OUTLINE AND OUTCOMES OF THE JICA TECHNICAL COOPERATION PROJECT ON REDUCTION OF SEISMIC RISK IN ROMANIA

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ABSTRACT :

Japan International Cooperation Agency (JICA) Technical Cooperation Project on Reduction of Seismic Risk for Buildings and Structures started in Romania on October 1st, 2002. The scope of the Project is to strengthen the capacity of earthquake related disasters prevention activities in Romania. The duration of the Project is five years and a half. The implementing agency of the Project is the National Centre for Seismic Risk Reduction (NCSRR) as a public institution of national interest subordinated to the Ministry of Development, Public Works and Housing of Romania. The activities are carried out by NCSRR in partnership with UTCB and INCERC by jointly organizing and using the testing laboratories and facilities. During the Project period, 29 young Romanian engineers were trained in Japan, 8 Japanese long-term experts and 39 Japanese short-term experts worked in Romania. Equipments for seismic instrumentation of the Romanian territory, dynamic characterization of soil and seismic testing of structures rising up approximately to 260 million yens (i.e. 2.17 million USD) are donated by JICA to Romania, through NCSRR. The total cost of the Project is roughly 7 million USD. The paper describes the main activities and outcomes of the JICA Project. Some conclusions of the JICA Final Evaluation Mission for the Project are mentioned.

KEYWORDS: Seismic, risk, reduction, JICA

1. BACKGROUND OF THE JICA TECHNICAL COOPERATION PROJECT IN ROMANIA

Seismic risk reduction is a major policy of Romania coordinated by Ministry of Development, Public Works and Housing, MDLPL. One important component of the policy for seismic risk reduction is the retrofitting of the existing vulnerable buildings. In the last decade of the previous century a large activity for the seismic evaluation of existing buildings was undertaken by specialists under the coordination of MDLPL and with the support of the local authorities. As a result of the seismic evaluation in Bucharest 125 medium and high-rise buildings ranked as seismic risk class I (most dangerous) were selected and MDLPL decided to retrofit them with high priority. However, since modern or/and effective retrofitting strategies and techniques were not available to structural engineers, the Romanian Government (MDLPL) requested to the Japanese Government (Japan International Cooperation Agency, JICA) to begin a technical cooperation on the seismic risk reduction focused on the improvement of retrofitting techniques.

In August 1998, at the initiative of Technical University of Civil Engineering, Bucharest, UTCB, the Government of Romania through MDLPL requested the Government of Japan to dispatch some experts in earthquake engineering. Afterwards, several schemes of cooperation, such as exchange of experts, etc. has been made, and on August 1, 2002, the Record of Discussions were signed between MDLPL of Romania and JICA, and the Project on the Reduction of Seismic Risk for Buildings and Structures started from October 1, 2002 with the initial planned period of 5 years until September 30, 2007. A six month extension for the JICA Project was obtained and the completion of the Project was on March 30, 2008.

The scope of the Project is to strengthen the capacity of earthquake related disasters prevention activities in Romania. According to the documents of the JICA Project the purpose is "Improving and dissemination of the technologies for reducing building collapse in case of devastating earthquakes are achieved". The target of the Project are Romanian citizens, in particular those in Bucharest.

The appointed tasks of the Project are:

- to improve the retrofitting techniques for vulnerable buildings in Romania;
- to revise / improve the Romanian seismic design, evaluation and retrofitting regulations;
- to develop the seismic evaluation and retrofitting manuals for Romanian existing buildings;
- to develop the post-earthquake evaluation techniques of the damaged buildings;
- to disseminate these developed / improved techniques to the Romanian civil engineers;
- to improve the disaster prevention education of the Romanian citizens.

According to the documents of the Project the schedule is:

- First year – October 2002 – September 2003 - investigation of Romanian evaluation and retrofitting techniques; study of Japanese evaluation and retrofitting techniques; installation of equipments
- Second year - October 2003 – September 2004 - collection of existing data on strong Romanian earthquakes, soil properties and vulnerable buildings; installation of equipments
- Third year - October 2004 – September 2005 - performing structural and soil tests and investigations
- Forth year - October 2005 – September 2006 - draft of technical manuals on building retrofitting, on seismic motion evaluation and on soil conditions
- Fifth year - October 2006 – September 2007 - preparation of manuals on seismic evaluation and retrofit of buildings; preparation of documents for improving seismic evaluation and retrofitting design in Romania
- Sixth year – October 2007 – March 2008 - knowledge transfer on quality management of retrofitting works; preparation of educational retrofitted RC frame and of quality management manual.

During the Project period, twenty nine (29) Romanian researchers/engineers were trained in Japan, nine (9) Japanese long-term experts and thirty nine (39) Japanese short-term experts were dispatched to Romania. Within the Project equipments for seismic instrumentation of the Romanian territory, dynamic characterization of soil and seismic testing of structures rising up approximately to 260 million yens (i.e. 2.2 million USD) are donated by JICA to Romania, through NCSRR. The total cost of the Project financed by JICA amounted at 7 million USD.

The implementing agency of the JICA Technical Cooperation Project on the Reduction of Seismic Risk for Buildings and Structures is the National Centre for Seismic Risk Reduction (NCSRR) as a public institution of national interest, a specialized legal entity, subordinated to the Ministry of Development, Public Works and Housing of Romania. The activities of NCSRR are carried out in partnership with Technical University of Civil Engineering Bucharest (UTCB) and National Institute for Research and Development in Construction and Construction Economics (INCERC) Bucharest. The NCSRR is organized in four divisions, namely:

- Division 1 - Building Retrofitting and Design Codes
- Division 2 - Seismic Observation Network
- Division 3 – Technical Experimentation for Soil and Structures
- Division 4 – Dissemination of Knowledge and Training of Engineers.

2. EQUIPMENTS DONATED AND ACTIVITIES ACCOMPLISHED WITHIN JICA PROJECT

2.1. Structural Testing

The structural testing equipment consists of a steel reaction frame, loading control device, data acquisition and

processing systems. The reaction frame is similar to the one in Building Research Institute, Tsukuba, Japan. The objectives of structural testing program are:

- testing of the representative vulnerable structural systems and components;
- testing of the efficient and innovative Japanese retrofitting techniques;
- development of constitutive laws for vulnerable structural components.

The following load combinations are possible with the provided equipment:
1) bending with shear force for beam testing,
2) bending with shear and axial force for column, shear wall and portal frame.
The maximum weight of tested specimens is 70kN and the maximum dimensions of the specimens are 2.5m by 3 m. The structural testing facility worthy of approximately 1 million US$ was donated by JICA to the NCSRR and installed in April/March 2004 at the UTCB/NCSRR site, Bucharest (Figure 1 and Figure 2).

This structural testing facility is used to support the seismic evaluation methods for structural systems with more reliable input data and develop cost-effective retrofitting methods. Data from the various structural experiments will be fed back to the seismic rehabilitation of vulnerable buildings at issue and as a result, would serve to mitigation of earthquake disaster. During the Project duration the following structural elements were tested: 16 RC columns, 5 RC walls, 59 masonry walls, 3 steel braces, 2 energy dissipation devices and 14 RC slabs. Figure 3 and Figure 4 show tests on various structural members.

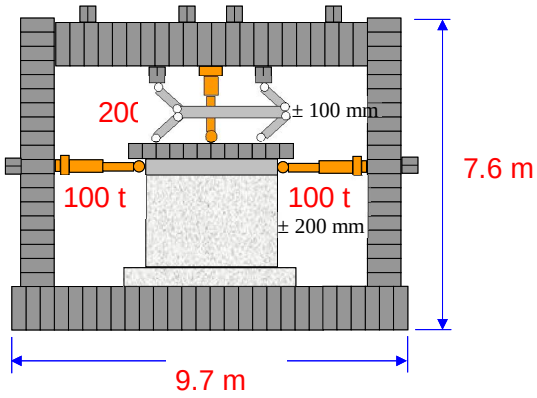

Figure 1 Overall dimensions, force and stroke capacities of loading system

Figure 2 Reaction frame and Column Specimen

Figure 3 Test on RC columns (original specimen, retrofitted specimen with steel plate and with CF sheet)

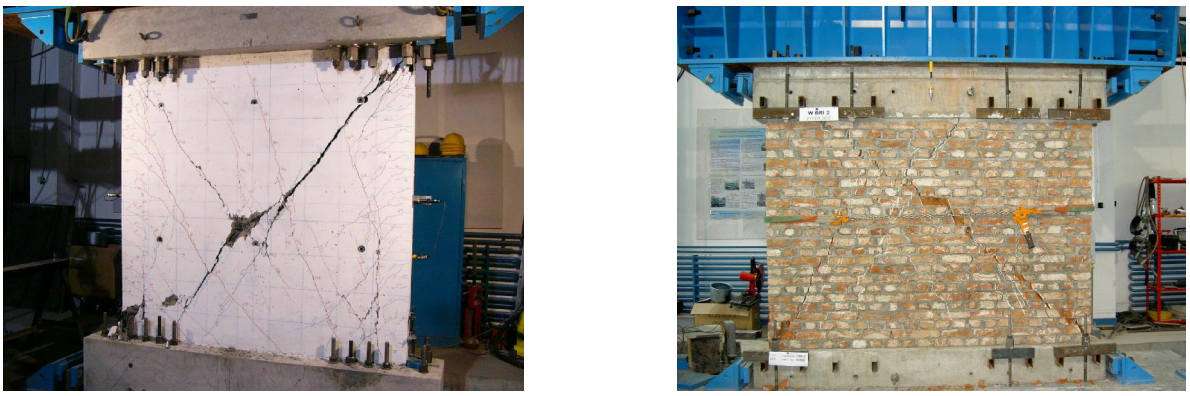

Figure 4 Test on walls (RC shear wall, masonry wall)

2.2. Strong Ground Motion Observation and Soil Investigation

The objectives of strong motion observation and soil testing and investigation equipments are:

- data collection on ground motion to examine the characteristics of earthquakes;
- soil condition investigation and seismic hazard investigation in Bucharest;
- data collection on seismic building response to examine the buildings behavior.

The equipment for strong ground motion observation, soil testing and investigation received by the *NCSRR* within *the JICA Technical Cooperation Project on Seismic Risk Reduction for Buildings and Structures* in May 2003 were installed by the staff of *NCSRR* in partnership with professionals from *UTCB* and from *INCERC* Bucharest and with the invaluable support of Japanese experts and technicians dispatched in Romania in June and July 2003.
The equipments for strong ground motion observation are installed outside Bucharest on a path that follows the most affected urban areas by earthquakes originating from Vrancea subcrustal seismic source, [Lungu & Aldea, 1999, Lungu et.al., 2001]. The E*TNA-Kinemetrics* and Geosig accelerometers are placed in free field outside Bucharest, Figure 5 and *ALTUS K2-Kinemetrics* and Geosig sensors and accelerometers in boreholes and buildings in Bucharest, Figure 6.

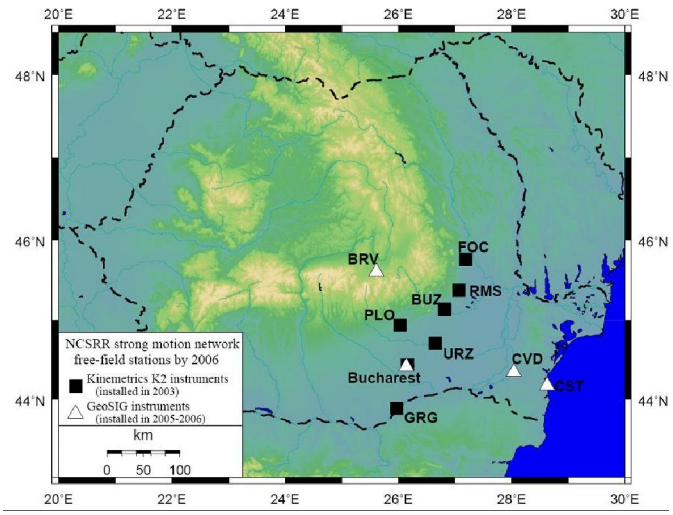

Figure 5 Seismic instrumentation outside Bucharest installed within the Project

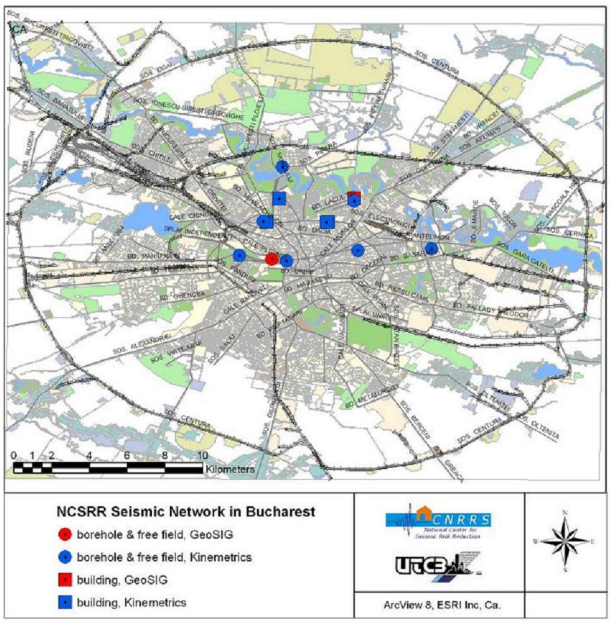

Figure 6 Seismic instrumentation installed in Bucharest within the Project

Since July 2003 within the JICA-NCSRR seismic network 137 seismic motions were recorded out of which 39 were recorded in free-field, 33 in buildings and 65 in boreholes. The seismic records obtained in JICA-CNRRS free-field network during Vrancea earthquake of October 27, 2004 are given in Figure 7.

The equipments for soil testing and investigation consist of drilling equipment, borehole sensor, data acquisition and processing systems and triaxial testing equipment (presented in Figure 8 and in Figure 9). PS logging equipment is used to measure the P-waves and S-waves velocity in boreholes before seismic instrumentation.. The PS logging equipment is also used for microtremor analysis and evaluation of dynamic characteristics of buildings.

Within the Project staff of Division 2 performed the following measurements:

- Geophysical measurements in boreholes – PS logging – 38 (in cooperation with Division 3)
- Single station measurements of ground ambient vibrations – 19 locations
- Array measurements of ground ambient vibrations – 5 locations
- Measurements of building ambient vibrations – 5 buildings.

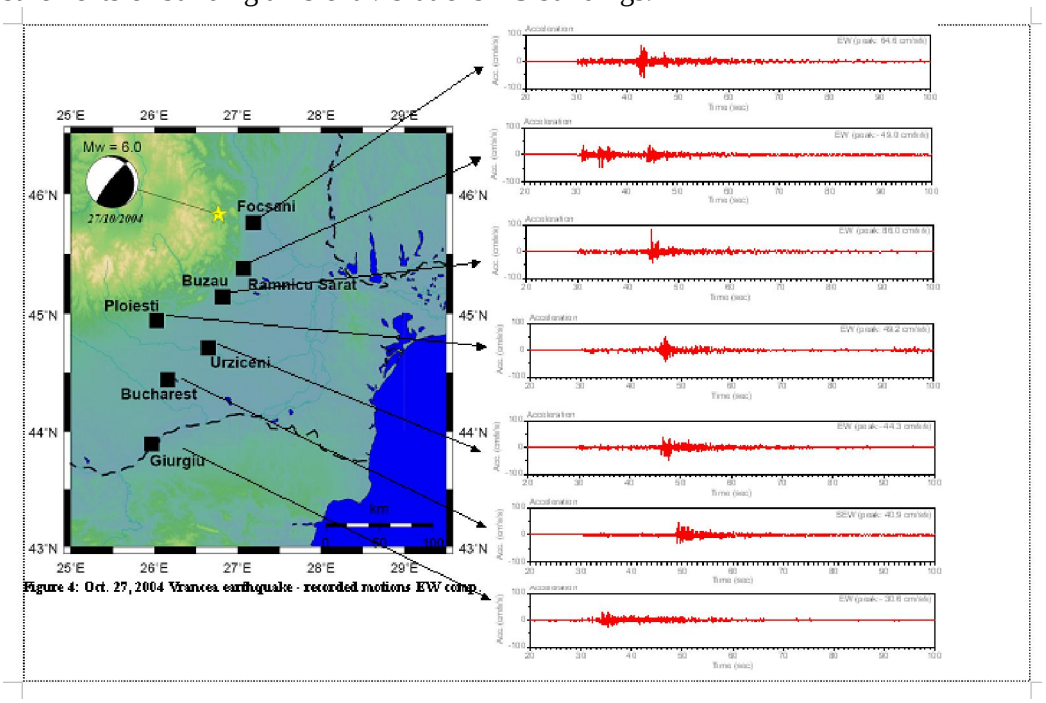

Figure 7 - Seismic records obtained in JICA-CNRRS free-field network during Vrancea earthquake of October 27, 2004

Figure 8 Drilling equipment on truck

Figure 9 Triaxial testing apparatus

Using the equipments donated within the Project staff of Division 3 performed the following activities:

- Drilled boreholes – 47
- CPT tests – 5, SPT tests – 22, Dynamic triaxial tests – 40, Static triaxial tests – 45
- Tests for geotechnical characteristics of soil – 50, Bender element tests – 15.

The results obtained from seismic observation and soil investigation are incorporated in the Manual for input ground motion.

2.3 Dissemination and Education of Citizens and Engineers

Seminars for engineers, inhabitants of vulnerable residential buildings and students are organized by *NCSRR* in cooperation with *MDLPL* and Bucharest City Office. The total number of seminars amounted at 46, out of which 4 were for citizens, 17 for students and 25 for engineers. The importance of preparedness for the next big earthquakes such as adequate behavior in the earthquake and seismic evaluation and retrofitting of the vulnerable buildings are emphasized in these seminars. Not only visual presentation but also "Bururu" equipments are used for easy understanding the characteristics of earthquakes and building responses as shown in Figure 10. Seminars for engineers are organized by *NCSRR* in cooperation with *UTCB* and *INCERC*. Lecturers in these seminars are Japanese experts and the staff of *NCSRR* as shown in Figure 11. The Project contributed in the preparation of a series of educational leaflets to instruct disaster preparedness for school children.

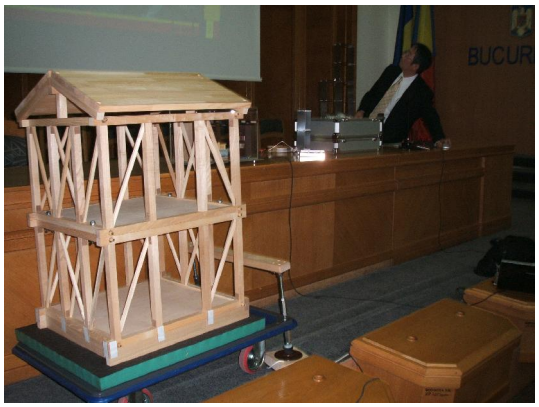

Figure 10 "Bururu" equipments for seminar

Figure 11 Seminar for students engineers

On April 26-27 2007 the most important dissemination activity was organized by *National Center for Seismic Risk Reduction (NCSRR)* within the *International Symposium on Seismic Risk Reduction* held in Bucharest at the *Romanian Academy Library*, Figure 12. The topics covered by the Symposium referred to seismic risk, from seismic hazard to seismic evaluation, rehabilitation and education. 60 scientific papers from 19 countries were selected to be presented during the Symposium and were published within the Proceedings of ISSRR2007, Figure 13.

Figure 12 ISSRR 2007 Opening Ceremony

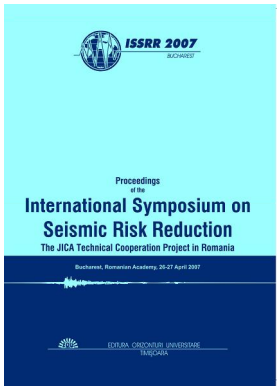

Figure 13 Proceedings of ISSRR 2007

3. MAIN OUTCOMES OF THE PROJECT

3.1. Development of technical manuals

Within the Project the following technical manuals were prepared:

- Seismic evaluation manual for existing RC buildings (based on P100-3/Vol. 1 – Code for seismic evaluation and retrofit of existing building – Volume 1: Seismic evaluation);
- Seismic retrofitting manual for existing RC buildings (based on P100-3/Vol. 1 – Code for seismic evaluation and retrofit of existing building – Volume 1: Seismic evaluation); the Manual and the Code gathered information from Japanese Guidelines and Technical Manual for Seismic Retrofitting (permission granted within JICA Project by Japan Building Disaster Prevention Association); structural testing results feed the preparation of the Manual;
- Manual for Design Input Earthquake Ground Motion;
- Quick inspection manual for damaged buildings; the manual was developed under the cooperation of NCSRR with INCERC, UTCB and IPCT and was enforced by MDLPL as Guideline in December 2006;
- Manual for quality control of retrofitting works.

3.2. Design of retrofitting of two existing vulnerable buildings

The Project selected two existing vulnerable buildings in Bucharest, classified in seismic risk class 1, and carried out the retrofitting design of them using the methods and techniques introduced in the project. One is a residential building with soft and weak ground floor built in 1960's and located at 90-96 Mihai Bravu Boulevard. The project adopted a retrofitting solution with fluid viscous dampers and steel jacketing in the ground floor and steel plate jackets in upper stories walls after detailed investigation and discussion (Figure 14). The other is also a residential building without proper seismic design built prior to 1940's and located at 20 Stirbei Voda Street. The retrofitting solution is to add new RC walls and steel jacketing of RC columns, of which most of the works will be done from the exterior. Both projects are developed in partnership with Proiect Bucuresti.

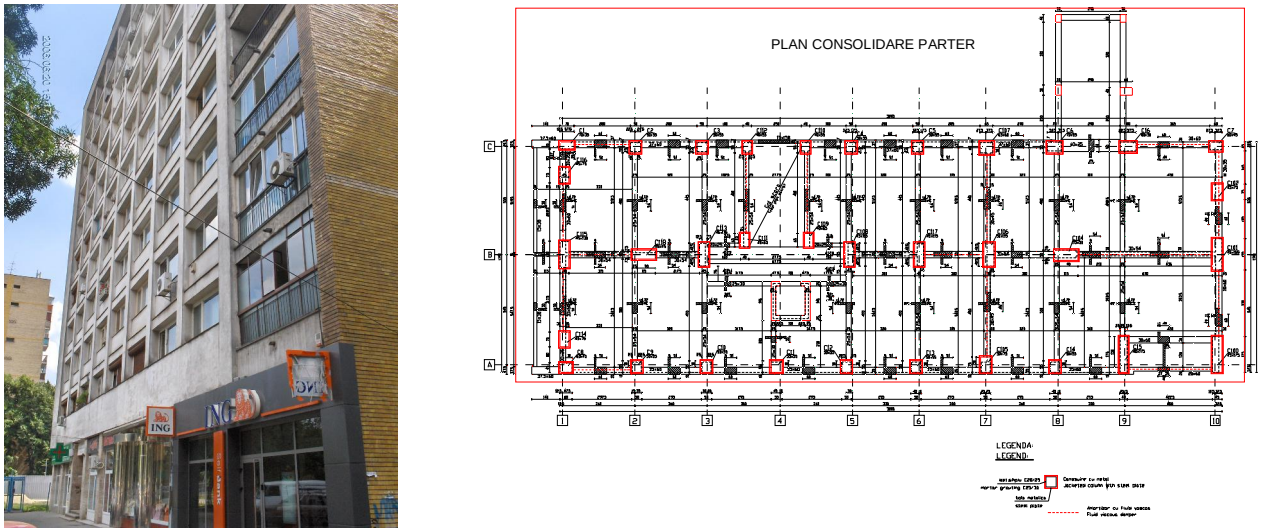

Figure 14 Soft and weak groundfloor RC building built in 1960's and retrofitting solution

4. CONCLUSIONS OF THE FINAL EVALUATION OF THE PROJECT

The Japanese Terminal Evaluation Team, organized and mandated by the Japan International Cooperation Agency, visited Romania from March 11 to March 21, 2007 in order to evaluate the JICA Technical Cooperation

Project on Reduction of Seismic Risk for Buildings and Structures in Romania. The Joint Evaluation Team, which consists of the Romanian and Japanese Terminal Evaluation Teams, evaluated the achievement of the Project. According to the evaluation report prepared by the Joint Evaluation Team, the Project has been implemented timely and properly according to the Record of Discussions towards the achievement of the Project Purpose. The Project Purpose and Overall Goal are valid and in line with the policy of MDLPL as well as with the principle of Japanese cooperation to Romania.

In the Project, the followings are the most highly rated achievements.

- The first retrofitting design using modern techniques was completed for a soft-story building in Bucharest.
- As a result of the cooperation between JICA experts in the Center and INCERC, manuals of earthquake education for school students were issued.
- Seminars and meetings with the residents in vulnerable buildings, students and engineers were held frequently, which improved their understanding on the earthquake effects and countermeasures.
- State of the art equipments were provided and are operated properly by well-trained Romanian counterparts.

Through the achievement of each Output, the Project Purpose was achieved by the end of the Project owing to sufficient ownership of the Center to the Project. Transfer of technology has also been made appropriately through the daily activities and counterpart training based on the strong partnership of Japanese experts and Romanian counterparts.

The closing ceremony of the JICA Technical Cooperation Project on Seismic Risk Reduction In Romania took place on March 4, 2008 at Bucharest.

4. ACKNOWLEDGEMENTS

NCSRR deeply acknowledge the generous, continuous and long-lasting financial support of JICA during the implementation of the Project. The technical support of Building Research Institute (BRI), Tsukuba and National Institute for Land and Infrastructure Management (NILIM), Tsukuba, Japan provided to NCSRR staff is gratefully acknowledged. The partnership between NCSRR, UTCB and INCERC for the implementation of the JICA Project is valuated. The financial support of MDLPL Romania by providing the yearly running expenses of NCSRR is most welcomed.

REFERENCES

Lungu, D., Arion, C., Aldea, A., Cornea, T., 2001, City of Bucharest seismic profile: from hazard estimation to risk mitigation, *JICA Internaţional Seminar "Earthquake Hazard and Countermeasures for Existing Fragile Buildings"*, November, 23-24, 2000, UTCB, D. Lungu and T. Saito, Editors, Bucharest, Romania

Lungu D., Arion C., 2001. Notes for JICA Study Team – July, August 2001 related to existing seismic networks in Romania (excerpt from response to JICA Questionnaire) and to future JRC-RSRBS national network, 3p.

Lungu, D. & Aldea, A., 1999. *Understanding Urban Risk Around the World. United Nations RADIUS Project at Geohazards Int., Ca., USA.* Document City of Bucharest Seismic Profile, 29p.+25p.+8p.
http://www.sharaku.nuac.nagoya-u.ac.jp/laboFT/bururu/index.htm, http://www.oyosi.co.jp/kbururu.pdf

Nagata, K., Vacareanu, R., 2007 – Joint Terminal Evaluation Report on the Project on Reduction of Seismic Risk for Buildings and Structures, 20p.

Vacareanu, R., Kato, H., 2007 – "Goals and Activities of the JICA Technical Cooperation Project on Reduction of Seismic Risk in Romania" - *Proceedings of the International Symposium on Seismic Risk Reduction, ISSRR2007*, Bucharest