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SEISMIC VULNERABILITY IN EDUCATIONAL BUILDINGS. PROPOSAL FOR ADAPTATION OF THE ITALIAN METHOD.

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Abstract

The capital of Mendoza and the surrounding departments are located in the area of the most seismic vulnerability in Argentina. In spite of having suffered destructive earthquakes, the reconstruction was made in the same affected area of the historical earthquake of 1861, or very near, as well as were the educational buildings, having nowadays more than 500 buildings for that purpose. Many of them are from times when no seismic resistance regulations were required. And other ones have been built under regulations that are different from the current ones.

The new regulations have achieved a great advance in the structural and not structural design of the buildings, and this is a tool which gives us a starting point to value what has been done in the constructions made in different stages of our history.

The lack of structural adaptation of these buildings can generate their collapse and consequently the loss of their occupant's lives, causing a great social and economic impact in the population. This makes us think about the way we will adjust those structures to avoid the possible disasters that a big earthquake could cause.

The correct assessment of the seismic vulnerability of the buildings facilitate the tools to design an optimal structural reinforcement.

The aim of the job is to propose a simple and dynamic methodology of the analysis of the security in front of this type of event in order to study the educational buildings. It is made an adaptation of the Italian Method of seismic vulnerability, destined for being applied specifically to those buildings. They are evaluated not only when they have structures of only one type, walls of enchained masonry or structures of reinforced concrete, but also when there is a combination or interrelation between them. It is also added in the analysis, the possibility of the nonexistence of a rigid diaphragm to distribute the seismic action in the seismic resistant vertical structural systems

The proposal methodology has qualitative characteristics of seismic vulnerability analysis and the results which were found have a concordance with other proposal methods by other professionals.

The reached conclusion is to work in a first instance with qualitative methods, in order to apply later quantitative methods, and consequently, if necessary, do the correspondent structural adjustments, so that this reduces the seismic risk at short term, providing more security to all the population.

Keywords: Seismic vulnerability, Qualitative method, Educational buildings

1. Introduction

The area with the highest population density of the province of Mendoza, in the Republic of Argentina, is located in the region of the highest seismic risk of the country. Since its foundation, and in spite of having suffered destructive earthquakes of great magnitude such as the ones of 1782 (magnitude 7.0), 1861 (magnitude 7.0), 1903 (magnitude 6.0), 1917 (magnitude 6.5), 1920 (magnitude 6.0), 1927 (magnitude 7.5), 1985 (magnitude 5.4), according to data of the Institute for Seismic Prevention (INPRES) [1]. The reconstruction of the city has been made in the same affected area by the historical earthquake of 1861, or very near. In the capital city and surrounding departments, the constructions have grown widely, as well as the educational buildings, counting more than 500 for that purpose. This geographical region and the educational buildings located there are the application cluster of the current work. Many of these constructions are from times when no seismic-resistant regulations were required, although many professionals of the specialty used some prescriptions suitable for the time to build, but they only responded to the professional practice of the moment and not to a theoretical or scientific fundament. Other educational buildings have been built under regulations that differ from the ones current now. With the approval and implementation of the regulations that take into account the effect of the earthquakes, the Seismic-resistant Constructions Code for the province of Mendoza of 1987 (CCSR) [2] and the regulations of the National Institute for the Seismic Prevention – Investigation Center for the National regulations for the Security for the Civil Works INPRES-CIRSOC 103 part I and part II (INPRES-CIRSOC) [3], the constructions of educational buildings suffered a favorable and innovative impact, causing a great advance on the structural and not structural design of themselves in seismic regions. This makes us think about how we are going to adequate those structures which have a great impact on society, such as schools with a high degree of vulnerability before this kind of event. Even though there are many qualitative methods to evaluate the seismic vulnerability, the qualitative method developed by Gruppo Nazionale per la Difensa dei Terremoti (G.N.D.T.), commonly called ITALIAN METHOD, has been taken into account, because it is the most widespread and applied all over the world, together with other versions which have been adequate by other professionals and researchers, mainly in Spanish speaking countries. Working in this way, where in a first step a qualitative analysis of the seismic vulnerability is done, and in a second and third stages the same analysis is done applying quantitative methods, and if needed, the structural adjustments, causes the reduction of the study time of the constructions and the reduction of the seismic risk in short time turn, in order to offer the most possible security to the population. Because of the characteristics of the occupants of the educational buildings, their lives losses and collapse would cause a great impact in the local and national society, and also an important social economic delay for the region. The present work tries to offer a simple and dynamic tool to evaluate the seismic-resistant security in the educational buildings with walls of enchained masonry and / or with the seismic resistant vertical structural systems (SiVES) of reinforced concrete, acting in individual or combined way.

2. The Italian Method

All the qualitative methods used to obtain the seismic vulnerability of a building, have the methodology to define some parameters of the construction to be assessed, and according to the established conditions in each of them, the categorization of them is made according to their seism-resistant security. The Italian Method does it as buildings type “A”, “B” or “C”, depending on the preset conditions, being the “A” type those of the best quality. This step of the analysis gives it a certain value “K_i” predefined for each parameter. Following it is multiplied by the factor “W_i” which represents the importance that it has in the assessment of the seismic vulnerability of the building. Once these operations are done, the Eq. (1) is applied and the rate of vulnerability “I_v” is obtained. This represents, in some way the seismic-resistant structural security of the building.

$$I_v = \sum_{i=1}^{11} K_i W_i \tag{1}$$

The parameters to evaluate Iv and the values of K_i and W_i that are represented by the Italian Method by Benedetti-Petrinni [4] are represented in Table 1.

Table 1 - Evaluated parameters and values of K_i and W_i, according to the different types of buildings, for the calculation of the I_v submitted by the method of the G.N.D.T. [4]

Nº of parameter	Parameter analyzed	Score of the class K_i			Weight W_i
		A	B	C	
1	Organization of the resistant system	0	6	12	1,00
2	Quality of the resistant system	0	6	12	0,50
3	Conventional resistance	0	11	22	1,00
4	Position of the building and its foundation	0	2	4	0,50
5	Mezzanine and/or cover	0	3	6	1,00
6	Configuration in plant	0	3	6	0,50
7	Configuration in elevation	0	3	6	1,00
8	Connection between critical elements	0	3	6	0,75
9	Elements of low ductility	0	3	6	1,00
10	Non-structural elements	0	4	10	0,25
11	State of conservation	0	10	20	1,00

With the obtaining of I_v a categorization of the construction is done according to seismic-resistant security, applying a specially designed table. Table 2 is presented. It was proposed by Aguiar Falconi R and Bolaños D [5] and Table 3, which is the one used by most of the professionals dedicated to the topic, where the percentage of the influence of each parameter in I_v has been previously quantified.

Table 2 - Classification of the construction according to the I_v proposed by Aguiar Falconí R and Bolaños D [5]

[0;30]	Secure
(30;60]	Moderately secure
(60;90]	Very vulnerable

The current proposal follows the same tendency of the Italian Method. Some changes are made having into account: the modifications made by other researchers, the specific cluster of application already defined, the performance that this type of constructions are supposed to fulfill, the materials and the characteristic constructive practices of the region, the scientific advance, the evident pathologies of the constructions due to less important earthquakes, the maintenance the construction has received, and, most important, the lessons that bigger earthquakes in the world had taught us, especially in the SiVES failures, such as the harmful effects of short column, short beam, mezzanine without beams, soft floor, torsion effect, the relative maximum distortion of the construction (Deriva de Piso), among the most remarkable.

The method was compared to other investigators works, especially to the one done by Agüera ND and Palencia JC [6] obtaining very satisfactory results in all the cases.

Table 3 - Classification of the buildings taking into account the percentage of influence of each parameter in the calculation of the Iv.

[0;9]	Not vulnerable	Does not require taking measures.
(9;25]	Little vulnerable	Maintain periodic observation vulnerable parameters.
(25;49]	Moderately vulnerable	Full annual periodic monitoring.
(49;60]	Vulnerable	Take special measures.
(60;90]	Very Vulnerable	Take special measures urgent.
(90;100]	Extremely Vulnerable	It is suggested to declare it not habitable or demolish it.

3. New proposal methodology

It is a method to evaluate in a qualitative way the seismic vulnerability in educational buildings located in the defined cluster, offering a frame of reference for the regulations which are in the process of updating. It also promotes the generation of human resources about the topic and provide a simple and dynamic tool to be applied by the authorities of the General Direction of Schools (DGE) in Mendoza, so they can control, in short terms, the structural and not structural security of its dependent buildings. Following the Italian Methodology the Table 1 is replaced by Table 4, and Table 3 is replaced by Table 5. Comparing them quickly big differences can be appreciated.

Table 4 - Evaluated parameters and values of K_i and W_i, according to the different types of educational buildings.

Nº of parameter	Parameter analyzed	Score of the class K_i			Weight W_i
		A	B	C	Pizarro 2015
1	Organization of the resistant system	0	1	2	9
2	Quality of the resistant system	0	1	2	5
3	Conventional resistance	0	1	2	5
4	Position of the building and its foundation	0	1	2	2
5	Mezzanine and/or cover	0	1	2	2
6	Configuration in plant	0	1	2	5
7	Configuration in elevation	0	1	2	4
8	Connection between critical elements	0	1	2	4
9	Elements of low ductility	0	1	2	9
10	State of conservation	0	1	2	3
11	Constructive modifications	0	1	2	2

Table 5 - Cataloguing of the building of the educational establishment under the new proposal.

[0;9]	Not vulnerable	Does not require taking measures.
(9;25]	Little vulnerable	Maintain periodic observation vulnerable parameters.
(25;49]	Moderately vulnerable	Full annual periodic monitoring.
(49;70]	Vulnerable	Take special measures.
(70;90]	Very Vulnerable	Take special measures urgent.
(90;100]	Extremely Vulnerable	It is suggested to declare it not habitable or demolish it.

As regards the detail of the characteristics that the edification must fulfill in each parameter, there are variations to the Benedetti-Petrinni proposals [4]. In some cases these have a simpler valuation criteria, and in others some requirements have been modified. There are several cases in which different changes have been introduced to classify the edification. Many of these are originated to fulfill the proposed objective, facilitate the construction assessment with simple and dynamic procedures, and to try to avoid considering demands which are less probable to be evaluated in situ. The following has been done to fulfill the premises of the job: to have into account the constructive typology of the studied cluster; to include the harmful characteristics of the SiVES interrelating them in an explicit or implicit way in many parameters. The aim of the arrangements is to provoke that the values which are taken by the different parameters, influence in the most homogenous possible way on the quantification of the construction seismic vulnerability.

Following, what has been expressed for each of the different parameters proposed in the new methodology, is described. The complete method, where all the valuable requirements are detailed, has an extended writing, and can be consulted in Pizarro NF [7].

3.1 Parameter: organization of the resistant system

The SiVES are analyzed, the ones of reinforced concrete and the seismic-resistant masonry walls, having into account the established requirements by the current regulations. Their dimensions, the openings and their position and pathologies. More demanding requirements are asked in comparison to the reference methodology, so the building has to have a suitable structure to be qualified as the best quality. We have to emphasize that mixed structural systems, reinforced concrete structures and masonry walls are included. Also, covered surfaces which have structures that are not connected to rigid diaphragms (reinforced concrete covers, solid or light) are considered. The fulfillment of the conditions which, in an implicit way, consider the harmful effect of short columns and the interference of masonry walls in the free distortion of a reinforced concrete porch has been considered.

3.2 Parameter 2: Quality of the resistant system

By the building observation it is expected to estimate the quality of the SiVES. It has to be determined the existence of those pathologies which can affect, in an unfavorable way, the construction at the moment of having to support the demands of the seismic action. This task is interrelated with the parameter 1. In this way they are linked with the purpose of trying to obtain a uniformity in the assessment of the seismic vulnerability, premise in this methodology. It is expected to reduce the relative differences of the percentage of influence in the Iv of each evaluated item. In the study of the quality of the resistant system of a building, it is convenient to know in which year it was built, that is why an enquiry has been included, although this datum is approximate. Based on this it will be possible to infer which materials were used in that year, what was the typology of the constructive system and the existence or no of seismic-resistant regulations.

The grade of the building quality is totally subjective. This is due to that the demanding characteristics in general and for the studied cluster, cannot be relieved, due to the impossibility of watching or doing the prescribed procedures, because of the type of flooring they have. That is why a reduction of the factor "W_i" has been done, following the expressed consideration about the homogeneity of the percentage of influence. This can be observed in Fig1, Fig2, Fig3 and Fig4, or analyzing the values in Table 4.

3.3 Parameter 3: Conventional resistance

This parameter is considered very important at the moment of analyzing the seismic-resistant security of a building, because it is here when the seismic action is especially taken into account. In several proposals made by other professionals, the way of assessing the effect of the earthquakes over the structures, make those methodologies take a less qualitative characteristic, and so, not very simple and dynamic in their application. In this new methodology the seismic action is included through the explicit indication of a seismic coefficient, having into account the soils which present or not the possibility of the liquefaction effect. It is also indicated a weight on each square meter of construction, as approximate value, to calculate the equivalent seismic force, in accordance with the similar characteristics which the existent schools in the geographical region of application. With this process the calculation of the equivalent seismic action for each direction and level of study is simplified. With the obtained values, the capacity of cutting not only for the seismic-resistant masonry walls but also for the reinforced concrete structures are checked with a simplified formula. In this parameter it is also included, in an implicit way, the harmful effect of torsion that could be produced in the building. It has been included because the given importance to it in the new regulations INPRES-CIRSOC 103 [3]. Before analyzing the present parameter, some characteristics related to the probability of the happening of the short column effect are studied. Very explicit requirements are given. They express the possibility of the existence of other SIVES, reinforced concrete walls or masonry walls, which can limit or not the distortions of the porch, where the studied effect is generally produced. This proposed analysis is due to that the majority of these educational buildings present the same or one very similar constructive typology. Many researchers, all over the world, have studied and verified this inconvenient in the reinforced concrete porches, besides the lessons that destructive earthquakes in any part of the world where there are buildings made by men have left. For this reason, the existence of short columns is punished widely, having decided to consider the edification as the one of the worst quality, type "C", without the necessity to follow the fulfillment of other requirements analyzed in this parameter.

3.4 Parameter 4: building position and foundation laying.

Here the type of soil and the surroundings where the building is founded are analyzed, considering as basic concept that an adequate foundation for a seismic-resistant design has to be stable and monolithic, in order to avoid relative movements of them. These relative movements could cause great efforts in the columns, which is a harmful effect for the structure. To avoid this problem it is necessary to provide beams at the foundation level (at the bottom of the column) which connect all the bases in two perpendicular or almost perpendicular directions, as it is expressed in the regulations. On the other hand, it is convenient not to have pressure of slopes over the construction, depending on the place topography. According to the defined characteristics in this parameter, there is little probability to verify the existence of the already mentioned beams, and more, that they are in good state. The professional who checks the building, if they have certain experience in the subject, they can take into account some signs easily visible in the building so that they could be considered to evaluate this topic. Other item included in the present parameter, and no less important, is that also the surrounding buildings and their states are taken into account. The state of conservation, the construction quality, their maintenance and the distance between them are observed. This is done to consider if the surrounding constructions can affect the educational building if they collapse during a seismic event. As it was expressed, there are subjective conditions which are not likely to be watched. It has been decided to adopt the same criteria as in other parameters which have the same problem.

3.5 Parameter 5: Mezzanine and /or covers

The presence or not of rigid diaphragms, the capacity or not to distribute the seismic action to all the seismic-resistant structure, respectively, are studied. When it exists, the state of their connections with the SiVES and the openings of the reinforced concrete covers are verified among the most relevant aspects. The mentioned characteristics, expressed in an explicit way, are differentiated, to evaluate an edification when the diaphragm is flexible, as the mezzanines or covers constructions are, generally made in wood or metal. This terminology is used for the regulations. It has not been found the case of considering structures with flexible diaphragms, in other researcher's proposals. The pathology in these construction elements (diaphragms) is valuated. The harmful effect of "mezzanines without beams", incorporated harmful effect, is taken into account with the inclusion of specific requirements. The existence of floorings under these structures, for example ceilings, common in these constructions, also makes their valuation gets a high degree of probability of not being able to be done correctly, that is why an identical criterion as the parameters which show similar circumstances are adopted.

3.6 Parameter 6: Configuration in plant

The demanding conditions to classify the quality of the construction, requires an analysis of the quantity and distribution of the SiVES, in each of the directions in which the seismic verification of the buildings must be done. It is kept the analysis of the outline shape which surrounds the plant of the construction, with some little changes in the dimensional relations of it, made by the reality of the studied buildings. There is a tendency to avoid inappropriate structural designs, as the actual regulations establish. Besides of what the new adopted method suggests, it is expected to value especially that a possible torsional effect in the building never happens. A good structural design in plant and also in elevation, (to be expanded in the next parameter), leads to seismic-resistant structure works properly at facing an earthquake. This request is considered very important in the case of the valuation of the seismic vulnerability. The new scientific advances which are expressed in the new regulations have been taken into account as new or modified integral characteristics.

3.7 Parameter 7: Configuration in Elevation

As it was mentioned in the previous paragraph, the configuration in elevation, in the SiVES as well as in the proper architecture of the building, represents the seismic-resistant security of the building. The rigidity variations of the SiVES in the different levels of the construction are detailed studied, as well as the variation and distribution of the mass in height. This involves the most harmful effects which appear in these types of constructions, when they are located in areas with an important seismic action. The most considered are the torsion, the soft floor and the interference of the masonry in porches. However, other harmful effects already mentioned, are also involved in the seismic-resistant construction. All these make to evaluate the fulfillment of the very demanding characteristics at the time of classifying the quality of the edification. That is why in the calculation of the vulnerability, this factor has an important weight, similar to the one of the configuration in plant.

3.8 Parameter 8: Connection between critical elements

The possible eccentricities between columns and beams in porches, their dimensions and the frame of the masonry are studied according to the demands of the new regulations. Even though it is very important what is here analyzed, to the building security, this parameter has little probability of being observed in situ, due to the typology of the classic constructive system of the educational establishments in the cluster of application, because of the covering subject. Therefore, the same criterion of punctuation that in other parameters with the same problem is followed, with the condition that the professional who does the relieve, has the possibility to classify the edification according to their vision, orientated by external data, such as the existence of technical documentation, or what other professional who may have been involved could express orally, between other options. This possibility has been included because it is important in the evaluation of the seismic-resistant security of the construction.

3.9 Parameter 9: Elements of low ductility

The elements of low ductility have a great importance in the structure seismic vulnerability. Mainly, the height demanding of the columns are put in a way to be considered as short columns. The existence of elements which produce a sharp rigidity difference in the SiVES, especially by means of differences in the level in the reinforced concrete covers or by the inclusion of elements that avoid the free deformation of a reinforced concrete porch, may cause the mentioned effect. Other of the main aspects evaluated here is the incapacity of the energy dissipation of a structural element which has not been taken into account in its design stage. The characteristics to be fulfilled in the building classification are expressed in an explicit way and they are more demanding than the one in the considered method. The study of the probable existence of an increase in the edification torsion has been incorporated, due to the rigidity variation of the SiVES.

3.10 Parameter 10: State of conservation

The professional in charge of evaluating the educational building must observe thoroughly the actual state of the structure, emphasizing the possibility of the existence of cracks, mending, settlements, wall humidity and other possible pathologies that can affect the seismic-resistant capacity of it. The not fulfillment of the requirements could influence considerably in the decay of the structure of the SiVES, damaging the seismic-resistant security. This parameter has a special importance according to the reality of the schools located in the area of application of the present methodological proposal.

3.11 Parameter 11: Constructive modifications

It is very common in schools, that as time goes on, some constructive modifications have been done to adapt them to the reality of each age. For example, the usage change of the premises may affect considerably the behavior of the structure, having into account the possible weight with which the first calculations were done compared to the ones existent at the moment of the evaluation of their seismic vulnerability. If this happens, the structure way of working when an earthquake happens could be altered substantially, amplifying the received demand, such as the building torsion as the main effect. So, the study of the modifications done in the building can reduce or improve the seismic-resistant security. The main characteristics to evaluate are: the existence of new constructions and if they are attached or dissociated to the existent, the state of the movement joints, the making of openings in seismic-resistant walls, and, generally, in any SiVES to watch and take notes of what other people tell as regards demolitions, or building of new walls. The conditionings are very explicit so that this parameter does not make the method less dynamic and easy to apply.

3.12 Final Consideration about de analysis of the described parameters.

To do the in situ relieve, verifying the demands in each parameter expressed in the new methodological proposal, a series of relieve charts have been done so that the professional who has the study can find the task simplified and tidy. He has to complete the charts and take them to the office. There, the last part of the work is done to value the seismic-resistant security of the educational building, obtaining the Iv, and in this way to be able to inform to the authorities of DGE, what comes at applying Table 5.

The detail of tthese charts can be found in Pizarro NF [7]. They are not presented in this work due to their extension.

4 Comparison to other proposals

The present methodology called: Pizarro 2015 is compared to the one made by other professionals who have worked in this same sense following the methodology proposed by Benedetti and Petrinni [4].

It has been chosen to be compared to:

- The original form according to Benedetti and Petrinni G.N.D.T. [8] (Fig.1) and the modifications made by these same authors (C.N.R.) (G.N.D.T.) [4] (Fig.1).
- The proposal of Aranda P [9] (Fig.2) and the adaptation according to Gent KA, et al. [10] (Fig.2).
- The methodologies according to Letelier González VC [11] (Fig.3) and Alvayay Barrientos DA [12] (Fig.3).
- And the project of analysis of Aguiar Falconí R y Bolaños D [5] (Fig.4).

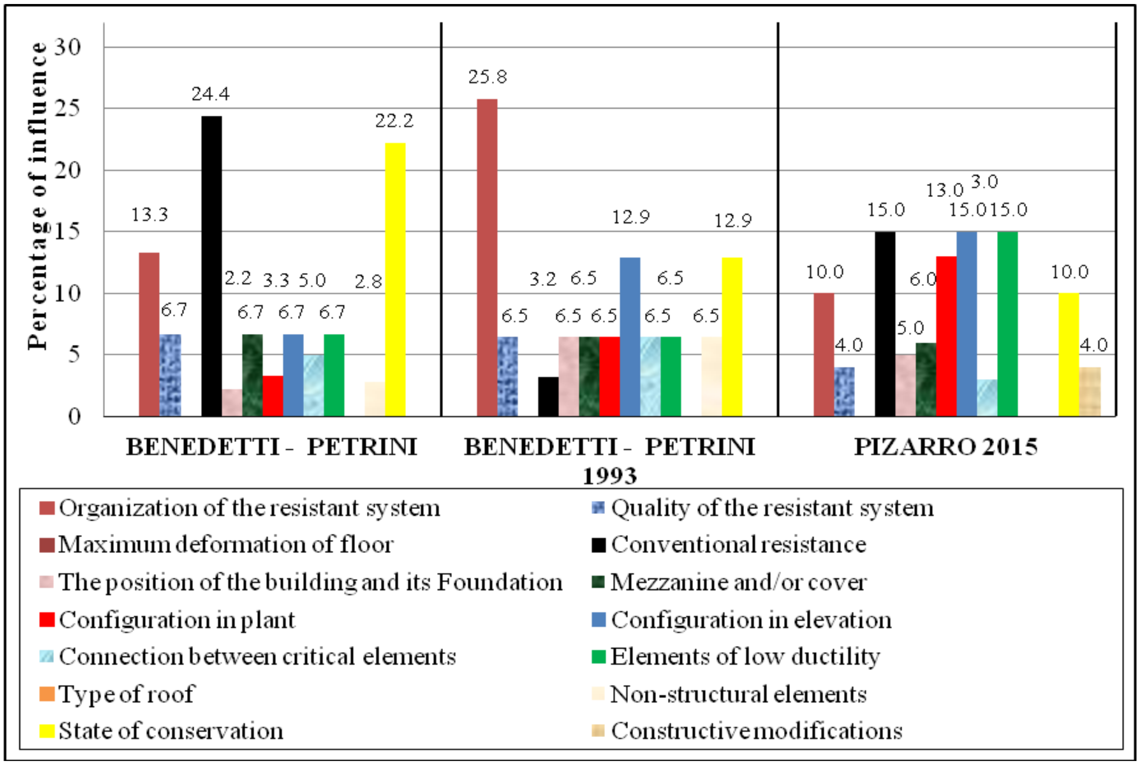

Fig. 1: Comparison with the proposals original of Benedetti and Petrinni G.N.D.T. [8] and the modifications made by these same authors (C.N.R.), (G.N.D.T.) [4].

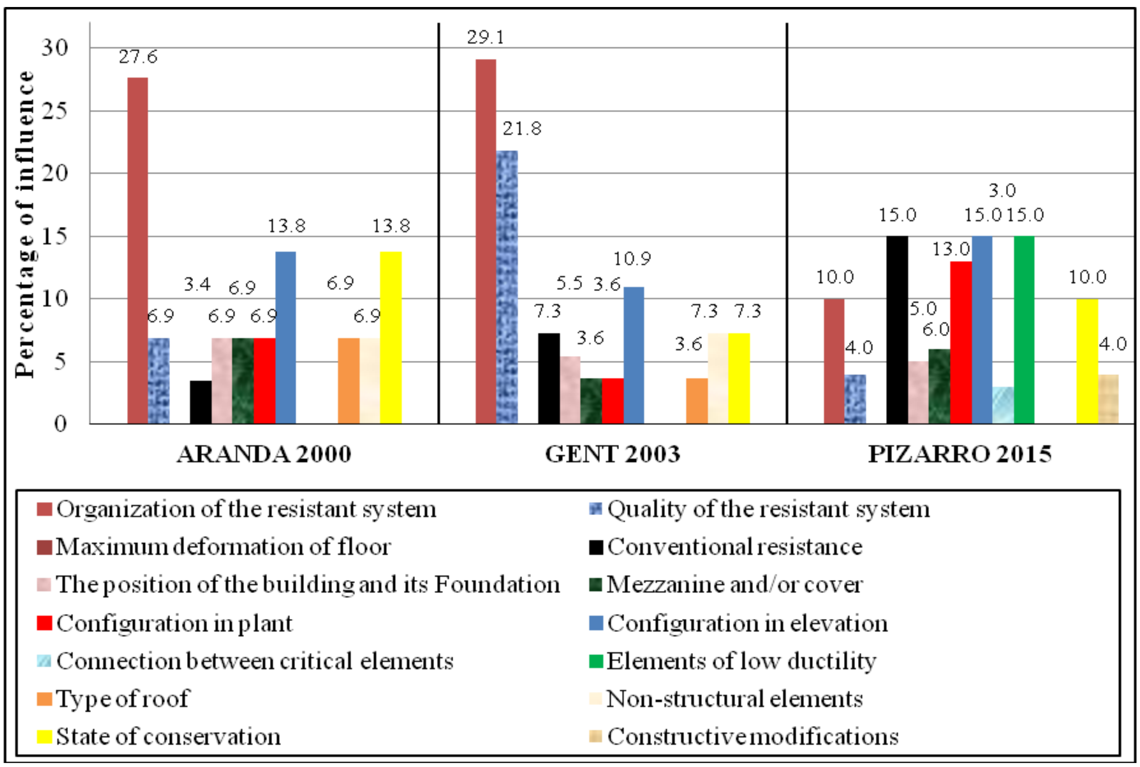

Fig. 2: Comparison with the proposal of Aranda P [9] and the proposal of Gent KA, et al. [10].

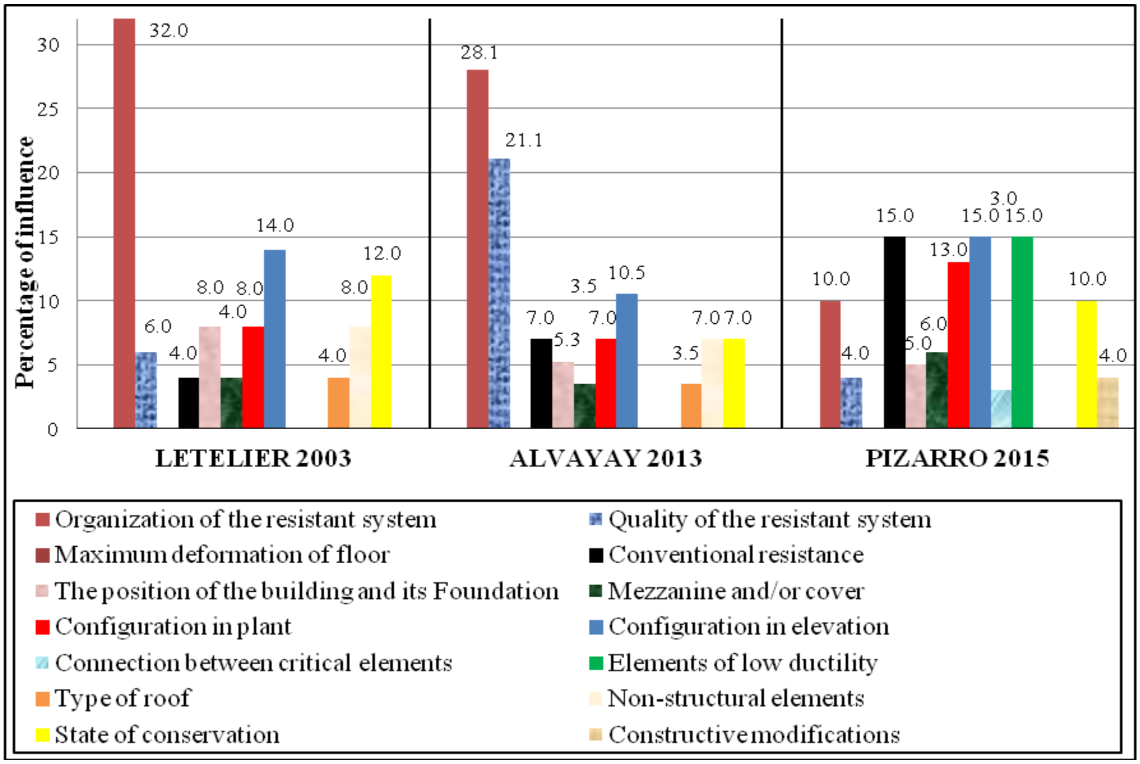

Fig. 3: Comparison with the proposal of Letelier VC [11] and the proposal of Alvayay Barrientos DA [12].

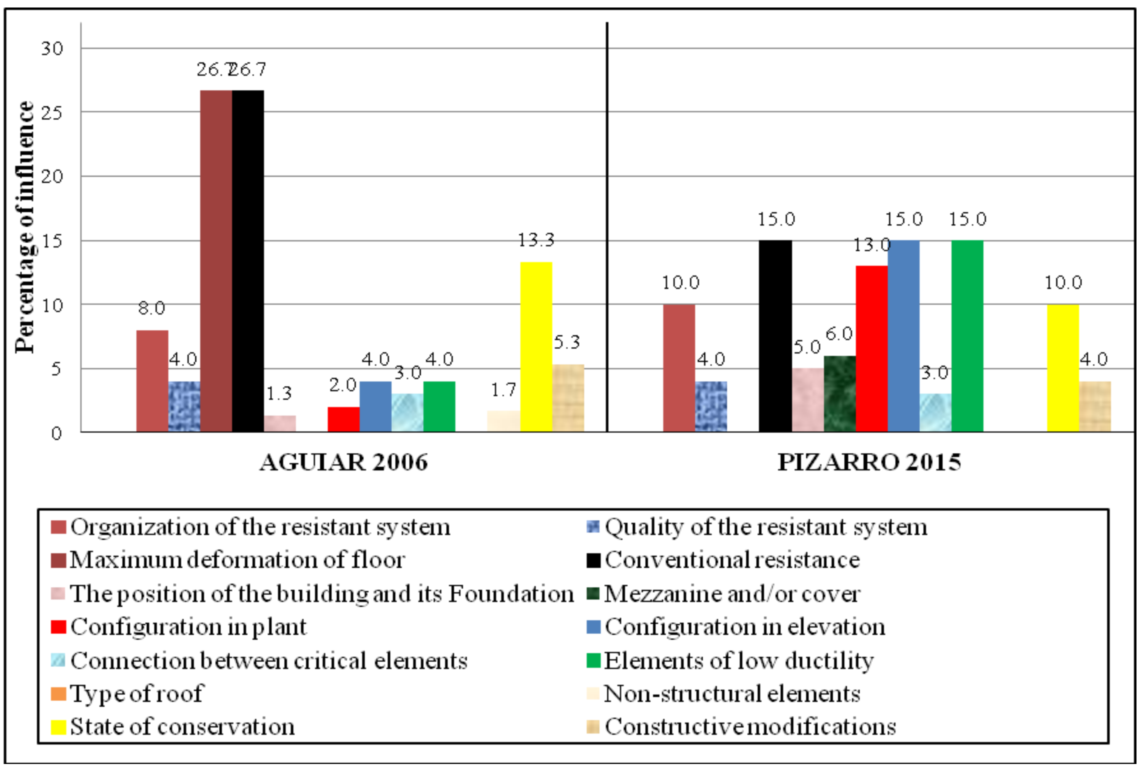

Fig. 4: Comparison with the proposal of Aguiar Falconí R and Bolaños D [5].

4.1 Considerations rising from the comparisons

En each case several combinations of the values the parameters can take have been analyzed, to calculate the structural security of the construction. It is mentioned that, in order to do the classification of the edification according to the different proposals, the particular characteristics taken by the authors of each proposal are not known. It is supposed they do not differ too much ones from the others, having as a base the proposal of Benedetty and Ptrinni [4], except the proposals of Letelier and Alvayay Barrientos, who subdivided the parameters given a value to each sub-parameter to obtain the total value of them. The speculative combinations of values that can be done, without knowing the edification, can cause that the vulnerability index does not represent reality. The existence of a considerable dispersion in the importance each author gives to each parameter can be observed. In the new methodological proposal it has been tried to correct this mistake, so that connections between some characteristics of the construction, between many of the parameters, are made, trying to that at the moment of the calculation of Iv reach as much as possible the true reality of the construction.It is very clear that the different authors give different importance values to the different parameters and also that they add or take out some aspects to value the seismic vulnerability. In the proposal of Aguiar Falconí R and Bolaños D [5], they consider a parameter that is not considered in the others, that is the "Maximun Deformation of Floor". This is a very important and significative parameter in the structural security of a building, but the target is that the method could be more qualitative, simple and dynamic. Evaluating this "Deriva de Piso", causes problem to get the objective. What these researchers have done is absolutely important, so it has been incorporated in an implicit way to many parameters, trying to value this harmful effect for the construction, in the best and most simple way possible. The new proposal has modified, incorporated or eliminated characteristic and / or parameters valued in the already done corroborations, with the idea of improving the evaluation of the seismic vulnerability of the construction of the cluster of application. A remarkable example of this topic is the incorporation of the constructive modifications, very frequent in these buildings that can influence considerably in the seismic-resistant structural security. In the proposal methodology it has been decide that the "Non Structural Elements" should be analyzed separately, as well as other structures that we call "Parts of the Construction", according to the terminology used in our environment, due to the importance they have before the security of the people occupying those buildings. A proposal about these two aspects is presented, following a similar procedure. It can be consulted in Pizarro NF [7].

5. Corroboration of the new methodology

In one of the cases the present methodology was applied, it was calculated the Iv to be compared with the results obtained by Agüera ND and Palencia JC [6], who made the analysis of the seismic-resistant security of one educational building in the capital city of Mendoza. They applied the Italian Method of Benedetti and Petrinni [4]. Also they analyzed the seismic vulnerability using the "Capacity Method" reaching to the following conclusion: *"…at determining the point of performance of the structure…, it supports the seismic demand imposed by the elastic spectrum of design according to the regulation used, INPRES-CIRSOC 103, part 1, but at the expense that the structure suffers a great level of labeling or lamination. That is to say that the energy dissipation is done through non-elastic deformations with an important structural damage…"*. The construction typology of that school is very common and also repetitive in the area. It has a two-level structure. The mezzanine is built with a reinforced concrete cover, creating a rigid diaphragm in the first level and in the second level the cover is metallic, which is considered as a flexible diaphragm. They got a value of "I_v" = 57 points, valuated in a maximum of 90, which represents a value of "I_v" = 63, considering the percentage of influence. The authors' conclusion is that the building is vulnerable so that it is necessary to take some special measures (Table 3). When applying the new methodology to the same building, the results were a value of "I_v" = 82, and in this way it was categorized as "Very Vulnerable" and it requires special measures urgently (Table 5). Comparing these results quickly, without an exhaustive analysis, there is a great variation in the values, but if we analyze them more thoroughly, there is a concordance between the qualitative method introduced by those researchers and what is expressed in this work. This can be asserted since the new proposal demand to the analyzed building to take into account its future use and so a better performance to support the earthquake action. As an example, the CCSR [2] requires to rise 40% the seismic demand, due to the destination of the building. If we apply this criterion, rising the value found by Agüera, ND and Palencia JC [6], we can observe that the compared values are very similar, which allows to say that, in the application of the new methodology, new values of "I_v" closer to the reality of the educational buildings in the area of application, can be obtained.

6. Conclusions

Through the investigation it was possible to elaborate a qualitative method to evaluate the seismic vulnerability of educational buildings located in the defined area, reaching very acceptable results and with a much more dynamic and simple procedure. The scientific advances expressed in the current regulations in the region have been introduced in the assessments, as well as the lessons left by the most destructive earthquakes all over the world. The elaboration of the relieve charts for each of the parameters in study, expedites the in situ evaluation of the building and assures not to forget any of the characteristics that each parameter demands and it is necessary to take into account for their correct valuation.

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