

Total illiteracy in construction—The tragic retribution for this will be very heavy and sorrowful: Seismic isolation strategies are the way to overcome such consequences

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ABSTRACT: Frequent earthquakes of medium and high intensities in different countries of the world constantly testify that engineers in most cases are illiterately solving the problem of the interaction of load-bearing and non-load-bearing structures in the buildings. As a result, the mass destruction of non-load-bearing walls and damage in load-bearing structures take place, and they are illustrated in the paper for various buildings in different countries. We must always remember the quote of Galileo Galilei: “*Ignorance is the mother of malice, envy, greed and all other low and gross vices, as well as sins*”. Therefore, this paper points to the total illiteracy and corruption that reign in the construction industry of Armenia in all cycles, starting from design, project expertise, issuing construction permits, and ending with construction and its technical and author’s supervision. It shows that the people employed in the construction complex have completely forgotten about the lessons of the devastating Spitak earthquake and completely ignored the high seismic danger in the territory of Armenia. Design organizations envisage old, unreliable methods for mass construction, where the dilemma of how to simultaneously minimize inter-story drifts and floor accelerations along the height of the buildings cannot be solved. This quite obviously leads to a significant increase in the cost of construction, which fully satisfies corrupt builders and corrupt state bodies. In the second part of the paper, the author states that one of the ways to overcome the current situation is the widespread application of the seismic isolation systems created by him and largely implemented in Armenia. In terms of the number of seismic isolated buildings per capita, the author brought Armenia to the second place in the world after Japan. The advantages and reliability of structures with seismic isolation systems both in the construction of new buildings and in the retrofitting of existing buildings are clearly illustrated. A comparative analysis of deformed states and values of accelerations along the height of buildings with and without seismic isolation systems is given. Paper also demonstrates the high economic efficiency obtained from the use of seismic isolation systems. It is shown that in the construction of new seismically isolated buildings, savings reach 40%, and the retrofitting of existing buildings by application of seismic isolation costs up to 5 times less, compared to traditional methods of strengthening. At the same time, the retrofitting of existing buildings by means of seismic isolation

is carried out without interruption of their operation.

KEYWORDS: total illiteracy in construction; unreliable methods in mass construction; corrupt construction and state bodies; modern and cost-effective seismic isolation systems; advantages of structures with seismic isolation systems; reliability and low-cost; comparative analysis; deformed states; inter-story drifts; accelerations; newly constructed seismic isolated buildings; retrofitting of the existing buildings by seismic isolation

1. Total illiteracy in construction—The tragic retribution for this will be very heavy and sorrowful

Armenia is located in an earthquake-prone zone. What is expected if a strong seismic event occurs in our country, this will definitely take place, as evidenced by the 1988 Spitak earthquake. At that time, according to our research, in a matter of seconds, we lost 52,000 people and had many cities and villages destroyed^[1]. In order not to be unfounded, I will refer to the World Bank Working Paper Series No.9 of 2004^[2], where it is mentioned: “*The Spitak earthquake took the lives of 50,000 people, and a total of 1,400,000 people suffered serious physical and material damage*”. The results of material damage and destruction of buildings are given in^[3].

We must finally learn lessons from our own experience, as well as from the world’s experience. How much longer should our population remain uninformed because of the criminal negligence of semi-literate officials? How much longer will the brains of our people be brainwashed by idiotic serials, programs on cooking all kinds of dishes and advertising their recipes, low-grade, so-called “humorous” programs, low-grade music, and other useless, moreover, and hostile to the spirit of the people information? At the same time, no information is given to people by the government propaganda about the hazardous situation with the existing building stock, schools, hospitals, etc. which, practically, do not have the required level of earthquake resistance. Also, no information is given about extremely low quality and illiterate construction of new buildings. The photos below in **Figure 1** are clear evidence of this.

In a few seconds, for example, in Yerevan (the capital of Armenia), in the event of an estimated earthquake of intensity 9, the nation will lose 300,000 people, and 80% of existing buildings will be destroyed or damaged by such a state that their restoration will become impossible. About 500,000 people will become disabled, and the number of people left homeless will be incalculable^[1]. As the author or co-author of many scientific papers, the author of the given paper has written about this many times in his books and articles, spoken at press conferences, and during his interviews on various channels and in the press.

In such conditions, will a very limited number of government rescue units be able to achieve tangible positive results in rescuing people from the 32,000–33,000 buildings and structures destroyed in the capital? Of course not. Let’s recall, for example, the sad experience of rescue operations on a small recently exploded building in Yerevan, where 200(!) rescuers worked, and as a result, they did not even temporarily fix one of the façade walls, which posed a threat of collapse. As a result, in a couple of days, this wall collapsed and brought new hardships.

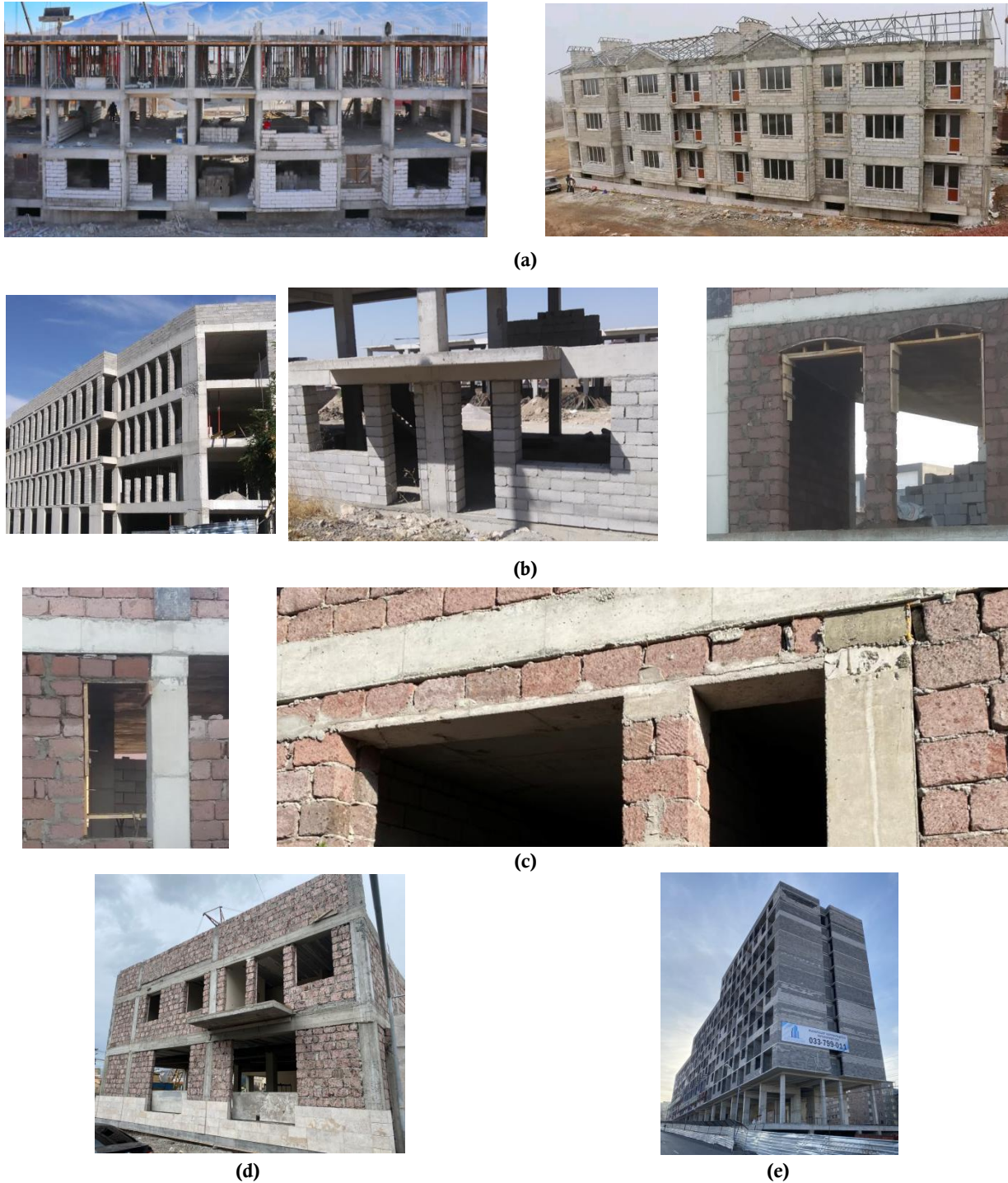


Figure 1. Examples of illiterate construction currently going on in Armenia. **(a).** Reinforced concrete frames in these buildings have unreinforced masonry infills constructed without soft joints with columns and beams. **(b).** The same as for the above examples plus the unacceptably small width of the piers between two doors or between a door and a window aperture. **(c)** The same as for the above examples plus unacceptable execution of the windows lintels. **(d)** This building includes all possible deficiencies and violations of the Armenian Seismic Code in force. **(e)** This building also includes all possible deficiencies and violations of the Armenian Seismic Code in force plus it has a soft ground floor which is prohibited for use in Armenia.

Thus, we can unequivocally state that, by and large, we have not learned anything after the Spitak earthquake. Moreover, we have simply forgotten this tragedy! Based on the above mentioned it should be stated that there is a danger that our people living in the territory of present-day Armenia will be wiped off the face of our earth by strong earthquakes. Of course, it may be objected to by the author

that we have long been considered a “builder people”. And this is true. We know what a magnificent construction culture our ancestors had. And we are proud of that. We are proud of the constructed churches, monasteries, castles, and fortresses. However, this does not mean that everyone, with or without the appropriate education, has the right to consider himself a builder and disgrace this noble and high title. We know that total illiteracy reigns now in the construction industry of Armenia, from the design and expertise of projects to construction and supervision.

Why is this happening? Mainly because the construction industry is now flooded with people who have completely forgotten the tragedy of 1988, who, due to their own illiteracy, do not even want and do not try to learn lessons from past disasters. These are also those who, at one time, used money to purchase term and diploma projects and in the same manner “delivered” these works, “defended” these projects, not caring at all about future crimes that are now taking place in construction. These people do not read anything and practically do not know the requirements of the current Standards for the Design and Construction of Earthquake-Resistant Buildings and Structures. And why should they do this, if the state bodies responsible for the mandatory observance of these norms and for the policy in the construction industry, as well as the regulatory authorities, are practically inactive due to their corruption?

The author has repeatedly explained in writing, as well as in his numerous television appearances, interviews on various channels, and in the press, that the seismic resistance and reliability of buildings depend on the competent design and construction of all structural load-bearing and non-load-bearing elements. However, the above photos prove that today’s “would-be designers” and “would-be builders” know nothing about this and do not want to know. If the author’s worldwide fame infuriates these people who reject prudence and literacy, then look at what the famous professor from Switzerland Hugo Bachmann writes in his book^[4]: *“It is necessary to abandon the construction of walls that fill the frame structures using the methods shown in the photographs. They are bound to be damaged and destroyed, resulting in death or injury”*. Two of the relevant illustrations are presented in **Figure 2**. Other examples of destruction of walls in different countries are shown in **Figure 3**.



Figure 2. Damage and collapse of illiterately constructed non-load-bearing walls in frame buildings.

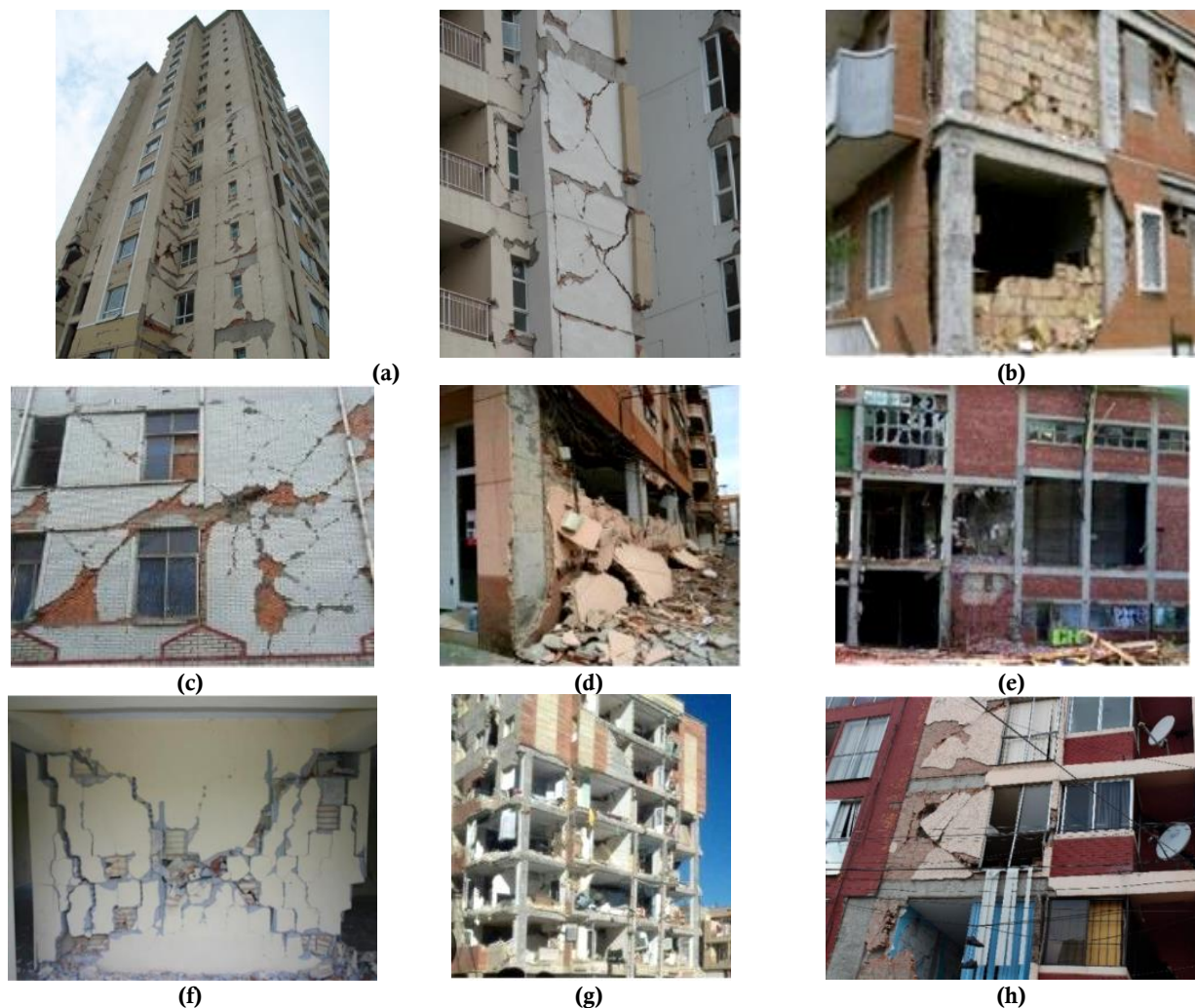


Figure 3. Examples of destruction of the infill walls in frame buildings during earthquakes in different countries. (a) Portugal; (b) Italy; (c) China; (d) Spain; (e) New Zealand; (f) Nepal; (g) Iran; (h) Mexico.

It is interesting that the current (as well as in the previous editions of the Armenian norms) unambiguously indicate the methods of competent construction of walls in frame buildings. However, our illiterate officials, designers, builders, and regulatory authorities do not know them, as they do not read literature and normative documents. I do not hope that they will be able to draw the necessary conclusions from the past, as well as from the above examples of disgusting construction. But they must do this in order to stop the inept and criminal construction. Yes, we need to put an end to this! You can't play with people's lives for the sake of your own enrichment. We don't have the right to do that...

In the territory where we live, we are simply doomed to observe the well-known postulates, namely, to prepare for future strong earthquakes by all possible preparatory means and measures to prevent massive damage and destruction of buildings. Constantly inform the population about the impending danger, discarding the false thesis that such information can cause panic. This thesis is needed only by officials in order to continue to squander public funds without doing anything, uselessly rubbing their pants on bureaucratic chairs and conducting an "ostrich policy". However, people should always be told the truth! This should be done at the state level by specialists with a high educational level, strong in spirit and will. This must be done everywhere: in public and private institutions, in schools, hospitals, courtyards, etc.

Among the priority buildings to be strengthened should be the buildings of schools, hospitals, and government offices from which officials are to carry out all necessary control actions during and after the action of the earthquake. The big question here is whether these unprepared officials know what they should do. The author is sure they don't. In Tokyo, the author had the opportunity to personally participate in a large exercise held right on the streets in the capital of Japan. A large number of the capital's population (several thousand people) took part in these well-prepared exercises, along with the employees of the governing bodies and rescuers. It is obvious that our arrogant officials would not agree to lie in the streets, pretending to be seriously wounded or killed. After all, they are only used to being saluted on the parade ground by the commanders of rescue teams, and, they say, everyone is ready to perform their tasks. The above-mentioned explosion in Yerevan showed quite the opposite. The buildings themselves, where rescuers or unfortunate officials are located, do not have the necessary level of seismic resistance. They will collapse in an earthquake of the design level and even below the design level in a matter of seconds.

How many more times must we be punished by the Lord God in order to finally understand that it is impossible to turn a blind eye to the most important problems under consideration, to the high seismic danger and the high risk of destruction of the buildings of the existing stock? We have to understand that we must avoid a new genocide of our people. Wake up, gentlemen officials and false builders! Why was the author, and not "you", able to make possible the implementation of the program of strengthening and rebuilding schools in Armenia, thereby fulfilling my duty as a specialist and my moral duty? Not being a government official, it took me about 4 years of unpaid work to finally convince and make it clear to the Asian Development Bank (ADB) about the need and importance of such a program for Armenia. Thank God that there are noble and grateful people who, unlike semi-literate officials, were able to highly appreciate my work! Here is what the director of the ADB Armenia Resident Mission wrote to me in this regard:

"Dear Professor Melkumyan,

...I am very grateful for your generous help and advice on seismic safety and school rehabilitation over the past 3-4 years. I can honestly and sincerely give you 100% of the credit for introducing this topic to ADB and helping ADB to understand its importance. You can rest assured that due to your efforts many generations of children in Armenia will attend schools that are safe from earthquakes.

...I will always be ready to help you in your noble and vital efforts to improve the safety of schools in Armenia...

Sincerely,

David Dole

Country Director, Armenia Resident Mission

Asian Development Bank, January 10, 2016"

As can be seen from the letter, Mr. David Dole assures me that thanks to my efforts, many generations of children in Armenia will attend earthquake-resistant schools. But, alas, as is evidenced by the material I have cited above, illiterate officials and designers, pseudo-specialists in the examination of projects, in technical supervision, and the pseudo-builders themselves have defiled this magnificent program in such a way that cracks in the walls of the already built new and strengthened existing schools are practically abundant. And this is the case even with small oscillations! It is not difficult to imagine what will happen during the design or close to its level of seismic impact.

Similar programs related to improving the seismic resistance of hospitals, residential, and other civilian buildings should be immediately thought about by such state structures as the Ministry of Territorial Administration and Infrastructure, the Ministry of Internal Affairs, and the Urban Development Committee of Armenia. Officials need to abstract from existing stereotypes in order not to allow future strong earthquakes to engulf our nation. We need to think outside the box and act outside the box. The mentioned state bodies, as well as the Hayastan All-Armenian Fund and the Territorial Development Fund, are not only the bearers of urban planning policy but are also responsible for the high-quality implementation of construction programs in our country. Unfortunately, I can say with confidence that in their activities and programs, these bodies have lagged behind the progress in modern construction for decades and have completely forgotten about the protection of the population from the threat of seismic hazards and the risk of destruction of existing buildings. As a result, state resources are senselessly squandered, as well as sums collected by the Diaspora or provided by donors, but in return, unreliable non-earthquake-resistant buildings and structures are built, and existing buildings are allegedly strengthened by the oldest inefficient “old-fashioned” methods, spending 5 times more resources and time. This suits the above-mentioned corrupt state bodies acting with impunity and without control.

All this is also negatively condoned by the State Supervision Service of Armenia, to which the author has repeatedly appealed with demands to inspect the disgraceful and illiterate construction. However, no action was taken by this state organization, and the author did not receive any written responses to his appeals. What can be said, the author’s conscience is clear. He has a better chance of surviving the coming devastating earthquake because he lives in a base-isolated house. Then, after the devastating earthquake, the author will be able to show the people and the judiciary all his programs, publications, speeches, and letters, with which he has warned illiterate and corrupt state actors and builders of the dangers and hell in which our nation will find itself. Then all of them, as well as various controlling organizations, will be held accountable to the people for what happened in the course of numerous court hearings.

2. Seismic isolation strategies are the way to overcome the heavy and sorrowful consequences of strong earthquakes

The author is absolutely confident that seismic isolation strategies are the way to overcome the above-described consequences. Due to his huge efforts Armenia now is the second country in the world after Japan by the number of seismic isolated buildings per the number of residents. This is evidenced in “Recent Worldwide Application of Seismic Isolation and Energy Dissipation and Conditions for Their Correct Use”^[5], where it is stated: *“It is worthwhile stressing that Armenia remains second, at worldwide level, and has the largest number of building applications of seismic isolation per number of residents, in spite of the fact that it is still a developing country”*. Currently, there are more than 60 base or roof-isolated buildings designed by the author that are newly constructed or retrofitted in Armenia. Some of these buildings constructed by different local construction companies are shown in **Figure 4**.

Why does the author consider seismic isolation as the way to reliably protect buildings from the impact of strong earthquakes? The matter is that seismic isolation solves the problem of reducing simultaneously inter-story drifts and floor accelerations at each level of the buildings. This is easy to understand looking at the deformations of the buildings along their height. Time history analysis was

carried out using the record of the 1988 Spitak Earthquake. A comparison of the deformed states of the same building with and without seismic isolation is clearly proving this statement (**Figure 5**).



Figure 4. Some of the base or roof-isolated buildings are newly constructed or retrofitted in Armenia. **(a)** 5-story existing stone apartment building in Vanadzor retrofitted by base isolation for the first time in the world without interruption of the use of the building; **(b)** 11-story building of the multifunctional residential complex “Cascade”; **(c)** 20-story business center “Elite Plaza”; **(d)** 16- and 14-story buildings of the multifunctional residential complex “Arami”; **(e)** 18-story buildings of the multifunctional residential complex “Northern Ray”; **(f)** 16- and 13-story buildings of the multifunctional residential complex “Dzorap”; **(g)** 17-story building of the multifunctional residential complex “Baghramian”; **(h)** 17-story building of the multifunctional residential complex “Sevak”; **(i)** 9-story existing frame building protected by the roof isolation system—Additional Isolated Upper Floor—acting as a tuned mass damper.

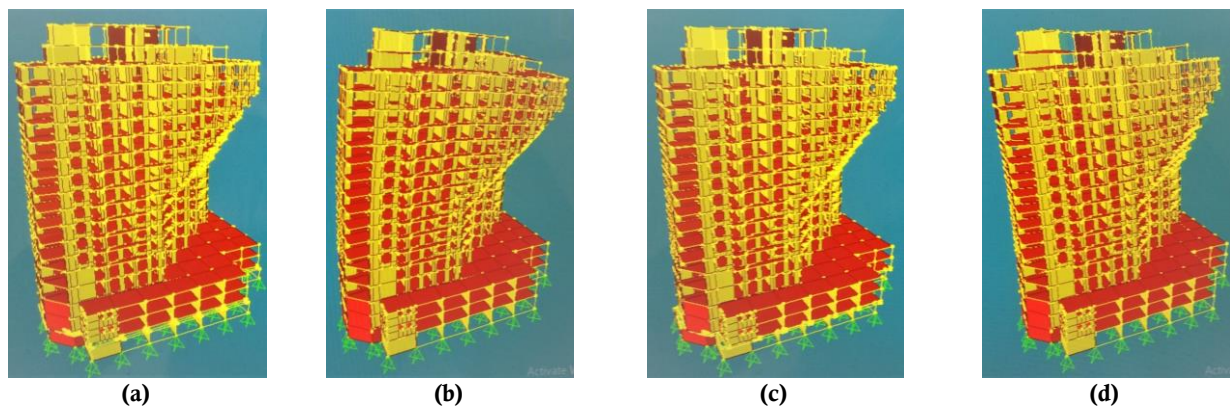


Figure 5. Limit deformed states of the 18-story buildings of the residential complex “Northern Ray” with **(a,c)** and without **(b,d)** seismic isolation systems.

Results of calculations show that inter-story drifts in base-isolated buildings are smaller than in fixed base buildings by 2.6 times on average and horizontal shear forces are smaller by 2.3 times on average. The other example (**Figure 6**) shows that in a base-isolated building reduction of 0.4 g input acceleration takes place along the height of the superstructure by 2.6 times on average, but in fixed base building vice versa amplification of 0.4 g input acceleration takes place along the height of structure by 2.25 times. Similar results were received by the author when carrying out comparative analyses for many other base-isolated and fixed-base buildings.

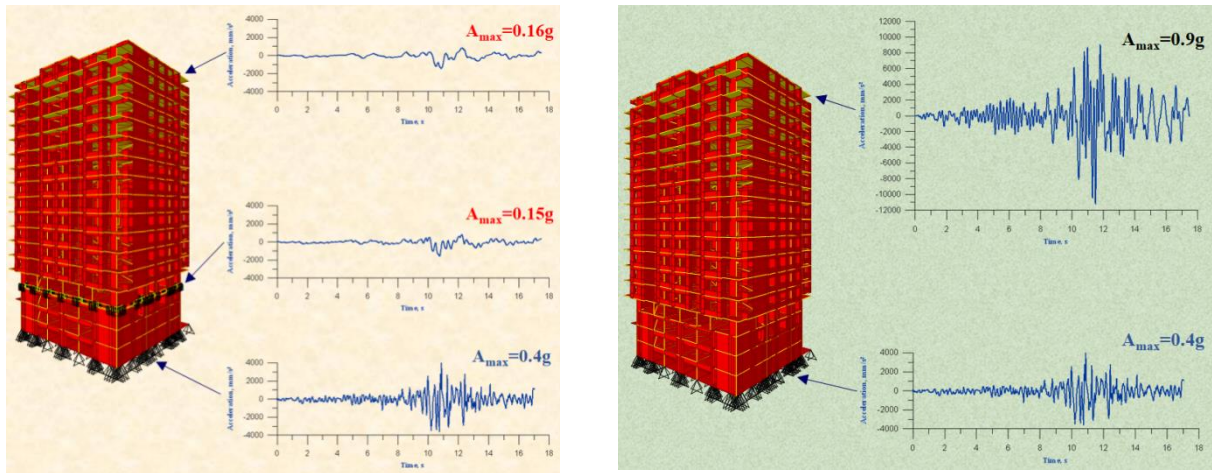


Figure 6. Reduction of input acceleration in 17-story base-isolated building of residential complex “Sevak” (left) and amplification of input acceleration in fixed base building (right).

That is why the experience of strong earthquakes shows and confirms that seismic isolated buildings demonstrate high resilience and excellent behavior while conventional fixed base buildings get huge damages and destructions^[6]. In seismically isolated buildings, people feel earthquakes from 8 to 10 times less and also no damage takes place to sensitive internal equipment. Therefore, the only practical way to overcome the above described in Part 1 negative consequences is to use seismic isolation systems. They provide the necessary flexibility, with the displacements concentrated at the isolation level^[7].

It must be especially emphasized that seismic isolation brings not only highly reliable construction but also, in Armenia, this system significantly reduces the cost of construction of new buildings and the cost of retrofitting existing buildings^[1]. As an example, let us consider the newly constructed Yerevan residential complex consisting of one 16-story and two 10-story base-isolated buildings (**Figure 7**). These buildings were designed by the author with the application of seismic isolation systems, but it is necessary to underline that previously these buildings, having the same architectural solutions, were designed by other engineers with fixed base structural systems. This made it possible to directly compare the consumption and cost of the concrete and steel in the structural elements of the fixed base and base-isolated R/C frame buildings with shear walls.



Figure 7. Design (a) and completed (b) views of the 16- and 10-story base isolated buildings in the residential complex “Our Yard”.

In the multifunctional multistory residential base isolated complex, “Our Yard” the reduction of consumption of the construction materials takes place due to changes in the cross sections of structural elements and a significant decrease in stories’ drifts, namely:

- Foundations changed from the 1500mm thick solid slab to the strip beams with a cross-section of 900 mm × 1500 (h) mm;
- Cross sections of columns in the superstructure changed from 600 mm × 600 mm to 500 mm × 500 mm;
- Cross sections of beams in the parking floors changed from 700 mm × 600 (h) mm to 700 mm × 500 (h) mm;
- Cross sections of beams in the superstructure changed from 600 mm × 520 (h) mm to 500 mm × 350 (h) mm;
- The thickness of the floors’ slabs changed from 200 mm to 150 mm;
- The thickness of shear walls in the parking floors changed from 400 mm to 300 mm;
- The thickness of shear walls in the superstructure changed from 300 mm to 160 mm;
- Consumption of steel per 1 m³ of concrete changed from 150 kg to 90 kg.

As a result of the changes due to the application of the seismic isolation strategy to the considered buildings, the total saving was revealed and given in **Table 1**.

Table 1. Comparison of consumption and cost of the concrete and steel in the structural elements of the 16- and 10-story fixed base and base-isolated buildings of the multifunctional residential complex “Our Yard”.

Structural elements		Fixed base buildings	Base isolated buildings
Consumption of concrete	Foundation	3131 (B25)	1648 m ³ (B25)
	Columns	3148 m ³ (B25)	1499 m ³ (B20)
	Beams	4254 m ³ (B25)	2488 m ³ (B20)
	Shear walls	2715 m ³ (B25)	1939 m ³ (B20)
	Slabs	4308 m ³ (B25)	3282 m ³ (B20)
	Beams below seismic isolators	-	334 m ³ (B25)
	Beams above seismic isolators	-	705 m ³ (B25)
Total consumption of concrete		17556 m ³	11895 m ³
Total consumption of steel		2635 t (150kg/m ³)	1071 t (90 kg/m ³)
Total cost	of concrete	\$1,773,156	\$1,179,500
	of steel	\$2,239,750	\$910,350
	of seismic isolators	-	\$270,200
Total cost of construction materials for the complex		\$4,012,906	\$2,360,050

Comparing the values of the total cost of construction materials for the complex it can be stated that savings due to application of seismic isolation comprise 41%. From **Table 1** one can see that for the fixed base building the grade of the concrete is B25, but for the base isolated, it is mainly B20. This means that a huge amount of cement will also be saved. Thus, the actual savings will be higher than 41%.

In relation to the existing buildings, it can be stated that retrofitting cost and time, due to the application of the invented by the author seismic isolation technology, are reduced to much higher

extent. As an example, let us consider the existing old 9-story large panel apartment building (**Figure 8**) constructed in Stepanakert many decades ago in the Soviet era^[8].

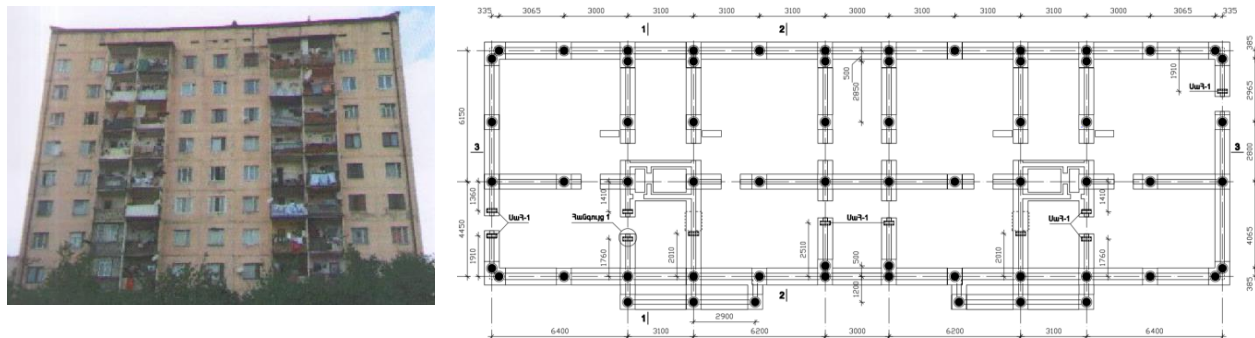


Figure 8. View of the existing 9-story large-panel apartment building and plan of the location of rubber bearings in the seismic isolation interface at the level of its basement.

The building has a symmetric rectangular plan with main dimensions of $34.6 \text{ m} \times 11.2 \text{ m}$. It has two exterior (300 mm thick) and one interior (200 mm thick) longitudinal load-bearing walls, as well as two exterior and six interior transverse load-bearing walls. All walls in the transverse direction have a thickness equal to 200 mm. The floors' slabs consist of precast reinforced concrete hollow-core panels.

Before the customer approached the author with the request to develop the base isolation retrofitting design for this existing 9-story large-panel apartment building using innovative technology, he had ordered earlier to another company to develop a design for strengthening the same building using one of the known conventional methods. Obviously, conventional strengthening requires the eviction of tenants from the building. Construction cost calculated based on the design for conventional strengthening was about \$1,000,000 and the time estimated for execution of conventional strengthening was about 2.5 years. After receiving and approving the author's base isolation retrofitting design the cost and time estimation was accomplished by the customer and it appeared that the earlier received figures were significantly decreased to \$185,000 and 6 months, respectively. Also, during the application of this new technology, there is no need to move people out of their apartments, and, on the other side, the cost and time of retrofitting decrease by 5 times on average.

3. Afterword

In the end, the author would like to stress that illiterate construction and corruption in the construction industry encouraged by some corrupt governmental bodies in Armenia must stop. Tragic consequences of the Spitak and other devastating earthquakes in the world must never be forgotten and lessons must be learned. The population of Armenia deserves to live in resilient buildings and should not become the victim of the future strong earthquakes and of illiterate, irresponsible dregs who lack a moral compass and overlook the problem of national security.

To overcome the current poor situation in the construction industry of Armenia the old conventional methods of construction must be left away and changed by the modern and highly reliable construction technologies and materials. One such technology is seismic isolation which, as evidenced by the consequences of the strong earthquakes in different countries, proves to be the most reliable technology providing an incomparably high extent of increase of earthquake resistance of newly constructed and retrofitted buildings and structures. Moreover, the seismic isolation strategy leads to huge savings in construction costs and improves the quality of life for people who live in such buildings.

Conflict of interest

The author declares no conflict of interest.

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