

DEFINITION OF CRITERIA FOR THE APPRAISAL OF THE CONSTRUCTION IN SEISMIC AREAS OF ARGENTINA

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ABSTRACT :

This paper presents the analysis in its most relevant aspects of two modern buildings of San Juan city. It considers their architectural and structural design as well as their conditions regarding their surroundings.

Two phases have been differentiated in the evaluation process: One phase consists in the study of the physical vulnerability of the buildings, identifying the relation between the potential seismic behavior of the buildings studied and the assumed seismic danger in the qualitative and quantitative way. The other phase corresponds to the study of the architectural space configuration, identifying the variable and characteristics of the modern movement.

Once we analyzed the aspects that form the Architectural Design, we made a diagnostic of the condition of the building conservation for each of the buildings studied for the Structural Design and the conditions of them. This was done in order to define parameters that would determine its building value, which will be later integrated into a provincial database to formulate criteria for the preservation of Patrimonial Buildings of areas with high seismic risks in Argentina.

KEYWORDS: Seismo-resistant Architectural Design, Vulnerability, Historical Heritage.

1. INTRODUCTION

The city of San Juan, Argentina is located in the center west of the country, the most seismically active zone, 350 km east from the convergence line of the Nasca and Sudamericana. Several earthquakes along its history have affected this region.

In January 1944, San Juan's city was destroyed by an earthquake of IMM = IX (M=7.4; DH =14 km).

The earthquake not only ruined most of the city but it also destroyed San Juan's culture. Therefore, the architectural heritage of of San Juan city is small, given the widespread destruction caused by this earthquake

The process of rebuilding the city was heavily influenced by the stigma of this earthquake. The engineering and architecture were involved in a process of building knowledge that would allow reduce the vulnerability of buildings to the occurrence of future earthquakes.

This fact made a considerable change in San Juan's colonial stamp, transforming it in an atypical city in the national context.

This point in history was crucial for the Argentinean technological development of the subjects associated to the construction in seismic areas.

This paper presents the analysis in its most relevant aspects of two modern buildings of San Juan city, the building of the Main Post Office and the Building of Nation Bank. It considers their architectural and structural design as well as their conditions regarding their surroundings. They had an acceptable "seismic" behavior on subsequent earthquakes such as the one that took place in November 1977. At present, these buildings are considered to be the legacy of the modern movement to the city.



2. THE MODERN MOVEMENT IN THE SAN JUAN CITY

The modern movement tried to draw up a powerful arc between the art and engineering. In which the Architect no longer is a superior class of topographer or sketcher, he is now the teacher of a special capability, and still mysterious, in which the art and engineering are united of so subtle and singular way, which disqualifies those who do not possess it.

San Juan's reconstruction followed the modern architecture's premises due to the historical time when the earthquake took place. Institutional buildings were design and constructed according to the design premises, which in turn had to give seismic safety to its inhabitants.

Many of those buildings were established on a new wide avenue –due to the reconstruction, which constituted the institutional public-spirited core of the city. These buildings are still working as originally, designed fifty years ago.

Since 1996, the Architecture Faculty of the Universidad Nacional de San Juan has been developing projects of investigations about buildings that are considered to be significant to this seismic city. This is done in order to contribute to the understanding of a building made in the modern movement and to incorporate it to the historical architectonical heritage of the city.

Two phases have been differentiated in the evaluation process: One phase consists in the study of the physical vulnerability of the buildings, identifying the relation between the potential seismic behavior of the buildings studied and the assumed seismic danger in the qualitative and quantitative way. The other phase corresponds to the study of the architectural space configuration, identifying the variable and characteristics of the modern movement.

Once we analyzed the aspects that form the Architectural Design, we made a diagnostic of the condition of the building conservation for each of the buildings studied for the Structural Design and the conditions of them.

For this paper, the Nation Bank Building and the Central Post Building were chosen and their surroundings, their architectural design and their structural design had been analysed.

3. SURROUNDINGS OF THE BUILDING

The building surroundings is defined like the immediate space that surrounds the building to study, where this one projects its influence and whose constituent elements interact positive or negatively.

The analysis of the surroundings was realised having in account this aspects:

- Considering the seismic vulnerability of the surroundings, analyzing how the surroundings contribute to the seismic preservation of the buildings.
- Considering the preservation of the surroundings like integral element of the architectonic heritage, detecting those elements that are necessary to preserve along with the buildings.

When the city of San Juan was reconstructed, the Central Avenue was designed and constructed, in east-west direction –Fig.1– its institutional character emphasized the own character of the buildings that settled down there. Indeed, many of the significant public buildings were established on the new avenue that constituted the institutional public-spirited core of the city.



Figure 1 The Central Avenue



Figure 2 The Nation Bank Building The Central Post Building



The design of this avenue, as much functional as formally, is highly appropriate for zones of the high seismic risk. The urban design in that the buildings are located proposes passages – open spaces– between each one of This grants not only space quality to the city but also security to the building since each one works independent way during the seismic actions. In addition to this space quality contributes at the design of galleries extends along the axis, and that does to the urban environmental quality.

The analyzed buildings –The Nation Bank Building and The Central Post Building– are located in this avenue. Figure 2

4. ARCHITECTURAL DESIGN.

The criteria adopted for the architectural analysis were to observe that in the Modern Architecture it can be constant that they allow the analysis from:

- Valuation of the geometry elements
- Polarization of the structural elements
- Internal place Continuity
- Emphasized of the interior height
- Search the continuity from exterior place to expand the internal place
- Flexibility spatial

4.1. THE NATION BANK BUILDING

The building prevails in its immediate surroundings, being observed its monumentality from all fronts. It is constructed in the centre of square, appears imposing but simultaneously accessible since the pedestrian can accede from several fronts.

The access to the building is in an ample space that it precedes to the same, emphasizing the entrance with generous yielded green space to the city. The plant of the building is symmetrical respect to a longitudinal axis, in the form of cross; it has a vertical clearance in the extended section, granting a spacious place. Figure 7/10

The building was designed in two blocks that operate independently, concerning of structure. This divides also it functionally in, the section attention publishes to the one of the administrative sector. The E-W plant is generated by a unidirectional structure of porticos in North-South sense, had each 4.5 meters and an approximated height of 9.00 meters. The singular of this plant is that the columns present, in its inner face, a sharp inclination in its vertical plane; and they constitute the elements of peripheral closing of the form clearing completely the interior of the building. Figure 3/6

Masonry between columns owns a height approximated of 2.5mts, from which the big windows are originated. The analysis confirms that the symmetry and regularity of the architectural design of this building has favoured the seismic response of the same, which is confirmed during the earthquake of 1977.



Figure 5 Secondary Facade (at East)

Figure 6 Cross Section C-D





Figure 7 Ground Floor



Figure 9 Main Facade (at west)



Figure 11 Lateral View



Figure 8 Second Floor



Figure 10 Longitudinal Cross Section



Figure 12 Front View

4.2. THE CENTRAL POST BUILDING

This building is situated to 200 meters of the city main square, occupying the fullness of the square. This building is also of significant size. Figure 19

The building is of rectangular plant like the previous example, continuing towards the public space with a gallery of columns, like a transition element between the private building and the urban context. This space of transition becomes particular and unique, so it is worth of the plant of high height to include the intermediate space, like a thickness that lets transfer the lines of vision and is simultaneously the structure of support of the building, This is a space shaded by columns. Figure15/16

The main hall of the attention to the public generates a place spacious; simultaneously its plant generates an innovation space where the structure is come off the facade. Figure 16/19



Figure 13 Secondary Facade (at West)

Figure 14 Secondary Facade (at East)





Figure 15 Main Facade (at North) $\Phi_{\mathbb{N}}^{+}$



Figure 16 Ground Floor



Figure 17 Third Floor

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Figure 18 Second Floor





Figure 19 View of Main Facade (Gallery at North) / Internal View

5. STRUCTURAL EVALUATION PROCESS

5.1. Overview

In this investigation the evaluation of the seismic performance of a building is determined by the analysis of its resistant structure. Calculations were performed to determine its capacity and it was contrasted with an assumed earthquake hazard.

In order to determine the seismic performance of the buildings was taken into account:

- The structural elements and the materials of the buildings.
- The structural typology.
- The irregularity of stiffness and / or the concentration of masses in plant and height



- The deterioration condition and cracking of the structure.
- The ultimate strength of the structure including; structural elements strength, structural typology, ductility of the buildings and assumed mechanism of failure.
- Considerations on the non-structural elements, respect to construction techniques that condition their behaviour in conjunction with the structure.

While to determine, the assumed earthquake hazard of the buildings was taken into account:

- Seismic Zoning: intensity of the assumed seismic movement in the site of the building.
- Conditions of ground concerning to; soil-structure interaction, amplification of movements in the upper layer of soil, or effects of topography.
- Functionality: use of the building.

The study was realised for every storey and every frame direction of the studied buildings.

From the analysis of the studied examples, guidelines for the design were obtained

5.2. The Building of the Nation Bank.

5.2.1. Considerations

The preliminary inspection which includes, the graphic building documentation contrast with site visits, the consideration of structural system and, the deterioration condition, was conducted properly at first.. Then we worked with two bodies separately, as is clear from the constructive joint. Both blocks display structural differences -Figure 20- was calculated the capacity and ductility of columns and walls on the basis of the theory of ultimate strength, so that the failure mechanisms were taken into account in estimating the structural capacity. we supposed that the beams that make up the frame were rigid like slabs.

5.2.2. Block East

At first, we setting up a suitable system model, in this case the structure consist in a reinforced concrete frame. We took into account the walls adjacent to the columns to consider their strength. This sector of the bank have a basement, it covers practically the total area of the plant, with its corresponding retaining walls. It have 3 storeys (ground floor, first floor and second floor), the vertical structural elements are extend across the three levels, except the central columns that are located in west building frame in NS direction, and they are not developed more than until the second floor. On the front that it gives to Jujuy street, tied columns are aligned with the rest of the columns and integrate the resistant frame. The slabs are armed in one direction and are considered rigid. The study was made for each floor in the two perpendicular horizontal directions X-X and Y-Y, satisfying the directions in plant of the structural frames.

The analysis included only those resistant elements that have continuity in height.

We were considered 4 resistant frames in NS direction with 12 columns each and 12 frames in the EW direction with 4 columns each in the levels of ground floor, first floor and second floor, for this building block.

5.2.3. Block West

It is of emphasizing the measures of this sector given that it covers an area of 24m transversely (NS direction) by 42m lengthwise (EW direction). With a height of 12m in a single plant. In this block the frames have outstanding shape and dimensions. There are glass panels between the columns of the 2 unique longitudinal frames. In the perpendicular direction, there are 9 frames spanning the hall, they separate among them 4.5 m. The west facade is a different frame in dimensions and characteristics.

The performance analysis was realised in both perpendicular directions and the procedure was adjusted to its structural typology.

5.23.Conclusion

The study of both blocks showed an index of capacity exceeding the expected demand, waited for the location of the building. The proper functioning of the structure on Caucete earthquake in 1977 stated it. The structure did not present significant damages.

5.3. Case of the Building of the Central Post

This building presents 9 independent bodies -Figure 20-, each one with different numbers of stories. The



building were analyzed by levels and for both perpendicular directions displayed in the schemes. The structural elements were considered extended in all the levels. We counted with detailed structural documentation, thereby was being able to compute the seismic capacity of the building, and it was superior to waited seismic demand, as in the case of the building of the Nation Bank.



Figure20 9 Independent bodies

5.3.1. Structural considerations of individual blocks.

The study of the structural typology of each block was settled like reinforced concrete frames in both directions.

5.3.2. Evaluated concepts

For the study, it was considered valid the hypothesis, of beams and slabs rigid. The properties of the materials used in the construction were obtained from the documentation. We had to compute the ultimate strength and the ductility of columns and resistant vertical elements to compute the seismic performance of the building. The strength of vertical elements was calculated by applying equations that considered, design and structural typology. It was established the failure mechanism for the adopted hypothesis. It was contemplated the irregularities in plant and height. It was considered the deterioration in the time of the structure. Finally, an evaluation of the capacity of each body was realised.

5.3.3. Conclusion

As in the previous case, the analysis of all blocks showed a demand-capacity ratio bigger than one. Thereby and being this building, shook by M: 7.4 Caucete, San Juan, Argentina Earthquake November 23, 1977, without meaningful damage, we contrasted the results of its seismic performance.

6. GENERAL CONCLUSIONS

The description and analysis of selected buildings, we can make some general comments

- The symmetrical distribution in plant and elevation of the structural elements, result in a greater



capacity of the structures.

- It is necessary to grant to the structures of the strength and the necessary ductility that allow developing greater capacities than the demanded ones, considering the different typologies and failure mechanisms present.
- To respect throughout the useful life of the buildings the charges for which they were projected as well as the functionality of the same.
- To respect the original configuration of the building; this means: not to add or to clear structural or non-structural elements
- To work for the maintenance of the structures, avoiding losses of water in pipings that could produce deterioration in reinforces or the accumulation of erosive agents that could degrade the expected strength of the employed materials.
- To maintain the conditions of the surroundings avoiding aggressive means for performance of the structures

6.1. **RECOMMENDATIONS**

- The analysis of the buildings will be later integrated into a provincial database to formulate criteria for the preservation of Patrimonial Buildings of areas with high seismic risks in Argentina.
- It is seen the necessity to realise three-dimensional dynamic studies that allow to analyze the model to the action of severe earthquakes.
- These projects form a comprehensive plan designed in order to reach a global understanding of the city and its meanings through its buildings. A case study is proposed, pointing out that every architectural piece is marked by its own individuality, which means a new challenge to study.

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