

# Post Disaster Resilient Sustainable Housing Program for Chietla, Puebla, Mexico

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**Abstract:** *Due to recent natural disasters occurred in the last September 2017 in Mexico with 3 seismic movements between 6 and 8.2Mw. All the 3 earthquakes affected the states of Mexico, Morelos, Puebla, Oaxaca and Chiapas. being the one occurred on the 19 of September that caused mayor damages. Despite the wide variety and diversity of interpretations and applications of the term resilience [17], for the present study its application in ecology and in the natural and built environment is better understood, as it is related to the use, management and depletion of the natural resources and resource land in the search of building materials as supplies.*

*The Initiative 8.2 is a group of academic and administrative staff members, students, and councillors from the Benemérita Universidad Autónoma de Puebla (BUAP) from architecture and other departments that work in a multidisciplinary scheme in collaboration with other academic units, research centres and institutes, as well with other academic institutions, NGO's, enterprises, civil society and civil associations as well with local governments. It aims to attend habitat problems related to natural disasters. Initiative 8.2-BUAP has set a program to develop resilient sustainable housing program attending the less favoured members of the communities affected from a natural disaster.*

*Results have shown that co-working with the community as well as using appropriate technology and technology transfer programs from universities can reduces the carbon footprint increasing the life expectancy of the building as well as reducing its environmental and economic costs.*

**Keywords:** *Post-disaster, Resilience, Mexico*

## 1. Introduction

Due to recent natural disasters occurred in September 2017 in Mexico with 3 seismic movements between 6Mw and 8.2Mw. The first one occurred at 23:49:18 (Local time Mexico) on September the 7<sup>th</sup> 2017 with epicentre in Pijijiapan, Chiapas (lat. N.14,85°, long. W.-94.11°, depth 58km and a Magnitude of 8.2Mw); a second shock occurred at 13:14:40 (Local time Mexico) on September the 19<sup>th</sup> 2017 with epicentre in Axochiapan Morelos (lat. N.18.40°, long. W.-98.72°, depth 57km and a magnitude of 7.1Mw); and a third movement occurred at 07:52:59 (local time Mexico) on September the 23<sup>rd</sup> with epicentre in Unión Hidalgo Oaxaca (lat. N.16.48°, long. W.-94.9°, depth 75km and a magnitude of 6.1Mw).

All the 3 earthquakes affected the states of Mexico, Morelos, Puebla, Oaxaca and Chiapas. being the one occurred on the 19 of September 2017 that caused mayor damages. In Puebla state alone, this shock left 45 casualties, 18,646 buildings affected, from which 279 were schools and of those 30 were sensed with structural damages, and 141 were religious temples [1].

The present research is based in the locality of Buenavista de Benito Juárez (Buenavista) is a remote rural community in Chietla, and it was highly affected accounting to 163 houses sensed whit severe damages on its

structures, and 44 complete destroyed from about 2610 houses sensed as damaged in the municipality of Chietla [2].

Post disaster programs in the affected regions of Mexico were established following the 19 of September earthquake, (FONDEN) from its acronym for National Fund for Natural Disasters in Spanish is a program that supports families that their homes were affected. However, not all the affected families were eligible due to diverse factors such as a legal status of the land or of the buildings within, according to local regulations. Which in most cases rural homes lack of such legal work.

## 2. Post Disaster Housing, Resilience and Sustainability

When referring and defining post-disaster dwellings there is not a precise definition, and therefore sometimes it is unclear the limits of a temporary shelter with a short-term building, or if a long-term house should be considered post disaster action. In all the cases it is important to establish a clear definition of each situation. Moreover, it is clear that no matter the category, in all the cases it should aim adequate facilities. According to the human rights definitions, the seven elements of adequate housing are highly pertinent regarding post disaster attention [3,4].

In one hand there are many and diverse efforts to attend post disaster housing problems, not always equally structured and organized [5], as many times immediate plans vary, according to particular local situations and levels of attention [6]. In the other hand, it is commonly accepted that immediate emergency housing with short life is not the best option and therefore not recommended, however, this should be studied from a local context approach as it is suggested that in some cases were the gap between eventualities can be very close in time, thus, the transition from a short-term to long-term shelter may be severely affected attention [7]. Notwithstanding that sustainability in the context of rebuilding after a disaster involves a much more integral view than solely the physical building [8] where strategies to involve community in rebuilding programs and economies have demonstrated a sustainable approach [9] as well as proper technology approach and transfer supported from academic research and institutions [10] to increase resilience recovery in communities [11,12,13]

Resilience is a term taken from the Latin verb *Resilere* meaning to rebound or recoil, introduced in the English language in the early 17<sup>th</sup> century [14], although the term is more commonly used in children psychology and thus extended to the clinical area. Here resilience is an attribute where individuals or social groups show the capability to upfront, recover and grow following a traumatic situation [15], such term implies to unfold a new perspective to improve design over strategic intervention programs, by looking at models of resistance and fundamental dynamics which allows individuals and communities to overtake such traumatic events by growing in the process [16].

Despite the wide variety and diversity of interpretations and applications of the term resilience [17], for the present study its application in ecology and in the natural and built environment is better understood, as it is related to the use, management and depletion of the natural resources and resource land in the search of building materials as supplies. In such disciplines the term was first applied to described properties of timber by Thomas Tredgold [18] in the early 18<sup>th</sup> century, latter this was extended to ecology by Holling [19] who describes it as: “The persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist” on its application from an ecological viewpoint, systems can yield very different approaches to the management of resources [20]. For the built environment can be said that resilience is the ability to accommodate abnormal or periodic threats and disruptive events, in many diverse forms, attempts to identify, communicate and assess risk as a vital component. Such principle can be applied in various levels from individuals to nations, therefore planners and decision makers should take it into account to understand the hazards, risks and threats of buildings, spaces and places. [21].

### 3. Case Study: Housing program after September 19th, 2017 earthquake in the community of Buenavista de Juárez in the municipality of Chietla, Puebla, Mexico

Mexican political division is organized as a Republic divided in 32 states and within each state many municipalities. Puebla state accounts 219 municipalities distributed in 7 geographical and cultural regions. Chietla is one of the municipalities of the Izucar-Atlixco valley region (see figure 1). The municipality of Chietla have 33,939 inhabitants, with a ratio of 53.05% - 46.95% of women – men population respectively [22]. Chietla municipality consists in a head town called also Chietla, and 11 communities: San Andrés Coayuca, Lagunillas de Rayón, Escape de Lagunillas, Ahuehuetzingo, Atencingo, Temaxcalapa, Pueblo Nuevo de Porfirio Díaz, Viborillas de Hidalgo, San Nicolas Tenexcalco, Tzompahuaca and Buenavista de Juárez. This municipality was one of the most affected municipalities in Puebla during the earthquake occurred in 19th of September 2017 as of being very close to the epicentre registered in Axochiapan, Jonacatepec, in the neighbour state of Morelos. (see figure 1)

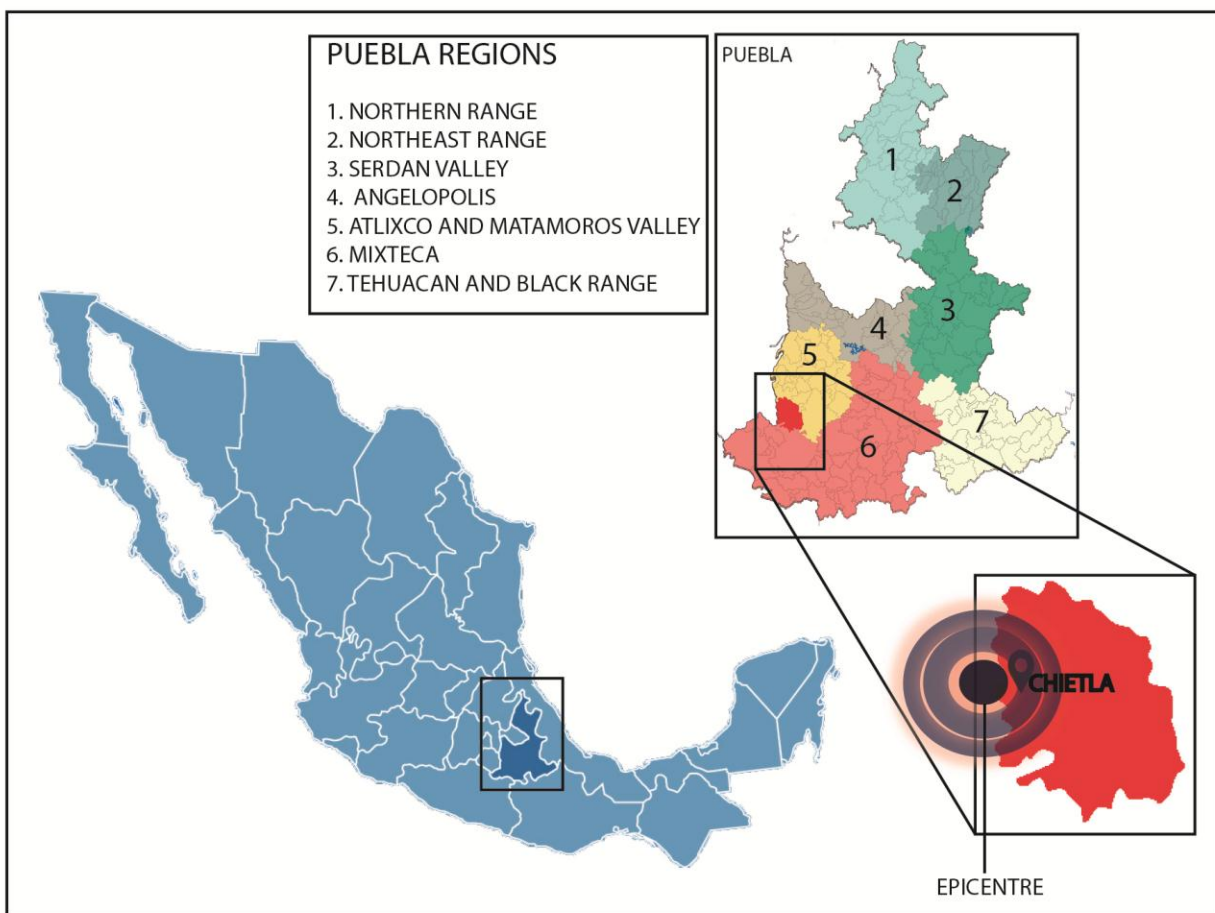


Fig. 1: Map of the region of study with the country of Mexico and its political division, Puebla state and its municipalities and regions, and the municipality of Chietla.

Chietla city and its 11 communities within are considered marginal with high levels of poverty and extreme poverty indicators with 11.4% of extreme poverty, 47.6% of moderate poverty and 28.2% of the total population considered socially vulnerable [23, 24], Related to housing needs can be seen that is equally underdeveloped, with highlighted data from Buenavista de Juárez as of being the locality of the case study (see table 1)

TABLE I: Housing statistics in the Municipality of Chietla, Puebla, Mexico

Lack of basic service	Average (%)	Total number of houses	House in Buenavista de Juárez
Lack of water pipeline	21.9	1953	117
With earthen floor	12.4	1106	74*
With only one room	6.3	558	?
Without sewage system	5.1	454	36*
Without any basic infrastructure	2.3	201	?
With no electric power	1.2	111	5

\* Top rank community over the whole municipal sense

Source: Sedesol and Coneval, 2010

### 3.1. Transfer of Technology, Research and Local Participation as Tools for Sustainable and Resilient Development

The Initiative 8.2 is a group of academic and administrative staff members, students, and councillors from the Benemérita Universidad Autónoma de Puebla (BUAP) from architecture and other departments that work in a multidisciplinary scheme in collaboration with other academic units, research centres and institutes, as well with other academic institutions, NGO's, enterprises, civil society and civil associations as well with local governments. It aims to attend habitat problems related to natural disasters. Initiative 8.2-BUAP has set a program to develop resilient sustainable housing program attending the less favoured members of the communities affected from a natural disaster.

It is advocated to develop opportunities based on post disaster resilience and sustainable practices, focused on transferring new building technologies with natural vernacular and alternative materials and building processes and in undertaking research about local natural building materials to create useful data to improve local building technologies.

During the work done in Buenavista, a series of workshops were delivered together with scholars, brigades, and local authorities and participants to construct five permanent dwellings for five families previously selected by the local government based on the level of need and impact caused by the September 19<sup>th</sup> earthquake.

### 3.2. Local Resources, Building Typologies and Dwelling Traditions as an Opportunity of Sustainable Development

Buenavista has a mix typology of buildings from vernacular wattle and daub, adobe, and stonework to modern conventional buildings in brick, cement-block houses or tin sheets. The 8.2 initiative has a program to sense and study such typologies based on the damage caused by the 19 of September quake. By studying both the ones that were most damaged and new emerging proposals after the earthquake it is possible to create a catalogue and a basis for research to improve a seismic resistant typology.

Based on a first fieldwork an initial catalogue of vernacular seismic resistant typologies was created where it was noticed that wattle and daub were the less damaged typology. Therefore, a hybrid building system was designed by a group of academics professors and scholars using regional certified bamboo based on the NSR-10 seismic resistant norm from Colombia [25] and pallets as envelop material reused from disposal material from nearby industries to simulate the wattle "weaving technique", walls are filled up with plastic bottles, earthen residual material product from collapse or demolition, as well as fibrous residual material product from local agricultural products to create a thermic insulation layer. Finally, a plaster made from limestone and cement to create the "daub" effect and to protect from harsh weather or fire risk was applied.



Fig. 2: Clockwise from top left: Scholars and brigades building a bamboo structure and pallets envelop; top right: House 1 with finished plaster and painting; bottom right: A detail of a weaving layer for roof insulation of local reeds and window made of re-usable wood from pallets; bottom left: Detail of the interior of house

#### 4. Conclusions

Further investigation related to how to assess and measure resilience and sustainability of the built environment is a second stage of this work. Where Life cycle assessment methodology is considered appropriated as it is suitable for an assemble model of production line. Where renewable energy is to be applied in prefabricating building elements in the BUAP university campus, complemented with local handwork, capacitation programs for technological transfer, therefore local materials such as a local specie of bamboo is under research to stablish its structural properties as a building material (see figure 3), and treatment methods can be taught to the community to re-activate local economies with alternative agro-forestall products with high value.

Learnings from experience is relevant as it is noticed that sustainable resilience goes further than just physical structures, for it a more holistic view should be adopted were services such as firs contact clinics, schools, public spaces for integration such as markets or technological transfer centres or cultural and sports facilities are equally important to proper develop healthy sustainable communities.

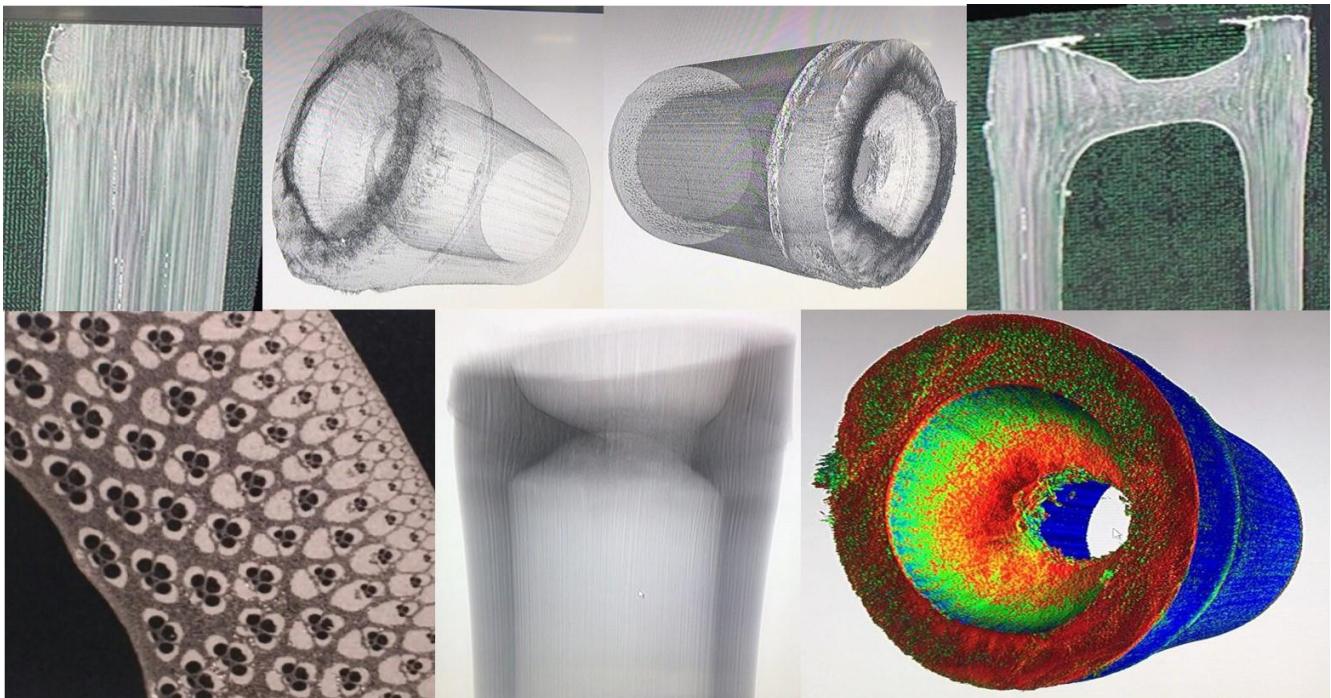


Fig. 3: Tomographic images of diverse bamboos proper for buildings found in the state Puebla, research of local building materials for sustainable dwellings in Puebla done at the non-destructive laboratory in BUAP

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