Risks influences and sustainable multihazard design on built environment

Razvan Oprita

***Abstract*—** The notion of risk is reported on local and transitory phenomenon that through them actions are remodeling the ecological system, affecting the built environment and endangers the human life. Risks are nature generated like earthquakes, floods, winds and fires; and human generated like terrorism. Defining and understanding risks and the problems that each of them raises on built environment is essential because they are changing human environment and the way of life. Each risk has its own characteristics and raises specific problems. A multi hazard approach of design teams is required for a proper mitigation assessment of the impacts on built environment. An investigation of built environment affected by risks leads to definition of specific measures for each risk category as well as commune measures for mitigation. Structural modification of the built environment outlook trough multihazard design and taken into consideration modern people needs can lead to remodeling of urban landscape with benefic effects on socialization needs and protection of humans.

***Keywords*—** risk mitigation assessment, built environment, multihazard design, urban environment

I. Current environmental risks

RISK-based issues on the aesthetics of architecture and their solving become more important at a global level.

The risks are conscious or unconscious consequences of people actions related to nature and society. In terms of environment, in the last century, the exacerbated and uncontrolled development led to the well-known climate change that currently endangers the human habitat.

In terms of the four natural elements, natural risks may be classified as follows: earth - earthquake, water - floods, fire - fires and air - wind. Man-generated risks are the terrorist attacks.

Only in recent years, it is raised the issue to improve the influence produced by the human society on the environment. However, the actions undertaken by the society to remove these consequences are not able to recreate the environment, but at most to slow its degradation. Nevertheless, these actions require time. Now, to protect the human habitat there are required local or area protection measures, depending on the type of risk to which the habitat is subjected to.

Measures to regenerate and protect the human habitat - and I mean all of the built environment - are increasingly stringent, due to intensification of risk power and rate, leading to the systemic change of the building design system.

Due to the external nature, the mitigation measures of the risk factors relate more to site and envelope configuration.

Risk influence in conscious design features in all its stages, starting with site selection and configuration, formal defining in the layout and spatial development, defining the access points, the height of building and the materials used for enclosing.

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II. Risk mitigation aspects on the built environment

The effect of human action and modern necessities (basically, technology and its needs) on nature lead to natural environment degradation and continuous more raised changed to produce hazards.

Every hazard risk has its own specific characteristics and ideal solving solution, but it may be envisaged a basic line that unifies the primary approach in multihazard design.

A. Earthquake

Earthquakes represent in a simplified definition, a vibration of the earth's crust caused by movements of the tectonic plates. This produces, depending on factors like power, depth and nature of the soil, complex systems of forces, movements and impacts on buildings.

Earthquakes influence the human habitat not just directly through his forces laid on buildings, but also indirectly by damaging built environment facilities like dams, bridges and ducts. Crack and breaks on manmade dams or naturally raised dams can produce floods, damages on bridges can cease communication and circulation of humans, crack in ducts can produce fire.

Mitigation assessment of risk factors in the case of an earthquake involves complex strategies for finding a structural proper response by a balance for form, size, type of foundation, building straightening and proper energy dissipation mechanisms.

One way to mitigate earthquake damages, whatever the type of the building (form, height, function), is to avoid a weak ground floor and to create large footprint.

The creation of a large footprint can be seen as unfavorable from building / natural land ratio point of view but effects, on long time, can be positive and can balance the lose, if we take into consideration possibilities to incorporate underground

parking in building and to create on the street level a topological landscape.

The benefits of such a design approach is improving the building performance through a pyramidal system of load discharge from the suprastructure to foundation.

Corroborated with the principles of earthquake architecture in which the structure is the main definition of the architecture, the value of the built environment takes a dynamic turn.

Fig.1. Global seismic hazard map, Global Seismic Hazard Assessment Program

A topic related to earthquakes is represented by the volcanic activity, a consequence of a different way of materialization of the tension in the earth's crust. In my opinion, seismic mitigation measures addressing the built environment cannot be taken - perhaps only radical measures - prohibition of settlement in proximity to already known volcanoes, which is impracticable. The only risk management measure in case of volcanic eruption is to develop evacuation plans and to facilitate rapid evacuation.

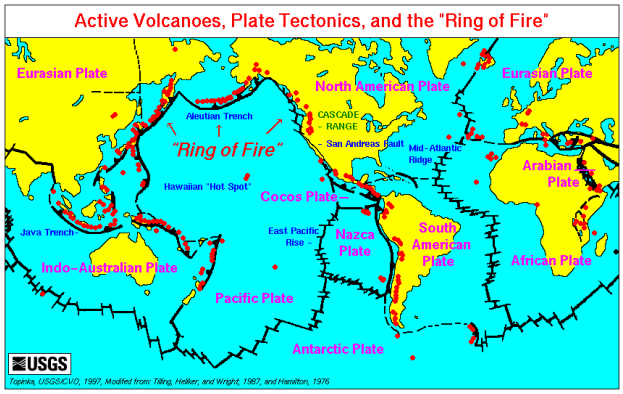

Fig.2. World Active Volcanoes, Plate Tectonics, U.S. Geological Survey

B. *Floods*

Floods consist in large quantities of water displaced accidentally from a natural hazard event like earthquakes, heavy rain or hurricanes, or from manmade acts, like terrorism on facilities like dams.

Risks on the built environment are the subject of punctual nature like water imbreating – velocity, impact from debris, wave action and the duration of the flooding – water stagnation and impossibility of fast force clearing.

Mitigation assessments in flood control and prevention of damages on human habitat consist in a series of strategies that should be taken into consideration from early stages of design to the end.

In case of flood hazards the designing team should have in the agenda strategies like: building on higher grounds that would naturally prevent building to be flooded, design strategies that allow positioning of the vital accesses on an elevated position that would facilitate the use of the building despite of the flooded basement, designing urban landscape from levees and floodwalls combined with a topological system that can protect and preserve the core of the building.

In the structure and exterior cladding system should be taken into consideration structural systems and finishing materials that can absorb impacts and in the same time to be waterproof.

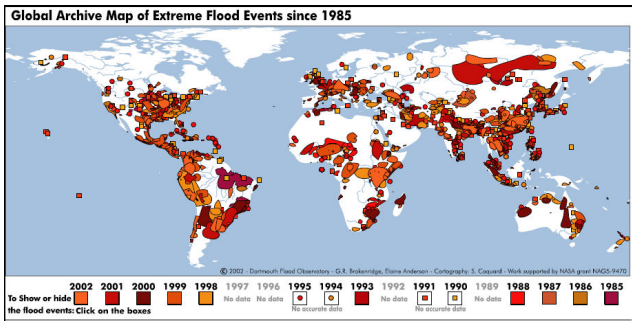

Fig.3. Global Map of Extreme Flood Events, R. Brakenridge, Dartmouth Flood Observatory

C. *Winds*

Winds are naturally in nature, but not normal wind creates problems to the built environment. High winds and tornadoes are raising problems and constitute risks to building and humans.

To high building, wind produces lateral forces and dynamic actions that have to be taken into consideration. But this is not all; this is only the direct influence. Indirect risks are made by objects raised and carryout by winds.

First involves the structure, second involves the skin of the building.

Mitigation assessments driven from the dynamic action of the wind entail, as wall as in the case of earthquakes, structural strengthening and stiffness.

Mitigation assessments driven from the indirect effect are more damaging in relation with humans, because the level of action is around ground level where humans move freely. Objects raised and detach by wind can be carried out, and, depending on the intensity of the wind, can cause significant impact on humans and on the building skin. Topics that should be taken into consideration in design are: impact resistant materials and elastic binds of façade and roof elements, but in the same time a more secure and homogenous site planning with green barriers and irregular relief and green roofs.

Benefits of this are, beside a friendly urban landscape, a

wind filter that can attenuate winds and the amount of flying objects that can harm.

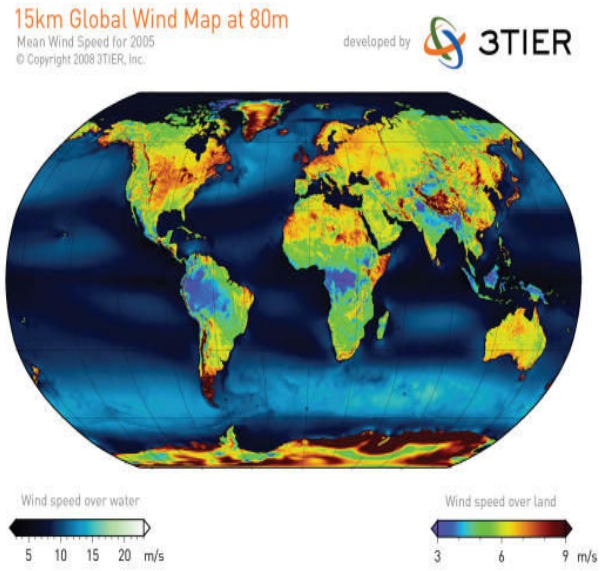

Fig.4. Global wind map, 3TIER

D. Fires

In nature, there are few cases in which the fire exists or develops naturally. Fire is the first means by which man really evolved. Control of the fire has produced the most important social and technological evolution of humankind, from prehistory until today.

Fire problem occurs when it leaves the control area and grows and spreads naturally, i.e. uncontrollably.

Situations in which fire affects the human habitat, without having to refer to situations in which it develops and affects the interior area are: a) fire in the natural environment near to people communities and b) development of a fire in the built environment from a building to another.

Effects of fire in the nature affect, on the one hand, the terrestrial ecosystem by reducing forest area and by the release into the atmosphere of greenhouse gases and, on the other hand, the human habitat, when fires extend from the neighbouring areas to urban areas, thus jeopardizing human life.

Fires in the built environment developing at a point from a building represent a danger to human groups because they may extend from one building to another.

In case of fire, some missions to mitigate risks in the context of the built environment would be: to create natural and successive green barriers (because communities are in a continuous expansion), to minimize the chances of fire to approach the human habitat, to create urban policies that compel the developers to increase by the site layout the distances between buildings or building complexes.

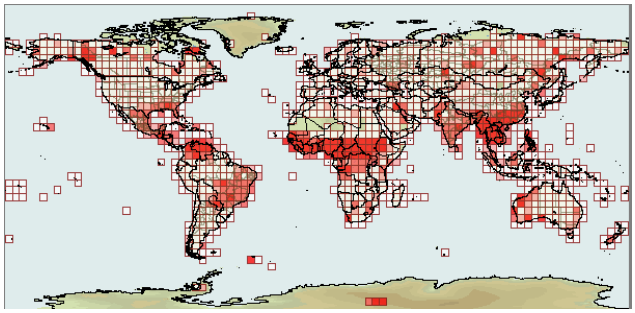

Fig.5. Brief History of fires in the World at the Web Fire Mapper,Fire Information for Resource Management System

E. Terrorism

Terrorism is a specific human activity, caused by social gaps created by religious or economic conflicts. Terrorism, unlike the armed conflict, which is shown open, is subversive.

The effects of terrorist attacks are directed to points, but have high intensity and produce constant panic / stress.

Terrorist attacks have the ability and purpose to cause massive losses in terms of damages, casualties and disruption of economic activities. They can be classified according to their nature in: exterior blasts, exterior attacks of biological, chemical or radiological nature or internal attacks from all types mentioned above.

Targets of terrorist attacks are mainly the centres of developed societies, which have a special importance in terms of social, religious or economic matters.

Efforts to prevent or minimize the terrorist actions that communities, urban planners and architects may take are to prevent the approach towards the building and to prevent access into the building.

Mitigation assessments in case of terrorist threat, in site layout design consist in a series of measures that can discourage or at least complicate the attacks, such as: increasing the distance between the building and the property border, and street, choosing an optimal shape, protection elements friendly for humans, but unfriendly for vehicles like poles or fences, rough areas, non-linear and controlled access, underground parking areas far away from the building, underground parking areas in the building, but not under the main core of the building.

Regarding the skin of the buildings and the exposed structure there have to be taken into account also modern systems and materials that take over the blast shock wave without complete destruction, such as: blast proof glass and frames, polymers for reinforcement of structural elements.

Regarding the utilities of the buildings, they have to be built from the elevation which can be reached by a person, so that by his actions he may prevent interruptions, damages and contamination with harmful substances.

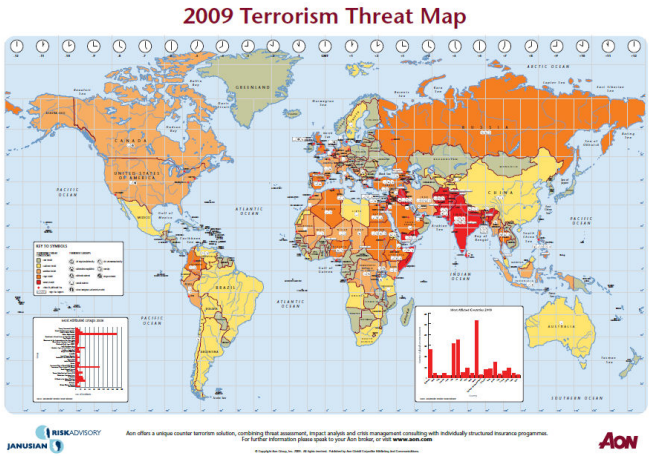

Fig.6. Global map of terrorism, AON Corporation

III. Multihazard Design Approach

Adverse events are caused by fluctuations of risk factors, but the built environment disasters occur when they reach or pass beyond certain intensity.

They occur at some points, with a certain periodicity and usually they are not single events. Even if the cause is single, from this single cause arise many consequences, in different levels. Thus, earthquakes can cause floods and fires, floods can cause landslides, but all of them lead also to damages of the built environment and disruptions in normal life style.

In the same time, as shown in the succession of figure presented on each risk category Fig. 1-6 correlated with the following one Fig.7, we can observe that in most of the cases areas with hot spots correspond to all. Our society reside in urban areas and those are located around multihazard areas.

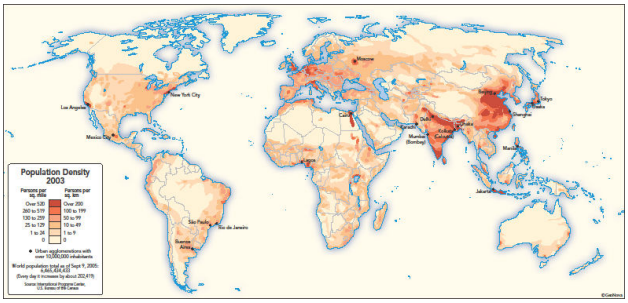

Fig.7. World Population Density, U.S. Census Bureau

From this point of view, there have to be found overall solutions through multihazard design which have to mitigate their impact on the human habitat.

The design process is complex and it should encompass the requirements of human needs - function, dimension, lighting, the aesthetic requirements, and also it should meet the safety conditions: structural integrity and mitigation of negative effects of natural or human hazards.

Traditional thinking according to which each risk should be addressed in part has to be replaced with a pluralist thinking, according to which all risks must be acknowledged and treated as a whole, of course, taking into account the degree of risk raised by each risk category for a certain geographic area, intensity and rate.

In addition, the problems related to the nature of risks and risk mitigation measures have to be taken into account and presented to all parties involved in the process of building the built environment, starting with the authorities establishing the rules and authorizing constructions, continuing with specialist designers, planners, architects, structural and building engineers, and ending with the developers.

The common foundation for all these risks can be defined for both spatial and functional compliance solutions, as well as for outdoor arrangements and indoor partitioning.

I will discuss the first part, as they affect the urban landscape and the human way of life.

As shown in the previous chapter on issues and solutions raised by independent risks for urban planning and site layout, it is foreseen a unified approach.

Creating buildings or complexes with a large footprint in the land, but green at the pedestrian level, with underground parking and ancillary areas surrounding the central body, with access levels elevated over the street and outdoor areas developed from the topology and landscape point of view with green spaces, sound barriers, water, inclined planes, and courtyards, might be a basic and common feature in the mitigation assessment of the multihazard design.

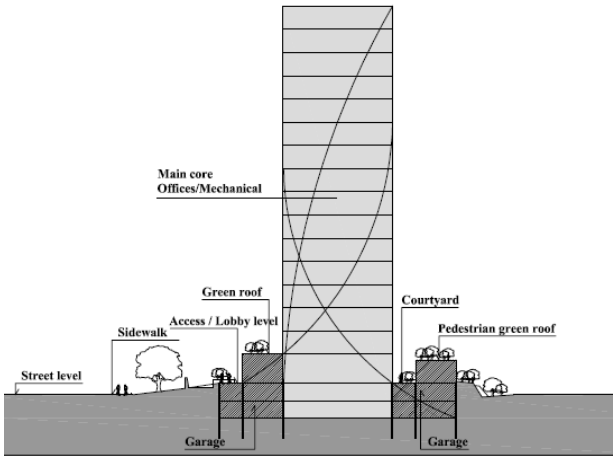

Fig.8. Principle of common mitigation measures

This principle can be applied regardless of the scale or function of the building and can solve the problems raised by the first line of defense in case of hazards.

A topic that falls within the scope of the above categories is the environmental noise. It is not a hazard in itself, but it equally affects people's lives and, respectively, the built environment.

Environmental noise is any unwanted sound created by people or their instruments and equipment. In essence, all aspects of modern life cause harmful noise to people. When exceeding a certain level of intensity and frequency, noises produce adverse effects on human health: anxiety, sleep disturbances, mental instability, deafness, etc. [4]

The compliance of the built environment - both in terms of modeling the constructions and in terms of the space between them - can enhance or reduce the harmful effects on human health.

The set of general mitigation measures outlined above is applicable and beneficial in this case.

Today, international competition are leading manifestos concerning architecture, engineering and green concepts. One example that is not necessarily directly linked with the principles shown above but that comply with them is KEPCO Headquarters Competition proposal by H Associates. H's design of a Green Energy Theme Park focuses on the integration of landscape with building to create an experiential awareness of the green energy life cycle. This strategy challenges the segregated tower / podium / landscape hierarchy which dominates current office complex typologies. The design inverts the normative scheme to create a polycentric organization with an open civic space at the heart of the site. This topographical strategy forms valleys that channel light and enhance air circulation while creating pedestrian friendly connections.[5]

Figs.9. KEPCO Headquarters Competition, Naju, South Korea, H Associates, www.archdaily.com

Multihazard design approach, can not and must not cover and address only future urban policies. At the same time, it must resort to the already built urban context, whether recently or historically.

In the same time, we have to look back and protect our heritage, because in it lays our cultural identity. Historical settings are part of our cultural heritage that reflects our socio-economic and cultural structure.

It is imperative to create modern cities that preserve their cultural identities and to transmit the cultural heritage to future generations. [6]

In case of historic buildings and ensembles, there are few mitigation measures - related to flood, wind, fire (as defined) or even to terrorism, because they would affect their intrinsic value. The widest area where measures can be and have to taken is the one related to earthquake protection.

The scientific community has realized that understanding the past is essential for projecting the future, so there have been commenced extensive investigations of the historic buildings (mainly masonry buildings) with modern means to identify their proper preservation. Unlike the buildings

currently built, for which are in place compliance and design standards, the historic buildings are not supported by comprehensive documentation. [7]

Closing the above loop, meeting the needs of present generation without jeopardizing the needs of future generation – a better quality of life now for generations to come is the meaning of sustainable development.

In this context, related to hazard risks, is essential to find the proper approach to protect the built environment, preserve the natural environment and human society, be it rural or urban.

When we talk about the built environment, we talk in fact about urban agglomerations (quasi-randomly) around historical centers. We talk separately about blocks of flats, house districts, parks or industrial and commercial areas, but we do not talk about their amalgamation, which actually characterizes the built environment.

A sustainable building pattern can improve the quality of the urban environment. A denser built environment pattern, not related to high rise, low rise or city segregation into dormitory, industry and commercial, but related to a mix of forms and functions, can be achieved trough a series of urban planning strategies that can even have roots in stated mitigation measures in cases of risks. Public open space and green areas have to be rediscovered and an education of all parties involved in building the built environment has to be done, because the wellbeing of the inhabitants is immense. [8]

Following figures illustrate the common principles related to site plan, mix of the high and low rise, topological landscape and green pedestrian areas as was mentioned above, and comply with current trends regarding to buildings functional requirements, society requirements and responsibility towards the environment.

Fig. 10. Kefalonia Hotel, Kefalonia, Greece,
Divercity Architects, www.archdaily.com

Fig. 11. Emerging Landscapes, Greece,
KLab Architecture, www.archdaily.com

Fig. 12. Højblokka PULS, Oslo, Norway,
MAPT + DARK Architects, www.archdaily.com

Fig. 13. Aquatic Center,London, United Kingdom,
Zaha Hadid Architects, www.archdaily.com

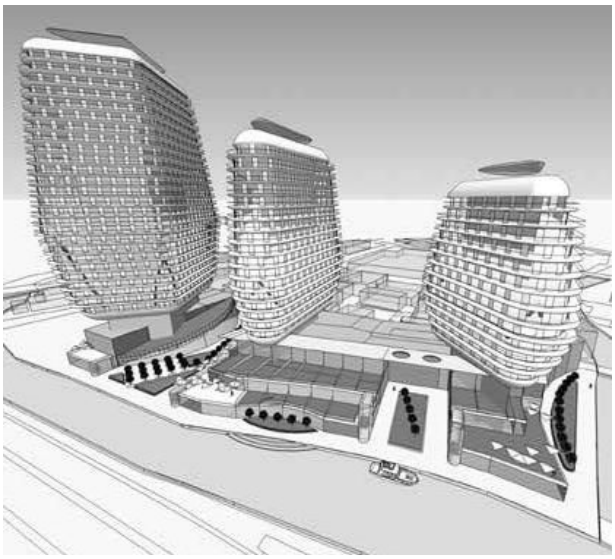

Fig. 14. Lea Square, London, United Kingdom,
Atkins Design

Fig. 15. Evergreen La Florida, Mexico City, Mexico, ROW Studio, www.archdaily.com

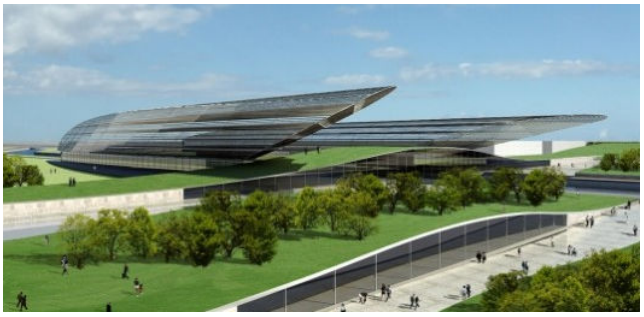

Fig. 16. SANY Beijing, Beijing,China, Perkins + Will Architects, www.archdaily.com

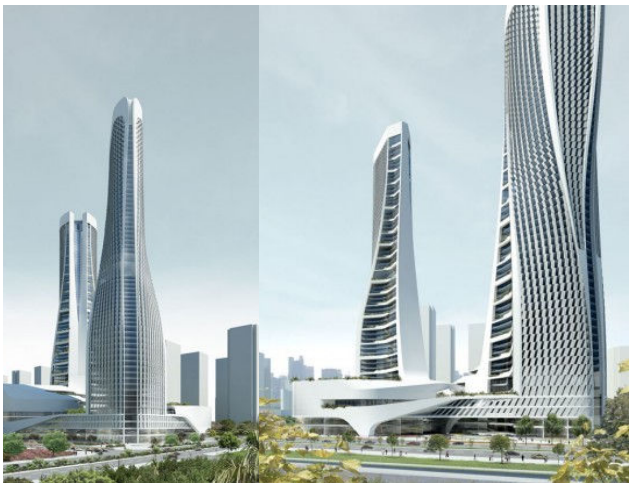

Fig. 17 Raffles City, Hangzhou, China, UNStudio

Fig. 18. Suncheon International Wetlands Center, South Korea, G.Lab*, Gansam Architects&Associates, www.archdaily.com

IV. Conclusion

Reconsideration of the urban presence of a building and its integration in a developed urban environment based on the multihazard design principles may influence in a beneficial and sustainable manner the way of life, even if economic benefits are not as easy to foresee.

Taking into account the current context, characterized by abundant "capsule-habitats", by a large number of vehicles, by the transformation of streets in unfriendly environment to pedestrians and by a minimum social interaction, such an approach could change the human way of life.

We must not forget that the way places and building are planned, design and look after matters to us all in countless ways. Built environment is a meaningful place and the source of everyday joy or everyday misery. [9]

The urban environment and landscape defined by the above-mentioned characteristics may gain social and environmental valences, where people can develop themselves protected against any risk.

Acknowledgment

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