GOALS AND ACTIVITIES OF THE JICA TECHNICAL COOPERATION PROJECT ON REDUCTION OF SEISMIC RISK IN ROMANIA

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SUMMARY

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 disaster related activities in Romania. The Project approval is the result of four years of intensive efforts made by professionals from *Technical University of Civil Engineering Bucharest (UTCB), Ministry of Transport, Constructions and Tourism (MTCT),* Romania, *National Building Research Institute (INCERC)* Bucharest, *JICA, Building Research Institute (BRI),* Tsukuba, and *National Institute for Land, Infrastructure and Management (NILIM)*, Tsukuba, Japan. The duration of the Project is five years. The implementing agency is the *National Center for Seismic Risk Reduction (NCSRR)* as a public institution of national interest under *MTCT*. The activities are carried out by *NCSRR* in partnership with *UTCB* and *INCERC*. During the Project period, 29 young Romanian engineers were trained in Japan, 7 Japanese long-term experts and 37 Japanese short-term experts worked in Romania. Equipments for seismic instrumentation, dynamic characterization of soil and structural testing rising up approximately to 260 million yens (i.e. 2.17 million USD) were 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 results of the Project until the *JICA* Final Evaluation Mission (March 2007).

BACKGROUND OF THE *JICA* PROJECT IN ROMANIA

Seismic risk reduction is a major policy of Romania coordinated by *Ministry of Transport, Construction and Tourism*. 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 *MTCT* and with the support of the local authorities. As a result of the seismic evaluation, 122 medium and high-rise buildings ranked as seismic risk class *I* were identified in Bucharest and *MTCT* 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 (*MTCT*) requested to the Japanese Government (through *Japan International Cooperation Agency, JICA*) to begin a technical cooperation on the seismic risk reduction focused on the improvement of retrofitting techniques.

The idea of the Project was born in August 1998 in Japan, after discussions between Prof.D.Lungu (*Technical University of Civil Engineering Bucharest, UTCB)* and *JICA* representatives. At the initiative of *UTCB*, the Government of Romania through *MTCT* requested the Government of Japan to dispatch some experts in earthquake engineering. The idea developed and transformed into the request of a Technical Cooperation Project that includes expert dispatch, trainings and donation of equipments. Afterwards, one dispatched long-term Japanese expert and several *JICA* investigation teams designed the project outlines in cooperation with representatives from UTCB, MTCT, *National Building Research Institute (INCERC)* Bucharest. On August 1st, 2002, the Record of Discussions was signed between *MTCT* and *JICA*. The Project "Reduction of Seismic Risk for Buildings and Structures" started from October 1, 2002 with the planned period of 5 years until September 30, 2007.

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NATIONAL CENTER FOR SEISMIC RISK REDUCTION

The implementing agency of the *Japan International Cooperation Agency (JICA)* Technical Cooperation Project "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, under the *Ministry of Transports, Constructions and Tourism (MTCT)* of Romania. The main activities of *NCSRR* are as follows:

- implementation of new technologies for retrofitting the earthquake vulnerable buildings;
- contribution to the revision of codes and regulations for earthquake resistant design, seismic evaluation and retrofitting;
- seismic instrumentation of Bucharest and of densely built areas;
- transfer of state-of-the-art knowledge in the domain of earthquake protection to specialists and issuing documentation regarding education of the population for preventing the seismic consequences;
- development of technical knowledge by trainings, studies and documentation, seminars, courses and lectures in Romania and abroad;
- promotion of the international cooperation in the domain of seismic risk management;
- publishing studies in the specific field of activity;
- other activities for the implementation of national and international projects.

The activities are carried out by *NCSRR* in partnership with *Technical University of Civil Engineering Bucharest (UTCB)* and *National Building Research Institute (INCERC)* Bucharest, and in cooperation with *Building Research Institute (BRI),* Tsukuba, and *National Institute for Land, Infrastructure and Management (NILIM)*, Tsukuba, Japan. Figure 1 shows the relationship of *NCSRR* with partner institutes and related organizations within the Project.
The activities of the *NCSRR* are carried out 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.

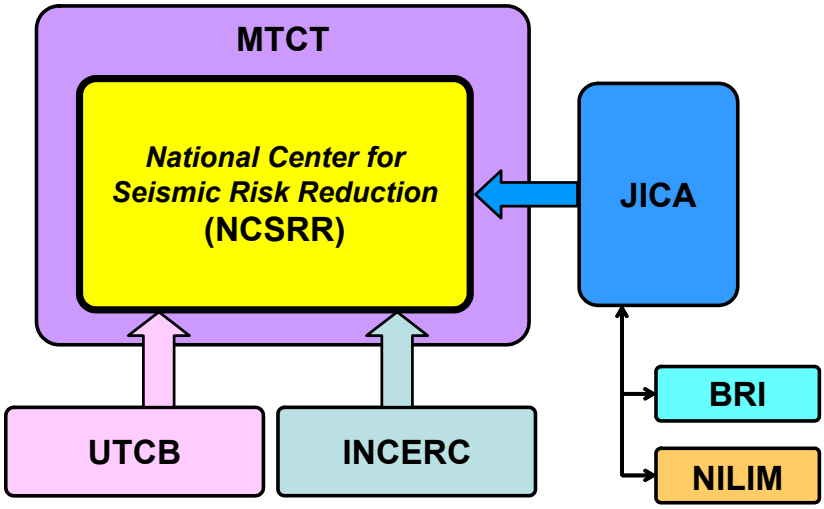

Figure 1: Relationship between NCSRR and other organizations in the Project

JICA TECHNICAL COOPERATION PROJECT

The Project started in 2002 with *NCSRR* as the implementing agency. The scope of the Project is to strengthen the capacity of earthquake disaster related activities in Romania.

According to the Project documents the planned schedule was:

- First year – Oct. 2002 – Sept. 2003 - investigation of Romanian evaluation and retrofitting techniques; study of Japanese evaluation and retrofitting techniques; installation of equipments

- Second year - Oct. 2003 – Sept. 2004 - collection of existing data on strong Romanian earthquakes, soil properties and vulnerable buildings; installation of equipments
- Third year - Oct. 2004 – Sept. 2005 - performing structural and soil tests
- Forth year - Oct. 2005 – Sept. 2006 - draft of technical manuals on building retrofitting, on seismic input motion and on soil conditions
- Fifth year - Oct. 2006 – Sept. 2007 - preparation of manuals on seismic evaluation and retrofit of buildings; preparation of documents for improving seismic evaluation and retrofitting design in Romania.

During the Project period, twenty nine (29) Romanian researchers/engineers were trained in Japan, seven (7) Japanese long-term experts and thirty seven (37) Japanese short-term experts were dispatched to Romania. Within the Project equipments for seismic instrumentation, 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.

Goals and Activities of the Project

According to the documents of the JICA Project, it's 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 the 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.

The Romanian-Japanese cooperation in the field of seismic risk reduction comprises the following activities:

- implementation of new technologies for retrofitting the earthquake vulnerable buildings;
- issuing of manuals for earthquake resistant design, seismic evaluation and retrofitting;
- preparing retrofitting design projects on typical vulnerable buildings in Bucharest using the manuals developed by the Project
- seismic instrumentation of Bucharest and of densely built areas;
- field survey for the soil structure of Bucharest;
- ensuring the development of technical knowledge by stages of training, seminars, courses and lectures in Japan, Romania and other countries;
- promoting the international cooperation in the domain of seismic risk management;
- earthquake disaster prevention education and preparedness of the population and students.

Equipments Donated by JICA within the Project

NCSRR Equipment for 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 2, Figure 3 and Figure 4).

Figure 2: Structural testing hall at UTCB were NCSRR reaction frame is installed

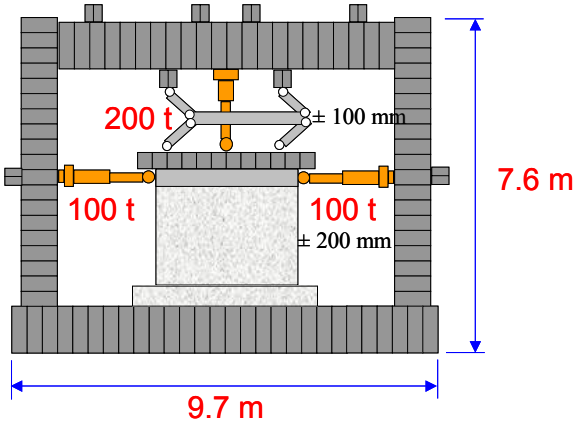

Figure 3: Overall dimensions, force and stroke capacities of loading system

Figure 4: Reaction frame

This structural testing facility is used to support the seismic evaluation methods for structural systems with more reliable input data and to 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. The number of tested specimens during the Project duration so far is listed in Table 1. Figure 5 shows details on some tested columns and Figure 6 some results of the series of tested columns. Figure 7 and 8 show some of loading tests on various structural members.

Table 1: Structural tests performed with the reaction frame

Structural element	**Number of tested specimens since 2004**
RC columns	16
RC walls	5
Masonry walls	27
Steel braces	3
Energy dissipation device	1
RC slabs	14
Total number of tests	66

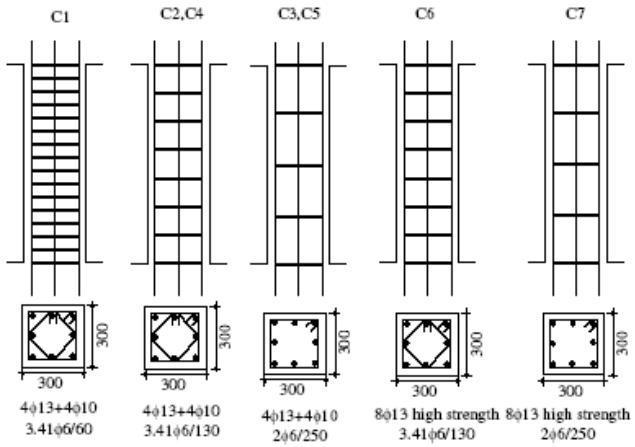

Figure 5: Details on some tested columns

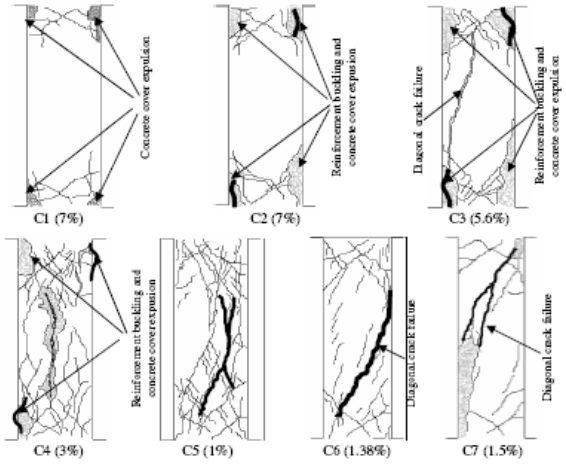

Figure 6: Some results on the series of tested columns

Figure 7. Test on RC columns (original specimen, retrofitted specimen with steel plate and with CF sheet)

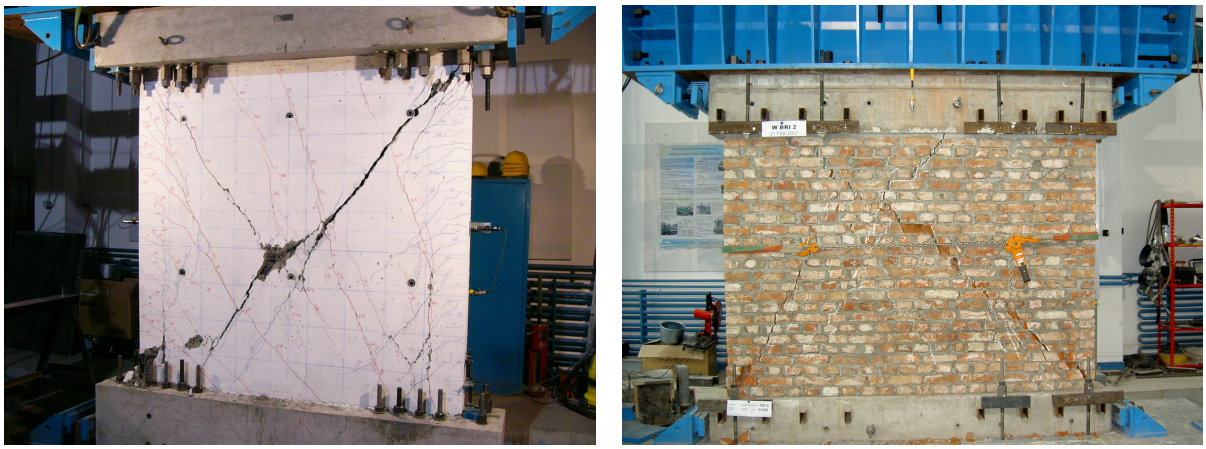

Figure 8: Test on walls (RC shear wall, masonry wall)

NCSRR equipment for strong ground motion observation and soil investigation

The objectives of strong motion observation and soil testing are:

- ground motion and ground condition collection for seismic input modeling;
- site investigation, laboratory soil testing, ground motion modeling for seismic microzonation;
- data collection on seismic building response to examine the buildings behavior;
- revision of strong ground motion design parameters.

The equipment for strong ground motion observation, soil testing and investigation received by *NCSRR* from *JICA* in May 2003 were installed by the staff of *NCSRR* with the cooperation of Japanese experts and technicians dispatched in Romania in June and July 2003.

NCSRR received from *JICA* seismic instrumentation equipments (*Kinemetrics*). *OYO Seismic Instrumentation Corp*. and *NCSRR* installed the equipments in 2003. In 2005-2006 the *NCSRR* network was enlarged with Romanian investment (within the budget ensured by *MTCT*), other sites being instrumented with *Geosig* equipments and technical support. *NCSRR* network [Aldea *et al.*, 2007 present volume] contains 3 types of instrumentation: free-field stations (outside Bucharest), instrumented buildings and stations with ground surface and boreholes sensors (in Bucharest).

Six (6) *Kinemetrics ETNA* stations were installed in 2003 on the SW direction starting from Vrancea epicentral area toward Bucharest, for ground motion attenuation analysis. All of them are in buildings with 1 or 2 storeys, which can be considered as a free field condition. Two *Geosig IA-1* accelerometers were installed in 2006 and 2007, on a perpendicular axis to the SW.

Two residential buildings with typified RC structures and two office buildings (National Public Television tower building and BRD-SG Bank headquarter) were instrumented in 2003. In 2006 the *Technical University of Civil Engineering Bucharest UTCB* main building was also instrumented.

NCSRR installed in 2003 in Bucharest seven (7) *Kinemetrics K2* stations with sensors at ground surface (close to free-field conditions) and in boreholes at two levels of depth: the first level at about 30m depth and the second level between 50m and 153m depth. In 2005 another site was instrumented with *Geosig* equipments (free-field and a 30m depth borehole). At all the stations the soil profile of the boreholes is known, and *NCSRR* and *Tokyo Soil Corp.* (Japan) performed down-hole tests. The principle of borehole instrumentation is presented in Figure 9.

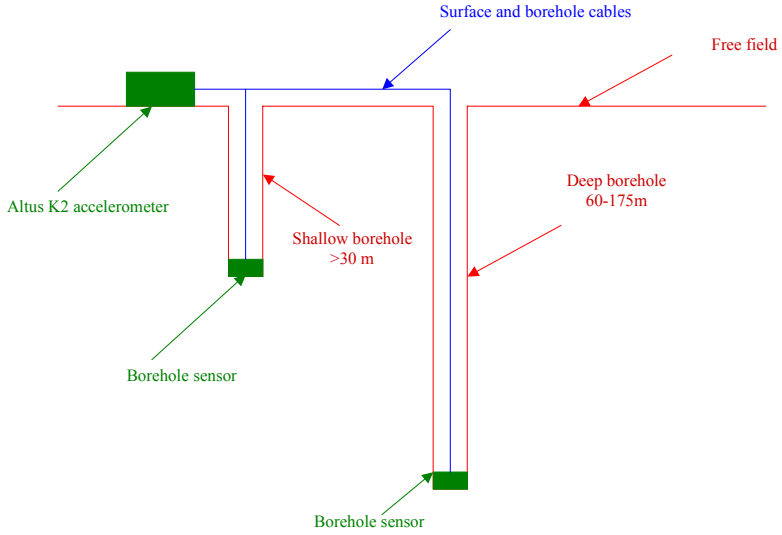

Figure 9: Principle of borehole instrumentation

Pictures of seismic station *UTCB* Tei and from the borehole and building instrumentation are shown in the following figures.

Figure 10: UTCB Tei seismic station

Fig 11: Seismic instrumentation of borehole

Figure 12: Seismic instrumentation of buildings

Since its installation in 2003, the *NCSRR* network recorded more than 170 seismic motions from 26 earthquakes with moment magnitudes ranging from M_W=*3.2* to *6.0* [Aldea *et al.*, 2007 present volume].

Between the earthquakes recorded by *NCSRR* network, 21 are from Vrancea subcrustal source, 2 from Vrancea crustal source, 2 from shallow sources in Bulgaria and 1 from North-Dobrogea shallow source. The seismic motions obtained in *NCSRR* free-field network during the Vrancea earthquake of October 27, 2004 (*Mw=6*) are given in Figure 13. This earthquake is the largest event recorded by *NCSRR* seismic network.

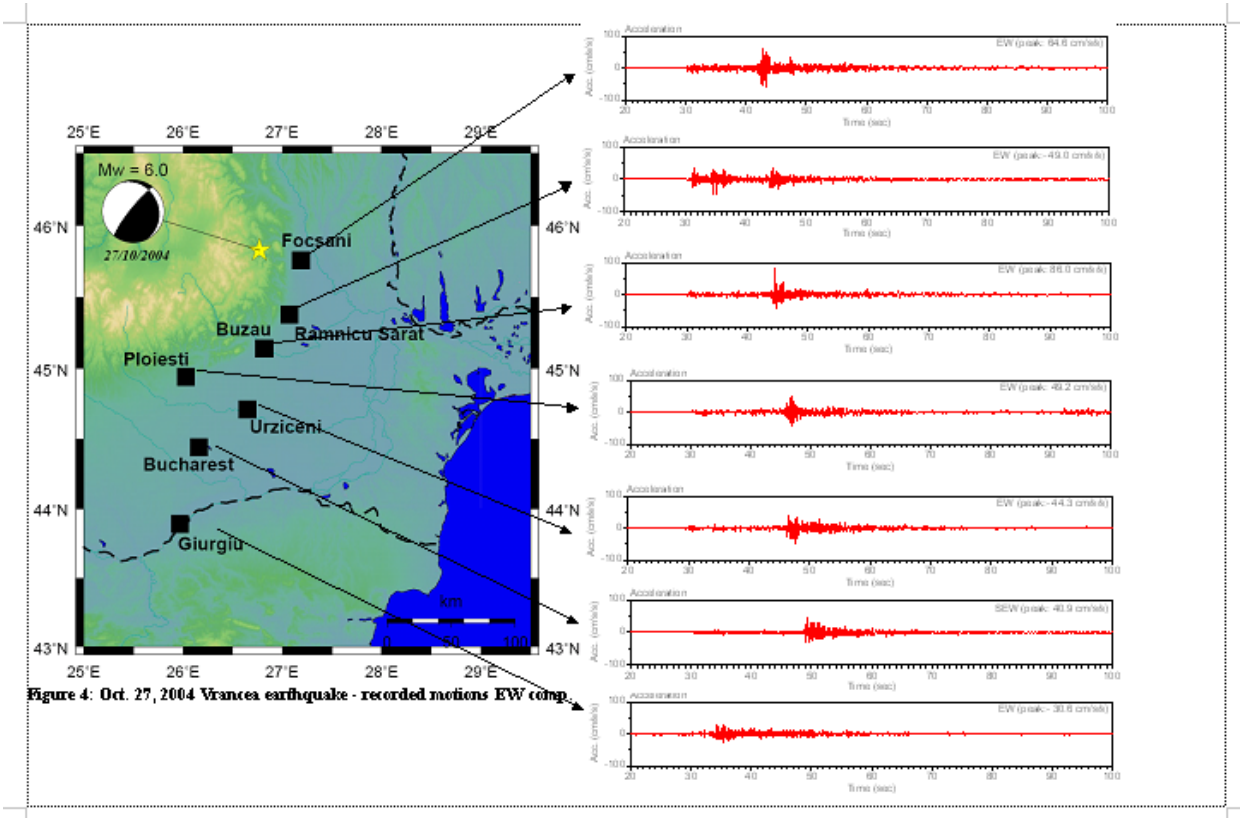

Figure 13: Seismic records obtained in NCSRR free-field network during Vrancea earthquake of October 27, 2004

JICA also donated the PS logging equipment - Figure 14 - used to measure the P-waves and S-waves velocity in boreholes. The mobile acquisition stations are also used for microtremor observation and analysis for both ground and buildings with microtremor sensors (as the one shown in Figure 15). Details on this are presented in [Arion *et al.*, 2007 and Aldea *et al.*, 2007 present volume].

Figure 14: Borehole sensor for PS logging

Figure 15: Tri-axial microtremor sensor

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

- Single station measurements of ground ambient vibrations – 19 locations
- Array measurements of ground ambient vibrations – 5 locations
- Measurements of building ambient vibrations – 5 buildings.

Division 3 in cooperation with Division 2 performed geophysical measurements in boreholes – PS logging – at 14 locations in Bucharest, and 2 locations in Timisoara.

The equipments for soil testing and investigation consist of drilling machine, SPT and CPT equipments and triaxial testing equipment (presented in Figure 16 and in Figure 17). Details in [Arion *et al.*, 2007].

The equipments for laboratory soil investigation are installed at *NCSRR* headquarters, Figure 18.

Figure 16: Drilling equipment on truck

Figure 17: Triaxial testing apparatus

Figure 18: NCSRR headquarters

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

- Drilling boreholes – 17;
- CPT tests – 5;
- SPT tests – 7;
- Surface wave tests – 6;
- Dynamic triaxial tests – 23;
- Static triaxial tests – 45;
- Tests for geotechnical characteristics of soil – 50;
- Bender element tests – 15.

The results of seismic monitoring and soil investigation are incorporated in the Manual for input ground motion.

NCSRR Activities for Dissemination and Education of Citizens and Engineers

Seminars for engineers, inhabitants of vulnerable residential buildings and students are organized by *NCSRR* in cooperation with *MTCT* and Bucharest City Office. The total number of seminars amounted at 32, out of which 4 were for citizens, 7 for students and 21 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[4]" equipments are used for easy understanding the characteristics of earthquakes and building responses as shown in Figures 19. 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 20. The Project contributed in the preparation of a series of educational leaflets to instruct disaster preparedness for school children as shown in Figure 20.

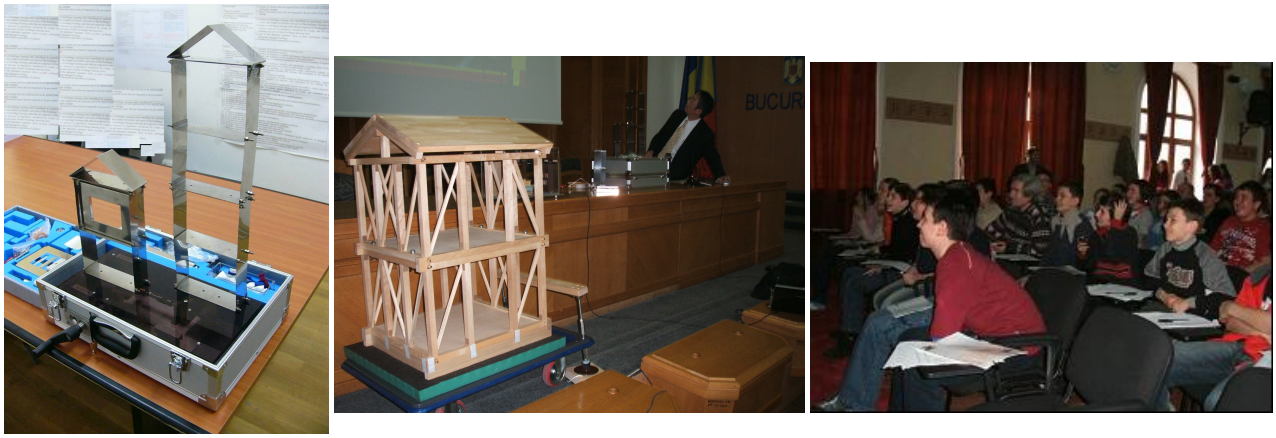

Figure 19: "Bururu" equipments for seminar

Figure 20: Seminar for engineers at UTCB and Iasi Technical University

Figure 21: Manuals on disaster preparedness for school children

OUTCOMES OF THE PROJECT

Development of technical manuals

Within the Project it is planed to issue the following technical manuals:

- 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); the first draft was proposed in December 2005 and the final draft will be completed by the end of the Project.
- Seismic retrofitting manual for existing RC buildings (based on P100-3/Vol. 2 – Code for seismic evaluation and retrofit of existing building – Volume 2: Seismic retrofitting); the first draft was proposed in March 2006 and the final draft will be completed by the end of the Project. 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; the first draft was issued in December 2005, the second draft was proposed in March 2007 and the final draft will be completed by the end of the Project.
- Quick inspection manual for damaged buildings; the manual was developed under the cooperation of *NCSRR* with *INCERC*, *UTCB* and *IPCT* and was enforced by MTCT as Guideline in December 2006.

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 22). 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 (Figure 23). Both projects are developed in partnership with Proiect Bucuresti.

CONCLUSIONS OF THE FINAL EVALUATION FOR 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 present achievement

Figure 22: Soft and weak groundfloor RC building built in 1960's and retrofitting solution

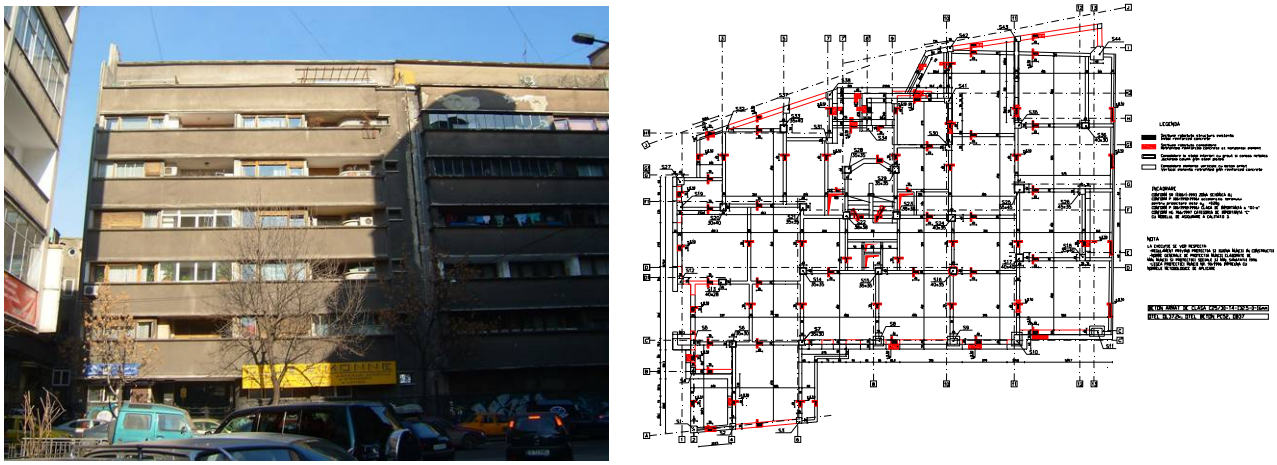

Figure 23: RC building built prior to 1940's and retrofitting solution

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 *MTCT* 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 at *NCSRR* 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 is highly likely to be 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 on the strong partnership of Japanese experts and Romanian counterparts.

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 *MTCT* Romania by providing the yearly running expenses of *NCSRR* is most welcomed.

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