottom. It consists of large rocks interspersed with small rocks and cement-sand mortar.

Confined Masonry Structures

Confined masonry as commonly used in Latin America consists of unreinforced masonry panels, typically measuring 1 to 2 meters in each direction, and joined by horizontal and vertical reinforced concrete elements that are poured in place after the masonry is laid. Such confining elements generally are roughly square in cross-section, with a cross-sectional dimension equal to the thickness of the masonry. They are generally reinforced with four #3 (9 mm) bars and transverse ties of heavy-gage wire. Structural continuity between masonry and confining elements is generally obtained by mechanical interlock between the running-bond masonry and the cast-in-place concrete.

The confining elements are intended to serve the same function as the continuous horizontal bond beams and vertical grouted cells that are used in the reinforced masonry construction of the US. They are generally placed horizontally above and below openings, and vertically at wall intersections and jambs of openings. Confined masonry walls are usually constructed with horizontal reinforced concrete elements at the bottom and the top. These are usually not mechanically connected to the foundation or the roof respectively, and are usually tied to the masonry only through the connection between horizontal and vertical confining elements. Cracking is common between masonry and these horizontal elements. Structures of confined masonry structures performed better than those of unconfined masonry or adobe. Cracks often formed between the masonry and the confining elements, and the latter sometimes failed, but this was the case solely when the number and arrangement of confining elements was inadequate. In most instances, confined masonry structures remained unscathed.
Unreinforced Masonry Structures

Unreinforced masonry structures are constructed without horizontal or vertical confining elements. They may have lintels of cast-in-place reinforced concrete, but wood is more commonly used. Their strength and initial stiffness may be increased by stucco. Observed damage to unreinforced masonry structures can be described as follows (Figure 8):

- Walls failed out of plane due to lack of mechanical connection between the top of the wall and the roof or floor diaphragm, combined with inadequate out-of-plane strength due to a lack of reinforcement.
- In-plane shear failures could occur separately or in combination with out-of-plane failure. Increases in in-plane stiffness and strength due to stucco would be lost as the stucco spalled off due to lack of mechanical anchorage. Due to the absence of reinforcement, combined in- and out-of-plane failure often led to collapse of walls and structures.

Performance of Adobe Structures

Typical adobe construction is very similar to that of unreinforced masonry. The foundation is typically constructed about 0.5 m below grade, and consists of large rocks interspersed with smaller rocks and mortar. Instead of a reinforced concrete grade beam (as with unreinforced masonry), the adobe units are laid directly on top of a layer of mortar with no reinforcement or other fastening method. Adobe structures commonly have wooden lintels, and may have wooden horizontal and vertical confining elements.

Figure 8 Typical damage to unreinforced masonry
In some locations, such as Villa de Álvarez, damage to adobe structures was severe. As with unreinforced masonry, damage to adobe structures took the form of separation of walls from roof and floor diaphragms, and in-plane shear cracking combined with failure out of plane. Due to the absence of reinforcement, such combined failure often led to collapse of walls and structures.

Out-of-plane overturning of cantilever adobe walls was common.

It is important to mention that the adobe and unreinforced masonry houses, damaged or with partial or total collapses, and located in urban areas, are quite old, perhaps several decades old. Indeed, the vast majority of adobe and unreinforced masonry houses in Mexico are built in rural areas, especially in economically disadvantaged areas.

Performance of Historical Monuments

The historical monuments visited, mostly churches, exhibited light damage, such as spalling of stuccos and plasters, and damage to nonstructural elements. Fine cracks were observed in walls; such damage does not compromise the stability of the structure. One exception is the church of San Pedro, in Coquimatlán, which suffered severe damage in the main building of the church, as well as failure of the south bell tower, which collapsed over the yard of the municipal building. The other tower showed damage in the columns of the bell tower, and permanent rotation over one of the columns. The main building showed severe shear damage in all walls and cupolas. The main cupola partially collapsed. Even though the damage is severe, the structure is considered reparable.

Summary of Structural Performance by Material

- Generally, structural steel and reinforced concrete structures suffered little damage. Had the earthquake accelerations been greater, damage to such structures could also have been greater.
- Generally, confined masonry structures suffered minor damage. Had the earthquake accelerations been greater, damage to such structures could also have been greater. Damage decreased as the number and size of confining elements increased, and also as the buildings’ configurations improved. General configuration issues are discussed below.
- While damage to unreinforced masonry structures varied by location, in those areas of relatively heavy damage, damage was concentrated in structures of unreinforced masonry and adobe. Damage was due to inadequate connections between walls and horizontal diaphragms and between intersecting walls, and to collapse of walls under combined in- and out-of-plane loads.

Summary of Structural Performance according to Configuration

Independent of material, structural performance was clearly enhanced by aspects of building configuration, such as the following:

- Presence and location of shear walls. The lateral resistance of wall-type structures depends entirely on the existence of a system of shear walls. For strength in all directions, walls should be oriented in both principal plan directions. For redundancy, multiple walls should
run in each principal plan direction. For control of plan torsion, walls should be arranged symmetrically around the perimeter of the plan. For sufficient strength, the structure should have a minimum wall density (ratio of wall area to total plan area) in each principal plan direction.

- Presence and location of openings in walls. Many buildings have large openings in walls at the street level for businesses, and smaller openings in residential units in upper floors. The large openings create a soft story parallel to the direction of the street, and lead to severe damage in the shear elements in the front of the building that resist lateral forces parallel to the street.

- Continuity of vertical and horizontal elements. Neglect of masonry infills is common in design. Regardless of this design intent, such elements may have high initial stiffness, and may cause the infilled structure to respond in ways that the designer did not intend. Discontinuous vertical or horizontal elements, whether structural or non-structural, can degrade structural performance.

- Location within a block. Corner buildings appeared to suffer relatively heavy damage, due to a combination of the effects of openings in walls, and the plan eccentricity between the center of mass (generally located near the plan center of the building) and the center of rigidity (generally located near the interior corner of the building plan). This plan eccentricity led to heavy damage in the shear-resisting elements on the corner façade of the building, and sometimes to collapse of the exterior walls near the corner (Figure 9).

![Figure 9 Typical damage to adobe structure at a corner of a block](image)
Concluding Remarks regarding Structural Vulnerability

As noted above, each structure's vulnerability could be categorized according to a hierarchy of materials:

- steel and reinforced concrete;
- confined masonry;
- unconfined and unreinforced masonry; or
- adobe.

Each structure's vulnerability could also be categorized according to a hierarchy of configuration:

- structures with good shear-wall layout, high wall densities, continuous horizontal and vertical elements, and few wall openings; or
- structures with deficiencies in one or more of the above areas.

Finally, a structure would be even more vulnerable if it were located at the corner of a block, or in areas with unfavorable soil conditions.

As a result, a structure would be relatively invulnerable if it were high on the hierarchy of materials, high on the hierarchy of configuration, and not located on a corner. Conversely, a structure would be relatively vulnerable if it were located low on either the hierarchy of materials or the hierarchy of configuration, and particularly vulnerable if it were located on the corner of a block.

Coherence of Response

Emergency Response and Recovery: Initial Assessment

To help the reader better understand the following discussion regarding the emergency response and recovery, it is useful to summarize the organizational relationship among the different groups participating in that response. That information is presented graphically in Figure 10. The primary purpose of the National System of Civil Protection (NSCP) is to coordinate the governmental and volunteer emergency response and recovery operations during disasters. The Secretary of Government is responsible for the NSCP. At the national level, the system is composed of three main elements: Emergency Operations (General Direction of Civil Protection); Scientific and Technical Support, provided by the National Center for Disaster Prevention (CENAPRED); and the National Fund for Natural Disasters (FONDEN), which provides the funds required to finance emergency response and recovery operations. The system relies heavily on the resources of all levels of government, academic institutions, non-governmental organizations such as the Mexican Red Cross, and wide range of volunteers such as the Colleges of Architects and Engineers, the Construction Industry Chamber, and search and rescue groups. After the disaster, those groups met almost daily to coordinate their efforts (Figure 11).
The emergency response to the January 21 earthquake was apparently rapid and well managed by the State of Colima’s Civil Protection System. Reasons for the effectiveness of this emergency response include the following:

- The Mw 7.8 earthquake did not cause the level of damage that one might expect. While it did cause significant damage to unreinforced masonry structures and some concrete frame buildings of low quality, it caused no major collapses of engineered buildings, and only
slight to moderate damage to the infrastructure such as roads, potable water, electrical power, and communication systems. The electrical power plant in Mazanillo has only one of six generating stations in operation, but the team has not been able receive official reports as to the cause of the plant going down.

- The demand for search and rescue resources was minimal and the medical system was able to rapidly treat, within hours after the strong shaking ceased, those injured by falling construction materials.

- The Colima Volcano has been active for many years, and in the past few years State Civil Protection has often had to evacuate towns located in the most hazardous areas. The frequent activation of the system has provided the agencies and personnel that comprise the organization with practical emergency response experience.

- Colima has multiple hazards, including earthquakes, floods, and hurricanes; the State Civil Protection System has been active in forming and training specialized teams to respond to these various events. Colima is also located in one of the most seismically active areas in the world, and has experienced several large-magnitude earthquakes in the past century alone. Earthquakes and other types disasters have produced significant damage and caused considerable socio-economic losses. According to Civil Protection authorities, much has been learned from these events and significant progress has been made in improving building codes and practices.

- There is a strong military presence in the City of Colima, with many types of resources that have been deployed to assist the civilian efforts. The military has thus far deployed personnel and equipment to provide shelter, demolition and debris removal (Figure 12).

- The City of Colima is the capital of the state, so all of its resources were readily available to assist the affected municipalities.

![Figure 12 Military personnel carrying out heavy demolition](image-url)
To what extent each of these factors has contributed to the apparent expeditious and efficient emergency response is a topic for further study.

The utilization of readily available and relatively inexpensive technology such Geographic Information Systems would have greatly assisted Civil Protection in the processing, categorization, and mapping of collected data for various applications during the recovery process. The utilization and versatility of applications of GIS during disasters has been well demonstrated and documented. In some municipalities, this technology is being used for data collection.

**Disaster Recovery**

Only 5 days after the occurrence of the earthquake the initial recovery from the disaster is well underway. Some of the major issues being addressed by the all levels of government, the private sector, and the affected population are the following:

- The most important issue being addressed is the need to continue with the safety inspection of damaged structures. In some towns in the outlying areas practically every structure suffered some kind of damage to adobe structures. Clearly some people were still occupying structures that were severely damaged. This situation has caused some concern among people, specially those whose home or businesses were damaged, since they are unsure about the safety of their structures and whether they can continued to be occupied. Currently there are only 95 volunteer inspectors in the field. These inspectors are being organized and trained by the Colleges of Architects and Engineers and the Chamber of the Construction Industry. The data that they are collecting is being categorized by “total damage,” “partial damage,” and “slight damage.” These rapid visual assessments will provide the basis for determining which structures will require a more detailed assessment, be designated for demolition, or be repaired. This an area where the utilization of GIS can dramatically increased productivity and efficiency.

- The Civil Protection System has tasked the Mexican military to begin the demolition of structures categorized as a totally damaged, and to remove the debris from streets. The team observed the demolition process in the Municipality of Villa de Alvarez, which borders the northwest section of the City of Colima. That part of the Villa de Alvarez had a high concentration of totally damaged adobe structures, in part due to very poor soil conditions. After the demolition in that area is complete, large parcels of adjacent vacant land will be left behind. It is difficult to discern at this time whether the municipality will prohibit rebuilding in that area.
Immediately after the earthquake, the Governor of Colima ordered all schools closed for the rest of the week to allow time for safety inspections. There are 703 primary and secondary schools in the state of Colima and according to initial reports, 220 suffered some level of damage. All schools were scheduled to open on Monday January 27, 2003. Students from schools with major damage were to continue classroom instruction in temporary safe facilities.

The direct economic impacts of the disaster are beginning to emerge, but remain somewhat murky. There is a great deal of discrepancy between the estimates being provided by various federal, state and municipal sources. Nevertheless, the federal government has already committed to provide 144.7 million pesos to be used for funding a variety of recovery programs:

- 42 million pesos for the repair or rebuilding of damaged housing units
- 79,700 million pesos for assistance to the private sector, primarily small businesses
- 20 million pesos to assist those unemployed due to the disaster
- 3 million pesos to promote tourism

This is only the initial installment of what will eventually amount to hundreds of thousand of dollars, but it is deemed enough to move the recovery forward and hopefully stimulate the recovery of the state’s economy. More importantly, these actions are an effort to distribute funds to those in need as quickly as possible.

The financing of this disaster will pose some major challenges to the federal government. The mechanisms used by Mexico to finance disaster recovery are complex and can at times be problematic. For example, the 144.7 million pesos that the Mexican federal government has already committed to this disaster, are being diverted from the federal fiscal year 2003 budgets of the key agencies involved in promoting socio-economic development. This diversion of resources runs the risk of retarding progress in this most important national priority. In recognition of this serious problem, the federal government instituted FONDEN (Fund for Natural Disasters) in 1996 and
allocates a fixed budget (in 2003 FONDEN’s budget is approximately 350 million US dollars) to carry out specific objectives, which are to finance the repair or replacement of uninsured public facilities, and to provide disaster assistance to poorest sectors of the affected population. In recent disasters, the FONDEN has been able to restore the funds diverted from other federal agencies, but there has also been other times when the occurrence of just a few major disasters will drive FONDEN into insolvency before the fiscal year is over. This is problematic in that the restoration of agency funds becomes impossible and if another major disaster occurs before the end of the fiscal year additional funds will need to be diverted since the effects cannot be ignored.

The FONDEN is a unique approach to financing disasters. Some aspects of FONDEN are innovative and may be of some interest to the U.S. In fact there are similarities between this approach and the federal disaster assistance programs in the U.S. This disaster may provide opportunities for knowledge transfer between the U.S. and Mexico and further study of how the FONDEN will be applied in this disaster may merit further study.

**How to Apply Lessons Learned to Future Rehabilitation?**

The experience from this earthquake and those of 1999 that affected the states of Puebla and Oaxaca, show that damage patterns are similar across broad classes of structures. For example, in adobe houses, it was common to observe cracks in the corners of walls and the collapse of roofs, as a result of poor connections between wall and roof elements. In masonry construction, the inadequate use of confining elements of reinforced concrete was evident; in some cases, such confining elements were completely lacking. In other cases, damage was due to deficiencies in supervision and execution of the construction. For those reasons, reconstruction and rehabilitation should not consist simply of replacing what has been damaged, but rather to propose solutions that decrease the seismic vulnerability of this construction.

In the particular case of adobe housing, which almost always is the most heavily damaged form of construction, rehabilitation approaches that strengthen the connection between walls and roof should be encouraged. These include:

- The use of welded-wire fabric and mortar, which substantially improve the overall behavior of adobe walls; and
- The use of vertical and horizontal confining elements in the adobe.

Another important prerequisite for the success of rehabilitation is to involve the owners of houses in do-it-yourself construction programs. For this purpose, it is necessary to involve technical experts, who can assess and supervise the execution of the rehabilitation.

These issues will need to be studied further, and the results will be reported in later joint reports.

**How to Transfer the Corresponding Technology to the US and Mexico?**

Throughout this quick report, examples have been given of technology which, if properly disseminated and applied, could significantly reduce the effects of earthquakes on the population of areas like Colima, and indeed in general in Mexico, the US, and other countries. Examples of these technologies are:
• basic concepts of structural configuration, wall area, materials and construction;
• basic concepts of seismic rehabilitation;
• basic concepts of coordination of disaster response among different levels of government;
• basic concepts of communicating with and involving local populations in the process of disaster recovery; and
• basic concepts of prioritizing needs and allocating resources at different levels to meet those needs.

For example, the investigative teams saw many residents repairing their adobe houses with the same type of adobe that had been shown to be inadequate. Would it be possible, we wondered, to generate and distribute, with every bag of cement sold at the local level in the State of Colima, a simple folder with cartoon-type instructions on how to use confined masonry to build houses more earthquake-resistant than is possible with adobe?

In many cases, those technologies seemed to be effectively in place in Colima. In other cases, they are not. Additional work needs to be done to identify essential technologies, and to disseminate and apply them in Mexico, the US, and other parts of the world. This is an open question.