METHODOLOGY TO EVALUATE THE PARTICIPATION PERCENTAGE OF THE CONTENTS, STRUCTURAL AND NONSTRUCTURAL ELEMENTS IN THE LOSS ESTIMATION IN MASONRY HOUSES IN TUXTLA GUTIÉRREZ, MEXICO

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ABSTRACT:

Literature shows a distribution of importance in the economic losses after earthquakes of: a) structural elements, b) nonstructural elements, and c) contents. These reports correspond to buildings used like hotels, offices and hospitals, same that keep very important contents in value, and not necessarily the typical furniture and contents that are lodged in a house. Additionally, there are studies on structures built in the west coast of the United States and Japan. This work presents a methodology to determine the percentage of participation of these three headings in masonry houses of two levels and buildings of apartments of up to four levels for the city of Tuxtla Gutiérrez, Chiapas. In order to elaborate the proposed methodology were used: data of field, information of the population censuses 2005, studies of market, and statistical tools. The obtained results show the distribution costs for structural and non structural elements of typical houses and apartments in the south part of México.

KEYWORDS: Loss estimation, masonry houses, structural elements, nonstructural elements, contents

1. INTRODUCTION

Since the antiquity, earthquakes have produced damages in diverse regions of the planet and in different structural systems, which has originated that, according with the use that each construction type and the structural system, presents a specific distribution of economic losses in each one of its parts and contents.

After San Fernando's earthquake in 1971, the economic losses in constructions began to divide, as much, in structural elements as in nonstructural ones. Later, after Northridge's earthquake in 1994 and Kobe's earthquake in 1995 was considered, additionally, the losses in contents. Since 1971, only two people per year on average earthquake have died in the United States due to buildings collapse, even though this period includes a number of large and damaging earthquakes. Average economic loss during this same period has been about $2 billon dollars per year. A FEMA (Federal Emergency Management Agency) study based on theoretical simulations suggests that future economic losses due to earthquakes could average $4.5 billion dollars pear year (Kircher, 2003). Before to 1971 the structural specialist identified damages mainly in the structure elements, generally the nonstructural elements were not designed to consider them secondary in the behavior of the structure. This idea was reverted because the damage of those implies, in many occasions, downtime costs, when not allowing the operation of the structures like hospitals, airports or communication structures.

Literature shows a distribution of importance in the economic losses after earthquake of: a) structural

elements, b) nonstructural elements, c) contents and d) facilities (this isn't studied in present paper). These reports correspond to buildings used like hotels, offices and hospitals, same that keep very important contents in value, and not necessarily the typical furniture and contents that are lodged in a house or apartment building. Additionally, there are studies on structures built in the west coast of the United States and Japan.

The importance of studying the influence of nonstructural structural elements and contents in the total cost after a disaster is not only for buildings like the ones studied in literature because they are essentials is important also in single-family houses. In first instance, there are no studied in that sense, and most important, in some regions as Tuxtla Gutiérrez city, exists a high level of risk due to a set of natural phenomena scenarios and an important vulnerability associated to diverse factors, and when lacking these studies cannot evaluate direct and indirect losses.

Figure 1. Damages in the constructions of Tapachula city, due to the Coatan river flooding during the Stan hurricane (Bitrán, 2006).

The poverty and social marginalization in Chiapas allow to anticipate that if happen a catastrophic phenomenon the city would take long time in recovering, as it were demonstrated when in 2005, after the passage of the Stan hurricane in Tapachula city (figure 1), so important damages in the region took place in the coast of the state of Chiapas, and almost three years after, there not have been yet able to be like before the Stan.

In literature we found diverse studies of costs, which are, generally, for buildings that keeps very important contents in value and operation. The houses of Tuxtla Gutiérrez are very different from those in its materials, use, earthquake design, maintenance, and quality construction. Additionally, the literature studies are focuses in the west coast of the United States and Japan, regions with material and structural configurations different that we can find in cities of south-east of Mexico. Examples of these technical works are the results resumed in table 1 and in figure 2.

Table 1 Cost distribution by material and used

Category	Wood structure	Concrete structure	Concrete structure	Hospital	Hotel	Office
Structure	10	25	40	8	13	18
Nonstructural elements	25	33	40	48	70	62
Contents	65	42	20	44	17	20
Author	Mayes (1995)	Mayes (1995)	Hirakawa (1997)	Taghavi (2002)	Taghavi (2002)	Taghavi (2002)

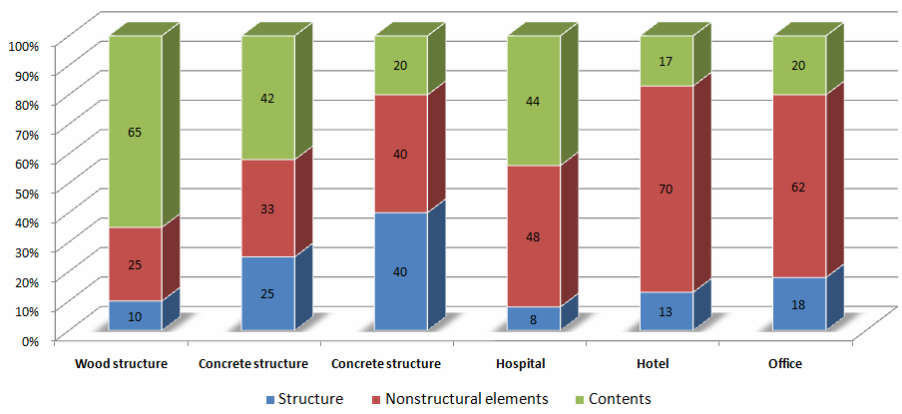

Figure 2. Costs distribution of the contents, structure and nonstructural elements (conform to table 1)

METHODOLOGY

In this work, a methodology proposal is developed to determine the percentage of costs participation of these three headings: structural, elements, nonstructural elements, contents and furniture, in houses of one and two levels and apartments buildings up to four levels in Tuxtla Gutiérrez city in Chiapas, México.

The studied construction typologies are from reported in the census of population and housing (INEGI, 2006), as well as of the observed during the surveys applied in the city, realized for this specific investigation; besides the outdoor work carried out by Hernández (2005) and completed by González (2007).

In order to elaborate the propose methodology, the following six steps would be developed:

1. To compile information of the city in study (population density by region, construction typology, materials, etc.)
2. Distribution of the universal population of the city, in a representative sample of the selected houses with some statistic methods.
3. Apply questionnaire throughout the city, in neighborhoods selected previously and sectors with greater density population.
4. Budget for houses and apartments of the studied conditions, separating the costs in structural and nonstructural elements.
5. Studies of market of typical contents and furniture. Elaboration furniture cost packages with the number of rooms of each house.
6. Use of statistical tools to obtain the costs percentage of participation for studied elements.

It is shown in figure 3, with different color intense, the regions with variable density population. The selected colors were divided in five intervals, which go from zero to 8 habitants by hectare, in the white zone, to with red vine, the zone of 69 to 145 habitants by hectare. We must emphasize that the typology of construction in Tuxtla Gutiérrez is basically horizontal, built with clay masonry or with concrete block units.

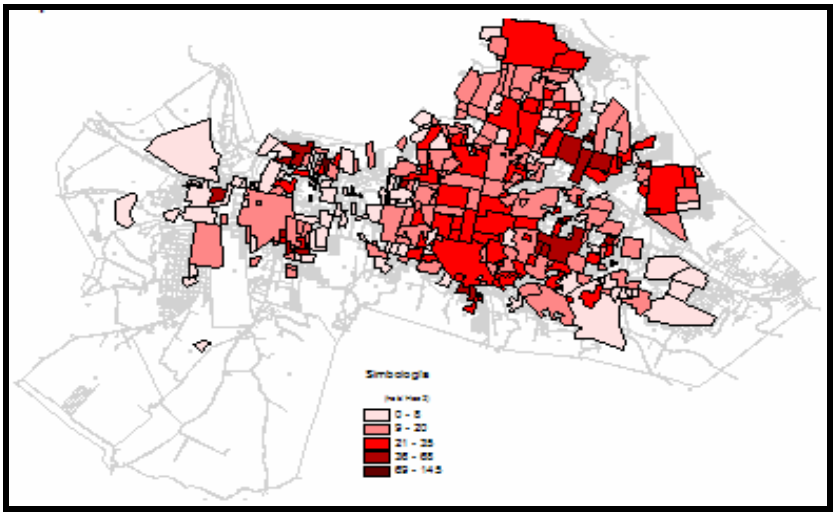

Figure 3. Density Map of Population (Room/Hectare) by different regions of Tuxtla Gutiérrez city. Information processed with municipal data.

The nonstructural and structural costs estimation is realized considering the budgets of a sample of 2,597 houses and 349 apartments. The studied structural projects were selected based on their location, and most important, the quality information that we had of them. For this reason, not all the projects are built in Tuxtla Gutiérrez. The study increased the house and apartment sample with prototypes developed in nearby cities, like Tapachula, San Cristobal, Comitán de Domínguez, Huixtla, Tonala, Cintalapa, Villaflores and Teapa (this last one is located to the south of Tabasco state, in the border to Chiapas state).

For the study of furniture and contents costs, price catalogues were obtained from the months of January to December of 2007 of the following furniture companies: Famsa, Elektra, SAM's Club, Home DEPOT, Salinas and Rocha, Coppel, Azcue, Minimalistic and Liverpool, all of them locate in Tuxtla Gutiérrez city. All the indicated companies are furniture stores and/or departmental stores with the highest index of acceptance in the city of study.

In order to determine the furniture cost statistics, we used the following product listed: bed, sofa, table and chair, bookseller, mattress and box, stove, refrigerator, washing machine, computer and television. The total products studied were 1,026 models of furniture and equipment, which goes from 166 types of box and mattress (this category corresponds to the greater number of analyzed elements) and 36 booksellers, who are the furniture with fewer models studied.

It was considered that the mean and standard deviation of each one of the studied furniture are sufficient to indirectly cover the different costs from clothes, accessories and electric home appliances, among others equipment, that were not related, nor was determined its cost. The studied models and marks are those of greater use in the city.

From the data reported in the census of population and housing (INEGI, 2006) we obtained the house percentage that has different furniture like: stove, refrigerator, washing machine, television and computer. Indirectly with the number of rooms, the rest of furniture availability was defined. These percentages can be observed in tables 2 and 3. We consider the number of rooms that have each one of the 121,312 houses and apartments that are constructed to date in Tuxtla Gutiérrez city.

Table 2 Furniture percentages reported by the Population and House Census (INEGI, 2006)

	Houses	Television	Refrigerator and stove	Washing machine	Computer
Units	121,312	115,569	106,644	71,211	30,341
Percentage	100	95	86	59	25

In table 2 we observed that while almost all the houses has a television, only one of each four has computer. Defined costs of packages of furniture, elaborated in agreement with the dimensions of the rooms and reports of his habitants, are shown in table 3. In agreement with these values, 71% houses are constituted by up to three rooms and 29% of them by four or more.

Table 3 Packs furniture costs in function of the number of rooms for each house by the Population and House Census (INEGI, 2006)

Concept	One room	Two rooms	Three rooms	Four rooms	Totals
Percentage	23	24	24	29	100
Package cost (dollars)	2,856	4,866	6,447	8,652	5,705
Package cost affected by the percentage of influence (dollars)	663	1,187	1,489	2,535	5,874

Amounts obtained for each one of the furniture packages are put in line two, the mean of the package cost corresponded to US$5,705. Line three was obtained multiplying the percentage (line one) by package cost (line two). The result for add the one to four room values is US$5,874, that coincidently is practically the same that we got using the first method.

PRELIMINARY RESULTS

Study results are considered preliminaries, because we only analyzed the 2.43% of the houses reported in the census of population and housing 2005. So, it is necessary to complement them with more information in upcoming studies.

Obtained results appear in figure 4, which is made with the data of table 4. We compare the costs results of the studies of Mayes (2005) and Hirakawa (1997), with the results obtained in this project. We do not consider the study of Taghavi and Miranda (2002), because their results belong to the specific use of hospitals and hotels, and our study is for houses.

Table 4 Distribution of construction costs by material

Category	Wood structure	Concrete structure	Concrete structure	Masonry house	Masonry bulging of 4 levels
Structure	10	25	40	33	34
Nonstructural elements	25	33	40	48	49
Contents	65	42	20	19	17
Author	Mayes (1995)	Mayes (1995)	Hirakawa (1997)	González (2007)	González (2007)

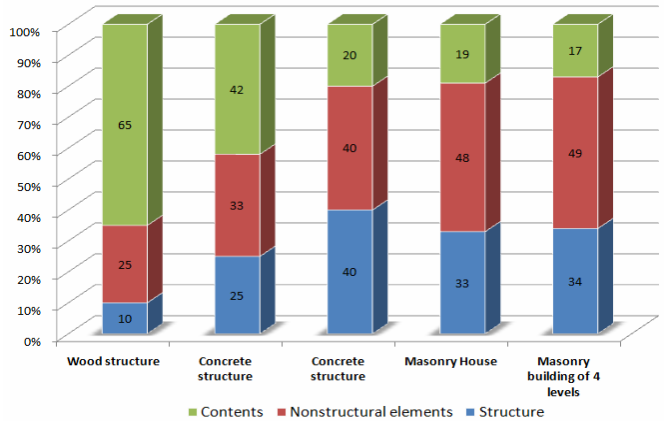

Figure 4. Costs distribution of the contents, structure and nonstructural elements (conform to table 4)

Peculiarly results are similar to Hirakawa (1997) ones and very different to Mayes (2005) studies. The costs distribution for typical masonry houses of Tuxtla Gutiérrez and apartments of three and four levels are similar.

Taking care about the uncertainties of the study, we could consider that they practically have the same costs distributions in Chiapas houses and apartments. For our study, the structural elements do not represent more than 33% of the cost of the construction and their contents and furniture.

CONCLUSIONS

Paper shows a simple methodology to determine the participation of nonstructural elements, structural elements and contents in the total cost of constructions. This methodology requires applying questionnaires in different regions of the city with personnel who inspire confidence to the owners of houses.

The costs of the nonstructural elements and contents of the typical houses of Tuxtla Gutiérrez correspond to 66% of the total cost of the construction. Then, we must use parameters like this to represent costs in risk studies associated to different sceneries.

Significant difference in the distribution of the costs parameters measured between the apartments and the typical houses of Tuxtla Gutiérrez was not observed, that is the reason why we assumed similar costs.

The methodology for houses and apartments manifolds difficulties of logistic that imply to take decisions that can induce minor level of confidence, by the implied epistemological variables. For that reason, in the present project we contemplate to a study of ambitious field work and analysis of real data bases of construction budgets and cost of furniture. This added to the homogeneity of the constructions of the city increase the confidence level of the present study.

After knowing the percentage of importance of the cost of nonstructural elements and contents in our constructions, the engineers of the practice and academics will count with elements that allow us:

- To have information that defends the structural project to the investors.
- To understand that structure represents a few of percentage from the total cost versus the investment. In this sense we could try to propose introduction of new devices to control performance in

the way to increase the security.

- To determine the necessity to study and investigate the behavior of the nonstructural elements and contents for local regulations.
- To have enough elements to make more reliable studies of risk.
- To define the money requirement of people after a disaster, this can be used by government authorities.

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