PROJECT FINAL REPORT

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FOR DYNAMIC TESTING OF LARGE SCALE MODELS

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AN EXECUTIVE SUMMARY

Participation in the FP7 programme means a lot not just to IZIIS but also to the Macedonian scientific community since IZIIS is one of the first Institutions to have the role of a Coordinator of a FP7 project. The main goal of the project was to increase the research and human resource capacities of IZIIS in order that it could become an integral part of the European Research Area.

Two experimental facilities of IZIIS have been selected to be involved in this project, namely the Dynamic Testing Laboratory and the Laboratory for Dynamics of Soil and Foundations. These two laboratories are the core of the experimental investigations of the Institute. With the activities encompassed by Working Package 2, the shaking table, as one of the most important experimental facilities, had to be upgraded, namely its analogue control system had to be replaced by a new, digital one. The process of upgrading of such a complex system as is the shaking table required a lot of effort, know-how and time. By maximum engagement of the entire human resource potential of both the laboratory and the other IZIIS' departments, the shaking table was upgraded with a digital control system that enables not only a more stable operation but also improvement of some of the basic characteristics of the shaking table itself.

The Laboratory for Dynamics of Soil and Foundations as one of the main experimental units of IZIIS was also the subject of upgrading with this project. The activities planned in Working Package 3 were anticipated to be carried out in two directions: improvement of the capacity from the aspect of element tests and the aspect of seismic shaking table testing of large geo-models. In the first part, a triaxial system for static and dynamic testing of soil specimens was installed. This system, in combination with the knowledge that has so far been accumulated, represents a very important segment in the research and scientific community not only in Macedonia but also beyond. Within the frames of the second task, a laminar container was designed and constructed in the laboratory. This container represents an excellent device for realization of shaking table experiments on geo-models. Such type of containers and such type of tests are still in their early phase of development in Europe and, from this aspect, this container will qualitatively contribute to the improvement of the capacity of ERA for such type of investigations.

An important segment of this project was dedicated to strengthening the cooperation with the European research centres with which IZIIS has so far had an excellent cooperation. ELSA, Bristol and LNEC were the three network partners which, inter alia, had to enable transfer of knowledge and experience for the purpose of faster accession of IZIIS to ERA. This cooperation was realized through short mutual visits and longer stays of young researchers from IZIIS at the network laboratories as well as participation in organized workshops and lectures within the frames of the project. The realization of these activities enabled signing of MoU with one of the network partners as well as concrete plans for joint applications for some European projects. Particularly noteworthy is the experience acquired by the young researchers from their stay and familiarization with the new technological trends in the European research centres.

UREDITEME FP7 project represents an important event in the long tradition of IZIIS and a big step forward to accession of our institute to ERA. The upgraded experimental and human resource potentials mean a strong impact on the quality of research in the area of seismic risk reduction and protection of structures against natural and technological hazards, enabling saving of human lives and reduction of economic losses as well as positive economic and social effects in the long run.

PROJECT CONTEXT AND OBJECTIVES

Based on Annex I to the Grant Agreement - "Description of Work" the following project objectives were considered to be realized:

A. Improving of the RTD capacities in the area of seismic risk reduction and protection of engineering structures.

   A.1. Upgrading of the Laboratory for Dynamics of soils and foundations. The objective is complete revival of the laboratory's activities through upgrading and renewal of its equipment. Integral triaxial system for testing soil specimens under static and dynamic loading and laminar box for testing large geo-models on the shaking table will upgrade the capacities of this laboratory. These experimental tools will put the Laboratory for dynamics of Soils and foundation on the top research laboratories dealing with earthquake geotechnical hazards in Europe.

   A.2. Upgrading of existing analog control system of the bi-axial shaking table at the Dynamic Testing laboratory. The shaking table is in good operational conditions due to very well maintenance. The replacement by digital control system will improved the performance and will enable more stable operation of the shaking table in the next 10-15 years. The shaking table with its dimensions and improved control system is one of the main experimental facilities to satisfy wide range of needs for experimental research in the field of earthquake engineering.

Since its establishment in 1965, the Institute of Earthquake Engineering and Engineering Seismology, IZIIS (www.iziis.edu.mk), has invested a major human and financial effort in the development of its dynamic testing laboratories as well as for the education of young scientists in well-known centres in Japan, USA and several European universities. In the last two decades due to unfavorable economic situation in the country and region IZIIS couldn't catch the fast technological train. Experimental facilities even very well maintained were not in position to be competitive with the experimental facilities from similar research centres in Europe and worldwide.

Therefore upgrading and updating of IZIIS's RTD capacities is one of the major objectives which have to be realized in order to see IZIIS on the same technological level as it was 20 years ago when IZIIS was leading earthquake research centre in Europe.

B. Strengthening of cooperation of IZIIS activities with network partners

   B.1. Bilateral visits with the Research Centres from Member States and Associated States;

   B.2. Exchange of experience regarding the latest scientific and technological achievements ;

   B.3. Obtaining of information about the mode of organization and managing of the process of investigations;

   B.4. Improving of RTD' human capacity by training of young scientists and researchers ;

   B.5. Planning of joint research projects ;

In order to strengthen the cooperation in the main area of IZIIS' activities, a network of research centres from EU Member States will be created. The following centres participate in the networking activities in the project: European Laboratory for Structural Assessment – ELSA, Ispra, Italy ; Earthquake Engineering

Research Centre- EERC, Department of Civil Engineering, University of Bristol, UK ; The Laboratorio Nacional de Engenharia Civil (LNEC), Lisbon, Portugal. Their role was to transfer the knowledge, experience and information in the field of earthquake risk reduction. But maybe more important role was to transfer their experience in organization and management of research projects and activities. The extended cooperation will create conditions for joint application for future research projects, training of staff in full compliance with the European norms and opening of our capacities for the EU partners who are interested in performing joint investigations.

C. Improving of the IZIIS's human research potential

   C.1. Hiring two young researchers

   C.2. Training of researchers at EU network centres

   C.3. Training of laboratory stuff on upgraded testing equipment

The renewal of the equipment available itself will not mean much without paying attention to improving the research stuff. Engagement of young researchers and their training will upgrade the IZIIS research stuff and bring new fresh ideas. Part of the training will be realized through networking at the network partner facilities but also training will be realized on the upgraded research equipment and IZIIS facilities. Creation of excellent working environment and possibilities for continues education will make IZIIS laboratories very attractive place for new ambitious candidates to come and join us. This can decreased further loss of generation due to "brain drain" problem.

D. Dissemination of the project achievements

   D.1. Organizing workshop, seminars, laboratories 'open days', training, technical meetings – main target group will be young students, researchers, professional practitioners.

   D.2. Building the public awareness regarding the seismic hazard and associate phenomena

   D.3. Present the scientific and technical results to decision makers from state agencies in an accessible format which summarizes and interprets the most relevant facts.

   D.4. Web page of the project

We consider that the realization of the project objectives will upgrade and improve the leading role of IZIIS in scientific society not just in Macedonia but also in the region and wider in Europe. Also it will enable harmonization with the European research institutions leading to future successful participation in European research programmes.

MAIN SCIENCE AND TECHNOLOGY RESULTS

Most significant achievements regarding science and technological results can be seen in:

- **Renewal of experimental facilities of two IZIIS's labs**
- **Upgrading of the human potential**

Renewal of experimental facilities of two IZIIS's labs

Dynamic Testing laboratory - DYNLAB

Renewal of existing analog control system into digital control system improved the performance of the bi-axial shaking table, significantly. There are not so many shaking tables in Europe and even worldwide with such technical characteristics. In fact as one of the main experimental facilities, upgraded and renew shaking table will be big step toward better integration of our Institute into European Research Area.

The existing bi-axial programmed seismic shaking table is the core part of the IZIIS' Laboratory. It has been in use for the past 25 years and served well the RTD activities of IZIIS. The existing analog control system, which is a crucial part for running the bi-axial shaking table, is an out of date technology and maintenance is a very difficult task, since there are no spare parts. Possible failure of this system means shutting down the shaking table, which will be heavy impact on IZIIS RTD capacity. By renewal/upgrading of old analog control system by digital control system it is expecting that the shaking table will have improved performance and will be operational in the next 10-15 years. The other parts of the shaking table are in very good operational conditions, very well maintained and will serve for more than 20.

Installation of the MTS 469D digital control system

Installation of the new MTS 469D digital controller was performed in the period from 14.03.2011 to 01.04.2011. To perform this operation Dale N. Maue, senior system engineer and James W. Rosenow, senior software engineer were sent by the equipment manufacturer MTS.

The old controller was successfully disassembled and physically replaced with the new one (MTS 469D).

Figure 1. New controller-available connections

Figure 2 Control room

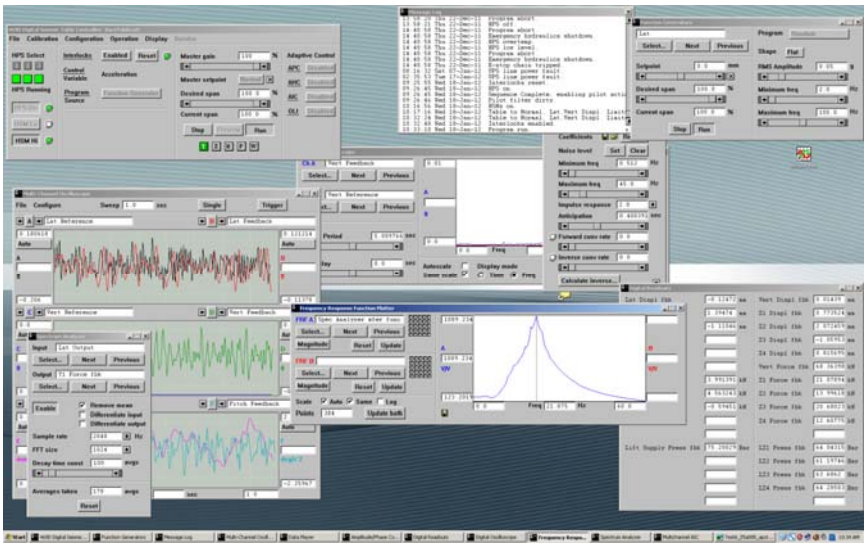

Figure 3 Control panel of the embedded controller

This is a list of separate activities that were taken:

- After the physical replacement of the controller, additional checks of the cable connections with HPM, HSM and station for static lift control were made.
- Also new connections for the pressure gauges for nitrogen were established.
- Additional links for the new accelerometers placed in the centre of the platform were also provided.
- During the process of equipment installation all of the system accelerometers were replaced with new ones (Endevco 7290E – R-D-10).
- Verification and adjustment of nitrogen pre-charge of all system accumulators.
- Change of the hydraulic filters
- Calibration of the current system LVDT sensors
- Test exploitation of the system
- Repair of the constant displacement pressure balanced bearing was made at the end of the replacement process, so the oil leakage was dramatically reduced.
- Additional filling of hydraulic oil to the system was made.

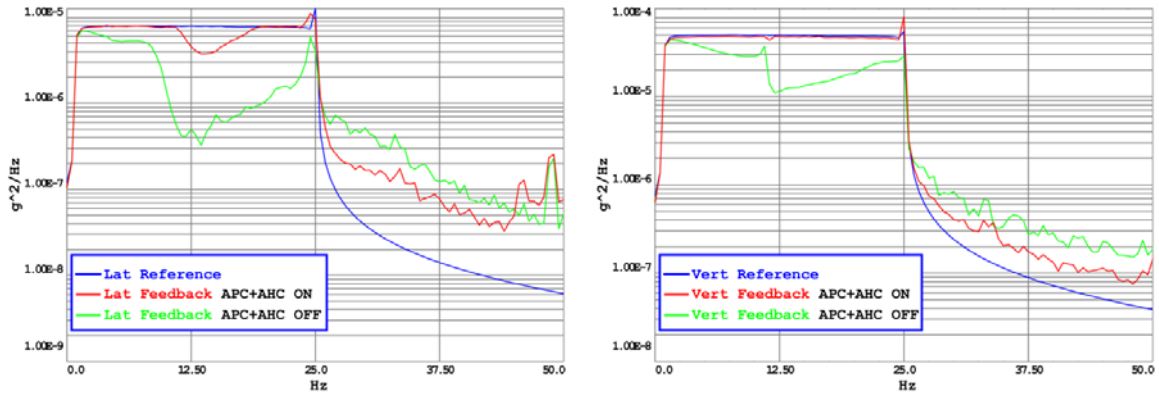

Figure 4. Auto Spectral Density, sine sweep PGA=0.05g ; Lateral and vertical direction (results from acceptance tests)

In parallel with the installation process a training program with the potential system operators was completed. Two young researchers have been hired to work on the projects' task.

The MTS 469D Digital Seismic Table Controller, besides high level fixed control techniques: Three-Variable Control (TVC), Degree of Freedom Control, Force Balance Compensation, Differential Pressure Stabilization, it provides additionally four advanced adaptive and iterative control techniques to improve the system performance and to compensate for linear and/or nonlinear sources of signal distortion.

It is worth to point out that the upgrading of the existing Seismic Shaking Table System in the Dynamic Testing Laboratory at IZIIS, Skopje, R. Macedonia with MTS 469D digital control system represents a significant and qualitative step forward in increasing the infrastructure's capacity for experimental earthquake engineering.

Laboratory for Dynamics of soils and foundations

In geotechnical engineering, the laboratory experiments represent an important segment in the sense of acquiring knowledge about soil behavior and simulation of behavior of soil materials. As an engineering material, soil has its own and very specific characteristics. It represents a discrete material with or without existence of connecting forces between its individual elements. The presence of water, air in the structure of the soil mass creates additional complexity to the problem that already existed. The behavior of soil under different types of loads has still not been sufficiently explained. In that way, the complex behavior on one hand and the fact that there is no constitutive relation to explain the soil behavior in a general sense on the other, clearly points to the necessity and the importance of laboratory experiments.

For the last years, instrumentation and development of new measuring devisices and control units have dramatically increase the capacity and especially accuracy of measured physical quantities. Nowdays it is not enogh to perform the laboratory test the challenge is to do it in your own way and with the highest possible qulity.
IZIIS has long tradition doing research in earthquake geotechnical engineering. The Laboratory for dynamics of soils and foundation from the beginning was equipped with testing machines like direct cyclic simple shear apparatus, triaxial dynamic apparatus. The continuous research gathered a lot of experience and knowledge which enables for researchers in in lab to face with most difficult geotechnical problems. This knowledge contributes toward successful realization of all the tasks in WP3 related to upgrading of the geotechnical experimental facilities.
Several scientific and technological issues can be highlighted as a results of upgraded testing facilities and human capacities :

1) Installation of integral triaxial system for static and dynamic testing of soils

The old triaxial system which was completed outdated and very difficult to maintain couldn't follow the needs of the science market and level of the research knowledge. The researchers were doing analysis and investigations far beyond the capabilities of this apparatus. Therefore they were forced to do laboratory experiments in some other facilities outside of IZIIS (Misko Cubrinovski went to Japan and never come back, Vlatko Sesov spent more than two and half years in Japan, Kemal Edip spent two years in Germany, Julijana Cvetanovska one year in Canada). Now with newly installed triaxial system the research capabilities significantly increased.
It is worthy to point out several important technological features of the installed triaxial system which allow us to do advanced research:

Static and dynamic triaxial WF system - Main features

The Wykeham Farrance feedback controlled cyclic triaxial system applies cyclic or dynamic loading to the soil specimen. The system is a digitally controlled, servo pneumatic (closed loop) system, which controls three parameters: axial stress, confining pressure and back pressure. The base system incorporates a integrated Multi-Axis Control System (IMACS), a digitally controlled 5 kN actuator, Tritech 50 load frame, auxiliary air receiver complete with two servo valves for cell and back pressure control, two air filters and associated cables. The system is supplied complete with cyclic and stress path software. A double acting digitally controlled pneumatic actuator applies axial load. This cyclic load can be applied in load (N), stress (kPa), displacement (mm) or strain (%). Digitally controlled pneumatic valves apply confining and back pressures. The dynamic tests are generally carried out in conjunction with static imposed conditions of stress to the soil samples. This means that the sample, in addition to the application of dynamic actions, can be saturated, consolidated upon different stress levels (isotropic, anisotropic, K0, etc.) and also carried out to failure under static monotonic conditions.

The WF Static and Dynamic Cyclic Triaxial system has been designed to perform the following tests:

- Standard triaxial tests (UU, CU, CD) including saturation, isotropic and anisotropic consolidation with pore pressure and volume change measurements
- Stress and strain path control tests, including K0 consolidation
- Cyclic loading
- Dynamic shear strength and deformation
- Liquefaction potential
- Shear modulus and damping ratio
- Resilient modulus.

Integrated Multi-Axis Control System (IMACS)

The IMACS is a compact self contained unit that provides all critical control, timing and data acquisition functions for the test and the transducers. The IMACS is linked to a personal computer through the USB communications link. The data acquisition module has 13 normalised (± 10 V range) transducer input channels. These channels are digitised by accurate high speed 20 bit (A/D) converters for data analysis and presentation. The control module has three channels for feedback control. One is dedicated to the actuator for vertical load, the second is dedicated to cell pressure, the third is for back pressure. The feedback control module and the data acquisition module have their own dedicated high speed USB interface (10 Mb/s). This allows uninterrupted, simultaneous communication enabling increased speed of operation and flexibility. Supervised by the PC, the IMACS automatically controls the operation of loading for individual types of test. The IMACS directly controls the servo valve to apply the requested loading rate or waveform, cell and back pressure. While the specimen is being subjected to loading forces, the IMACS captures data from the transducers and transfers these, via the USB link, to the PC for processing, display and storage.

Software

Multi testing Windows environment providing the following software modules:

- ASTM D5311-96 Standard test method for load controlled cyclic triaxial strength of soil
- ASTM D3999-96 Standard test method for the determination of the modulus and damping properties of soils
- Cyclic stress test (standard sine, square, haversine, etc.)
- Cyclic strain test (standard sine, square, haversine, etc.)
- User definable wave shapes using 512 point description. 100 data point collection per cycle
- Liquefaction
- Stress path: with increase/decrease of radial stress with increase/decrease of axial stress

Automatic volume change apparatus

When connected with a suitable display or data acquisition system the apparatus provides an electrical signal directly proportional to the volume of water flowing through the unit. The apparatus comprises a piston connected to a 25 mm travel linear transducer and sealed against a precision-machined calibration chamber so that the linear movement of the piston is exactly proportional to the volume of water in the calibration chamber. Basic capacity: 100 cm^3 ; Transducer input: up to 12 V DC ; Accuracy: ± 0.1 ml.

On-sample transducers

Additional efforts were made to installed state-of-the-art on-sample transducers Consist of two axial and one radial transducers. In conventional triaxial testing the determination of axial stiffness is based on external measurements. This method brings errors due to sample bedding effects of the porous stones on either end of the sample and to the loading system and load measuring system.
Furthermore the two ends of the specimen are subjected to restraint, differently from the middle third of the sample, where the strain transducers are mounted and where the realistic deformations occur.

Axial and radial strain transducers give the opportunity to measure with high accuracy the deformations directly on the triaxial test specimen.

Above all what is mentioned for the triaxial apparatus it should be stress out that this equipment can be used for wide range of geotechnical problems under static and dynamic loading (Fig. 5, 6 7)

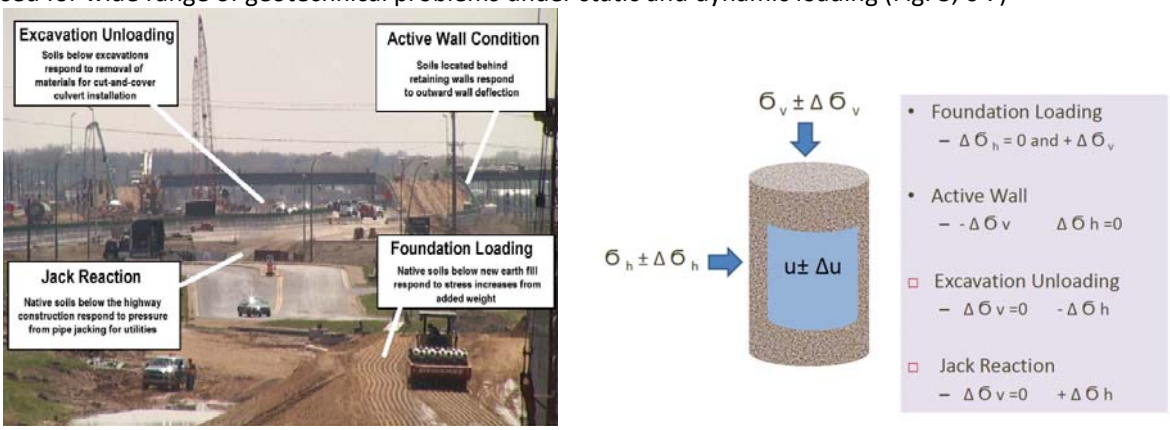

Fig.5 Stress-path application in the real world

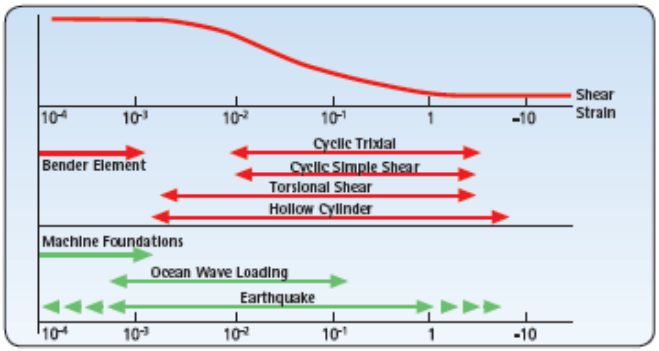

Figure 6. Capabilities of different type of testing machine to cover the wide range of shear strains

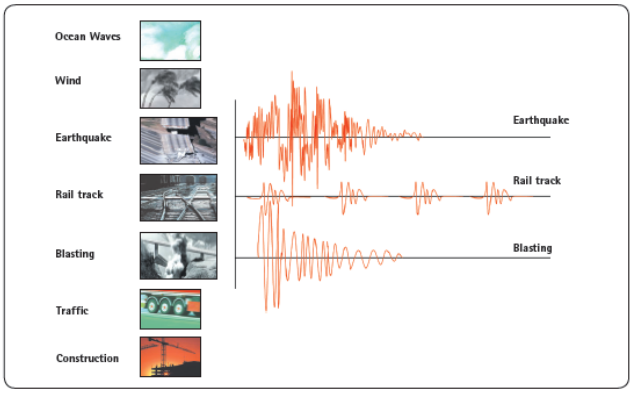

Figure 7. Types of vibration and their nature

These technological features of newly installed triaxial system gave us opportunity to perform advance research studies. Here are some of the scientific results which were achieved using the installed triaxial system:

Research study regarding the liquefaction occurrence during the Kraljevo Earthquake, 03.11.2010. Earthquake with magnitude M=5.4 happened near city of Kraljevo, 121 km from Belgrade, Serbia. From

scientific point of view it was very interesting there were evidence of liquefaction occurrence as result of this not so strong earthquake. Usually liquefaction as phenomena is related with strong earthquakes. Experts team from University of Belgrade (Geological and Mining faculty) went at the struck area and collected samples from the sand boils. Since there no experience and no equipment to investigate liquefaction at this University, they contact us and they gave us the soil samples which they collected from the several sites. This study is still ongoing but so far several test series were done on triaxial apparatus. Measuring devices and very stable control of the equipment allowed us to perform liquefaction tests on very low cyclic stress ratio with high accuracy, simulating the real earthquake that struck city of Kraljevo.

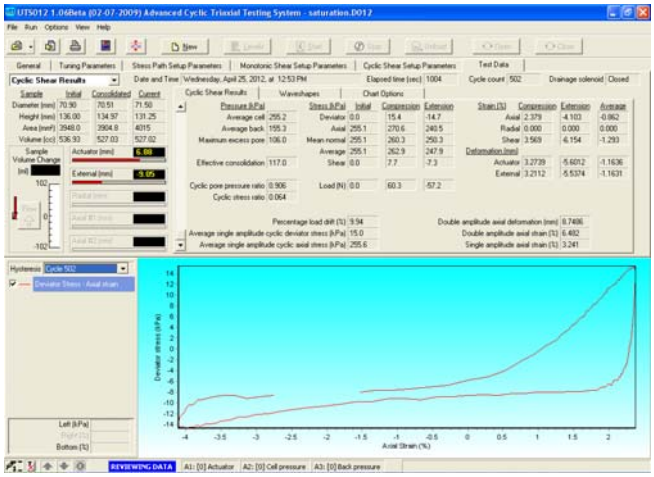

Figure 8. Undrained cyclic test; Deviator stress versus axial strain,

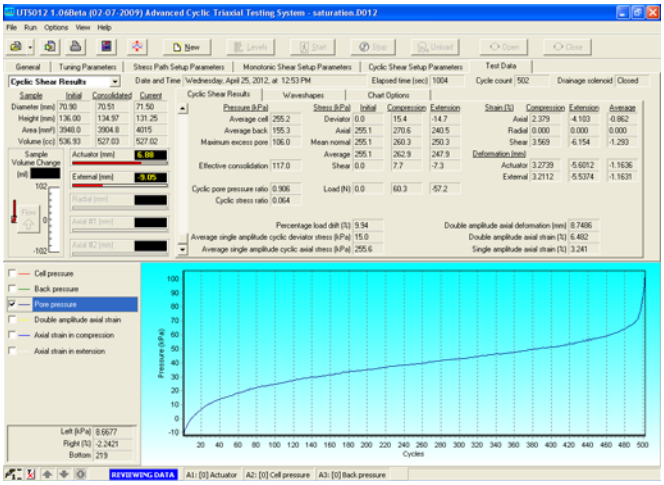

Figure 9. Undrained cyclic test; build-up of excess pore water pressure ,

Verification of numerical model developed at the Lab – this is a part of doctoral thesis of Kemal Edip, MSc research assistant at the Lab. In order to improve the numerical simulation of soil behavior a multiphase soil element has been proposed. The plane element is programmed using the programmable features of the ANSYS software. The new element simulates the soil as a medium composed of three phases, namely solid, water and gas phases. The main advantage of using a three phase soil model is that the simulation is done nearly to the real conditions. The programmable features of ANSYS allow modelling of constitutive equations in order to take into consideration the plastic behaviour of the soil medium. The considered three phase soil element takes into consideration both linear and non-linear material models in such a way that the soil simulation is done in accordance with the real conditions. For such complex numerical

simulation first of all the input parameters have to be obtain in very reliable way. Second thing is that results from such numerical analysis have to be compare or verify with high quality data from laboratory test. Both things ,input parameters and verification and calibration of numerical model were done by running a lot of triaxial tests (cyclic and monotonic) on newly installed equipment. This study/Ph.D thesis is almost finished and soon one journal paper will be published.

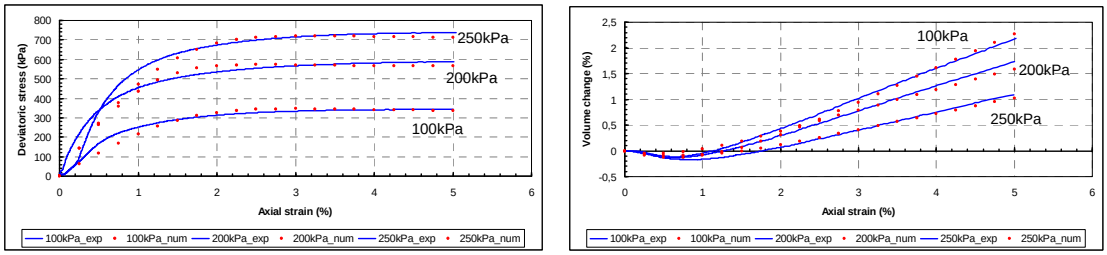

Figure 10. Verification of the numerical model with the triaxial tests (monotonic shear test)

LAMINAR CONTAINER

Earthquake geotechnical studies can involve different methodologies and approaches such as dynamic soil element tests, reduced scaled models, numerical and analytical models and full scaled field tests. If done properly, scaled model tests can be advantageous for seismic studies due to their ability to give more realistic information about ground acceleration amplification, change in pore pressures in the soil medium, nonlinear behavior of soil, occurrence of failure, and soil structure interaction phenomena.

European research laboratories so far, didn't pay a lot of efforts to use laminar container or shear box for laboratory investigations. The application of shear box / laminar container was very limited and the tests were done in most cases on dry soil models. Research centres in USA and Japan are much more advance in this manner.

Since IZIIS has shaking table with capacity which allows testing large models the idea was to design and construct the laminar container. This will be small contribution to ERA to overcome a large gap that exists regarding the shaking table testing on large geo-models.

The ideal container is one that gives a seismic response of the soil model identical to that obtained in the prototype, i.e. the semi-infinite soil layer 1D response under vertically propagating shear waves. The boundary conditions created by the model container walls have to be considered carefully, otherwise the field conditions cannot be simulated properly.

The following criteria were use as guidelines to design laminar box at IZIIS:

- Rings/ laminar layers should allow free horizontal movement, no friction
- The membrane inside should have minimum stiffness to horizontal shear.
- The laminar box should have mass much smaller than the soil material
- The laminar box with membrane should retain water and air without leakage.
- Little resistance to vertical settlement of soil.
- Height of each layer should be small enough to follow the deformation of soil model.
- Fairly large to better simulate field behavior.
- To maintain its horizontal cross section during shaking.
- To provide good contact between the bearings and groove.
- Free movement of soil along the transverse cross section.
- Enough space for instrumentation.
- Strong and stable against all the dynamic forces and moments.
- To provide stiff connection to the shaking table

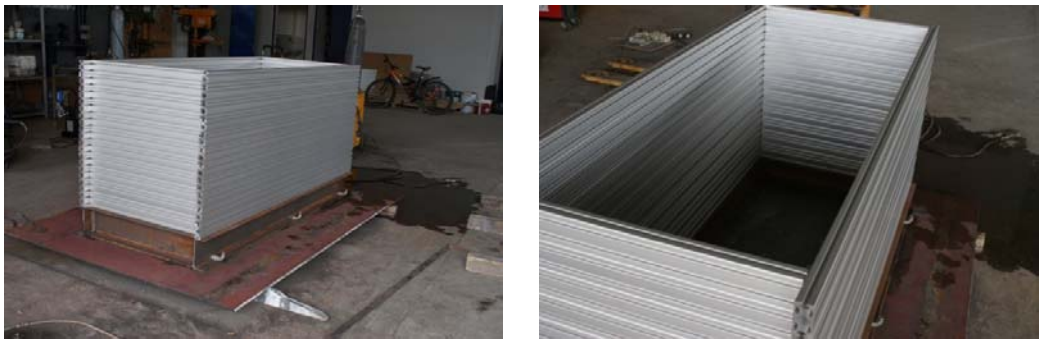

Figure 4. *New laminar box at IZIIS*

Design and constructions of Laminar Box for state-of-the-art testing of large scaled geo-models is made. The laminar box is designed and is set in the laboratory for dynamic testing of soils at the Institute for earthquake engineering and engineering seismology IZIIS in Skopje, Macedonia. The laminar box is planned to be used for experimental testing on fully saturated cohesionless soil in order to investigate the liquefaction phenomena and cyclic behavior of cohesionless soil in earthquake conditions. The results from the planned investigations will have big influence in the European region for the development of the geotechnical earthquake engineering.

Upgrading of the human potential

The renewal of the equipment available itself will have real impact if at the same time upgrading of human potential is made. A lot of efforts had been paid during the project to improve the quality of the research stuff. Several achievements are worthy to be stressed out :

- Two young researchers were hired and actively involved in the project activities and tasks. Since they showed very good capabilities and skills we decided to keep them working at our Institute even after the project finished.
- Seven members of laboratory for dynamics of soils and foundations (three senior, three young researchers and one technician) successfully passed basic and advance training on the new installed triaxial system for static and dynamic testing of soils.
- Six members of Dynamic testing laboratory were trained during the installation of the New Digital Control system.
- Six young researchers from the above mentioned laboratories visited the similar experimental facilities at LNEC, Lisbon (one of our project network partner).
- At the end of the project Training Seminar "*Capabilities of experimental facilities toward seismic risk reduction" was organized especially for young engineers and researchers. More than 30 participants have chance to be informed about latest achievements in the field of experimental investigations in earthquake engineering from the distinguished experts.*

We will continue to increase the quality of the human potential and to involve as much as we can younger researchers at our laboratory facilities. Their fresh and new ideas with the experience of our senior researchers will put our labs on higher level in ERA.

IMPACT AND DISSEMATION ACTIVITIES

Upgrading and renewal of the institutional research capacities has great impact toward the society efforts for seismic risk reduction strategy and protection of human lives and from natural catastrophes. The potential impact can be seen through following:

- **Technology impact.** Protection of structures against strong seismic events primarily depends on the quality of the applied standards for design and construction. Earthquakes have far more disastrous consequences where building codes are not rigorously enforced as they are in other circumstances (example: Skopje 1963 earthquake, which was not so strong earthquake but more than 1000 human lives were lost and over 200000 people lost their homes. Main cause: Building codes at that time didn't take seriously seismic loading on structures). Evaluation of high quality of standards in protection of human lives and material goods depends on the level of the knowledge built into the standards. Critical information for this knowledge is obtained from different kinds of laboratory and site testing. It should always be kept in mind that there are no perfect standards and that they should always be in the process of improvement for the needs of the society.
  The reinforcement of the IZIIS' RTD capacities creates the conditions for knowledge delivering which should be built-in into the technical standards. Two IZIIS's laboratories with new and upgraded equipment now are capable to perform high quality tests and experiments using the latest technological achievements. New state-of-the-art devices and measuring transducers enables researchers to get information and results from the tests with the highest level of reliability and confidence. This is very important issue in experimental investigation. With such improvement on experimental facilities IZIIS overcomes the technological gap that was created in the last ten years compare with the EU, USA and Japan research centers in the domain of dynamic testing of large structural and geo-models. Just as an example: new constructed laminar box will allow to perform experimental investigation on large geo-models (liquefaction, SSI, retaining walls,.) which is, at the moment, still very rare research topic not just in Macedonia but also in ERA. On the other hand replacement of the old analog control system with new digital, improve the quality of the shaking table tests concerning several issues: stability, reliability, exploiting the maximum of actuators, open new frontiers for hybrid testing, etc. With the new triaxial system for static and dynamic testing of soils and the on-sample transducers we are capable to perform big variety of dynamic tests on soil samples within the wide range of deformation (from very small strain measurements 10^{-5} to large strain 5-10 %).

- **Impact on the European / regional and domestic economy.** It is well known that earthquakes are one of the costliest disasters in terms of both deaths and monetary damages. They are natural phenomena whose devastating effects do not recognized countries boundaries and their consequences can have impact over large area. Having in mind that the Balkan region is known as a region of high seismic activity, the reduction of seismic risk is not only national but also regional problem. Improving of the IZIIS's RTD capacities enables and opens possibilities and establishing the fundamentals for decreasing the seismic risk through advanced experimental testing and to participate in projects as equal partners with the remaining European institutions. The experimental studies that previously were done in US or Japan now can be perform on upgraded and renewed equipment at IZIIS. On the other side installation of such an advance equipment will push the local and regional companies to upgrade their quality in order to be able to offer services for maintaining and servicing such apparatuses, devices , transducers

- **Impact on the EU policy or EU legislation.** Improvement of the IZIIS's RTD capacities, both human and infrastructure increased the IZIIS's competitiveness in the field of research. Reinforcement of the IZIIS' experimental facilities and strengthening of international cooperation will lead to an increase of the overall IZIIS's RTD capacities and to successful integration into the European

Research Area. Considering the impact of this project on the EU policy for gender issues it's important to mention that more than 30% of the project participants are women which follows the Commission's efforts towards the promotion of the role of women in science and technology and ensuring effective mainstreaming of the gender dimension in the Framework Programmes. The main objectives of this project also to address a wide range of actions outlined in the Social Policy Agenda established by The Lisbon European Council i.e., creating of more and better jobs, enlargement and promoting of international cooperation, promoting mobility etc.

- The Institutional capacities and the high level of professional skills gives the IZIIS leading role in the process of harmonization and application of European Seismic Codes in the country, as a set of unified international codes of practice for designing buildings and civil engineering structures (legislative impact).

- **Impact on the environment.** The construction industry faces a transformation process in which the environmental aspects represent a key role. The earthquake effect on the environment could be devastating. The failure or even repairable structural damage to complex technological systems like facilities with large quantities of hazardous materials-toxins, explosives and radioactive materials, then dams, pipelines etc. can cause enormous destruction of the environment. Additionally triggering of landslides, tsunamis and other natural phenomena always causes huge casualties in both human deaths and economic losses. The improved and renewed IZIIS's testing facilities allows realization of experiments towards increasing the capability of structures to prevent the environment against hazards, (including seismic hazards). The knowledge which will be gained as a result of advanced research will enable efficient earthquake protection and will reduce the seismic vulnerability of structures having in mind that earthquake doesn't kill but built environment does.

- **Social impact.** In accordance with the structure of the economy and the institutional infrastructure in the domain of science, the Ministry of education and science of FYROM has set out several priorities regarding the science and technology development. The objectives of this project address at least two of them: geological science and environmental protection. Reinforcement of the IZIIS' research capacities and improving of international cooperation contributes for boosting the human capital ("young brain") and will offer better career opportunities and better working conditions. Young researchers will have no reasons to look abroad for continuation of their education and training in the field of earthquake engineering since the improved experimental facilities at IZIIS provides the same quality and possibilities for research as any other European laboratory. This is also important in the way to stop the so called "brain drain" problem that the country is facing in the last ten-twenty years. Young researchers are the 'new blood', which will accelerate the efficiency of seismic risk reduction, and lead to overall better living standards.

Dissemination activities

- Organization of a Workshop - - *'Seismic Research Testing Facilities in Earthquake Engineering'*
  The workshop was planned within the activities of working package WP4 (Task4.1). Main objectives of the workshop were to present the achievements which were obtained during the Project period and to exchange and compare the results with similar the researchers from EU countries. State administration and professional practitioners were major target group as participants for this workshop. We tried to invite as much as possible representatives from governmental agencies in order to make them aware of the upgraded technological and human capacities of our Institute. Also all Project Network Partners were invited to take active participation on this Workshop. The programme of the workshop was realized with two main topics.
  - UREDITEME FP7 Project: achievements, experience, future plans
  - New developments in Research testing facilities in Earthquake Engineering

  The technical programme of the workshop and other details related with the workshop were posted on Project web site (http://www.iziis.edu.mk/urediteme/news.html). The workshop took place at UKIM-IZIIS, from March 22 to 23, 2012. Four distinguished experts from EU were invited to give presentations. Their valuable contributions gave additional impact on the expected outcomes. The workshop fulfilled its aims since we got positive feedback from participants and what was very interesting the participants from Macedonia were pleasantly surprised with the level of research and human capacities of our Institutes.

- Training seminar for young scientists '*Capabilities of experimental facilities toward seismic risk reduction'*
  The training seminar was planned within the activities of working package WP4 (Task4.3). Seminar was organized at IZIIS premises. Main objective of the seminar was to introduce the new research capabilities, possibilities for joint projects and strengthening of cooperation to young researchers. Invitations for the seminar were sent to several research laboratories and departments from all Universities in Macedonia and also to laboratories from neighboring countries. Two experienced researchers from EU (from UK and from Greece) and two from host Institution were invited to give lectures on this Seminar. The seminar fulfilled its aims since we got very positive feedback from young participants and several of them visited us few days after the Seminar looking for additional information for possibilities to do research at IZIIS

- Presences at annual congress and symposia of several national professional associations of engineers.
  Third symposia of Macedonian Association for Geotechnics, Struga, June 2010.
  14th International Symposia of Macedonian Association of Structural Engineers, Struga, 2011

- Participation on international conferences or workshops organized by related European or World professional associations (ISSMGE, IASPEI, EAEE, WCEE, EACS, IACS, ...):
  14th European Conference on Earthquake Engineering, Macedonia, Ohrid2012. Five participants
  5th World Conference on Structural Control and Monitoring Tokyo, 2010. Participant Prof. d-r Zoran Rakicevik;
  Second International Conference on Performance Based Design in Earthquake Geotechnical Engineering, Taormina2012, Italy. Participant Prof. d-r Vlatko Sesov;

5th European Conference on Structural Control, Participants, Genoa2012, Italy: Prof. d-r Zoran Rakicevik & Prof. d-r Mihail Garevski

These events were good opportunities for promotion of the results from our project.

- Organization of days of "open laboratory"
  Days of "open laboratory" were organized from March 15 to 16, 2012. Students and researchers from several Macedonian Universities with similar scientific fields of interest were invited to visit IZIIS's newly upgraded laboratories. Presentations and practical demonstrations of newly upgraded equipment were done during the two days of "open laboratory". More than 70 students and young researchers visited IZIIS's laboratories during the two days of 'open laboratory' event. We were more than satisfied with the number of attendees and it was positive experience which we will practice in future

- Article regarding the UREDITEME project was published in "PORTA3" most distingushed journal for Architecture, Civil Engineering and Ecology in Macedonia (Number 138, 2010, pp.42-43)

- Web page of the project was created on IZIIS web site - public area of the web site of the project is used to disseminate information about the project, its progress and its RTD results to the public at large. The web page was build and maintain by IZIIS informatics. (http://www.iziis.edu.mk/urediteme/).

RELEVANT CONTACT DETAILS

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