Report on Retrofit Procedure of School Buildings in Islamic Republic of Iran

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SUMMARY:
One of the most important undertakings of Iranian government in reducing the seismic vulnerability of the country against the earthquake is "Study and performing Retrofitting of the Important Buildings and Lifelines" which covers 7 structural groups and was enacted since 2003 in the form of possession of stock finances. The school buildings are one of the major structural groups in the aforementioned plan. In parallel, the preliminary guideline for structural retrofit was prepared in 2003. Besides the aforesaid guideline, 4 billion dollars was granted by the Iranian Parliament according to 4th Development Plan in order to demolish and reconstruct the seismically dangerous schools and retrofitting the vulnerable ones. "State Organization of School Renovation, Development and Mobilization (OSRDM)" Is responsible for execution of seismic risk reduction plan in the educational buildings. This report is a brief review of the national project and achievements for retrofitting school buildings in I.R.Iran.

Keywords: School retrofitting, Masonry building, typical retrofitting patterns,

1. ENACT OF THE DEMOLITION, RECONSTRUCTION AND RETROFITTING OF SCHOOLS LAW

Iran is one of the high risk seismic zone and catastrophic earthquakes of every decade show the importance of structural safety. The importance of each building in earthquake resistant aspect is determined based on some parameters like functionality, serviceability of the building after the disaster, and the possible human and financial losses due to earthquakes. School buildings, are one of the most important buildings, because, they contain accumulated population and they have crucial role in post disaster management.

Based on 2800 code (Iranian code for seismic resistant design of buildings), School buildings are assigned to the category of the buildings with high importance which ranks second after the buildings with very high importance. Regarding this importance, 4 billion dollars was granted by the Iranian Parliament in 2007 according to 4th Development Plan in order to demolition and reconstruct the seismically dangerous schools and retrofitting the vulnerable ones. According to this law, 132 thousands classrooms should have been demolished and reconstructed and 126 thousands ones should have been retrofitted. It is noteworthy that the quality control of these projects was within International Institute of earthquake Engineering (IIEES) responsibilities. This state organization is responsible for execution of seismic risk reduction plan and the demolition and reconstruction plan (2007) in the educational buildings.

2. INTRODUCTION TO STATE ORGANIZATION OF SCHOOL RENOVATION, DEVELOPMENT AND MOBILIZATION OF IRAN

The establishment law of this state organization which is one of the branches of Ministry of Education dates back to 1975 and this organization formally started its work in 1976. The responsibilities of this organization are construction, development, renovation and reconstruction of the school buildings and also providing them with facilities and equipment throughout the country. Concentration of these responsibilities leads to similar details, architectural and structural plans in school buildings.

3. TECHNICAL CERTIFICATE OF SCHOOL BUILDINGS

In 2004 and based on a national plan, a comprehensive database about the structural specification of all school buildings was prepared. This database includes vast spectra of information e.g. the number of students to the situation of the foundation and the building facade and consists of 74 items. The most important items in this database are: the number of students, and staffs, the geometrical and technical specification of the structure, the possible hazards to the building like earthquake or landslide...

According to this project, more than 380 thousands classrooms in 100 thousands school buildings were analyzed by the staff of the ministry of education. One of the most important outcomes of this database is classifying the school buildings in the stability point of view in three categories: 135 thousands school in type of demolition and reconstruction, 126 thousands school buildings in type of vulnerable school buildings which needed to be retrofitted and 139 thousands schools are resistant school buildings. This evaluation provided the primary tools for programming of first 5 years of the project from 2006 to 2010. So, the technical certificate of schools buildings had key role on Enact of the d, reconstruction and retrofitting law**.** Based on the experienced learned during 5 years of execution of this project, the technical certificate of school building has been revised and completed. The new certificate is better than the previous one in different aspect. The extension in the parameters for data gathering, the method for data gathering and data storing are of examples which have been altered in the new certificate.

4. SELECTION OF PROJECT AND COMPATIBLE STRATEGY FOR RETROFITTING

As previously stated, this state organization deals with the problematic school buildings in two ways: demolition and reconstructing or retrofitting school buildings. Considering the differences between these two ways adds to the importance of proper selection and classification of the projects. Classification and prioritizing the school buildings is the first stage in retrofitting projects. This classification is divided into two phases: the first phase has something to do with the general policies related to all school buildings throughout the country. The second phase concerns with the decision making processes for each school buildings. The main aim is to reach highest safety level with specific fund. Te main question in this part is that “which school building should be demolished and reconstructed and which one should be retrofitted?” For answering this question, one should answer the questions below:

1- How much is the price of the school building? (The combination of the structure price, architecture preponderance and the facilities.)
2- How much is the cost of the retrofitting? (All the structural, architectural and facilities’ implementations)
3- How much would be the expected life of the building after retrofit? (Architectural preponderance after retrofit)

Answering all the above questions requires the in-depth studies which performing them is feasible for

100 thousands school. So at the beginning in 2004, this organization confined for rapid screening of school buildings nationwide. It classified all the school buildings in three structural types: satisfying, retrofit needed and demolition-reconstruction needed for general planning and budget estimation processes. In the next stage and during the retrofitting studies processes, each of the abovementioned questions was answered with an acceptable accuracy. Finally, it was decided whether a typical school building should be demolished-reconstructed or retrofitted. In 2010 and based on the experiences gained from the projects, the technical certificate of school buildings was revised.

This time, besides the structural specifications of each building, a proper estimation about the architectural condition and the facilities of the school buildings were made in order to better answer the aforementioned questions. Accordingly, the classification of the school buildings has been modified. In the new classification, rapid screening forms have been used, and the school buildings were fallen into one of the seven types below:

- Satisfying schools: The schools which were designed based on the final version of seismic design code of Iran, and all of these specifications were considered. These schools were constructed after 2006.

- Buildings with low retrofitting preference: The buildings which were constructed based on previous version of seismic design code of Iran during 2001 to 2006. Moreover, other buildings which were constructed out of this period, and were assigned to satisfying schools based on rapid screening forms are ranked of this type.

- Partial rehabilitation schools: These school buildings have sufficient shear resistance against earthquake; however, the slab integrity faces with problem. A large amount of school buildings with jack arch slab with low integrity is the main reason from considering this type of school buildings.

- Typical Retrofitting Pattern (TRP): Most of Iranian one story masonry buildings are assigned to this type. These buildings have similar deficiencies, so typical details and methods of retrofitting could increase their performance level to life safety.

- demolition-reconstruction needed schools: the schools which retrofitting cost is more than 50% of demolition and reconstruction cost , buildings with low quality of architectural aspect, or located on developing areas that will need to larger educational area in future are ranked in this type.

- Schools without the sufficient price for spending money: most of Iranian schools were retrofitted in rural areas and population of these areas decreases by time.

- Complete retrofitting: frame structural buildings without any lateral system of resistance or serious deficiency on this system are ranked on this type. These schools should be studied by complete circular of evaluation (screening evaluation, analyze report, retrofitting preliminary plan and final retrofitting plan). As it is obvious, this process takes long time for finalization.

In the next step, preference of retrofitting between schools is determined based on seismic hazard, population of schools and development program of region.

5. QUALITATIVE EVALUATION OF THE SCHOOL BUILDINGS WHICH SHOULD BE RETROFITTED

The number of classrooms which should be retrofitted is more than 126 thousands. Most of these schools were constructed by unique organization, and some similarities could be observed in these school. An overview to the qualitative evaluation of them could conduct the general strategy of

retrofitting method or research funds.

Table1: Qualitative results of school buildings

Type of Roof		N.Story		Type of Structure	
4.99	Concrete	86.09	1 story	88.53	Masonry
9.70	Wood				
5.35	Other				
79.96	Jack arch masonry				
		12.40	2 story		
		1.51	3&More		
				7.98	Steel
				2.00	Concrete
				1.49	other

6. CIRCULATION OF ACTIONS IN COMPLETE RETROFITTING

Circulation of complete retrofitting is comprehensive method of evaluation that starts from project selection and covers all steps of study and finally enters to part of construction. Project management a large amount of these projects increases the importance of accurate control. In this circulation, selection of retrofitting and geotechnical and material consultants is the next step after the project selection stage. Totally, qualitative report, geotechnical and materials testing, analyze report, preliminary retrofitting plan, final retrofitting plan are presented. All of this process is controlled by peer reviewer.

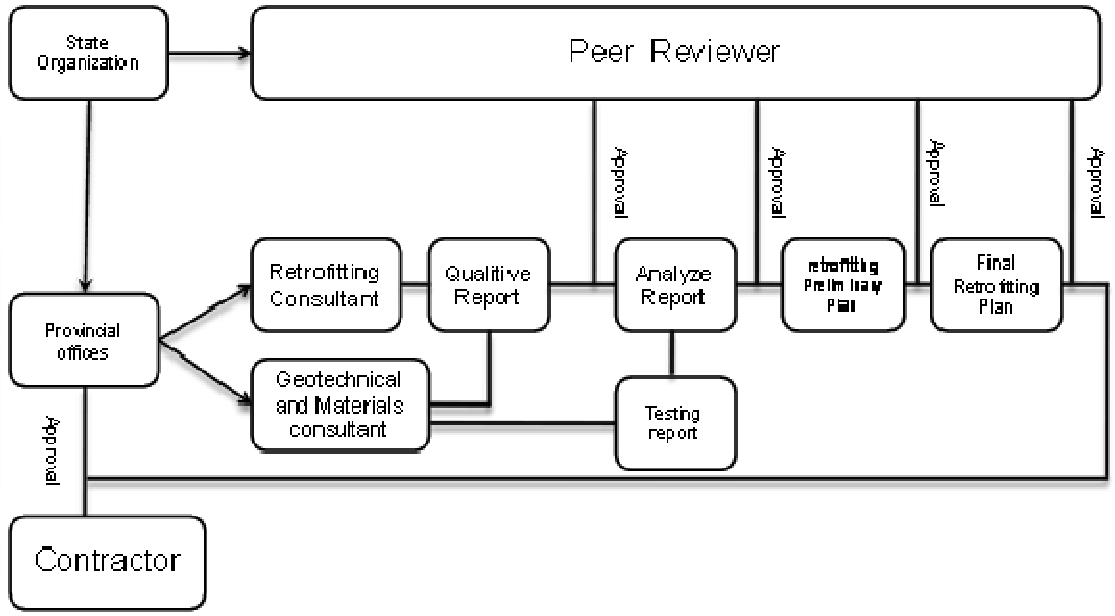

Figure1: Schematic representation of the study process of the retrofitting projects

7. DEVELOPMENT OF NEW METHODS FOR RETROFITTING OF SCHOOL BUILDINGS IN IRAN – TYPICAL RETROFITTING PATTERN

The results of the studies reveal that the retrofitting process in Iran is a very time-consuming and costly one. Covering all the stages in this process for structures with close details and specifications is very rare in the world. It was because this state organization has been considered new methods and criteria for its retrofitting projects. More than two years the different methods were studied and discussed. Various reports in this realm have been published and the results finally came in the form of new instruction on the new method for retrofitting of school buildings – Typical Retrofitting Pattern (TRP). The utilization of this new instruction was started in 2009 on limited number of school buildings and led to satisfactory results.

Typical retrofitting patterns increase performance level of buildings to target level with specific methods; however, minor deficiencies exist after retrofitting by this strategy. Required time for seismic evaluation by this strategy considerably decreases because the long time of prepare and verification are eliminated. This state organization follows three following goals in development of these methods:

1- **Reducing the time of retrofitting projects studies:** since a lot of school buildings should have retrofitted according to same methods and because of the close structural details, passing all the steps in retrofitting procedure for each of them is not logical. Moreover, this will require much longer period of time to achieve our goals in retrofitting of all school buildings in 5 years.

2- **Increasing the speed and quality of execution:** since implementation of these instructions leads to a unique retrofitting specifications and details, this will result in fast adaptation of the contractors with the executive methods and providing them with the equipment for a repetitive process.

3- **Reducing the cost of retrofitting process:** the total cost of the project greatly depends on the require tome of the project, the speed of execution and the amount of necessary equipment of the contractors. So repetition with the projects details and equipment will result in considerable cost saving in the retrofitting projects.

Development of the new solutions of this organization consisted of the four method; two of them were complemented in 2010. From the two remaining, one of them is in the study and research phase and the other which was not technically and economically justified was abandoned. The methods of this organization are as follows.

7.1. TYPICAL RETROFITTING BY SHEAR WALL PATTERN

In this instruction there are some tables containing the capacity of the shear walls and the piles with known details of the reinforcements and concrete in different soils. In the following, the standard specifications have been presented. A typical engineer can simply calculate the base shear of the building and in doing so, can evaluate the required number and length of shear wall(s) for reaching the calculated base shear. In the calculation of the number and length of shear wall(s), the load-bearing capacity of the masonry walls is neglected.

The roof of the buildings which should be retrofitted cording to this instruction is jack-arch and should be converted to the composite concrete one. Also specifications have been designed for the connection of the roof and the walls which leads to improvement of the in-pane and out-of-plane wall performance. In this method, one meter of the upper length of the wall is reinforced.

The engineers should follow and consider the specifications in this instruction in their technical ketches. This method was successfully implemented in some of school buildings in summer2010.

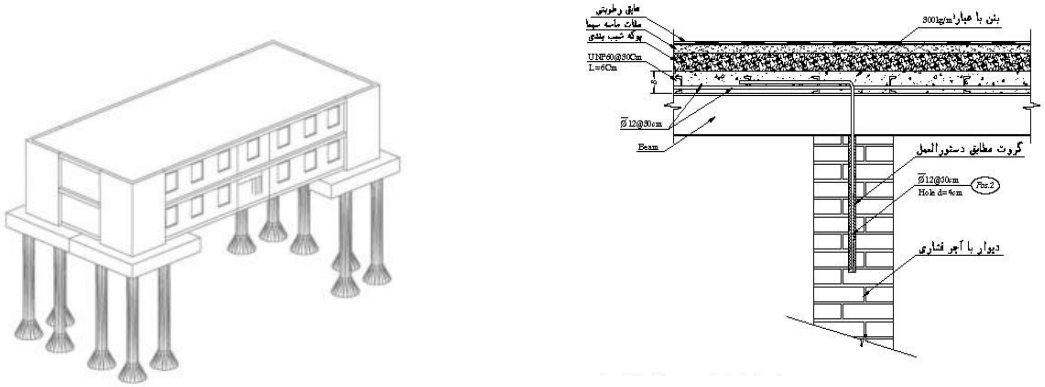

Figure2: Schematic overview and detail of retrofitting by shear wall pattern

Figure3: Samples of retrofitted school buildings with shear walls

7.2. TYPICAL RETROFITTING BY PERIPHERAL SHOTCRETE PATTERN

This method has been chosen based on the successful experiences from other countries and numerous experiments on the masonry walls. In this method, the surrounding area of the one-story brick building is shotcreted. The size of the rebar and the thickness of concrete are chosen in such a way that can fulfill the seismic demand of the buildings. In calculation of the base shear of the building, the total weight of the structure plus the brick walls are considered and load-bearing capacity of the walls is neglected. The roof of the buildings in this class is jack-arch which should be converted to composite concrete. The engineers should follow and consider the specifications in this instruction in their technical ketches. This method was successfully implemented in some of school buildings in 2010. Figure 5 shows some samples of this project which have been executed in summer 2010.

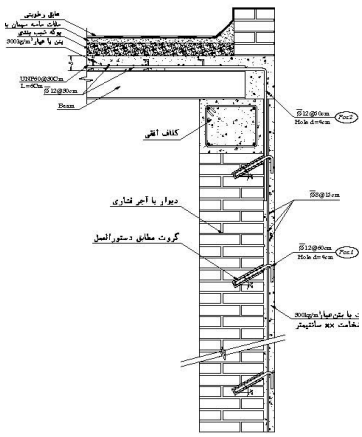

Figure4: Samples of retrofitted school buildings with shear walls

Figure5: Samples of retrofitted school buildings with peripheral shotcrete

7.3. TYPICAL RETROFITTING BY SAFE ROOM PATTERN

In this method, a steel frame is constructed for each classroom regardless of the capacity of the building, the variety of construction, structural and non-structural specifications. The aim of this method is to prevent falling of the debris on the present students in the classrooms. The different parts of the steel frame is designed and manufactured in order to easily and fast assemble the whole frame (in the sliding manner). In this way it can be guaranteed that the steel frame is become tight inside the classroom. Of the advantages of this method is fast recycling of the retrofitting material in the case of demolish-reconstruction plan. However this method could not bear enough chances to compete with other methods technically and economically and was not implemented widespread.

Figure6: Schematic overview on retrofitting by safe room pattern

7.4. TYPICAL RETROFITTING BY CENTER CORE PATTERN

State Organization of School Renovation, Development and Mobilization of Iran has developed retrofitting techniques in the scope of increasing the accuracy and speed of study and execution of the projects. Also it has worked on the modern methods especially for the brick buildings with historical background. This issue seems important considering that ministry of education of Iran posses a lot of school buildings with more than 70 years of age. Moreover, there are numerous historic brick buildings in Iran and retrofitting them by the conventional retrofitting techniques can endanger and intrude their historical value. The center core method is one of these retrofitting methods which has been in the center of attention of This organization.

The center core method is one of the specialized retrofitting techniques for masonry buildings against the earthquakes and for the first time was implemented in the U.S. in 1987 for retrofitting of some masonry buildings. The first step of this method is excavating vertical holes determined diameter in

the whole height of the wall and in determined distances. In the next step, the holes are filled with rebar and grout and this will result in improvement in seismic performance of masonry walls. Since in this method no apparent damage is posed to the architecture of the building and all the rehabilitation actions are outside the building, this method can be the best and the only solution for the buildings with historical importance and the buildings for which it is desired to maintain their service and functionality. In Iran, numerous historic masonry buildings which require stabilization against earthquake can provide good opportunities for this method to be vastly implemented.

Figure7: Alborz high school in Tehran with more than 120 years of age

8. ACHIEVEMENTS OF THE DEMOLITION, RECONSTRUCTION AND RETROFITTING SCHOOLS LAW

An overview on achievement of last five years is presented in this section. In figures 8, 9, numbers of retrofitted and constructed classrooms and fund distribution during the 2006-2010 are shown.

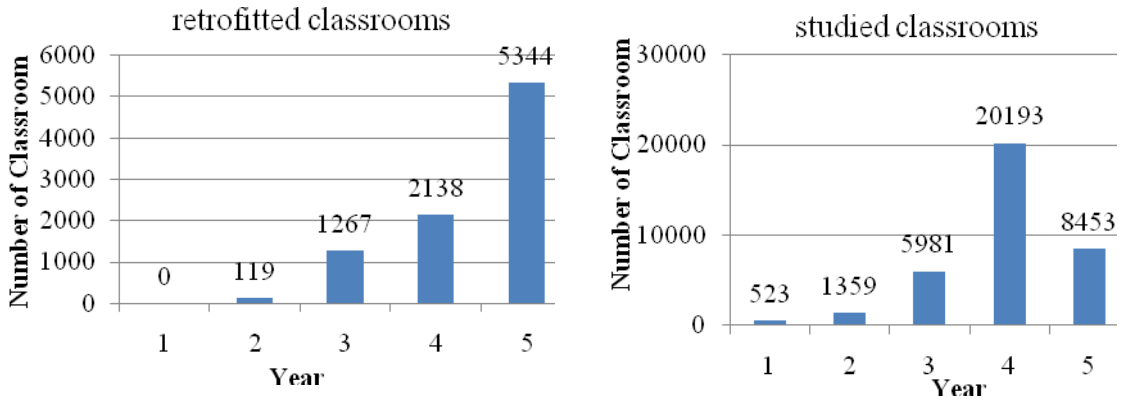

Figure8: Number of studied and retrofitted classrooms from 2006 to 2010

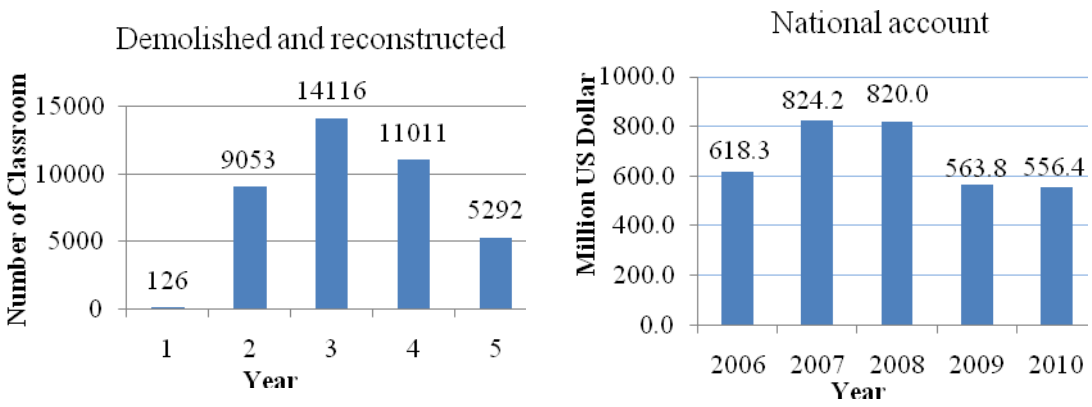

Figure9: Number of demolished and reconstructed classrooms, the distribution of expenses from national accounts for demolition, reconstruction and retrofitting of school buildings from 2006 to 2010

According to the statistics, The Islamic Republic of Iran has upgraded seismic safety of more than 9000 classrooms (equal to 1 million m^2) in the form of retrofitting and more than 40000 classrooms (equal to 6.5 million m^2) in the form demolition and reconstructing from 2005 to 2011. It is noteworthy than although the number of reconstructed classrooms is considerably higher than the retrofitted ones, the rate of retrofitting projects is increasing when compared to the decreasing rate of the reconstruction projects.

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REFERENCES

A.Mahdizadeh, "Report on retrofit procedure of school buildings in Islamic Republic of Iran. ", reports of state organization of schools renovation and mobilization, Iran

Permanent committee for revising the Iranian code for seismic design,"Iranian Code of practice for seismic resistant design of buildings, Standard No.2800-05 (3rd Edition)", BHRC-PN S 253, 2005.

J.Borzouie, A.Mahdizade; "Peripheral shotcrete for Seismic retrofitting of one-story masonry buildings"; 6th International Conference on Seismology and Earthquake Engineering (SEE6), Iran.

A.Mahdizade, J.Borzouie; "Perforating the masonry walls in rehabilitation of masonry buildings using center core method"; 6th International Conference on Seismology and Earthquake Engineering (SEE6), Iran.