SEISMIC-RESISTANT ARCHITECTURE ON AN URBAN SCALE (A MORPHOLOGICAL ANSWER)

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SUMMARY

This is an architectural answer thought to an urban scale from a conception of integral seismic design. This proposal is conceived from the morphology and also from considering the urban net as a whole made up of a series of components interacting during a seismic action. These components can have a positive or a negative influence in the seismic behavior of the urban net. The objective "Adjusted Final Form", aimed in this work, is the compatibility of such interrelations as a contribution to the inhabitant's safety.

INTRODUCTION

During the last two decades, natural disasters, especially earthquakes, have been increasing their destructive consequences due to their damaging effect on larger concentrations of people and individual property, affecting significantly not only regions but whole countries as well.

According to the United Nations estimates by the year 2000, more than 50% of the world population will live in urban areas. In the case of Latin America, this process is developing in a concentrated way; there is a significant increase in population and economic activities in some parts of the region. In this way, there is a strong probability of an important rise in the social and economic impacts of natural disasters.

The decrease in vulnerability is one of the aims of prevention. These vulnerabilities are closely related to physical, socio-economic and cultural factors, so the Prevention of Natural Disasters goes beyond the technical field, it has political connotations and it is inserted in the environmental aspects of the development of a country.

Seismic hazard is a natural feature of some regions in our world. The danger of a catastrophe depends on the level of seismic risk and the vulnerability presented by a Habitat.

We are considering the concept of multidisciplinary Habitat that comprehends all the scales, "a continuum" from the building scale to the region, considering the urban and rural aspects. This allows the inclusion of Seismic Risk within the concept of Habitat, and consequently the inclusion of all the disciplines that are connected to the concept of habitat that transcends the field of Architecture and Urbanism, and includes them.

Within the concept of Habitat, we focus on our specific domain which is to produce Architecture; an Architecture related to the building scale and the urban scale.

In this sense, we have given the name of "Seismic-Resistant Architecture" (SRA) to the responsibilities the architects must assume to contribute to the integral solution of the seismic problem. In general words it includes three study lines:

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- Seismic-Resistant Architecture on an urban scale.
- Seismic-Resistant Architecture on a building scale.
- A Program of Seismic Protection.

One can immediately deduce that Seismic-Resistant Architecture is present in the main body of Architecture, hence its importance to the professional architects.

A DEFINITION OF SEISMIC-RESISTANT ARCHITECTURE

It is an architecture whose aim is to optimize the processes of design and materialization of human settlements located in areas of significant seismic hazard. It is mainly based on the compatibilization of the interrelations among its components or subsystems interacting during a seismic action, with the purpose of avoiding maladjustments that can affect it negatively.

BASIC CRITERIA

- The starting point is the consideration of the urban texture as a whole, where all its interacting parts or components must adjust among themselves and/or be compatible to avoid negative effects during a seismic action.

- An integral solution to the seismic problem is being searched, contributing to the Seismic-Resistant Engineering an answer to the problem from the responsibility of Architecture, convinced that the "Physical Vulnerability of the Urban Texture" is not only a function of the resistant capacity of buildings, but it also depends on the compatible interrelations of buildings included in parcels, with the network of roads, with open places, system of infrastructure and the ground.

- A fundamentally morphological answer is also being searched. This answer is the decisive aspect when the aim is to satisfy the requirements of the seismic design of the urban texture.

OBJECTIVE

From an architectural point of view, we are emphasizing the contribution to a decrease in the physical vulnerability of the Habitat, by means of the investigation of a conception of design alternative generation of "Architectural and Urban Form". These design alternatives guarantee a better capacity and quality of answer to the alteration produced by a seismic movement. The Seismic-Resistant Architecture allows, in this way, to control and make compatible the interrelations of all the constituent elements of the building and urban totality. Therefore, the basic aim is to organize, make compatible and optimize all the components of the urban texture, to give a positive and efficient answer during a seismic action, ensuring the minimal building and urban vulnerability.

METHODOLOGY

The Components of the Urban Net:

We start by defining the components of the urban net that interact during a seismic action with its corresponding parameters. These parameters determine their seismic behavior.

Buildings:

a) Buildings themselves

- Materials: Walls
  Ceilings
  Structure
- Age
- Number of floors
- Organization and structural layout
- Plan and height continuity

- Plan and height symmetryPlan and height proportion
- The relation between hollows and solid parts in the perimeter
- Placement and size of hollows

b) As part of the urban net
- Parcel area
- Width and length of the parcel
- Position of the building in the parcel
- Housing Density by hectare
- Housing concentration
- Kind of parcel
- Proportion: Housing height – distance to the street and sidewalk
- Proportion: Housing height - Distance to open places belonging to the community and inner open places of the block.
- Distance to adjacent buildings (lateral buildings and opposite buildings)

Roads:
- Street width
- Sidewalk width
- Road network: Regular
  Irregular
- Accessibility to the area (number of connections to the principal roads)
- Disposition of roads

Green Areas:
- Percentage of open spaces in relation to the total area.
- Number of open spaces belonging to the community
- Area of open spaces
- Location in relation to the roads
- Location in relation to the built spaces

Waterworks, electricity, sewer, gas.
Hospital centers.
Schools.
Hazardous industries (chemical industries, power stations, atomic plants).
Engineering works (bridges, dams).

Seismic Referential Variables
For urban design
- Seismic hazard: magnitude and intensity.
- Amplification of the kind of ground.
- Dynamically unstable grounds (liquefiable grounds).
- Vulnerability of buildings and engineering works: bridges, dams, hazardous industries, etc.

And for design on a building scale, the following areas are added:
- Dynamic nature of the seismic movement.
- Predominant periods.
- Pseudo-resonance.
- Far and near epicenters.

Requirements or conditioning aspects that must be made compatible or must be avoided in seismic resistant buildings:
- Flexible or soft floors.
- Short columns.
- Seismic torsion.
- Liquefiable grounds.
- Crash of buildings
- Drastic changes of resistance and/or rigidity in height.
- Undesirable asymmetries in seismic-resistant structural design.

Requirements or conditioning aspects of urban seismic design:

- Making the accessibility to areas of disaster possible (main road network).
- Hospital centers invulnerable to seismic effects (functional and instrumental building safety).
- Schools with high seismic building safety and fitting in the virtual event of their use as temporary shelters (enough toilets, open spaces, etc.)
- Private or common open places to be used as temporary shelter and as first aid areas.
- Avoiding high density of population, especially in areas of high seismic vulnerability.
- Buildings with an appropriate compatibility of architectural and structural design.
- Buildings with an appropriate insertion in the urban net.
- Avoiding that elements of the perimetral finishing of the building could hurt or kill people.
- Avoiding the spreading of fire.
- Special seismic safety measures for hazardous industries (chemical industries, power stations, atomic plants).
- Seismic safety in engineering works, such as bridges, dams and others, that can have negative effects on the performance of the urban system during seismic emergency.
- Others.

Each of these seismic conditioning aspects interact with the components of the urban net. The intention of this methodology is to define, from an integral and multidisciplinary approach, the formal-spatial characteristics that can reduce or eliminate seismic risk, not only building seismic risk, but also urban seismic risk.

This can be achieved interweaving the set of seismic conditioning aspects and the components of the urban net, just as it is shown in table 1. In the first reference in the list of the Reference section, one can find the chart corresponding to the building scale.

Table 1: Interrelations of seismic conditioning aspects and the components of the urban net.

		Seismic Conditioning Elements											
		1	2	3	4	5	6	7	8	9	10	11	12
Components of the Urban Net	Construction on a building scale	●	●	●	●	●	●	●	●	●	●	●	●
	Construction on an urban scale	●	●	●	●	●	●	●	●	●	●	●	●
	Roads	●	●	●	●	●	●	●	●	●	●	●	●
	Green Places	●	●	●	●	●	●	●	●	●	●	●	●
	Networks	●	●	●	●	●	●	●	●	●	●	●	●
	Hospitals	●	●	●	●	●	●	●	●	●	●	●	●
	Schools	●	●	●	●	●	●	●	●	●	●	●	●
	Hazardous Industries	●	●	●	●	●	●	●	●	●	●	●	●
	Bridges	●	●	●	●	●	●	●	●	●	●	●	●

The interaction between a definite component of the urban net and the seismic conditioning elements is studied for each point in this chart, based on the knowledge of seismology and seismic resistant engineering stated in

terms of referential seismic variables of architectural design on building scale and urban scale. Aware of the nature of the corresponding interaction, it is necessary to find a way of avoiding negative effects and also a way of optimizing its answer, trying to satisfy the requirements of architectural design on building and urban scale appropriately.

A MORPHOLOGICAL ANSWER

The proposed methodology demands the turning of every seismic conditioning element into morphological conditioning elements of seismic resistant design of buildings and urban net.

With respect to the urban net scale, the following sections constitute a brief synthesis which shows the immediate application of the proposed solution. The article mentioned in reference 2 must be read to see seismic resistant design of building.

Accessibility to areas of disaster.

The morphological answer demands an interconnected main road network to cover with a certain regularity the urban net. Main roads are those which will go in working after the earthquake.

Hospital centers.

They must be placed in an area with a direct access from the main network, with planned open spaces. Buildings with a final adjusted form on a building scale, distributed with a coherent regularity taking into account the areas of high vulnerability.

Schools.

Accessibility to the main road network or to areas of disaster. Seismic resistant buildings and an architectural design compatible with a structural design (a final adjusted form on an urban scale).

Open spaces.

Large enough, adapted to become temporary shelter (enough toilets), and first aid areas. Distributed with certain regularity, taking into account the areas of high vulnerability and population density.

Avoiding large population density in areas of high seismic vulnerability.

This can be morphologically interpreted as low buildings, wide streets and sidewalks, a greater number of open spaces and appropriate insertion of parcels.

Buildings with an appropriate compatibilization of the architectural and structural design.

It is related to areas with new constructions and also to continually growing areas. Updated seismic resistant codes are assigned to these kind of areas. The morphological aspects refer to seismic resistant buildings with an adjusted final form. In other words, its particular plastic expression in connection to the requirements of symmetry and spatial-formal regularity.

Buildings with a n appropriate insertion in the urban net.

The relevant morphological aspects that also refer to the areas of buildings or new settlements are:

- Open areas in tower buildings that help the concentration of people affected by panic, an inevitable situation during the seismic action.
- Easiness to escape in the building itself.
- Street width, in relation to the height of buildings that let an easy and quick evacuation.
- Enough distance between buildings to avoid a crash and people injured by loose material as well as the blockage of exits to the outside of the building.

Avoiding the falling down of elements of the perimetral finishing of the building.

Heavy finishing should be avoided because it may fall down during an earthquake: like marble walls, glasses in windows, etc. A way of stopping their negative effects would be to place protection canopies.

Avoiding the spreading of fire.

This can be achieved with wide streets and wide sidewalks, not very high buildings if they are made of wood and the appropriate distribution of open spaces.

Hazardous Industries.

If at all possible, this kind of industries must be located outside the urban net, or they must be surrounded by spacious open spaces with a direct access to the main road network.

Seismic safety of civil engineering works.

The seismic risk of a dam that can fail during an earthquake depends on graphic morphology of the area that relates the dam with the urban settlement.

The seismic risk of bridges depends on the amount of bridges of a scarce seismic safety and their location, especially, those that make main road network functional.

CONCLUSION

- The proposal of this approach constitutes a comprehensive, systematic and rational methodology of the set of responsibilities architects and engineers have when they face the widest spectrum of the seismic problem.
- The main aim of the "final adjusted form" is to satisfy the requirements the seismic resistant design of buildings and of the urban net from a morphological view. This facilitates the understanding and practical application to "the Process of Architectural Planning."

REFERENCES

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