Research Inventy: International Journal of Engineering And Science
Vol.12, Issue 1 (January 2022), PP 70-76
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

An Example of an Illiterate Increase in the Number of Stories and an Alleged Increase in the Seismic Resistance of an Existing Building in Yerevan

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Date of Submission: 17-01-2022 Date of Acceptance: 31-01-2022

I. INTRODUCTION

It should be immediately clarified what moved the authors of the below described example of an illiterately developed and implemented project to such a risky step. The fact is that some of the "powers that be", representatives of the former (until 2018) authoritarian and corrupt regimes in Armenia, wanted to have apartments in the very center of Yerevan. Naturally, permission to build four more (!) floors on the already existing 8-story building on Amiryan Street in Yerevan was obtained without any delay. In order to somehow give this obviously reckless and risky project some justification, they decided to "dress it in a scientific shell", and in addition to four floors to build an oscillation damper over them. As will be shown below, this device can justifiably be called a spectacle – a "false damper".

All those, both in Armenia and far beyond its borders, who are engaged in the problems of earthquake-resistant construction and seismic resistance of structures, are well aware [1,2,3,4,5,6] that in Armenia structural concepts and technologies of seismic isolation have been created, investigated, developed, designed and implemented by the author of this paper since 1993. The author is the permanent leader of all the works on seismic isolation systems and a direct participant in their experimental and theoretical research and implementation in construction practice. There are numerous opinions of famous scientists and engineers from around the world about the structural concepts and technologies of seismic isolation created by the author, which the reader can find on the pages: Mikayel Melkumyan – Facebook (www.facebook.com/mmelkumi).

For completeness of information, it should also be noted that for the conditions of the construction industry of Armenia, the author proposed the following structural solutions and appropriate technologies for their implementation: (1) seismic isolation in the foundation (basement) part of buildings, developed both for (a) newly built low-rise and multi-story buildings, and for (b) existing buildings also of various numbers of stories, and (2) seismic isolation at the roof level of the buildings, designed as (a) an additional seismic isolated upper floor and (b) a seismic isolated upper cover slab (Figures 1 and 2).

Figure 1. General view of the apartment building, the seismic resistance of which has been increased by the method of additional seismic isolated upper floor (proposed by the author of this paper), and the design model of this building

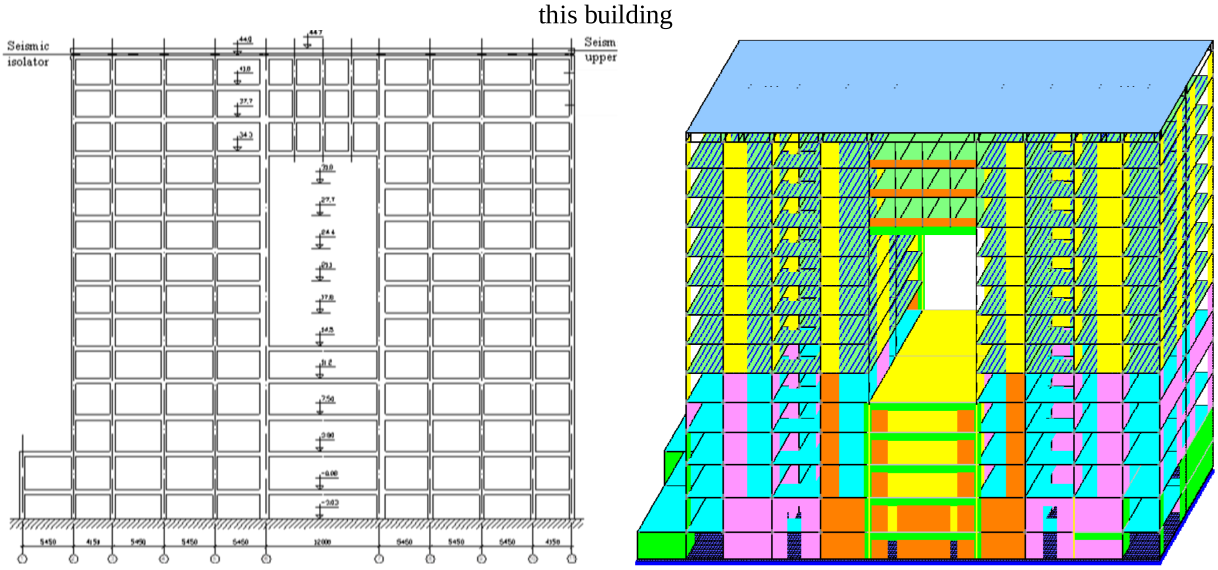

Figure 2. Vertical structural elevation of the building, the seismic resistance of which was suggested to be increased by the seismic isolated upper slab method (proposed by the author of this paper), and the design model of this building

Many of the concepts of seismic isolation and technologies for their implementation developed by the author are unique, since they were introduced for the first time in the world without interruption of the functioning of existing buildings [7,8,9,10] or with the simultaneous reconstruction of the floors of the superstructure (part of the building above the seismic isolation system) of existing buildings [11,12]. Originality also lies in the concept and technology of installation of seismic insulators not one by one, but in groups (clusters) under the bearing structures of both newly built [13,14] and existing buildings [11,12,15]. The noted uniqueness is confirmed by the documents of international organizations and conferences [16,17,18], as well as publications of scientists and engineers from different countries [1,2,3,19,20].

Specialists who do not even work in the field of seismic isolation unanimously recognize, based on world experience in studying the consequences of strong earthquakes, that seismic isolation systems are the best that has been invented to date to ensure the indisputable reliability of earthquake-resistant buildings [21]. To date, in addition to structural concepts and technologies of seismic isolation, the author has developed, in fact, the entire regulatory framework for the design and application of seismic isolation, adopted and approved by the

Government of Armenia. These are primarily Chapter 10 "Buildings and structures with seismic isolation systems" in the current Design Code of the Republic of Armenia; further, approved in 2007, "Guidelines for the design and construction of buildings using laminated rubber-steel bearings", and Standard of the Republic of Armenia SRA 261-2007 "Seismic isolation laminated rubber-steel bearing. Specifications". These documents are exactly what is needed so that engineers can independently design seismically isolated buildings.

II. DESCRIPTION OF THE PROJECT OF ILLITERATE INCREASE IN NUMBER OF STORIES AND ALLEGEDLY INCREASE OF SEISMIC RESISTANCE OF THE EXISTING BUILDING IN YEREVAN

The developed project was carried out by the design company "Seismanaкhagits" LLC for the existing 8-story building on Amiryan Street in Yerevan. The design envisaged increasing the number of floors up to 12 and arranging a dynamic vibration damper in the form of a cover slab connected to the building by seismic isolators at the top of the building (Fig. 3). In fact, this design company was intended to apply the concept of seismic isolation at the level of the roof developed earlier by the author of this paper [22], but, as it will be shown below, nothing actually came of it.

Recalling the events of the recent past, it should be emphasized that when the author developed and implemented his concepts of seismic isolation at the level of buildings' roofs [7,8,13,22], those who have now applied these concepts in the building under consideration, then criticized, arguing that seismic isolators cannot effectively perform their functions in the system of dynamic vibration dampers. Therefore, the author notes with satisfaction that so-called "specialists", who, due to a lack of knowledge in the field of seismic isolation of structures, had a negative attitude to these systems, finally grew up to understand their high efficiency. Well, they can be praised, since these "specialists" tirelessly insisted that they would create their own concepts of dynamic oscillation dampers, but never came to anything. It is never too late to admit one's own inadequacy, and, putting aside one's own baseless ambitions, to rely on the concepts that have proven themselves in the republic from the most positive side.

a.

b.

Figure 3. View of the existing 8-story building on Amiryan Street in Yerevan with the added four floors and a cover slab constructed on top and connected to the building by seismic isolators to form a dynamic vibration damper
a.– from the side of Amiryan Street, b.– from the side of the courtyard of the building

However, to great regret and disappointment, it must be stated that the project under consideration, in fact, does not stand up to criticism, replete with numerous flaws and, actually, discredits both the developers themselves and the idea of seismic isolation at the building's roof. The author of this paper has an official report compiled in 2013 by the developers of this project. The report is signed by candidate of technical sciences Z. Khlgatyan and engineer A. Khachaturyan. From the report it follows that before the start of the design on increasing the number of stories, they initially analyzed the existing 8-story building, which was designed according to the Seismic Code II-2.02-1994 that was in force in the republic at the time of construction of this building. The aim was to assess the actual seismic resistance of this building and, if necessary, to make suggestions for it's improving.

It was obtained that the periods of the first mode of oscillation of the 8-story building are equal to: T_x = 0.789sec. and T_y = 0.853sec. The maximum displacements at the top of the 8th floor are equal to: X_{max} = 200mm and Y_{max} = 212mm. Based only on these results, an erroneous conclusion was made about the insufficient seismic resistance of the building and the need to increase it. The question immediately arises, on the basis of which normative documents in force in Armenia, such a conclusion was made? Apparently, the developers really needed to come to such a conclusion, which was made without thinking about their own reputation. After all, it is obvious that in order to assess the actual seismic resistance, it is necessary to have data on the real bearing capacity of the structural elements of the building, based on their actual reinforcement and strength of concrete, and then compare them with the values of the required bearing capacity obtained as a result of the calculation performed according to the current standards [23]. The developers of the project did not do this. Moreover, the conclusion about the need to increase the seismic resistance of the 8-storey building was made on the basis of incorrectly defined periods of its oscillations.

In accordance with paragraph 6.5.2 of the Seismic Code II-6.02-2006, the periods of the first mode of oscillation of this reinforced concrete braced-frame building should be approximately 0.5sec., which is 1.58-1.71 times less than those obtained by the designers. This means that the actual rigidity of an 8-story existing building is 2.7 times higher than that which was erroneously determined by the designers for this building. Consequently, their claim that the building does not have sufficient rigidity is meaningless. At the same time, the report gives the values of the calculated floor drifts, and, obviously, their amount should be equal to the values of horizontal displacements at the level of the 8th floor slab in mutually perpendicular directions of the building. Using the data of the report, we get that in the direction of X the magnitude of the displacement is approximately 114mm, and in the Y direction - 101mm, and these values differ significantly from the above values of X_{max} and Y_{max}. So which values are true? One thing is clear that the developers of the project arbitrarily and consciously manipulate the numbers, only to show that this existing 8-story building needs to improve seismic resistance. And to achieve this goal they suggest (you can imagine!) to construct over an existing building additional four floors with a dynamic vibration damper. Given that this project has already been implemented in the heart of Yerevan, where the cost of apartments is very high, it is not difficult to guess who needed such a manipulation of the results. It is also not difficult to imagine what will happen to this building and its occupants under seismic impacts even below the design level. This can also be judged from the following criticisms.

According to the developers of this project, the newly constructed additional four floors will allegedly neutralize the torsion of the building. To this end, they provide a cantilevered protrusion in the added part, which is clearly visible in Figure 3b. However, it is obvious that the mass of this protrusion is so small in relation to the mass of the entire building that it is naïve to rely on any tangible counteraction to possible torsional oscillations. On the other hand, this ledge is ugly reflected in the appearance of the building. Even if we assume that the existing 8-story building really needs to increase the seismic resistance, this could be reliably carried out by means of one isolated upper floor according to the technology of the author of this paper (see, for example, Fig. 1) and at the same time effectively neutralize its torsion.

The fact that the developers of the project in question simply deliberately demonstrate the alleged lack of rigidity of the existing 8-story building is also evidenced by the following. If this building, as indicated in the report, was calculated according to the Seismic Code II-2.02-1994, then the values of the permissible drifts of its floors should not exceed 9.4mm. The question arises, how is it that for the same building, calculated already according to the Seismic Code of II-6.02-2006, where the permissible damage coefficient K_1 is reduced by 1.13 times, and the values of displacements must also be multiplied by a coefficient of 0.8, the authors of the project have obtained the magnitudes of the floor's drifts 1.57-1.80 times greater? The answer is obvious; either they were unwilling, or their lack of knowledge did not allow them to comply exactly with the requirements of the current Seismic Code. As a result, the formation of the design model for the existing 8-story building was done incorrectly. In the design model, the horizontal stiffness of the load-bearing elements was incorrectly assigned and many factors that would allow the dynamic characteristics of the building to be most accurately calculated were not taken into account.

III. ABOUT THE PARAMETERS OF THE APPLIED DYNAMIC "FALSE DAMPER" OF OSCILLATIONS

Moving on to the already implemented 12-story building with a dynamic "false damper" of vibrations in the form of an isolated cover plate, it should be noted that the report does not provide data on the periods of oscillation of the building without a damper. However, the report states that the estimated mass of the damper is

460tons, which is about 4% of the mass of the entire building. With this mass of the damper, the total horizontal effective stiffness was selected for it, equal to 10935kN/m. From here, performing the simplest calculations, it is easy to show that the period of the first mode of oscillation of a 12-story building will be equal to about 1.3sec. It was this value that the authors of the report (the developers of the project) did not want to mention, apparently realizing that the period of a 12-story residential building cannot be so large. Indeed, according to the requirements of the Seismic Code in force in the republic, it should be equal to about 0.7sec., that is, less than 1.86 times. But, apparently, this fact did not worry the developers of the project much, since, probably, the goal was set to implement this dangerous project as quickly as possible. Its introduction, in fact, not only did not increase the seismic resistance of the building in question, but, on the contrary, the seismic risk of destruction of this building was increased many times over.

Every self-respecting specialist working in the field of seismic resistance, before proceeding to the design (implementation) of a dynamic vibration damper, must necessarily determine on the spot in full-scale conditions by direct instrumental measurements the periods of oscillation of the building over which the damper is supposed to be erected. And only on the basis of the results obtained, it is necessary and possible to make a final clarification (adjustment) of the parameters of the damper and perform its design. Based on the report in question, all this was not done, and it is not difficult to imagine the danger posed to this building by an incorrectly calculated and designed vibration damper. After all, the accepted mass of the damper (460tons) seems very doubtful, since it is well known from many scientific works [24,25,26,27,28] that for this type of building the effective mass of the dynamic vibration damper should be from 7% to 10% of the mass of the protected structure, but not 4%, which was accepted by the project developers.

Another danger to the building is the designed installation nodes of seismic isolators, which, according to the authors of the report, are supposed to provide the required stiffness of the damper. These so-called "specialists" did not really understand that according to the SRA 261-2007 standard developed by the author of this paper, seismic isolators do not have a constructive connection with structural elements located above and below them. According to the standard, seismic isolators are freely placed in their nests (upper and lower reassess rings). If the developers of the project decided to place two seismic isolators (a total of 54 pieces) in each of the 27 nodes above each other, then the horizontal stiffness of one such node cannot be equal to 0.405kN/mm, that is, half the value of the standard horizontal stiffness of one seismic isolator. This means that with regard to the dynamic oscillation damper, its design model is also built incorrectly. Under seismic impacts, seismic isolators installed on each other, but not having a connection with each other, will not be able to work together and provide the necessary rigidity adopted by the project developers. This is well illustrated by the tests of the "false damper" nodes, which were carried out on demand and in the presence of many specialists participating in public discussions of this project (Fig. 4). The main condition of the tests was to bring the horizontal displacement of the node of paired seismic isolators to the calculated value.

Figure 4. Moment of testing at the "Firm TNT" LLC of the node with seismic isolators installed on top of each other under the action of horizontal force at the level of the lower plate (red color) of the lower seismic isolator

At the time recorded in Figure 4, after which the tests were forcibly discontinued, the value of horizontal displacement was brought to only half of the calculated value. According to the white grades on the side surfaces of seismic isolators, it can be judged that even with such small values of horizontal displacements, seismic isolators came out of their nests vertically by more than 40mm. Consequently, the designed node, consisting of two freely installed seismic isolators on top of each other, being crimped by a vertical load due to the weight of only the reinforced concrete slab of the "false damper", is not able to perform the functions of an element which provides the needed stiffness. Such a node practically does not work, and seismic isolators simply gradually come out of their nests already at negligible (almost zero) values of horizontal force.

It is quite clear that in this case, there is no need to talk about any horizontal stiffness of such nodes here, and the zero efficiency of this "grief" damper becomes obvious. The zero knowledge of the project developers about the concepts of shape factors and reliability of seismic isolators is also obvious. Otherwise, it would be clear to them that with the calculated horizontal displacement of 360mm of the damper, even under the assumption that the seismic isolators placed on top of each other work together, there will be a loss of stability of each such node and the entire structure will collapse under the influence of the weight of the damper slab. Note that the diameter of these seismic isolators is 380 mm, and the height of each is 202 mm.

IV. CONCLUDING REMARKS

In the project under consideration (report) for a 12-story building with a so-called "false damper", the drifts of the floors, based on the requirements of the current standards, should not exceed 11mm. However, as the calculated values given in the report show, the drifts in the mutually perpendicular directions from the 3rd to the 10th floors exceed the permissible values by 1.1-1.4 times. This clearly confirms the inadmissibility of adding of new four floors over the existing 8-story building, the total weight of which is 27650 kN, and also once again proves the uselessness of the vibration damper implemented here. Thus, the weight of the building is increased by 1.4 times. Taking into account that the building was built on the soils of the category II, it can be stated that if the periods of oscillations of the 8-story and 12-story buildings were calculated correctly, then the corresponding dynamic coefficient for a 12-story building would be only 1.1 times less than the dynamic coefficient for an 8-story building. This indicates that it is the mentioned additional weight that has a much greater negative impact on the formation of seismic loads, and the values of these loads given in the report, alas, cannot be considered reliable.

There is another important factor that negatively characterizes the work in question. The report does not contain data on the results of tests of seismic isolators. Consequently, there is no corresponding scheme of layout of each of the tested and numbered seismic isolators both in the nodes (where they are installed on top of each other) and in the building plan. The fact is that all seismic isolators, as the project developers say, were tested in accordance with the SRA 261-2007 standard in force in the republic. This means that each tested element has its own specific characteristics and cannot, as it happens (in any order) be installed in the vibration damper system. That is, for each node, seismic isolators should be selected so that, regardless of the differences in their stiffness characteristics identified during the tests, the final stiffness of each of the 27 nodes was equal to the design stiffness. In addition, even if it is not possible to fully satisfy this condition, then it is necessary to distribute the stiffness in the building plan in such a way as to completely eliminate the torsional oscillations of the entire system of the damper. It is for this purpose that a scheme with the numbering of seismic insulators should be competently drawn up, which was not done.

The developers of the project also did not consider it necessary to show in their work how the bearing capacity of the existing structural elements of the lower floors of the building was checked in the conditions of adding the mentioned huge weight. Probably, the "specialists" who made so many of the above mentioned mistakes were no longer up to it, and they also had no desire to estimate the magnitude of additional vertical forces in the columns of the frame from seismic impacts. After all, consideration of these loads would further aggravate the already deplorable state of the existing columns. They needed only one thing: as quickly as possible to implement this project. However, public discussions of this project have shown that at least two columns of the first tier of this building, in fact, will not withstand (collapse) under seismic loads even below the design level impacts. The authors of the described ultra-risky adventure do not even suspect and do not realize all the dangers that abound in this project, and which, with seismic impacts, even below the calculated level, will lead to irreparable human and material losses. In addition, a project carried out with the above flaws and with such an irresponsible approach can become a very bad precedent for developers who want to create additional living space in the center of Yerevan and other cities of the republic in their apartment business, putting people's lives in mortal danger.

It should be emphasized with all responsibility that the author of this paper fully supports and welcomes the desire of the republic's specialists to apply created by him structural concepts of seismic isolation and the technologies for their implementation in construction, but this must be done competently, understanding the essence of these concepts.

In turn, all projects newly developed on the basis of these concepts should be subjected to thorough examination by comprehensively trained specialists who should not allow irresponsible and illiterate work that poses a real threat to people's lives.

After all, if, God forbid, the collapse of the mentioned building occurs, it will discredit the seismic isolation systems that have highly proven themselves all over the world, and, most importantly, will lead to the death of people and the loss of material values.

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