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TRIP REPORT

**STUDY TOUR, ENGLAND, FRANCE, RUSSIA, AND
JAPAN, CENTRIFUGE INSTALLATIONS AND
MODELING TECHNIQUES IN STRUCTURE
FOUNDATION DESIGN**

13 June-13 July 1977

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⑥ ⑨ Trip Report.
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CENTRIFUGE INSTALLATIONS AND MODELING TECHNIQUES
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PREFACE

In accordance with the Protocol signed in Washington, D. C., on 28 March 1977 by the co-chairman of the U. S./USSR Joint Working Group 10.05 "Building for Extreme Climates and Unusual Geologic Conditions," representatives of the U. S. participated in a study to the Soviet Union during the period 19 June-7 July 1977. The U. S. representatives were Professor M. E. Harr, Department of Civil Engineering, Purdue University, West Lafayette, Ind., and Mr. W. C. Sherman, Soil Mechanics Division, Soils and Pavements Laboratory, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. The primary purpose of the tour was to become acquainted with the use of centrifuge and large-scale modeling techniques employed in the design of foundations for structures under static and seismic loading. Preceding the visit to the USSR Professor Harr and Mr. Sherman visited institutions in England and to obtain background data on centrifuge testing techniques. Following the visit to the USSR, Mr. Sherman visited Japan to review current work on centrifuge testing in that country. Information obtained in the various countries is summarized in this report.

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STUDY TOUR, ENGLAND, FRANCE, RUSSIA, AND JAPAN
CENTRIFUGE INSTALLATIONS AND MODELING TECHNIQUES
IN STRUCTURE FOUNDATION DESIGN

19 June-7 July 1977

Introduction

Purpose

1. The following report pertains to the study tour conducted by Professor M. E. Harr, Purdue University, and Mr. W. C. Sherman, Soil Mechanics Division, Soils and Pavements Laboratory, U. S. Army Engineer Waterways Experiment Station (WES) during the period 11 June-7 July 1977 in England, France, and Russia. It also covers Mr. Sherman's visit to centrifuge installations in Tokyo, Japan. It was ^{was} the primary objective of this study ^{to} to become familiar with centrifuge installations and modeling techniques employed in the design of foundations for structures under static and dynamic loading. In addition, attention was to be directed toward construction methods in seismic areas and the evaluation of various techniques that have been employed in this regard. To be added to these objectives is the information to be gained from the exposure to new (if not different) engineering methods, needs, and procedures. It is believed that all the objectives were amply satisfied, and the ~~tour~~ ^{study} could be characterized as an unqualified success. It is hoped that the following comments can affirm this assertion.

Schedule

2. The schedule in chronological order was as follows:

- a. 13 June (a.m.) - King's College, London
(p.m.) - Imperial College, London
- b. 14-15 June - Cambridge University
- c. 17 June - Laboratoires des Ponts et Chaussees, Paris
- d. 20 June - NIIOSP, Moscow
- e. 21 June (a.m.) - Fundamentproject, Moscow
(p.m.) - Hydroproject, Moscow
- f. 22-25 June - Baku, Azerbaijan SSR

- g. 22-29 June - Erevan, Armenian SSR
- h. 29 June-2 July - Tbilisi, Georgia SSR
- i. 2-4 July - Kishinev, Moldavian SSR
- j. 5 July - NIIOSP, Gosstroi, Moscow
- k. 8-13 July - Tokyo, Japan (Mr. Sherman only)

Attitude and conduct of Russian hosts

3. Except for the confusion as to our scheduled time of arrival at Scheremetjevo Airport in Moscow, all subsequent events, meetings, and activities were conducted under friendly, professional, and extremely hospitable circumstances. The initial difficulty was due in part to last minute changes in Aeroflot's schedule. However, even though, at the time, "not being met at the airport" and its consequences were quite traumatic--subsequent events amended this early experience.

4. We were accompanied on our travels by interpreters Katrina Ivanova Suslova and Anatoli Alexandrovich Vashilevskii. The latter, in addition to serving as part-time interpreter, also made hotel and air reservations, set up meetings, and paid the bills. In accordance with the terms of the Protocol, they did pay all expenses for the study tour once we made contact in Moscow. There is little doubt that the success of the tour owed much to the special efforts and ability of Mr. Vashilevskii.

5. Another factor that greatly contributed to the success of the study tour was that contact within the separate republics was made at the highest engineering level: that of the Directors of Gosstroi, who hold the official rank of ministers of their republics. In concept, he is much more powerful than a Commissioner of Public Works in the U. S., as there are no private works in the USSR. The word "Gosstroi," itself, even when used in restaurants, improved service.

6. Travel between the republics was by jet (Tupelov 134, 154, Yak-40) and very comfortable, indeed. At each landing, we were met by two or three high ranking engineers, generally with one at the deputy-director level. They then acted as our hosts, guides, and contacts throughout the visit in their respective republics.

7. In addition to the engineering meetings, visits to construction

sites, power station, hydraulic works, and field prototype tests (see below), there were numerous cultural excursions to museums, ancient churches, and general sight-seeing tours. On several occasions we were guests at rather lavish banquets. In all, hospitality and friendship (with best wishes for more between our countries) were the bywords.

Visit to England and France

London, U.K.

8. The visits to King's College (Professor R. E. Gibson and Dr. Dick Bassett) and Imperial College (Professor A. W. Bishop, Dr. P. W. Vaughan, and Professor N. N. Ambraseys) were intended to learn more about "what we might expect" and "what we should look for" in Russia.

9. Gibson suggested that we try to see their soil mechanics laboratories. "We are well aware of their theoretical developments, but what testing have they performed?" He also suggested we look into consolidation of sands and sample sizes related to their offshore studies. Professor Gibson showed us his own laboratories and the work he was doing with models of "sand islands" to be built in the North Sea. Professor Gibson, in accordance with previous correspondence, was invited to visit and lecture at WES. He indicated that he would do this in October or November 1977. We also met with Professor Bassett, who has five packages available for testing at Cambridge.

10. Professor Bishop suggested we look at "creep testing" in Russia. Mr. Ambraseys, who had visited Russia several times, said that he had heard that foundation liquifaction may have occurred in Kishinev as a result of the March 1977 earthquake. The earthquake was unusual in that very violent ground motions had occurred at large distances, up to 280 km, from the epicenter. He recommended that we inquire about the "shake table" work in Tbilisi. He had heard about it but had not seen it himself. He also suggested that when in Kishinev, because of its proximity to Rumania, we pay special attention to the effects of and the damage resulting from the March 1977 earthquake.

Cambridge, U.K.

11. Arrived at Cambridge in time to attend seminar by Professor Lade of University of California at Los Angeles on constitutive relations for soils.

12. Professor A. N. Schofield showed us his geotechnical centrifuge. The machine was designed by the late Professor K. H. Roscoe in 1969. It normally operates with swinging platforms which have a working radius of 4 m. At the maximum rotational speed of about 186 rpm, the acceleration is about 155 g. The swinging platform torsion bars are adjusted to accomodate a package not exceeding 700 kg mass. Thus, in its present operations it has $125 \text{ g} \times 0.7 \text{ tonnes} = 87.5 \text{ g-tonne}$ capacity at 4-m radius. The drive motor is below the machine, with the entire unit setting below ground level. Photographic access permits observations during testing.

13. Professor Schofield offered the following thoughts in regard to Russian centrifuges:

- a. He referred to the latest book (in Russian) on centrifuge testing by Yo. N. Malushitsky, Kiev, 1975. A copy is available at WES. He noted that he was waiting for the new book by G. A. Aliev (see below) and G. I. Pokrovsky (in Russian), which he hopes to translate. He also looks forward to receiving the book (also in Russian) by G. I. Pokrovsky, I. C. Fedorova, and A. I. Teitelbaum. G. I. Pokrovsky is the "father" of Russian geotechnical centrifuge testing.
- b. The Russians use "factor experiment planning;" that is, they find integrated effects and then experiment changing only one factor. This calls for a large number of tests.
- c. He suggested that, if possible, we should find out about the nature of the crews, the scale and crudeness of the instruments, whether or not they use transducers and/or make pore pressure measurements, whether they can control temperatures during testing, and whether they have or can use explosives during testing.
- d. With regard to pore pressure measurements, if they do not monitor them, they must run tests for very long times (tens of hours) to allow them to dissipate before inducing loadings.
- e. He suggested we note the nature of the bearings of the swinging payload and the photographic equipment.

- f. He noted that in Russian centrifuges the drive motors were above the ground. This offered a great advantage over his own apparatus in providing direct access and simplifying the receiving of electrical output.

Paris, France

14. Dr. B. Pilot and Mr. B. Pincent of the "Laboratoire Central des Ponts et Chaussées," Paris, related to us the history of their use of the (French) centrifuge for geotechnical testing and of their current and future work plans. Plans are developing for the construction of a new centrifuge closer to Paris. They have a small 1-m-radius centrifuge in their laboratory; however, generally they use a modification of the centrifuge originally built by their atomic energy commission (Centres du Commissariat à l'Energie Atomique, le Centre d'Etudes Scientifique et Techniques d'Aquitaine, CESTA) near Bordeaux (designed by Latecoère). The device (also called CEA) is operated by 4 350 horsepower engines. It has a 10-m arm, carries a package of 2 tonnes (1 m × 60 cm × 30 cm), maximum acceleration is 100 g in one minute (for 2 tonnes), and can produce a maximum of 200 g. Unlike the usual centrifuge, this device operates on a circular track at approximately 3 m from the center of rotation. The motors are below the apparatus. It cost them 200,000 francs (in 1977) to modify the device so as to accommodate swinging buckets. They have conducted experiments involving both excavation and embankment construction. In addition to transportation and manpower costs, they pay a user fee of 25,000 francs for each use. They claim they can examine 30 effects simultaneously. They consider the device to be particularly valuable in exposing "modes of failure," "rupture," and "phenomena." In this regard it is thought to be more qualitative than quantitative. They plan to reduce the radius of their proposed device to 5 m, similar to that of the present Cambridge centrifuge.

15. Dr. Pilot had visited Moscow recently, and he and his Russian counterparts at NIIOSP, as part of a cooperative program initiated in 1969, were conducting tests (separately) to ascertain reproducibility of results for a fine and coarse sand. Results are not yet available.

Visit to the USSR

Initial contacts-20 June

16. After some initial difficulties and with the help of Mr. L. Sell of the U. S. Embassy, contact was finally made with Gosstroi at the Embassy, shortly after lunch. Messrs. Vashilevskii and Sadovskii met us and drove us to NIIOSP (Research Institute of Bases and Underground Structures), which is the main "soil research arm" of Gosstroi in Moscow.

NIIOSP, Moscow

17. We were met at NIIOSP by Professor G. V. Porkhaev, who is Science Director of the Institute and Deputy Chairman of the Soviet part of the U. S./USSR Joint Working Group 10.05. We discussed in some detail the proposed program of our visit to the USSR and the scheduling of Professor Harr's lecture on 5 July at NIIOSP. Invitations would be extended to interested engineers and organizations.

18. Dr. Porkhaev explained that the Institute was the main scientific center in the USSR for research concerning problems of foundation engineering, soil mechanics, and underground structures. At the present time the Institute has more than 700 employees, including 18 doctors of science and 74 candidates of science (like our Ph. D. candidates). Of present interest are their theoretical and experimental studies of problems in soil dynamics and of seismic induced loadings. Large-scale seismic experiments on various types of foundations are being conducted at their proving ground in Kishinev as described below.

19. V. A. Ilyichev, head of the Soil Dynamics Laboratory, stated that his laboratory was the leading laboratory in the USSR on dynamics effects on foundations. His work is primarily directed at developing and improving construction codes and standards. "They do not use models...do not believe in modeling!" He sees his group's task as providing simple, but reasonable, procedures that most engineers can use; for example, to suggest that the effect of earthquakes (in moderate range) can be accounted for by simply considering an additional horizontal force of say 0.1 g.

20. For piles, they have developed standard procedures (see the Russian Code). They use only vertical piles, not battered or inclined piles, for seismic loadings. They have conducted full-scale tests at Kishinev using vibrators and explosives for both single piles and groups of 2 to 4 piles. Their procedure is to apply correction factors to static capacities. They do not consider liquifaction induced by seismic effects to be a very important problem in USSR--even though they acknowledge its existence. They consider "dynamic creep" of thin silt layers to be a much more severe problem!

21. Professor Polshin showed us around the large testing bins used for model testing of foundations. Three present bins are $4 \times 4 \times 4$ m, $8 \times 8 \times 8$ m, and $12 \times 12 \times 12$ m. All parts and panels are interchangeable, and they can construct units to desired dimensions. They have conducted large-scale models and full-scale models and full-size foundation elements (including piles) under static and dynamic loadings. Bins have also been used to investigate stress, strain, and deformation characteristics under various contact pressures and shapes using load cells (based on work of Gersevanov-Posadov).

22. Professor Polshin also showed us the NIIOSP centrifuge. It was built in 1960 by Pokrovsky. The installation looks as though it has been around for some time, but appears to be in good condition. The unit is below the floor level, but the motor extends above the floor. The equipment is shown in Figure 1. It is contained within the main building of the NIIOSP laboratory! In fact, it was quite a surprise to find it in what appeared to be a rather large laboratory room. It appeared to have seen considerable use. The device is not used for pile models and generally they consider only bearing capacity problems. Maximum acceleration is 100 g. Generally, two tests are conducted--one in the swinging buckets, and one test being used for control. Most tests are run on cohesionless materials and tests are not run for long periods, although they have run tests for up to three hours maximum with clays for consolidation as required. No pore pressure measurements are made. The radius of the centrifuge is 2 m. It can carry a weight of 200 kg at a speed of 350 rpm. It can produce 100 g (maximum). Two samples are

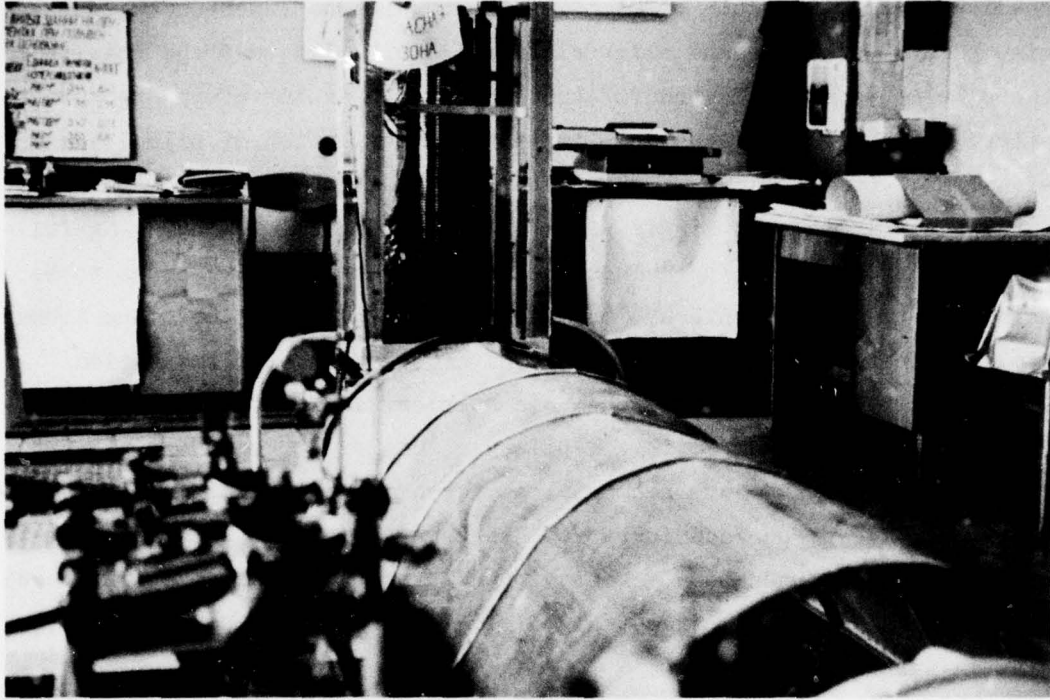


Figure 1. 100 g centrifuge at NIIOSP

always run together. The installation is equipped with an automatic loading device and a closed-circuit TV system. They are considering building a new centrifuge--they claim they do not need the high accelerations they previously thought necessary.

Foundations Design Institute, Moscow

23. The Foundations Design Institute (Fundamentproject) in Moscow carries out engineering and geological investigations throughout the Soviet Union. We were briefed on the activities by Dr. A. G. Trofimenkov, Director, and his staff. The Institute carries out site investigations, including borings and geophysical investigations, hydrogeological investigations, field tests, and designs complex investigations, including design of construction methods. Because of the short time available, the briefings were concerned primarily with work involving pile foundations. The Institute relies heavily on pile tests using model piles, which are the same length as the prototype piles but of smaller diameter. This permits the use of smaller load testing equipment than would be

required with full-scale piles. Test piles are instrumented to determine point resistance and skin friction distribution, and the results of the pile tests are adjusted for the increased diameter of the prototype piles. Data are also available for the redistribution of pile loads with time. Dr. Trofimenkov described some of the available comparisons between settlements of single piles and groups of piles, including full-scale structures on piles. These data are summarized in reports to be submitted to the 9th International Congress on Soil Mechanics and Foundation Engineering, Tokyo, 1977. They have done much experimentation with slurry walls, including 60-m diameter caissons with precast elements. Although the majority of piles in the Soviet Union are precast concrete piles, they have been giving increased consideration to cast-in-place piles. Much consideration has been given to the seismic response of pile foundations. Design procedures have been developed based on analytical work and large-scale field tests at the Experimental Station in Kishinev.

24. Among the additional items presented were various penetration rigs and apparatus used for site investigation, the use of shallow "screwed-in piles (8 m)" for TV transmission lines, not necessary now because they use Sputnik for TV transmission. Very special efforts have been made to render devices mobile. Dr. Trofimenkov described a particularly difficult problem with respect to a very high TV tower in Alma-Ata (loess, 40-deg slope). There followed a home movie presentation of site investigation methodology.

25. Subsequently, Engineer Hanin, Chief Design Engineer of "Fundamentproject," provided more details about their pile work. He estimated the use of $8 \times 10^6 \text{ m}^3$ of piles per year in the USSR. They seldom use anything but concrete. Because of transportation problems, only in the North do they use timber or steel piles. They do not use air-entrained concrete. Workability is determined by slump.

Hydroproject Institute, Moscow

26. In the afternoon we visited the Scientific Research Center of the Hydroproject Institute and were met by Dr. V. I. Vutsel, Head of the Department responsible for centrifuge testing, and his staff. This was

to prove to be one of the more important events of the study tour with respect to centrifuge testing. Their device was built in 1965 and has been used for both practical problems and fundamental research in soil behavior. It has a 2.5-m radius, and can achieve 322 g, although generally they operate at 200 g. Maximum speed is 340 rpm. Dimensions of test model were approximately 0.9 × 0.5 × 0.4 m; the maximum weight of sample is 200 kg. The swinging buckets can accommodate a vibratory driver for simulation of seismic loading.

27. Centrifuge tests have been performed for a number of conditions: induced horizontal shearing forces, retaining walls, filling and emptying reservoirs of dams, stability of soil slopes, seepage through embankments and foundations, and piping phenomena. A number of tests have been conducted to investigate propagation of cracks with time, and strains and deformation in soil slopes.*

28. A complete test demonstration of the modeling of a soil slope (slope angle at 75 deg, 30 cm high, $\tan \phi = 0.72$, $c = 0.23 \text{ kg/cm}^2$) was narrated by Mr. Scherbina. The progress was monitored very clearly on TV. The development of cracking and of its propagation were easy to follow. The clarity of the results and of the information gained were very impressive. The ability to see the development of instability and its manifestations is of extreme value from a theoretical point of view. This ability alone renders centrifuge testing a very necessary source to uncover the complicated interaction of soil structures under load. This simple test demonstrated phenomena never before reported in the literature.

29. Hydroproject has compared centrifugal results favorably with finite element methodology. When examining suitability of some dam models, they experimented with remedial measures in the centrifuge before advocating solutions for prototype.

30. Hydroproject is a first-class operation with respect to personnel, equipment, planning and use of results of centrifuge testing.

* V. I. Vutsel and V. I. Scherbina, "Experimental Investigations of Slope Deformations," Proceedings of the 6th European Conference on Soil Mechanics and Foundation Engineering, Vienna, 1976.

Mr. Scherbina came across as being extremely knowledgeable. Staff members are interested in exchange programs with the U. S., and it appears that a visit of three to four weeks by a U. S. specialist to this Institute would be extremely worthwhile. They stated that they had invited Pokrovsky to meet us, but he was too ill to come. They informed us that they had translated Professor Harr's book "Groundwater and Seepage" into Russian and were well aware of his work.

Baku, Azerbaijan

31. We arrived on the afternoon of 22 June in Baku (which means "wind"), the fifth largest city in USSR. The population is 1,200,000 out of a total of 5,500,000 in Azerbaijan (which means "land of fire"). Baku is located along the western edge of the Caspian Sea, in the heart of the USSR oil fields. We were met at the airport by Dr. H. A. Aliev, who was a student of Pokrovsky. Dr. Aliev had designed the Baku centrifuge, reportedly the largest in the world. We were told we would be the first "Westerners" to see it. Baku was very hot and humid.

32. On the afternoon of 23 June, we met with Ya. Izmailov, Chairman of the State Building Committee of the Azerbaijan SSR, and with the various Chiefs and Directors of the subsidiary organizations. He explained the role of Gosstroi in Azerbaijan and of its special responsibility to the great oil fields. Of particular interest in this regard are the man-made islands in the Caspian Sea which contain thousands of workers. Granted more time, he would have shown them to us. He hoped we would enjoy and profit from our visit to Baku and would also feel free to inform them of anything which we saw that could be improved. In response to the question as to the exchange of information between Republics, he stated that he met with his counterparts at least twice a year. His people meet regularly with others as the need arises. He was pleased that we are interested in the Baku centrifuge.

33. Baku, as is all of the Caucasus, is in a seismic area. To date no problems are noted in precast structures. On the afternoon of 23 June, we visited the construction site of a 16-story precast building founded on piles. To please engineers, we went to the top of the building (by construction elevator); it was scary but we had a magnificent

view of the city and bay. Construction work was only fair.

34. In the evening on 23 June we were taken on a tour of the city, including Metro Station, Ancient Palace of Shah, and monument to 26 Commissars executed by White Russians during revolution. We had a traditional banquet of Azerbaijan food in ancient dome-shaped Caravansarai.

35. On the afternoon of 24 June, we visited F. Z. Musabekov and AzNIISM (Azerbaijan National Institute of Construction and Building Materials). This is the location of the Baku centrifuge. The Director of the Institute, F. Z. Musabekov, told us of the natural wealth of Azerbaijan in petroleum, stone, rocks, valuable minerals, bentonite, mercury, and gold. He noted some major construction problems: the world has 12 climate zones, Azerbaijan has 9 zones (from Tropic to Alpine). The Institute has 15 scientific laboratories--mainly dealing with rock, ceramics, and soils. They have a staff of 100 scientific workers, 32 candidates, and 1 Doctor of Science (Aliev). Building construction involves consideration of seismic effects. Building heights are limited to 16 stories, although they are planning a 50-story building to be founded on rock.

36. Dr. Aliev, a student of Pokrovsky, said that they were very familiar with the literature on earthquake design from other countries. They are aware that accelerations of greater than 1 have been measured, and this has precipitated a crisis in existing theories among Soviet engineers, as obviously no buildings would stand under the measured accelerations. They felt that there was a greater need for understanding which could only be obtained by observations of structures during earthquakes and mechanical modeling. They considered it more rational to study soil structure interaction by modeling as they feel they can't predict earthquakes yet. They have used shake tables but haven't been able to get good results. They consider that the centrifuge was the best technique for studying soil-structure interaction problems under seismic loading. For this reason they constructed a centrifuge of 11-m radius which presumably is one of the largest in the world. The outside housing is shown in Figure 2, the sample pod and arm are shown in Figure 3. It took six years to construct and was finished in about 1974.



Figure 2. Exterior of 500-g centrifuge facility in Baku

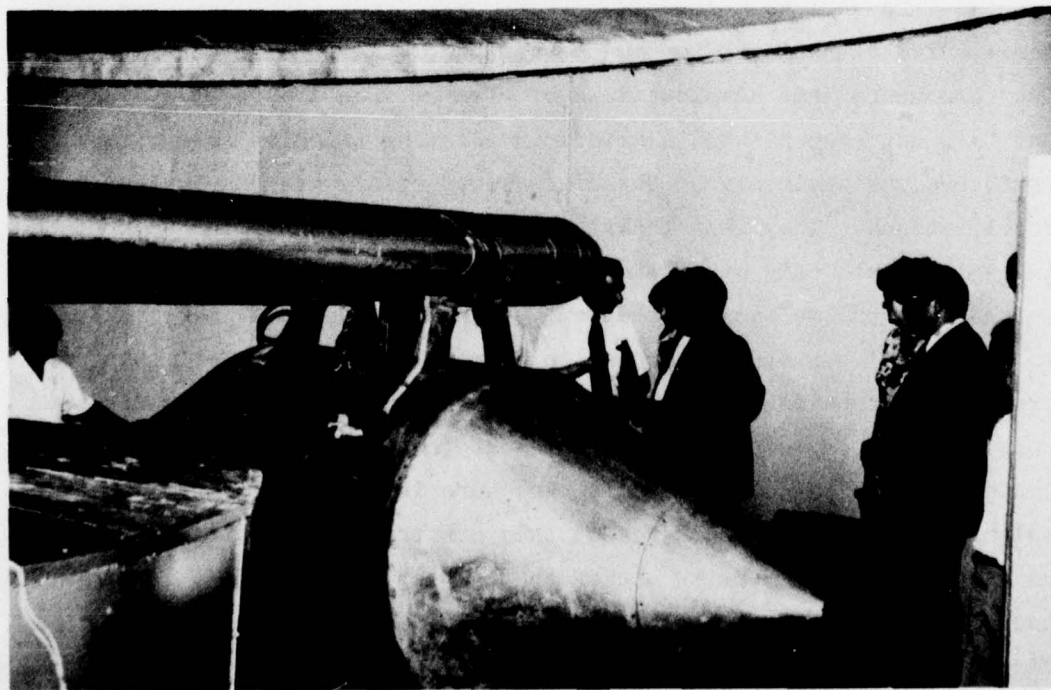


Figure 3. Interior of 500-g centrifuge facility in Baku

Design considers the aerodynamic loading to be proportional to the speed of loading. Tests are conducted under a partial vacuum of about 0.5 atmospheres. This lessens the resistance by two or three times. An elaborate control room is located in an adjoining building. Tests can be monitored on two TV screens. They have tested soil samples; however, most of the work has been done on soil structure interaction using models of concrete constructions (see Figure 4). The chamber is 1.5 m in length by 80 cm wide by 1 m high. A maximum of 500 g can be imposed at 300 rpm. Two 1500-kg samples can be tested at a time in the streamlined pods. Provisions are made for 170 measurements with electrical slip rings. Dr. Aliev found that conventional (Russian) slip rings did not work well so he designed his own. A test was conducted during our visit; extremely little vibration was noted.

37. In the afternoon we were taken on a guided tour through a new home-window air-conditioning factory which was designed and equipped by the Japanese. It now produces 800 units per day. They expect to

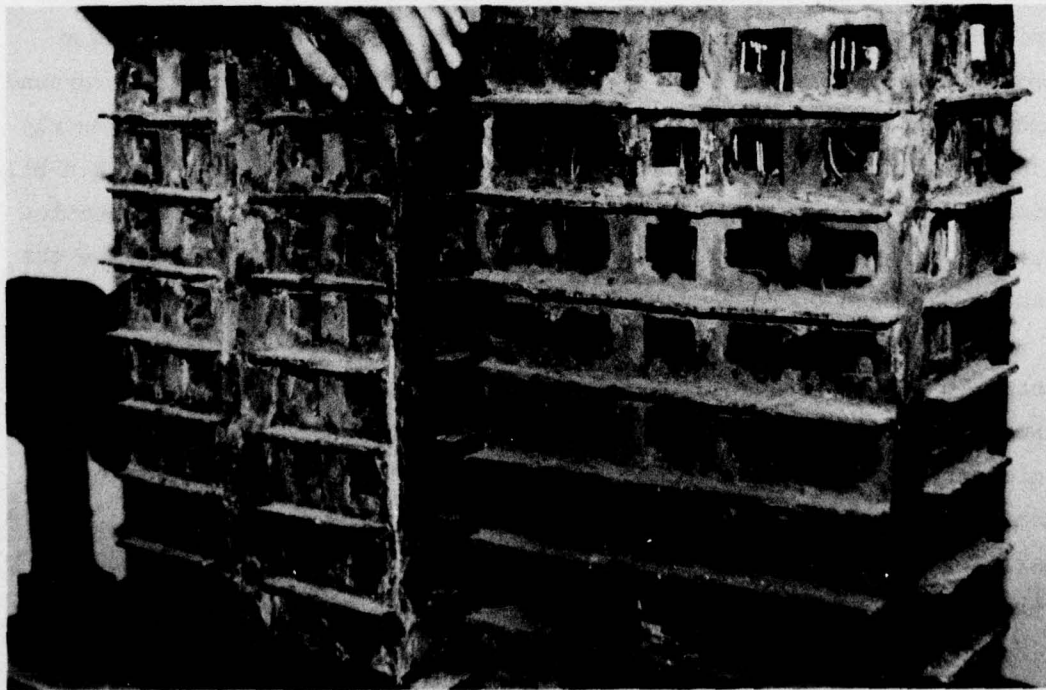


Figure 4. Example of model structures tested in 500-g centrifuge

produce 1500 per day within a year. Afterwards, we were taken to the shore of the Caspian Sea for dinner and swimming. The water was very salty and warm, but refreshing.

38. Dr. Aliev has written a new monograph on centrifuge testing which he will send to the U. S. and to Professor Schofield, who will have it translated and will publish it in English.

Erevan, Armenia

39. On Saturday, 25 June, we flew to Erevan, Armenian SSR. We were met at the airport by R. A. Badalyan, Director of ArmNIISA (Armenian Institute of Construction and Architecture), L. Koorbanian (of Armenian Gosstori) and Dr. E. E. Hachiyani (of ArmNIISA). After arranging for the arrival of the baggage, they took us to our hotel. In the evening we were taken on a sightseeing tour of the city of Erevan (the monument to Armenians killed by Turks, 2,000,000 in 1915; the Victory monument; the statue of Mother Armenia; Victory Park).

40. On Sunday, 26 June, we were taken to see the Sevan-Razdan Cascade Hydroelectric Stations. This system consists of six hydroelectric stations on the Razdan River, which connects Lake Sevan (2000 m above sea level) to Erevan, approximately 80 km south. Both underground and aboveground stations were inspected. The gradient is approximately 1:60. The system was completed in 1962 and the annual output is 2.3 billion kwh. In addition, the water is used for irrigation. Construction quality was particularly good. In the evening we were taken to see the famous Armenian opera "Anush" (based on a Romeo-Juliet theme).

41. On the afternoon of 27 June, we met with G. G. Agababyan, Chairman of Gosstroi, Armenian SSR. He showed us a seismic map of Armenia which designates regions of 7, 8, 9 (Soviet 12-point seismic intensity scale similar to modified Mercalli): 9 is equivalent to a horizontal acceleration of 0.1 g, 8 to 0.05 g, and 7 to 0.025 g. The maximum in Armenia is 9. If in highly populated region, they add 1 point, that is, say for 9, horizontal acceleration would be $0.1 + 0.1 = 0.2$ g.

42. Dr. E. E. Hachiyani has placed and activated heavy vibrators on buildings (up to 16 stories). In summary he found:

<u>Type of Structure</u>	<u>Number of Stories</u>	<u>Period of Ambient Vibrations, sec</u>	<u>Velocity m/sec</u>
Large stone-block walls	5	0.2-0.3	600-750
Large panel construction	9	0.3-0.4	800-900
Reinforced concrete	9	0.6	600
	10	0.8	200
	14	1.1	210
	16	1.3	330
Steel framed	16	1.35	228

He also published a book (in Russian) on his findings.

43. In the afternoon we went to the Institute of Geological Science where Dr. Aslanian, Director, went into considerable detail on the geological nature of Armenia. These are active faults. There exists much gypsum--and, hence, there are many problems if water is also present. There are also many (very active) landslide areas which we were later shown by Dr. G. I. Ter-Stepanyan. Landslide activity has been generated by earthquakes, particularly along faults.

44. The landslide region is about 25 km from Erevan. The slopes are very steep and the region is complex, from a geologic point of view, river valley. Movements of 60 cm/year are regularly recorded over one landslide which covered an area of 50 to 60 ha. Road maintenance is a constant problem. On the return trip, we visited an ancient Armenian monastery, cut into the mountains, and recently reconstructed 1st Century Greco-Roman temple. In the evening, we were taken to an Armenian Folk concert.

45. On 28 June, we met with Dr. Aryutyunyan of Gosstroi and discussed groundwater problems. They have developed special aluminum well-point filters, details of which were not available. Standard procedure is to use vacuum drawdown for temporary control of groundwater. The major seepage problems occur in tunnel construction in mountains; sometimes under as much as 500 ft of rock. In the afternoon, we visited Armenian Vatican at Ecmiadzin, the domicile of the Armenian Patriarch: the "Catholicos." In the evening, Mr. Agababyan hosted a magnificent farewell party for us.

Tbilisi, Georgia

46. On 29 June, we flew to Tbilisi, Georgian SSR. We were met at the airport (the most elaborate and most attractive air terminal we saw in the USSR) by T. K. Kutateladze, Deputy Chairman (Chairwoman) of Gosstroi Georgian SSR and two assistants. They were to be our guides in Georgia. After checking into our hotel, we were taken to meet Lado Gudiashvili, who is a world-renowned painter, and Koba Guruli, who is equally renowned for his metalcraft. Both men were extremely hospitable and very friendly. In the evening we were dinner guests of Georgian geologists, agronomists, and city engineers.

47. On 30 June we met with I. N. Tsitsishvili, Chairman of Gosstroi Georgian SSR. He told us about Georgia: 1,000,000 people in Tbilisi; 5,000,000 in Georgia, 40 percent of republic is rock with seismic intensities of 7 to 8. If they build on rock, they decrease horizontal accelerations by one point (paragraph 41 above); there is also considerable peat to be found in Georgia.

48. The city of Tbilisi is in a long, narrow (Kura) river valley. New construction will center around a new reservoir to the left of the river. They do have a subway now which they intend to extend into new areas. They anticipate considerable seepage problems. Buildings in Tbilisi are limited to 20 stories.

49. Gosstroi has complete design responsibilities for all new buildings, railroads, roads, transmission lines, nuclear power plants, and location of airports; but they have no maintenance responsibilities. The chairman conceded that this and very low rental charges could be the reasons for the apparent poor maintenance level of dwellings one sees in the USSR. He noted that they can build better quality structures, but they had decided some time ago that the need was for providing the cheapest and fastest buildings. Each year there is a marked increase in space allocated per family. He stated that the next thrust will be directed toward better quality control.

50. We then visited the Georgia Geographic Institute, which houses a large shake table. The Director of the Institute, Professor K. Zabriev, welcomed us. A number of people sat around a table telling us

various things. One told us that the use of piles has often been prohibited in Tbilisi because it was thought they would cause too much settlement. (This was a strange statement, later shown to be wrong.) The Soviet code prohibits friction piles in seismic regions of intensity 9. They have used the El Centro earthquake records extensively. They have used the shake table among other things to investigate the stability of slopes for road construction.

51. Professor Napetvaridze, who does much of the seismic design, stated that the shake table was 6×6 m with 3 deg of freedom. It was activated by hydraulic jacks and could get 50 Hz. Unfortunately, it was being worked on, and, hence, we could not see it. They had no experience with liquefaction. They are doing some finite element work, but apparently not on an advanced level. They have put 20-ton vibrators, 5-50 Hz on buildings, but no results are available.

52. In the afternoon, we visited the Georgian Research Institute of Energetics and Hydraulic Engineering Construction (GrozNIIEGS). The Director, Dr. G. I. Schogovadze, described the responsibilities of his organization. His was one of only two such agencies in the USSR; the other was in Leningrad. They had the responsibility of all energy resources in the Caucasus. The Institute consisted of 36 departments and laboratories. Of all energy, 75 percent is hydroelectric; the rest are nuclear, coal, oil, etc. They also have some thermal springs (30 to 100 deg C). He estimates that the USSR uses only about half its present potential. They are presently very much interested in a new arch dam (about 270 m high) in Western Georgia: Inguri Dam; we would see models of dam later.

53. Professor Djiev, the head of bases and foundation work, told us his main interest is in loess soils, which are plentiful in Georgia. He is also doing work with soil anchors and cement stabilization. He did not volunteer to show us his laboratory.

54. Professor Gugidze told us very briefly about some theoretical and model studies of the dynamics of arch dams. When asked his opinion of the relative stability of rock-fill dams versus earth dams with respect to seismic effects, he replied that rock-fill dams were better.

They had observed some seismic activity upon filling of reservoirs. In a high seismic risk area they recommended two types of dams: rock-fill or arch...the preference is a matter of economics.

55. Professor Chanishvili showed us two scale models of Inguri Dam (1:100 and 1:30) which were being used to study the erosion of the downstream banks and channel due to discharge. The 1:30 model was very impressive.

56. In late afternoon we visited the new stadium of Tbilisi (75,000 seats), which was built on short piles. We then met with the Chief of City Planners and his staff. In the evening we were dinner guests of GrozNIIIEGS.

57. On 1 July, we were given a guided tour through the newly renovated city opera house. The old building had been completely gutted and completely rebuilt. The quality of construction was at a very high level. In the afternoon, we were taken on a cultural tour of the environs of Tbilisi, including some ancient churches (under repair) and the ancient capital of Georgia. The city engineer of Tbilisi was our guide and our host at dinner.

Kishinev, Moldavia

58. On Saturday, 2 July, we flew to Kishinev, capital of Moldavia (formerly known as Bessarabia). We were met at the airport by V. Litviak of Gosstroï, Moldavian SSR and V. G. Taranov, Chief of NIIOSP experimental station. Kishinev (480,000 people; 4,000,000 in Moldavia) was almost completely destroyed in World War II. It is a very modern city with row upon row of high-rise dwellings interspersed with large parks and tree-lined boulevards. Foundation soils consist primarily of loess which tend to collapse when wetted.

59. After lunch we were taken to the site of a future duck farm. It is estimated that 750,000 ducks will be processed per year. The buildings are founded on bored cast-in-place piles, 10 m (\pm) deep. The foundation appeared much too elaborate for the buildings. They probably could have gotten by with spread footings; when asked, they said that the pile boring equipment was available, hence, was used. They have experimented with forming footing foundations by dropping a heavy cone

shaped hammer in the ground and filling the hole, thus formed, with concrete.

60. The countryside around Kishinev was covered with vineyards, fields of corn and fish ponds. All appeared very well kept. We were taken to the "Romaneshti" winery, where we were given a number of local wines to taste. They were the equal of the better wines of France.

61. On Sunday, 3 July, we were taken to the Moldavian Institute of Construction (Moldgiprostroï). P. G. Shipko, Chief Engineer of the Institute, began the conversation in very good English. Two-thirds of the soils of Moldavia are loess soils (silty-sands). Rock is very deep, and, hence, they make considerable use of friction piles, generally 8 m cast-in-place. For high-rise buildings, 20 stories, they use raft foundations. They are aware of potential liquefaction and make special efforts to drive through those layers where the potential exists. In response to our question, they stated that there had been no experience with liquefaction failure during earthquakes. Adobe buildings did not fare well at the time of the Rumanian earthquake of March 1977. Modern structures showed little or no damage. The Rumanian earthquake, with its epicenter 500 km from Kishinev, produced an intensity of 6.5.

62. Mr. N. S. Fisher, Chief of the Technical Branch, took over the discussion. He spoke perfect English (he had been in England during World War II). Subsiding soils were a severe problem for them before developing ramming with heavy weights (2-1/2 to 3 tons, falling 4 to 5 m). They are able to get very good compaction to depths of 1 to 1-1/2 m. Sometimes they use 4 to 5 tons through 6-m drop to compact to depths of 2-1/2 to 3 m. They found that piles (30 to 70 tons) solved the problem of saturated sands. They do not use battered piles. Their major responsibility is the construction of 15-story structures. They believe the use of basements, for inspection and maintenance, has reduced the effects of earthquakes. They have located active faults in Moldavia, although most epicenters are in the Carpathian Mountains. They have prepared seismic intensity maps which are used to give lateral accelerations. They favor the Chilean construction procedure where they excavate material below the structure, then drive piles and backfill the

excavation with granular material. The structure is placed on the surface of the ground with the granular soil providing a cushion between the bottom of the structure and the top of the piles. They have used explosives at the bottom of boreholes to provide lateral compaction. They perform tests at every site, usually cone penetrometers with sleeves, and they often instrument new structures. They like to use box panel foundations to reduce seismic effects (this is like a cellular basement). The record of the Rumanian earthquake surprised them. It showed small periodic displacement followed by rather large periodic displacements. The maximum recorded horizontal acceleration in Rumania was 0.1 g; in Moldavia, 0.05 g was recorded. Stone buildings showed some distress, rigid structures performed well, and box panel design was best performer. Messrs. Fisher and Shibko were very impressive. We were most appreciative of their spending Sunday morning with us.

63. We were taken to a food processing plant under construction which employed cast-in-situ concrete piles. The superstructure, including trusses, were reinforced concrete. The foundation was set on groups of 4 piles. Piles were installed at the rate of 4 to 6 per day. Each pile contained 7 percent steel reinforcement to resist seismic loadings.

64. We were then taken to the site of a new structure. The building was to be constructed by using vertical slip-forms. The structure, 22 x 42 m, rested on a raft 1.3 m thick. The walls were 18 to 22 cm of reinforced concrete. The structure was to be 26 stories. Another method, soon to be tried, will build a story, then jack it up, placing another under it, etc. They estimate that 40 men can provide two stories per month using slip-form construction versus 12 men producing the same for precast construction. That is because of less familiarity with monolithic construction. However, this type uses less steel.

65. On the afternoon of 4 July, we met with Mr. O. K. Lintvarov, Deputy Chairman of Gosstroi, Moldavian SSR. He apologized to us for the Chairman not being present to meet us. He repeated much that we had already learned about Moldavia and its construction problems. He did note that 30 percent of dwellings in the republic were monolithic. According to USSR codes, panel construction is limited to nine stories;

that is why they are turning to monolithic construction. Much of the construction involves small structures for agricultural purposes.

66. In the afternoon we visited the NIIOSP experimental station where we were met by V. G. Taranov, Chief of the Laboratory. Unfortunately, it began to rain quite heavily as we arrived at the site. Taranov noted that the site was set up in 1972 to conduct prototype experiments on different types of foundation materials and designs, with particular emphasis on seismic effects and foundations for vibrating machines. They also conduct similar work at other sites in USSR (Zagorsk, for example). They perform tests and check calculations when methods are available. Otherwise, they develop new procedures. They have conducted many tests with tapered (pyramidal) piles, 3 to 5 m long. They registered increased bearing capacity for same volume of concrete over rectangular uniform piles. They have no soil testing facilities. They also perform pile tests on jobsites. They have often tested groups of three and four piles, maximum static load of 100 T. They have also performed vibratory tests (simple harmonic motion) and have tested piles to failure. They have recently completed a study wherein they induced realistic seismic effects by using combinations of explosives at various lateral distances and depths. Due to the heavy rainfall and lack of time, we were not able to visit the field installation.

67. In the evening we flew back to Moscow. Professor Harr presented a lecture on "Reliability of Soil Structures" at NIIOSP in Moscow to about 100 people on 5 July; Mr. K. I. Suslova translated. Professor Harr left Moscow on 6 July.

68. Mr. Sherman reviewed results of study tour with representatives of NIIOSP on 7 July and signed official memorandum, summarizing results of study tour. He left for Tokyo, Japan, on 7 July. The memorandum (in English and Russian) is shown in Appendix A.

Japan

69. Mr. Sherman met Professor M. Mikasa, Osaka City University, who has been conducting centrifuge tests since 1966. His equipment and program are described in the technical literature and involved tests for both basic research and practical design works. He recently increased the

rotational radius of his centrifuge from 1 to 1.55 m, and the container enlarged to 50 × 30 × 16.5 cm. Samples with weights up to 200 g can be tested in swinging buckets. Water tanks are provided on the buckets to permit water loadings on the models. Professor Mikasa considers centrifuge model testing to be a reliable and effective means for investigating practical problems of slope stability and bearing capacity. There was no opportunity to visit Professor Mikasa's centrifuge; however, he suggested a visit to the centrifuge at the Tokyo Institute of Technology which had a more advanced model of his centrifuge.

70. The centrifuge at the Tokyo Institute of Technology is operated under the direction of Professor T. Kimura. It is used primarily for research by graduate students. It has a diameter of 1 m and handles two swinging buckets of relatively small size. Research on consolidation of clays has been performed, although most tests have been with dry sand. Unusual features include a device for conducting in-flight bearing capacity tests with small footings, dual arms with provisions for tilting the specimen to simulate a horizontal loading for earthquake conditions, and radiographic equipment for monitoring development of internal deformations and slip surfaces. The instrumentation and recording equipment appeared to be well designed and apparently give excellent results. Some of the techniques could profitably be considered for application to future centrifuge construction in the U. S.

Recommendations

71. There is, at the present time, no large centrifuge for geotechnical studies in the U. S. This is a very serious shortcoming. Experiences in Western Europe, Russia, and Japan have demonstrated the applicability of such devices to provide information as to the performance of soil structures at phenomenological as well as quantitative levels. Many problems facing the U. S. Corps of Engineers are amenable to this approach; for example, the liquefaction of Mississippi River banks, the stability of new and existing dams under seismic loading, etc.

72. In France and in Russia designs are being developed for the next generation of centrifuges. Their value is beyond question. It is the opinion of the writers that a concerted effort should be made to ameliorate the present situation and provide centrifugal testing capabilities in the U. S.

73. Future technical exchange visits under the U. S./USSR Joint Working Group 10.05 should include visits by U. S. specialists to institutions in the USSR with large centrifuges. A visit of two months to work with the centrifuges at Hydroproject Institute in Moscow and the AzNIISM Institute in Baku would be exceedingly profitable.

APPENDIX A: MEMORANDUM

1. In conformity with the agreed programme of scientific-technical co-operation and the resolutions adopted at the Second meeting of the joint USSR-USA Working Group 10.05 "Building for Extreme Climates and Unusual Geological Conditions" (Protocol, signed on April 28th, 1977) there was received on the equivalent exchange terms (the principle "receiving side pays") at NIIOSP, Gosstroi USSR, a group of U. S. experts, namely:

- a. Mr. W. C. Sherman - Supervisory Civil Engineer, the U. S. Army Engineer Waterways Experiment Station.
- b. Mr. M. E. Harr - Professor, School of Civil Engineering, Purdue University.

2. Within the period from June 19 up to July 8, 1977 the U. S. experts visited Moscow and took part in a study tour to Baku of the Azerbaidjan SSR, Erevan of the Armenian SSR, Tbilisi of the Georgian SSR and Kishinev of the Moldavian SSR.

3. Itinerary for the group of the U. S. experts is given in Appendix 1.

4. The purpose of the U. S. expert trip was to become familiar with various design methods, based on utilization of the centrifuge modeling method, and also with the practice of pile foundation, engineering under different geological conditions.

5. During their stay in the USSR the U. S. specialists had all the opportunities to become familiar with problems which are as follows:

- a. Centrifugal modeling techniques, used for investigations of bearing capacity of footing foundations for industrial and hydrotechnical constructions (NIIOSP, Institute "Hydroproject", Moscow).
- b. Centrifuge modeling studies concerning the seismic stability of structures, erected under various geological conditions in the Azerbaidjan SSR (AzNIICM after Badashev, Baku).
- c. Investigations in the field of geology, structural geology, soil mechanics, rheology and vibrocreep of soils (Geological Institute, Academy of Sciences ArmSSR, Erevan).

- d. Techniques for lowering ground water table and hydroisolation for foundation parts of structures (ArmNIIS, Erevan).
- e. Techniques for construction of multistory dwellings on weak soils, their stability testing, and also methods for studying friction pile behaviour (ISM&S Academy of Science Georgian SSR, Tbilisi).
- f. Calculation methods, field and model investigation of hydrotechnical structures (Georgian NIEGS, Tbilisi).
- g. Techniques for improving the engineering properties of subsiding and expansive soils as foundations used in construction of rural, industrial and dwelling structures under various geological conditions of the Moldavian SSR (Moldgi-prostroy, Kishinev).
- h. Design and construction techniques for building 18-20 stores administrative and dwellings in the city of Kishinev (Minseljstroy Mold. SSR, Minstroy Mold. SSR).
- i. Investigations of various pile designs for geological conditions of the Moldavian SSR (NIIOSP Experiment Station, Kishinev).

6. During their study tour the U. S. specialists had opportunities to meet with responsible members of the staff of the State Building Committees of the above-said Union Republics and to discuss problems of mutual interest.

7. The list of Soviet participants in these meetings is presented in Appendix 2.

8. The U. S. experts also were given all the opportunities to familiarize themselves in detail with the history, culture and art of the peoples in the Caucasus and Moldavia and to visit architectural monuments, historical places and Museums pertaining to the folk arts in Baku, Erevan, Tbilisi and Kishinev.

9. The U. S. experts expressed their deep satisfaction with the results of the study tour and also expressed their gratefulness to the Soviet Side for the excellent and well-organized preparations for their visit in the USSR.

10. The present memorandum is written both in Russian and in English languages.

11. Each side will have one copy of the Russian and English texts of the Memorandum.

12. Signed in Moscow, USSR, on 6 July 1977 in Russian and English,
both texts equally authentic.

For the American Side

W. C. Sherman, Jr.

Mr. W. C. Sherman, Jr.,
Supervisory Civil Engineer
U. S. Army Engineer Waterways
Experiment Station
Member of the U. S. side of the
joint USA-USSR Working Group
10.05

U S A

For the Soviet Side

G. V. Porkhaev

G. V. Porkhaev,
Professor, Dr. Sc. Deputy
Chairman of the USSR side
of the joint USSR-USA
Working Group 10.05

U S S R

APPENDIX 1: SCHEDULE OF VISIT OF TWO U. S. SPECIALISTS
(MR. SHERMAN AND PROFESSOR HARR) TO THE USSR
FOR THE PERIOD 19 JUNE-8 JULY 1977
THE USSR-USA WORKING GROUP 10.05

<u>Day :</u>	<u>Date:</u>	<u>Departure:</u>	<u>Arrival:</u>	<u>Flight:</u>	<u>Daily Programme</u>
<u>1</u>	<u>1977:</u>	<u>2</u>	<u>3</u>	<u>N :</u>	<u>6</u>
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Sun.	VI-19	London	Moscow	SU-581	Meeting at the airport "Scheremetjevo", Visiting the U. S. Embassy in Moscow. Hotel accommodation. Free time.
Mon.	VI-20	Moscow			Visiting NIIOSP. Meeting with Deputy Co-Chairman of the USSR-USA Working Group 10.05. Coordination of the schedule of visit. Familiarization with Soil Dynamics Laboratory, Centrifugal Modelling Laboratory and Experimental Station.
Tues.	VI-20	Moscow			Visiting Institute "Fundamentproject", Familiarization with designing and testing methods for pile foundations. Visiting Institute "Hydroproject". Familiarization with Centrifugal Modelling Laboratory. Discussions with the Lab. staff.
Wed.	VI-22	Moscow	Baku	SU-861	Wheels up for the Azerbaijan SSR. Meeting at the Baku Airport. Hotel accommodation. Sight-seeing about the city.
Thu.	VI-23	Baku			Visiting Gosstroi Az. SSR. Visiting Engineer Research Institute Familiarization with Bases and Foundations Lab. Discussions with Lab. staff.
Fri.	VI-24	Baku			Visiting Projects completed and under construction. Cultural outing.

<u>Day :</u>	<u>Date:</u>	<u>Departure:</u>	<u>Arrival:</u>	<u>Flight:</u>	<u>Daily Programme</u>
<u>1</u>	<u>1977:</u>	<u>2</u>	<u>3</u>	<u>N :</u>	<u>6</u>
		<u>4</u>	<u>5</u>		
Sat.	VI-25	Baku	Erevan	SU-6645	Wheels up for the Armenian SSR. Meeting at the Erivan Airport. Hotel accommodation. Sight-seeing about the city.
Sun.	VI-26	Erevan			Visiting the Razdan hydro-power complex. Cultural outing.
Mon.	VI-27	Erevan			Visiting the Erevan State University, Institute of Mechanics of the AS Arm. SSR Familiarization with the studies in Soil Mechanics, Soil Rheology, Soil Vibro-Creep and Slope Dynamics.
Tues.	VI-28	Erevan			Visiting Projects completed and under construction.
Wed.	VI-29	Erevan	Tbilisi	E-21	Wheels up for the Georgian SSR. Meeting at the Tbilisi Airport. Hotel accommodation.
Thu.	VI-30	Tbilisi			Visiting Gosstroi GRRS. Visiting the Georgian Polytechnical Institute. Familiarization with studies in Soil Mechanics and Soil Dynamics.
Fri.	VII-1	Tbilisi			Visiting projects under construction.
Sat.	VII-2	Tbilisi			Sight-seeing about the city. Cultural outing.
Sun.	VII-3	Tbilisi	Kishinev	SU-7726	Wheels up for the Moldavian SSR. Meeting at the Kishinev Airport. Hotel accommodation. Sight-seeing about the city. Cultural outing.
Mon.	VII-4	Kishinev			Visiting Gosstroi Mold. SSR. Visiting NIIOSP Seismic Experimental Station.

<u>Day :</u>	<u>Date:</u>	<u>Departure:</u>	<u>Arrival:</u>	<u>Flight:</u>	<u>Daily Programme</u>
<u>1</u>	<u>1977:</u>	<u>3</u>	<u>4</u>	<u>N :</u>	<u>6</u>
	<u>2</u>			<u>5</u>	
		Kishinev	Moscow	SU-1750	Wheels up for Moscow. Meeting at the Airport "Vnukovo" Hotel accommodation.
Tues.	VII-5	Moscow			Visiting NIIOSP. Lecture by Prof. Harr.
Wed.	VII-6	Moscow	London	12:00 a.m.	Departure of Prof. Harr for London, England.
		Moscow			Mr. Sherman's visit to NIIOSP Final negotiations.
Thu.	VII-7	Moscow			Visiting NIIOSP. Signing of Protocol.
Fri.	VII-8	Moscow	Tokyo	Subject to definition	Departure of Mr. Sherman for Tokyo, Japan.

APPENDIX 2: LIST OF THE SOVIET PARTICIPANTS
IN THE MEETINGS

1. Porkhaev, G. V. Professor, Deputy Chairman of the Soviet part of the joint USSR-USA Working Group 10.05.
2. Izmailov, Ya. P. Chairman of Gosstroi Azerbaijan SSR.
3. Agaguseinov, R. Ya. Deputy Chairman of Gosstroi Azerbaijan SSR.
4. Musabekov, F. Z. Director of AzNIISM after Dadashev.
5. Aliev, G. A. Chief Laboratory AzNIISM after Dadashev.
6. Rzaev, S. A. Chief GlavBakstroya.
7. Agababyan, G. G. Chairman of Gosstroi Armenian SSR.
8. Badalyan, R. A. Director of ArmNIISA.
9. Hachiyan, E. E. Chief Laboratory ArmNIISA.
10. Aryutyunyan, R. N. Chief Laboratory ArmNIISA.
11. Ter-Stepanyan, G. I. Chief Laboratory, Geological Institute, Academy of Sciences, ArmSSR.
12. Tsitsishvili, I. N. Chairman of Gosstroi Georgian SSR.
13. Kutateladze, T. K. Deputy Chairman of Gosstroi Georgian SSR.
14. Chkuaseli, N. P. Chief branch Gosstroi Georgian SSR.
15. Djabua, Sh. A. Vice-director ISMIS Ac. Sc. Georgian SSR.
16. Kareselidze, N. B. Vice-director Georg. NIIEGS
17. Gogichadze, G. D. Manager of building trust Minstroya Georg. SSR.
18. Lintvarov, O. K. Deputy Chairman of Gosstroi Moldav. SSR.
19. Shipko, P. G. Chief engineer institute "Moldgiprostroï".
20. Fisher, N. S. Chief of technical branch institute "Moldgiprostroï".
21. Taranov, V. G. Chief of NIIOSP experimental station Kishinev.
22. Sadvskii, A. V. Secretary of the Soviet part of the joint USSR-USA Working Group 10.05.
23. Vasilevskii, A. A. Chief Engineer NIIOSP
24. Suslova, E. I. Interpreter.

ПАМЯТНАЯ ЗАПИСКА

В соответствии с согласованной программой научно-технического сотрудничества и решениями второй встречи совместной советско-американской Рабочей Группы IO.05 "Строительство в районах со сложными геологическими и климатическими условиями" (Протокол от 28 апреля 1977г.), НИИОСП Госстроя СССР принял на условиях безвалютного эквивалентного обмена (принцип "принимающая сторона платит") группу американских экспертов в составе

1. г-н У.К.Шерман - Инженер-инспектор Экспериментальной станции водных путей Армии США.
2. г-н М.Е.Харр - Профессор Высшей школы гражданского строительства, Пердьюсский Университет.

В период с 19 июня по 8 июля 1977г. американские специалисты посетили г.Москву и совершили ознакомительную поездку в г.Баку Азербайджанской ССР, г.Ереван Армянской ССР, г.Тбилиси Грузинской ССР и г.Кишинев Молдавской ССР.

Программа пребывания группы американских экспертов приводится в Приложении I.

Цель поездки американских экспертов заключалась в ознакомлении с методами проектирования, основанных на использовании результатов центробежного моделирования, а также практикой советского фундаментостроения в различных геологических условиях.

За время пребывания в СССР американским специалистам была предоставлена возможность ознакомиться со следующими вопросами:

- методами центробежного моделирования, применяемыми для исследований несущей способности оснований фундаментов промышленных и гидротехнических сооружений (НИИОСП, Институт "Гидропроект", г.Москва);

- модельными исследованиями с помощью центрифуги прочности надземных конструкций гражданских сооружений, возводимых с учетом геологических условий Азербайджанской ССР (АзНИИСМ им. Дадашева, г. Баку);
- исследованиями в области геологии, тектоники, механики, реологии и виброползучести грунтов (Институт геологии АН Армянской ССР, г. Ереван);
- методами понижения уровня грунтовых вод и гидроизоляции фундаментной части сооружений (АрмНИИС, г. Ереван);
- методами строительства многоэтажных жилых зданий на слабых грунтах, их испытания на устойчивость, а также методами исследования работы висячих свай (ИСМиС АН Грузинской ССР, г. Тбилиси);
- методами расчета, модельными и полевыми исследованиями гидротехнических сооружений (Груз. НИИЭГС, г. Тбилиси);
- способами улучшения строительных свойств просадочных и набухающих грунтов, а также применяемыми типами фундаментов сельскохозяйственных, промышленных и жилых объектов для геологических условий Молдавской ССР (Молдгипрострой, г. Кишинев);
- методами проектирования и возведения 18-20-этажных общественных и жилых зданий в г. Кишиневе (Минсельстрой МССР, Минстрой МССР);
- исследованиями различных типов свай в геологических условиях Молдавской ССР (Экспериментальная станция НИИОСП, г. Кишинев).

Во время ознакомительной поездки американские специалисты имели возможность встретиться с ответственными представителями Государственных комитетов по делам строительства названных союзных республик и обменяться мнениями по вопросам, представляющим взаимный интерес.

Список участников встреч от Советской стороны приводится в Приложении 2.

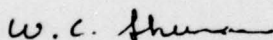
Американским экспертам также была предоставлена возможность подробно ознакомиться с историей, культурой и искусством народов Кавказа и Молдавии; архитектурными памятниками, историческими местами и музеями прикладного искусства в гг. Баку, Ереване, Тбилиси и Кишиневе.

Американские эксперты выразили полное удовлетворение результатами своей поездки и выразили глубокую признательность Советской стороне за хорошую и содержательную организацию их пребывания в СССР.

Настоящая Памятная записка составлена на русском и английском языках. Каждая сторона будет иметь по одному экземпляру русского и английского текстов Памятной записки.

Подписано в г.Москве, СССР, 6-го июля 1977г. на русском и английском языках, оба текста идентичны.

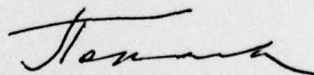
От Американской Стороны



У.К.ШЕРМАН
Инженер-инспектор Экспериментальной станции водных путей Армии США
Член Американской части совместной США-СССР Рабочей Группы IO.05

С Ш А

От Советской Стороны



Г.В.ПОРХАЕВ
Профессор, доктор технич.наук
Заместитель Председателя Советской части совместной СССР-США Рабочей Группы IO.05

С С С Р

Приложение I

П Р О Г Р А М М А
 пребывания в СССР американских специалистов
 г-на В.К.Шермана и проф. М.Е.Харра, принима-
 емых по линии рабочей группы IO.05 в период
 с 19 июня по 8 июля 1977г.

Дата	Мероприятие и место проведения
19 июня воскресенье	Прибытие в Москву, встреча в аэропорту Шереметьево. Посещение посольства США. Размещение в гостинице. Отдых.
20 июня понедельник	Посещение НИИОСП, ознакомление с лабораторией динамики грунтов, экспериментальным корпусом, с установкой центробежного моделирования
21 июня вторник	Посещение ГПИ "Фундаментпроект" Ознакомление с методами проектирования и испытания свайных фундаментов. Посещение НИС Гидропроекта. Ознакомление с методами центробежного моделирования.
22 июня среда	Вылет в г.Баку авиарейсом 861 (11.35 час) Прибытие в г.Баку, размещение в гостинице, знакомство с городом.
23 июня четверг	Посещение Госстроя АзССР. Посещение инженерно-строительного института. Ознакомление с работами кафедры "Основания и фундаменты".
24 июня пятница	Посещение строительных объектов.
25 июня суббота	Вылет в г.Ереван авиарейсом 6645 (11.30час) Прибытие в г.Ереван, размещение в гостинице
26 июня воскресенье	Осмотр гидроэлектростанции Разданского каскада.
27 июня понедельник	Посещение Ереванского Государственного Университета и института механики АН АрмССР Ознакомление с исследованиями в области механики, реологии и виброползучести грунтов. и динамики склонов.
28 июня вторник	Посещение строительных объектов, ознакомление с городом
29 июня среда	Вылет в г.Тбилиси авиарейсом Е-21 (15.40) Прибытие в г.Тбилиси, размещение в гостинице

1	2
30 июня четверг	Посещение Госстроя ГрузССР. Посещение Грузинского политехнического института им. В.И. Ленина. Ознакомление с исследованиями в области техники грунтов, оснований и фундаментов.
1 июля пятница	Осмотр строительных объектов
2 июля суббота	Тбилиси. Знакомство с городом. Отдых
3 июля воскресенье	Вылет в г. Кишинев авиарейсом 7726. (7.20) Прибытие в г. Кишинев, устройство в гостинице. Осмотр города.
4 июля понедельник	Посещение Госстроя Молд. ССР, ознакомление с сейсмополигоном НИИОСП. Вылет в Москву авиарейсом 750. Прибытие в Москву, размещение в гостинице.
5 июля вторник	Лекция проф. Харра в НИИОСП.
6 июля среда	Вылет проф. Харра в Лондон (12 час.) Ознакомление г-на Шермана с Москвой.
7 июля четверг	Посещение НИИОСП, согласование и подписание Протокола. Свободное время.
8 июля пятница	Вылет г-на Шермана в г. Токио. (время рейса уточняется)

Приложение 2

СПИСОК

участников встреч от советской стороны

1. ПОРХАЕВ Г.В. - Профессор, Заместитель Председателя Советской части совместной СССР-США Рабочей Группы IO.05.
2. ИЗМАЙЛОВ Я.П. - Председатель Госстроя Азербайджанской ССР.
3. АГАГУСЕЙНОВ Р.Я. - Заместитель Председателя Госстроя Азербайджанской ССР.
4. МУСАБЕКОВ Ф.З. - Директор Азербайджанского НИИСМ им. Дадашева.
5. АЛИЕВ Г.А. - Заведующий лабораторией Аз.НИИСМ им. Дадашева
6. РЗАЕВ С.А. - Начальник Главбакстроя
7. АГАБАБЯН Г.Г. - Председатель Госстроя Армянской ССР.
8. БАДАЛЯН Р.А. - Директор АрмНИИСА.
9. ХАЧИЯН Э.Е. - Заведующий лабораторией АрмНИИСА.
10. АРУТКНЯН Р.Н. - Заведующий лабораторией АрмНИИСА.
11. ТЕР-СТЕПАНЯН Г.И. - Заведующий лабораторией Института геологии АН АрмССР
12. ЦИЦИШВИЛИ И.Н. - Председатель Госстроя Грузинской ССР.
13. КУТАТЕЛАДЗЕ Т.К. - Заместитель Председателя Госстроя Грузинской ССР.
14. ЧКУАСЕЛИ Н.П. - Заведующий отделом Госстроя Грузинской ССР
15. ДЕЖАБУА Ш.А. - Заместитель директора ИСМиС АН ГрузССР
16. КАРЕСЕЛИДЗЕ Н.Б. - Заместитель директора ГрузНИИЭГС
17. ГОГИЧАДЗЕ Г.Д. - Начальник треста Минстроя ГрузССР.
18. ЛИНТВАРОВ О.К. - Заместитель Председателя Госстроя Молдавской ССР
19. ШИПКО П.Г. - Главный инженер института "Молдгипрострой"
20. ФИШЕР Н.С. - Начальник технического отдела института "Молдгипрострой"
21. ТАРАНОВ В.Г. - Заведующий экспериментальной станцией НИИОСП, г.Кишинев.
22. САДОВСКИЙ А.В. - Секретарь Советской части смешанной СССР-США Рабочей Группы IO.05.
23. ВАСИЛЕВСКИЙ А.А. - старший инженер НИИОСП
24. СУСЛОВА Е.И. - переводчица.