ISSN: 1857-9000, EISSN: 1857-9019

CONTEMPORARY ARCHITECTURE IN SEISMIC ZONES, CONCEPTS AND REALIZATIONS

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UDC: 72.036:550.349

SUMMARY

With the rapid development of society and the demand for a better and more modern life, there is a need for the development of civil engineering in general, and of earthquakes. Recently, we are witnessed by many natural disasters occurring in the world, leaving huge footprints, taking a large toll on human lives and causing extensive material damage.
The main problems remain without clear and precise answers now. Which arise during the impacts of dynamic loads, and the origin of those loads can be from: earthquakes, winds, explosions, working with cars, etc.
Earthquakes are still one of the greatest nature threats which is causing to mankind. Although earthquakes cannot be prevented, modern science and engineering have provided the means and tools that if they will be used properly can significantly reduce the impact of powerful earthquakes.

Key words: *earthquake, seismic architecture, objects, seismic zones*

1. INTRODUCTION

The earthquake was and remains one of the most terrifying natural occurrences for mankind. During this occurrence, “man made” buildings collapse, major material damage is caused and, unfortunately, we have a large number of human casualties.
Earthquakes are associated with the creasing and tearing of the Earth's crust, respectively, with the physical activities that occur deep inside the Earth's

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interior. The interior of the Earth is still in a gaseous state where tectonic movements occur. The earthquake is due to the sudden movement of the tiles from which the Earth's crust is formed, during which earthquakes are created. The Earth's crust is formed by so called plates that are touched with each other in long cracks, i.e., cracks in the Earth. The thickness of the tectonic plates goes up to 70 km, under the seas, and twice as much under the ground.
In this paper, I will not deal with earthquake concepts and the causes of earthquakes. Areas where earthquakes occur, forces of action, calculations on earthquakes and so on.
But like architects, designers of construction sites in the regions where we operate, they are still limited in design and modeling due to seismic impacts. But in the world, it is quite different.
The analysis in the paper will be elaborated by questions and answers

2. QUESTIONS

2.1 QUESTION (1)

Does contemporary architecture in seismic zones differ from that in "calm" zones?
or:
How much does the earthquake affect the architectural shaping of objects?.

2.2 QUESTION (2)

Do basic seismic rules, such as:
• the necessary horizontal and vertical symmetry of objects,
• uniform distribution of stiffness and rigidity, etc.,
so that contemporary architecture in seismic zones is less interesting and attractive?

2.3 QUESTION (3)

Do standardized rules on the construction of buildings in seismic zones affect the quality of architectural expression?

3. ANSWERS TO THE QUESTIONS ASKED

- Architecture today represents a phenomenon that lies between art, fashion, and structure. It contains the characteristics of different disciplines, and above all it is diverse. The very dynamic development of science, as well as the constant technological transformation, have largely opened the door to

new / non-Euclidean forms that are met today, as often as in the past, to domes or other regular forms.
- We are witnessing the redefinition of the phenomenon of beauty and its relation to the function of the object, which has produced "no structure" architecture, which reminds us more in scenery, design or sculpture, and less in true architecture, which should be at the service of its users. This complexity of architectural forms and expression requires complex analysis of construction.
- In addition to these trends in architecture, design norms and standards in seismic zones are 'moving in place' and consistently point out that simple forms respond better to seismic, so their performance during earthquakes can be predicted.
- The primary seismic requirement is horizontal stiffness for the two orthogonal directions of the object. Stiffness to the torsion is also a necessary condition. Symmetry and uniformity in the distribution of impediments are one of the basic conditions for a "sound project".
- There should be a certain hierarchy in the bearing system, namely, the vertical bearing elements need to be more rigid and rigid than the horizontal ones, which is a minor difference compared to the constraints in seismically inactive areas.
- There are also a large number of other secondary requirements, which in one way or another affect the configuration of the structure - object.
- The question arises: to what extent do these principles and rules restrict architects working in seismic zones?
- So far no study has been published comparing the architecture-urbanism of cities with different levels of seismicity, to identify the seismic factors that have influenced architecture, namely urbanism.
- Many factors influence the shape, size, and configuration of objects, making it impossible to identify the impact of seismic factors.
- Cities like Tokyo, Los Angeles, San Francisco, and Mexico City are just some of the metropolises that have been historically hit by powerful earthquakes.
- However, these cities are full of objects that with their shapes, dimensions and expressiveness do not speak of any restrictions on architecture.
- Irregularities in the composition are, for example, very pronounced in Los Angeles buildings.
- Escalations and "jumps" along with object height, curved walls, asymmetric retention systems, are almost everyday phenomena.
Good examples are the works of Californian architect Eric Owen Moss (Stealth building, Art Tower I Glass House) and Frank O. Gehry (Walt Disney Concert Hall - Fig. 4).

- On the other hand, Mexico City, a city with unfavorable geo-seismic conditions, which in 1985 experienced a truly devastating earthquake, is on the cutting edge of new architectural trends. After the earthquake, the construction of objects higher than 4 floors was not allowed. Today, the fear of the earthquake has been overcome.
Multi-story buildings, (Torre Bicentinarrio-350m, Torre Mayor 300m and those with complex geometries (Tayoma Museum Fig. 5,6,7)), can be found everywhere in the city.
- Japanese architecture is quite "rich" with asymmetrical structures at the base and height, with large consoles as well as sculptural forms. In general, Japanese objects are "heavier" and there are many examples where elements, asymmetric devices, are visible and important parts of the object's architecture (visible facades, etc.). On the one hand, there is frequent use of seismic insulation * and damper **, but on the other hand, there is no evidence that seismic parameters and factors are restrictive to Japanese architects.
Despite the island's regular seismic activity, Japanese architects have always been carriers and pioneers of interesting architectural solutions..
*) concept of seismic base isolation - the support of the object on several seismic isolators which with its flexibility amortize the effects of the earthquake. The object gains reduced seismic force.
**) Passive energy dissipators are special elements designed to absorb earthquake energy 3

3.1 TOKYO

- A good example is the TOD "s object, authored by Toyo Ito (Fig. 1, 2, 3).
- The design is inspired by the natural structure of the simple tree-trunk, where the "trunk" itself is the main driving force to the foundations, while the "branches" are thinner, respectively less loaded.
- This concept is reflected in the facade of the building, the facade which is also a retaining system, which consists of a series of "trees". No particular algorithm was used to determine their dimensions, but they were largely conditioned by aesthetic conditions.
- The facade, in addition to being the main retaining system, it also provides space without pillars on seven floors. This space, without pillars, implies the construction of a 50cm thick midrange, which in no small measure increases the seismic force, that is, the displacement of the object as a whole. To minimize horizontal displacements the object is seismically insulated at base*).

Figure 1 & 2: Inovative Structurec -Tod's Omotesando building-Toyo Ito-Tokyo

Figure 3: Inovative Facade- Tod's Omotesando construction

- Indeed, often extravagant forms can only be achieved by irregular facade construction, while the holding structure may be quite regular. Accounting and analysis are done the same as for simple objects, including the facade in the account only as a load on the primary structure.
- The situation is quite different when the non-symmetry and "irregularities" in the architecture of the building are achieved with the retaining design itself.
- The typical and extreme cases are the works of the famous architect Frank O. Gehry who with their complexity have confused and are constantly confusing many engineers

3.2 LOS ANGELES

- The orthogonal organization and positioning of the retaining elements in Gehry can rarely be met. Its objects must be viewed - analyzed only as three-dimensional, and the position of the key holding elements can very often only be described through X, Y and Z coordinates.

- Although 3D models enable detailed analysis both static and dynamic, in these cases engineers are almost completely dependent on software outputs and cannot predict object response.
- Modeling of the Walt Disney Concert Hall facility (Fig. 4), is implemented in CATIA software mainly used in the aviation and auto industries. At present, it is the only software that has the capacity for these types of modeling. For the same account, the same model has been exported to commercial SAP2000 software.
- The heavy dependence on software leaves engineers in the dark because standard formulas for accounting and dimensioning cannot be used in highly non-standard constructions. Due to a large number of approximations, it has not been possible to perform the test in a reduced model, so the software account remains the only way of analysis.
For this reason, designers have, in certain cases, pre-dimensioned some of the key retaining elements.

Figure 4: Walt Disney Concert Hall-Frank O Gehry

3.3 MEXICO CITY

- The 1985 Mexico City earthquake has left trauma and fear unspeakable to citizens. However, this fear has recently disappeared. Thus, the controversial Torre Bicentinarrio (Rem Koolhaas) project has not been halted due to its atypical configuration and high altitude (350m) but has been halted for other reasons, such as economic and property.
The Tayoma Museum building (Fig. 5,6,7) located on one of Mexico City's outskirts has been completed (May 2009). The main parts of the facility are consoles over 25 meters in length. The entire console design relies on the narrow concrete core, which is also the main carrier of seismic loads.

- The object generally represents a highly cumbersome seismic configuration.
- The account is made with SAP2000 and ETABS commercial software

Figure 5. Tayoma Museum Rojkind Arquitects & BIG (Mexico City)

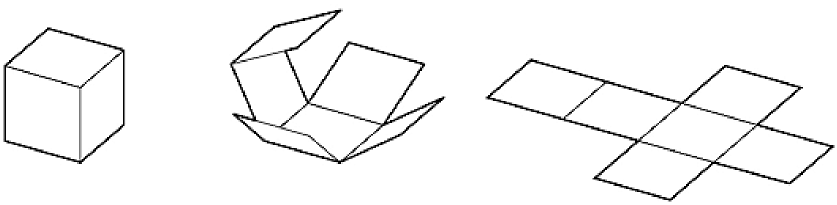

Figure 6. Initial concept of the museum

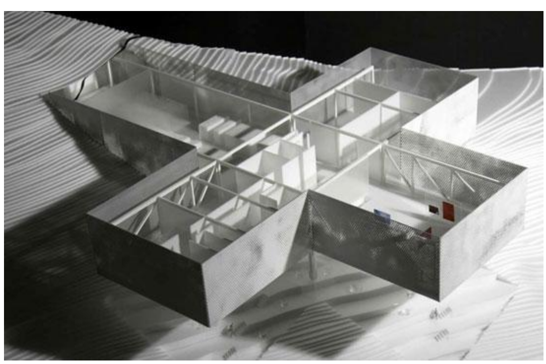

Figure 7. Model of Tayoma Museum

3.4 PEKINI (BEIJING)

- The Chinese National Television Building, CCTV, in Beijing (Fig. 8.9) designed by Rem Koolhaas, represents one of the boldest projects of today.

The size, shape, unstable configuration and seismicity of the site has produced an extremely complex static and dynamic analysis.

- The concept of holding is extremely inventive. Thus, the facade of the object also represents the main conductor of all lateral loads, thus creating a continuum holding tube. The largest shake table test to date has been carried out in China, the 1: 30 model, while the characteristic facade nodes have been tested in the 1: 5 model. Complex linear and nonlinear analysis was performed on over ten powerful software (Oasys LS-DYNA. GSA, GSRaft, CSI SAP 200, X-tract, MSC / Nastran, X steel).

- Seismic analysis is based on performance-based design - taking into account the 2500 year earthquake return period.


Figure 7. & 9. No stability illusion – CCTV- Rem Koolhaas

The elaboration of this paper is somewhat different from that of the researchers but the principle of what is a model and design philosophy in modeling structures. It presents a conceptual approach to the design of buildings today, especially multi-story structures. Today's architecture does not support a certain set of architectural philosophies and therefore deciphering the symbolism is highly subjective. Symbols are undefined today, it happens that architecture justifies the symbolism. This approach to architecture enables creators greater freedom, often inspiration is metaphorically and symbolically derived from the earthquakes themselves.


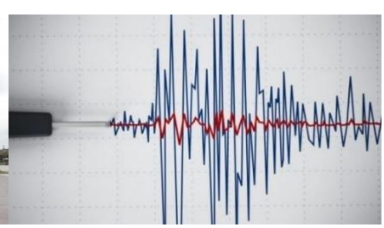

Figure 10. The Museum of Transport in Glasgow

Figure 11. De Beers Ginza Building Tokyo Japan

CONCLUSIONS

Resume (1)

- From these, but also many other examples, it can be seen that today's architecture is largely independent of seismic factors. Seismic factors do not prevent it from being diverse, asymmetric, irregular, fluid, extraordinary and at first glance contrary to basic asymmetric principles.
- A new approach to computation, analysis, fair and unreserved use of software, modeling, use of new materials and modern asymmetric equipment have made a major contribution to making modern architecture possible.

Resume (2)

- This situation is a bit different in our country. Although architects complain that seismic limits static spaces, increases the dimensions of retaining elements, limits console sizes, seismic factors play a secondary role in the architectural shaping of objects.
- Architecture in our country is more a product of meeting the requirements of functionality and economics, and there are rare instances where we can notice a "part" of the good contemporary world experience.

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