EXPERIENCE OF WORK OF STRONG MOTION REGISTRATION STATIONS DURING EARTHQUAKES IN THE SOVIET UNION

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SYNOPSIS

The information concerning the experience of work of strong motion registration stations during earthquakes in the Soviet Union (Engineering Seismometric Stations and Uniformed System of Seismic Observations) are discussed in the present paper. The paper is also concerned with the estimation of optimal quantity and dislocation of seismometric apparatus of the Engineering Seismometric Stations in different regions of the country taking into account seismic activity of the regions, ground conditions, use of modern constructive decisions of buildings and other factors. The considerations concerning the perspectives of the development of Engineering Seismometric Stations in the USSR and the main problems which necessary to be solved in the nearest future are discussed as well.

The first strong motion registration stations were organized on the territory of the USSR in the beginning of our centure. At present there are about 200 stations of the Uniformed System of Seismic Observations (USSO) in the USSR. Yet wide system of USSO stations can not answer the needs of engineers and scientists working in the region of earthquake engineering for a number of reasons. In particular, information concerning real character of deformations of different constructions during earthquakes is primarily necessary for builders. Especially it is essential relative to creation of constructions with complex constructive schemes. Data about vibrations of identical constructions in different ground conditions are of great interest as well. Uniformed System of Seismic Observations does not reply the mentioned and other similar questions. The main problem of USSO is the obtaining of instrumental data about seismic ground vibrations. The data are necessary for the solving of seismology problems: study of seismicity of various regions, seismic zoning, search of earthquake forerunners and so on. All these data only partly help to solve the problems of earthquake engineering. Therefore it was decided to

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organize system of stations for registration and record of seismic vibrations of buildings, constructions and adjacent ground regions.

The First Engineering Seismometric Stations (ESS) were organized in the USSR in I965-I966. At first seismometric instruments were installed only on some dwelling houses and civil constructions. Since I968 ESS stations have been installed on industrial and hydro-engineering constructions. Taking into account specific characters of the constructions of different types, various character of seismometric information, three main types of engineering seismometric stations for registration and record of seismic vibrations are elaborated:

- stations located on industrial and civil buildings and constructions;
- stations located on hydro-engineering constructions (dams of different types, locks, supporting walls and so forth);
- transport and other like constructions (bridges, tonnels, embankments, pipe-lines and so on).

ESS are provided with methodic materials (for instance, there are instructions on establishment of engineering-seismometric devices in these documents. There are parameters of the devices being installed on objects of each types, scheme of its location and recommendations on the operation of observation stations in the methodic materials as well). Sources of financial support of ESS installation works are determined at the cost of resources of capital construction. (I,2).

Fig.I presents a map of seismic active regions of the USSR territory (European part of our country; Central Asia, Siberia and Far East). There are registration stations of Uniformed System of Seismic Observations and Engineering Seismometric Stations on the map. System of ESS was organized according to the necessity to cover all seismic active zones of the USSR taking into account different intensities. Instruments are located in the buildings of various number of storeys and different constructive schemes of the objects of mass construction, located in different ground conditions. Fig.I (a,b,c,d) shows the diagrams characterizing the distribution of ESS depending on region seismicity, number of storeys and constructive characters of buildings, and on ground conditions of building sites as well.

Future work on developing of ESS of the USSR will direct to the solving of the following problems:

- organization of ESS in the regions of East Siberia, on Altai and Sayan;
- increasement of number of multy-storeyed buildings equipped with seismometric devices; of buildings and constructions located on muddy, loessial and clay soils.

In the nearest future it will be provided for:

I. To guarantee the registration and record of vibrations of adjacent ground parts at all stations; further equipment of the stations which are not equipped with three-component kits and instruments for recording of the earthquakes with intensities of 8-9 (as a result of deficiency of devices in the first years of the organizing of ESS). For this purpose about 600 units of various type devices are additionally provided to install at the stations: seismic detector VBP, S5S, oscillograph N-700 and others.

2. To provide the possibility to receive seismometric data which can be used for the determination of volumetric operation of constructions. Primarily it depends on the great number of devices which can be located at different levels within buildings and constructions. In this case it is necessary to achieve a high precision of identification of frequency-phase and frequency-amplitude instrument characteristics. Mutual synchronism of its records must be not lesser than 0.001 sec. On the basis of these data estimation of precision of different theoretical methods will be carried out. The methods have been elaborated for allowance of spartial work of construction during earthquakes last years. The conclusions concerning the reserves of load-carrying capacity of aseismic building constructions will be made.

3. To improve methods of record and registration of seismic vibrations. In some cases registration of vibration difference at two points in various combinations is turned out more effective but demands sharp concentration of devices on each building .

4. To provide records of the whole vibration process including longitudinal wave- It connects with the fact that short-period P-waves carry a considerable part of destructive effect, especially for massive constructions. Continuous record with all channels on each construction is difficult. Therefore the system of records of seismic vibrations must be in triggering regime but equipped with storage (2-3 sec.).

The authors analysed comparatively the possibilities of different storage (S). Taking into account the necessity of obtaining of registration data about volumetric operation of construction, technical conditions of record and storage make allowance for:

- range of registrated frequencies: 0-3 Hz;
- dynamic range of 60 db (10 binary classes);
- frequency of commutation (number of inquests of one channel in sec.) - 100 Hz;
- number of channels of ESS is 48;
- memory time is 2 sec.

Now the main instruments used in the system of ESS are those of analog type. Its shortcomings are small dynamic range, deficient precision, the necessity of future treatment of information, connected with transformation into digital code,

convinient for input into electronic computer. The more perspective direction is digital devices consisted of serial industrial units according to technical conditions mentioned above. The possibility of usage of storage in the systems with digital registration provides that each channel will be inquested I00 2 = 200 times and storage must remember 200 ten-class words. Storage capacity (SC) is 48 channels: 200 48 = 9600 ten-class words.

Four main technical methods of remembering of digital information (in real time) can be used:

I) Magnetic-drum memory (MDM). Drum diametre for parallel record of 9600 ten-class words is 305 mm when record density R is I0 impulses per I mm. The length of circumference of magnetic drum L is: L = SC/R = 9600/I0 = 960 mm.

2) Memory with displacement register (DR). Structurely the registration system with this type of memory is analogous the system with magnetic drums. When displacement register have capacity of I28 bit in an integral scheme (IS), its quantity necessaty for one class 9600/I28 = 80 units or for 9600 ten-class words is 800 units. In this case square of assembly plate for unsoldering of 800 integral schemes is I600 cm^2 (8 plates dimensions of which are 20 I0 cm). The use of integral scheme of more high capacity let us decrease the square of assembling. The required power of memory with displacement registers is less than I0 w.

3) Ferrite-cube memory (FCM). The usage of memory cubes has its specific character as our industry turns out cubes which are well conformed only with devices of control of a concreate electronic digital computer. Such devices have a high energy capacity; required power is hundreds and more watt The lesser reliability in comparison with the magnetic-drum memory and memory with displacement registers, and also great gabarits limit the use of these devices in autonomous systems of ESS. Ferrite-cube memory can be effectively used in large registration systems (for instance, in great hydro-engineering constructions).

4) Magnetic disk unit (MDU) is analogous to the system with memory cubes and can be used only with electronic digital computer.

In conclusion the authors note that the experience of exploitation of Engineering Seismometric Stations on record and registration of strong earthquakes (intensity of 7-9) which occured last years on the territory of the USSR (Bujnaksk, I970; Petropavlovsk-Kamchatskij, I97I; Gazli, I976) confirm expediency and effectiveness of its use. Information concerning seismic vibrations of buildings and constructions during these earthquakes: accelerations, velocities, displacements in graph and digital form and data of spectral and statistic treatment are presented in periodic publication "Instrumentation data of Engineering-Seismometric Stations in the USSR". The collected articles are prepared at the centre on collection and treatment of arrived information.

At the same time to provide the possibility of quick consentration of stations in epicentres of future earthquakes (with the aim of registration and record of vibrations during aftershocks) it is planned the organization of some complete sets of mobile engineering seismometric stations. These stations must be located on objects and be transported to the region of epicentre during earthquakes.

LITERATURE

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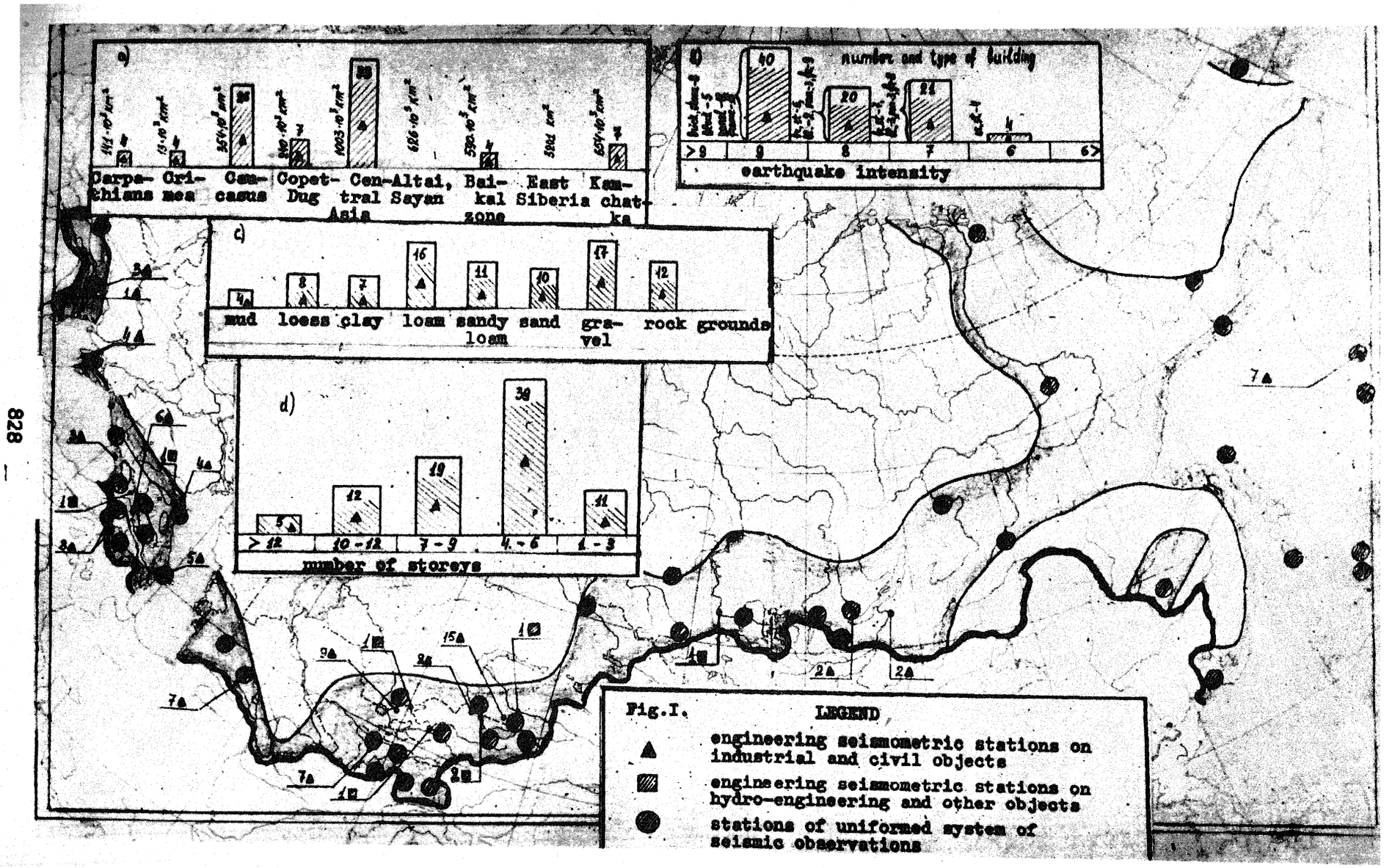

Fig.I.

LEGEND

- ▲ engineering seismometric stations on industrial and civil objects
- ▨ engineering seismometric stations on hydro-engineering and other objects
- ● stations of uniformed system of seismic observations