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THE PROVISION OF EARTHQUAKES SAFETY CORES IN MULTI-STOREYS BUILDINGS

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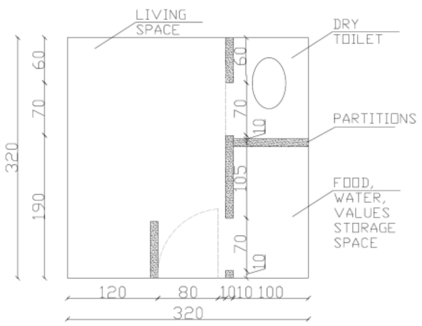
Abstract:In countries with "traditional" catastrophic events due to hurricanes or typhoons shelters are provided, but they generally occur in either low-rise buildings, single family. There are some items and materials for a period of survival and of course there are so varied range of shelters, made by different companies, with different prices.Based on a personal idea, a similar sfatey room variant, usable for multi-storey buildings (and so in each apartment, at every level), is presented in this paper for use in earthquake cases.*
Keywords:masonry, walls, ductility, capacity, curves*

1. INTRODUCTION

Most times, when we are witnessing a major seismic event, under more or less panic, we want to find as soon as possible the safest place in the house, in general, not only for us but especially for entire our family. And even if we are civil engineers, knowing that anytime a high intensity earthquake (greater than so-called "design earthquake") may occur, we never feel completely safe and comfortable. From Japanese experience we should realize the need of a "security package" (including small stocks of food, water, medicine, light sources and batteries, radios, clothing, mobile phone or radio transmitting station) ... but how many of us take into account the everyday reality? Also, important documents, values, are often located in areas "as safe" as the whole house and rarely safer. Naturally the question arises: who would be the advantage of this kind of safe room, designed to remain intact in the event of a major earthquake, if otherwise the whole building will collapse? Therefore, the next step was thought a superior alternative – would you have these safe rooms in each apartment, located on the same vertical within certain "safe cores" to be essentially "decoupled" from the rest of the structure complete resistance? Such safety cores made of reinforced concrete structural walls were considered, with their own foundations, with own floor slabs (at each level) with a separate electricity production (a generator in the basement) with a space designed to meet the functional needs of minimal and simplistic safe space designed to provide a perfectly elastic range behavior in the event of earthquakes with higher intensity than the “design earthquake”, so that even if the building (correct designed for an elastic-plastic behavior, for the a "design earthquake") is significantly damaged, with partial/local or general collapse – the safety cores will remain "standing" (so that the occupants life to be maintained for a period sufficiently long to be mobilized reaction forces after the Earthquake). A minimal compliance space arranged at each level for a safety core is shown in Figure 1.



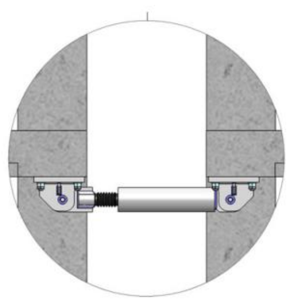


Figure 1. Example of a minimal safe room conformation Figure 2 – Alga device for pounding avoidance

2. CASE STUDIES TO DETERMINE THE BEHAVIOR OF BUILDINGS EQUIPPED WITH SAFETY CORES

2.1. Establishing the research plan

In this paper only the studies of RC frame structure buildings will be presented, for three different heights of the buildings (5, 10 and 15 levels). In accordance with EC8 [8] two peak ground accelerations were used – 0.30g for the main buildings (excepting the existence of safety cores) respectively 0.30g and 0.40g for the existing buildings together with safety cores.The safety cores were designed for the 3 height levels so if we have the buildings originally located in an area with PGA=0.30g it can remain in elastic stage including two levels of seismic intensity above. In our case PGA=0.40g.

2.2. Buildings structural data

We established the permanent load on the floor slabs (excluding the self-weight of their which is automatically considered by ETABS [4], uniformly distributed loads on beams, the walls closing facade and interior partitions; the structural elements were predesigned as follows (reinforced concrete frames for PGA=0.30g and safety cores for PGA=0.40g). [1]; [2]; [3]; [7]
The following main stages of calculation were established:

1st Phase:

- After the predesign of structural elements were performed according to the method EC8 A method, in order to determine the vertical and horizontal structural reinforcement of RC frame type structures (without consideration of safety cores) for PGA=0.30g; for all level heights;
- Calculations were performed according to the method A of EC8 in order to determine the reinforcement in the RC safety cores for an elastic behavior including PGA= 0.40g; for all level heights.

2nd Phase:

- Static biographical nonlinear calculations (pushover analyses) for buildings with RC frame structure were performed for all level heights without considering the contributions of RC safety cores;
- It may consider a sufficiently large gaps between the main structure and the RC safety cores treated so that no pounding occur between structural elements (structural frames) and the safety cores.

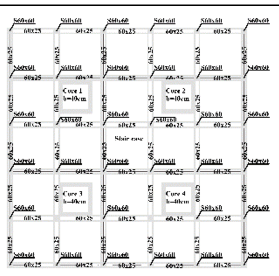
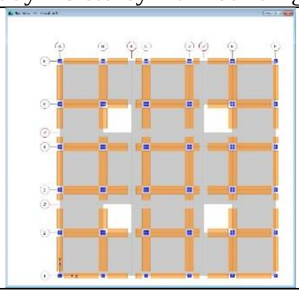
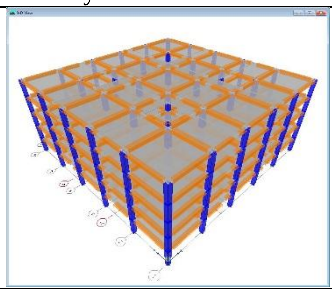
3rd Phase:

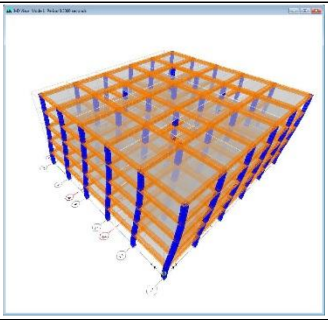
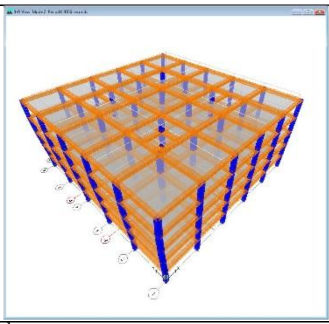
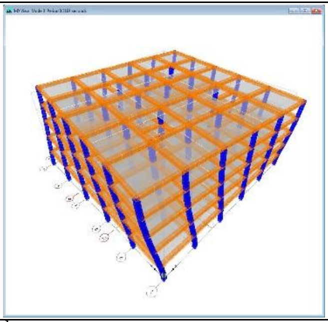
- Static biographical nonlinear calculations (pushover analyses) for buildings with RC frame structure were performed for all level heights with consideration of the contributions of RC safety cores - they are connected to the structure by means of special devices to mitigate poundings (ALGA - STU200-50), presented in the followings chapters and modeled as a link type GAP (working only in compression and not tension).

To ovoid the poundings between the main buildings and safety cores were chosen devices made by ALGA Company in Italy, which has great experience for decades in dampers, including seismic base isolators, dampers, etc. [12]. Based on [6], [9], [10], [11] and [13] the following results were obtained:

2.3. Structural system responses from nonlinear biographical static analyses – only for 5 and 10 storeys

Table 1 - 1st Case study – 5 storey main building – without safety cores:

		
Formwork plan	ETABS plan	ETABS 3D model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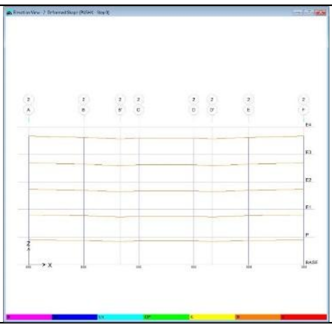
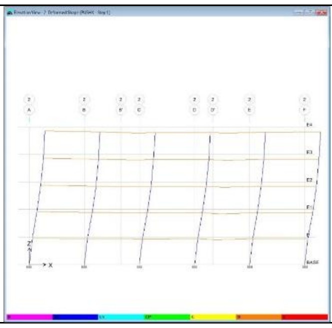
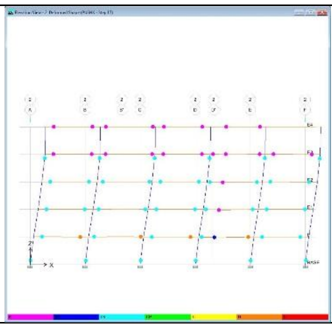
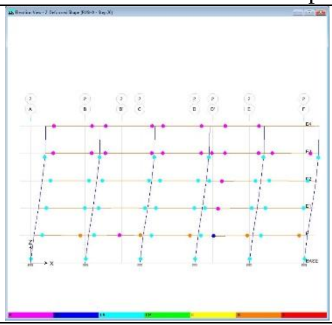
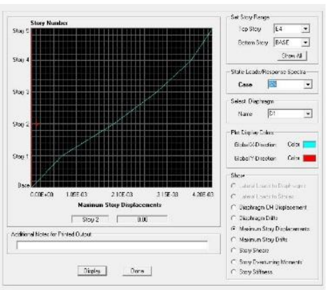
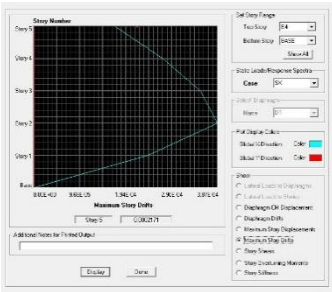
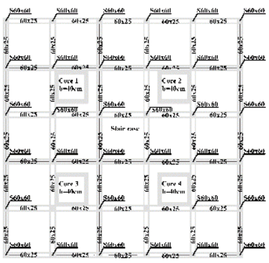
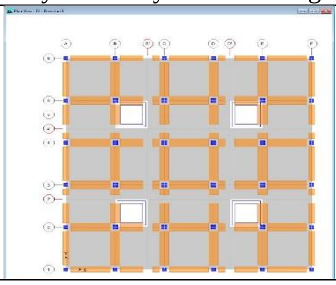
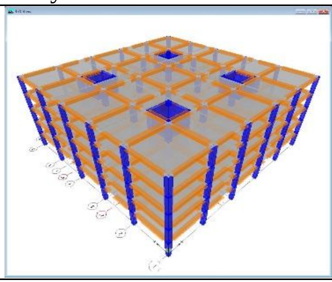
		
Central Frame – Pushover step 0	Central Frame – Pushover step 1	Central Frame – Pushover step 10
		
Central Frame – Pushover step 11	Maximal deflection 2.835 cm	Maximal drift 2.61‰

Table 2 - 2ndCase study – 5 storey main building – with safety cores: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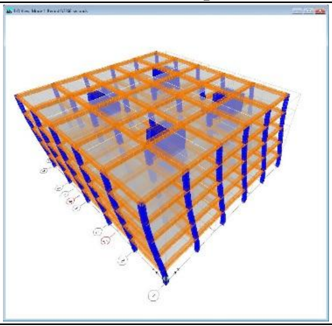	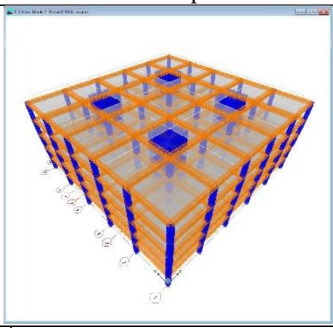	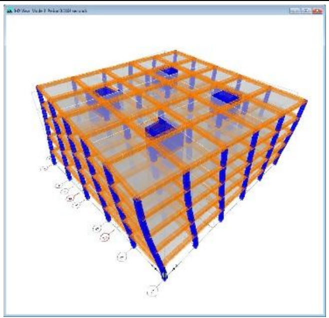
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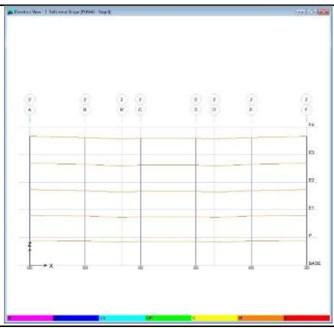	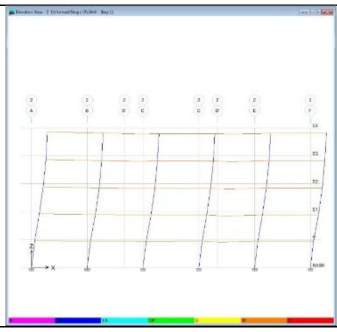	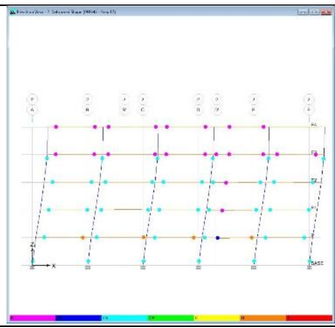
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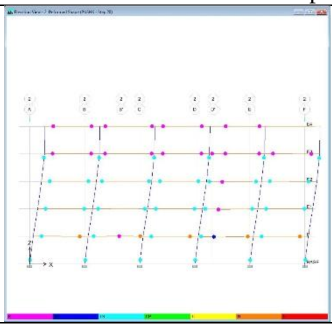
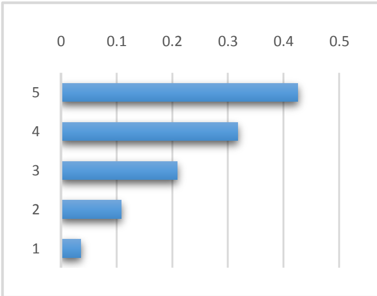
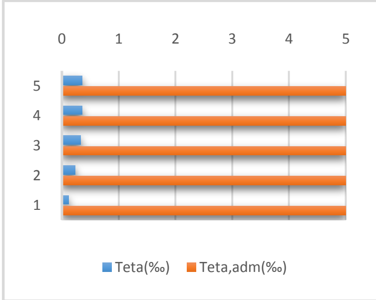
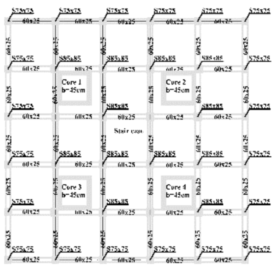
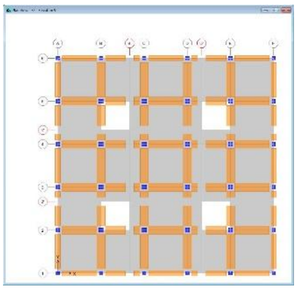
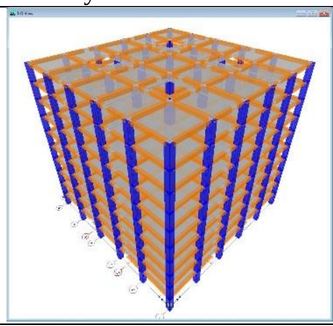
		
Central Frame – Pushover step 13	Safety cores deflection	Safety cores drifts
No plastic hinges occur in safety cores		

Table 3 - 3rd Case study – 10 storey main building – without safety cores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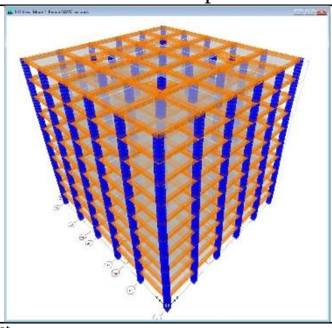	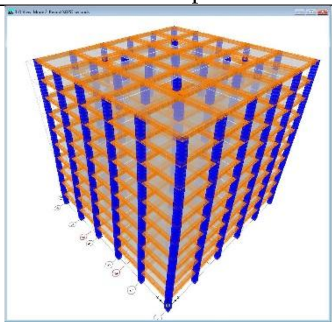	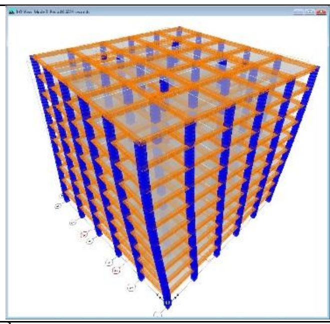
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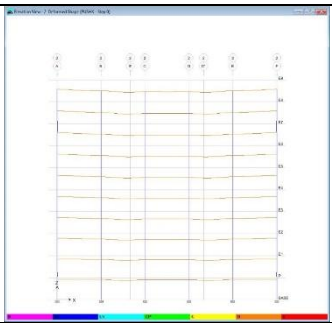
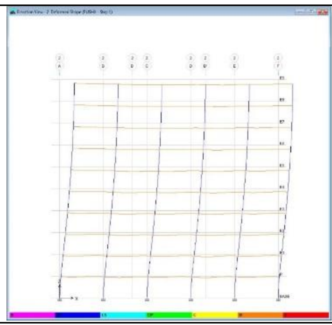
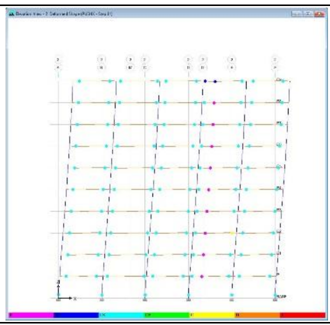
		
Central Frame – Pushover step 0	Central Frame – Pushover step 1	Central Frame – Pushover step 10

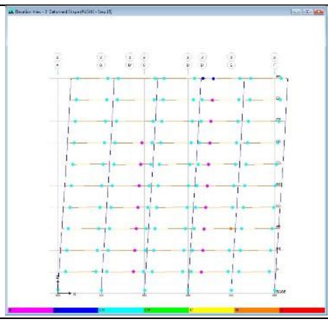
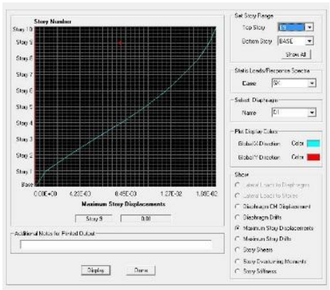
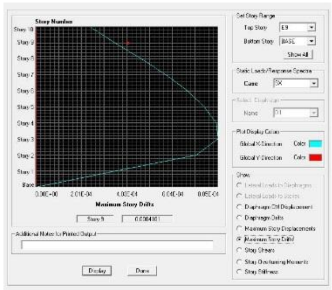
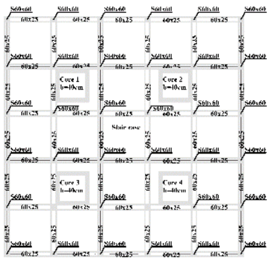
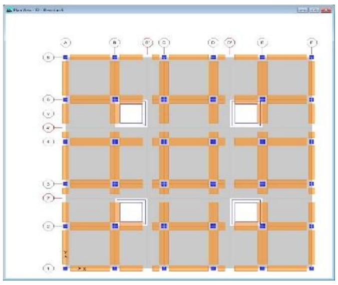
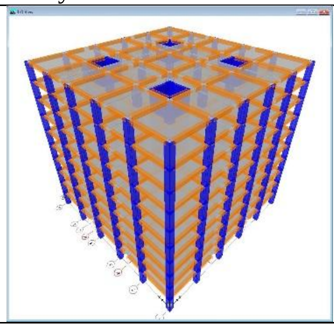
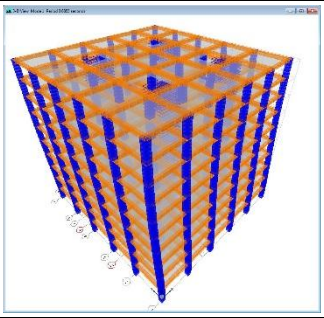
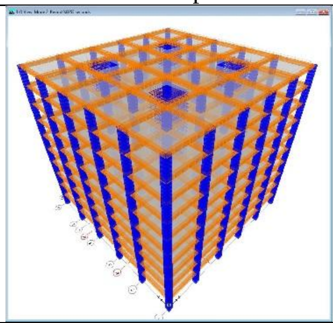
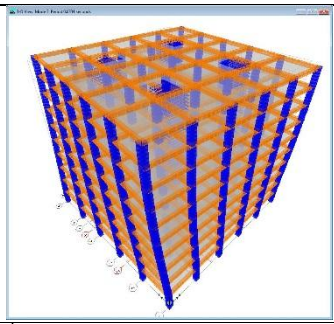
		
Central Frame – Pushover step 11	Maximal deflection 11.41 cm	Maximal drift 4.98‰

Table 4 - 4th Case study – 10 storey main building – with safety cores:

		
Formwork plan	ETABS plan	ETABS 3D model
		
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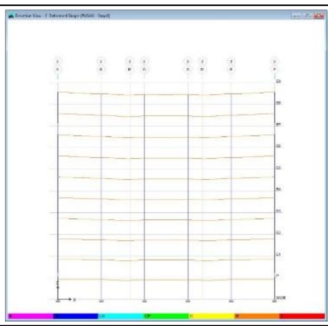	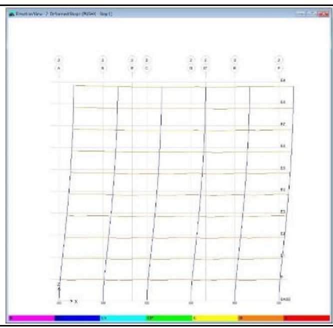	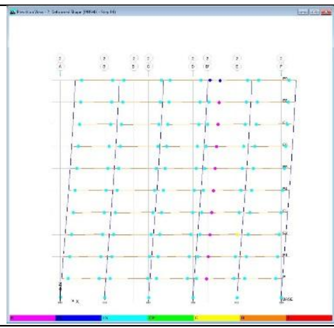
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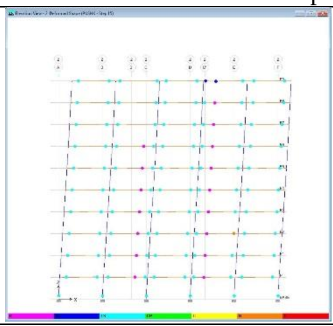
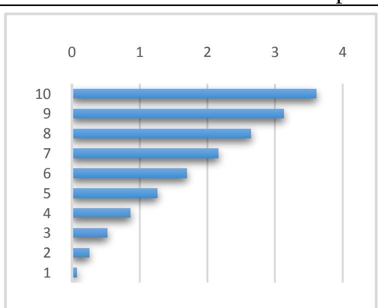
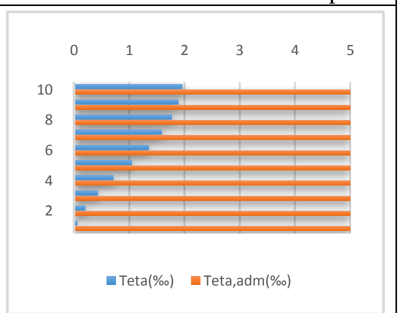
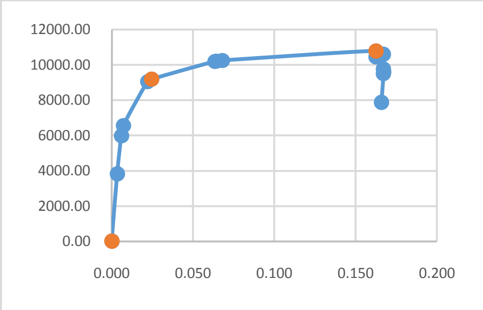
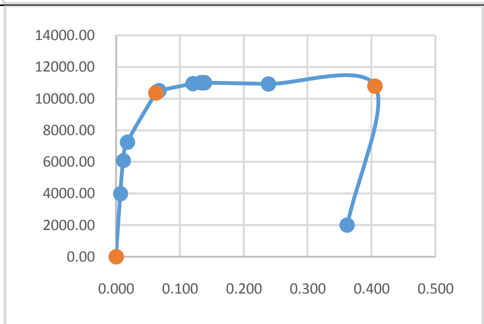
		
Central Frame – Pushover step 11	Safety cores deflection	Safety cores drifts
No plastic hinges occur in safety cores		

3. CONCLUSIONS

From all the studied cases the followings were obtained:

Table 5–Capacity curves and capable ductilities for the main structures

Structure	MDOF CAPACITY CURVES	Ultimate displacement [m]	Yielding displacement [m]	μ_Δ
5 storeys		0.163	0.025	**6.64**
10 storeys		0.406	0.062	**6.50**

- The linear and nonlinear static analyzes found that the structures of the initial buildings were properly designed;
- It observed that an earthquake is considered superior (PGA=0.40g) than the design earthquake (PGA=0.30g) some plastic hinges appear also in other areas of the main structure columns not only at the base (given that it is considered that all previous assumptions are correct design and after execution);
- It is easily to find that in these cases, the safety cores remain in the elastic range;
- The main conclusion is that this paper has achieved its intended purpose. We conducted a brief overview of this idea, based on the lack of bibliographic similar data about safety cores and right highlight a general idea from where to start an improvement of this unpatented yet idea.
- Although the assumptions made and the work has achieved its purpose that in the second stage there will be necessary and similar studies for other types of buildings, shapes, including other types of structures (even materials other than reinforced concrete used for the actual structure) height levels, seismic zones;
- The third stage must be the soil-structures interaction analyses;
- It also should be understood further a lot of supplementary series of technical and technological matters.

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