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SEISMIC SOIL PROPERTIES UNDER REACTOR BUILDINGS

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ABSTRACT

The majority of the nuclear power plants (NPP's) in Russia are located on soft sand-clay soils. The strength of these soils is comparable with loads transfered by main buildings. Therefore the study of natural seismic soil properties and technogenic-changed (under load of reactor building) conditions in situ is necessary. The purpose of the study is to obtain the initial soil properties for seismic design of the NPP's and to justify stability of soil-structure system during operation of object. At the NPP's sites soil properties are investigated with use of "Cross-hole" method on short-distance (to 20 m) and long-distance (to 100 m) bases. Results of field study are processed on analyzed with the help of computer. The methods was applied to the Crimea NPP site. Distribution of natural compression seismic waves (Vp) and under technogenic-changed conditions in situ is obtained. The Vp field picture under reactor building is revealed.

KEYWORDS

Reactor building; soil-structure interaction; soil properties.

INTRODUCTION

The majority of NPP's sites in Russia are located on soft sandy-clay soils. These soils are different with genesis, structure, condition and physical-mechanical properties (Comarov et al.,1991). As a rule, major features of such soils are:

- significant unsimilarity of soil mass structure (change sandy-clay soils, thinning out and change of capacity of layers and etc.);
- variability of stable, deformation and filtering soils properties;
- complex hydro-geological conditions.

The mentioned features create large difficulties at development of rational design decisions and their practical realization. During construction and exploitation of buildings it is led up to complication of technology and organization of work; to deterioration of soil massive properties in process of technogenic change of hydro-geological conditions; activization or manifestation of adverse geological processes and etc. Situation is complicated under seismic or other specific dynamic effects (explosion, impact of plane, effect of shock wave and et.).

Therefore it is rather important not only to study the dynamic parameters of soils, but also to supervise their variability during construction and operation of object. The given problem is urgent when construction the NPP's is in process and connected with their safe operation which is largely determined by stability of reactor buildings. Reactor buildings have definite specific features (Energoisdat, 1982):

- availability of rigid monolithic containmant, advansed on uniform foundation plate 70 m x 70 m;
- significant average loads on the soil foundation, wich is attained 0,5 - 0,6 MPA. These loads are comparable with extreme allowable loads for some types of soils.

The forecast of behaviour of soil-structure system in such conditions is utterly difficult. All above marked submits increased requirements to study stress-strain state of the soil under the reactor building.

STATEMENT of TASK

World practice has fulfilled techniques of study of dynamic soil parameters on the base of field and laboratory methods. In staff of the field researches enter Surface and bore-hole seismic methods of survey are included in range of field researches. In the case of bore-hole cross-hole method on short and long distance is used. The laboratory researches use resonant-column and triaxial tests.

The results of researches executed before construction are used for evaluation of earthquake resistance of objects. However, during construction fase above-mentioned feature soils and buildings introduce the considerable corrective amendments into initial data and require their refinements in view of influence of technogenic-changed conditions.

Soil massive, located directly under reactor building, is not accessible for conventional methods of research (drilling, penetration and etc.). Therefore it is necessary to develop technique of study of change of soils under effect of technogenic-changed conditions in this zone.

The works conducted in this way are:

- installation of special cells under mats of the reactor building for registration of intense condition of soils in limits of the compression soil massiv;
- installation of geodetic marks for registration of deformations of the soil layers;
- executing of field and laboratory researches for soils located not from reactor building.

However, these researches use original techniques and not always permit to receive the volume decision of delivered task. In this connection works prepared by the Association "Atomenergoproject" at the Crimea and site present definite practical and methodical interest.

NATURAL CONDITIONS of THE CRIMEA SITE

The geological cross section through foundation of the reactor building is based materials of engineering-geological explorations to the depth of 100 m. It is submitted by quarternary sediments of small capacity, layed on pliocene deposits. The latest are characterized by layers of clay, fine sand and limestone. In situ velocity of seismic compression waves (Vp) were determined by seismic profiling method (SPM) and "cross-holl" on short distance (to 20 m). Vp velocity smoothly grows up with increase of depth and changes from 300 - 600 m/s near the surface to 1600 - 1700 m/s on the level of ground-water (20 m from surface of ground). Below this level soil massive is characterized by constant Vp velocity equal to 1600 - 1700 m/s. Increase of Vp velocity to 2200 m/s is established at depth of 80-100 m. It is connected with availability of limestonelayer.

TECHNOGENIC-CHANGED CONDITIONS

For evaluation of influence of loading from reactor building on change of Vp waves "Cross-hole" on large distance (to 80 m) to depth of 100 m was executed. Distributed of Vp waves under reactor building is shown in Fig. 1 and has sharply different character:

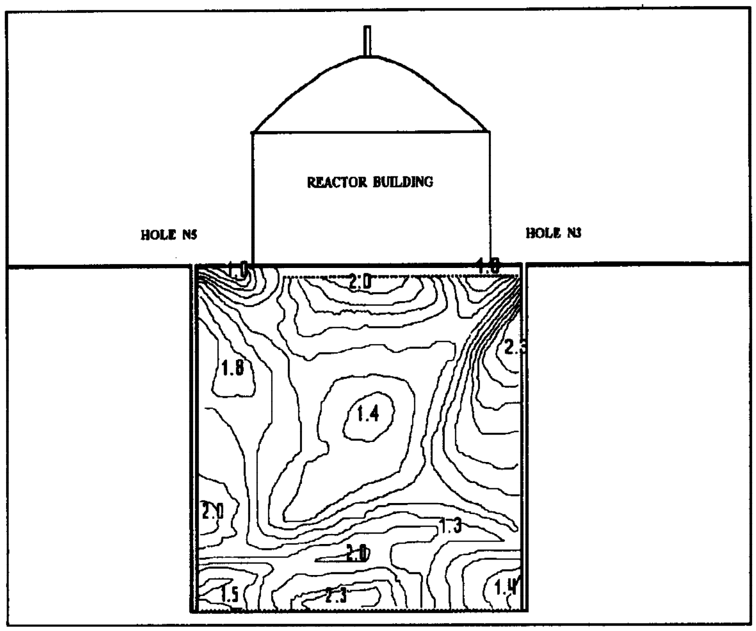

Fig. 1. Distribution of Vp waves under reactor building, km/s.

- top part of the cross section directly under centre of the reactor building is characterized by zone with Vp velocity to 2000 m/s (in situ these part provides soils with low natural Vp velocity from 300 to 600 m/s);

- zones of increased velocity are observed also under corners of the reactor building: Vp to 2300 m/s is obtained at depth from 5 to 50 m (in area of minimum capacity of soft soils), and Vp to 2000 m/s at depth of 60 - 70 m (in area of maximum capacities of soft soils);

- in bottom part of cross section, at the depth of 90 - 100 m marks the availability of zone with increased Vp velocity is observed (to 2300 m/s), which falls under angle of 15 degrees. Accoding to results of drilling and seismic researches by method of reflected waves (MRW) this zone is identified as Pontian limestone;

- in central part of cross section, under reactor building the extensive zone of lowered Vp velocity (to 1400 m/s) is odserved with centre at depth of 45 m (for natural conditions in this area Vp =1600-1700 m/s);

- zones of lowered Vp velocity (to 1400 m/s) are marked also in diagonal areas under corners of the reactor building.

The marked features of field Vp are connected with redistribution of stress under loading of reactor building in particular soil conditions. Received picture is well agreeed with results of loading and finishing to destruction of samples of dense soils and rocks, as well as simulation of tectonic shear zones, and shown in Fig. 2 (Batugina et al.,1988).

GEODINAMIC CONDITIONS & FIELD Vp

According to results provided by Batugina I. (Batugina et al., 1988) process of shearing has enough smooth nature and is divided at two stages of deformation: plication and disjunct-plication.

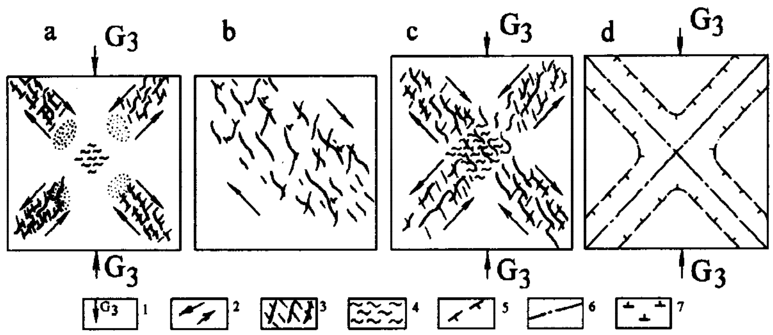

Fig. 2. The Development disjunct-plication of stage of shear:

a - initial stage; b - internal structure of shear; c, d - form of development of shear; 1 - direction of action of compression loading; 2 - shear loading; 3 - system left-hand and right crackes in deformable area; 4 - zone of development intensive plication and disjunctive deformations; 5 - border of shears; 6 - axial line of shear; 7 -direction of fall of plane of amalgamator of individual cracks

At plication stage plastic current of material is registered. With occurrence of first systems of cracks the mentioned stage is replaced by disjunct-plication stage, at which deformation of shear zones happens. These zones space conterminous with diagonals of deformable area. Thus two shear systems of diagonal cracks with greater activity of one of them are formed. Simultaneously in central part ("nucleus"), in the area of the future intersection of diagonal shear zones development of microovertrust structures is observed, indicating concentration of local stress of compression.

Increase of load leads to integration of all originally distingerated cracks with subsequent difficult structural reorganization of node central zone. Thus type of shear depends upon trend of process of reorganization of node zone.

After connection of all cracks in uniform system breaking up node crosspiece happens, as a rule, along one of diagonal directions. It is condition of loss of foundation stability.

According to obtained data in conditions of the Crimea site development of described process before stage of deformation is occured and it reflects redistribution of stress and probability of elastic deformations.

Thus arising of zone of consolidation and unconsolidation of soils and their dynamic parameters are well fixed by "Cross-hole" mehtods at distance 80-100m.

It is possible to pick up. Zones of lowered velocities connected with development of areas of unconsolidation of soils and in versely. Follow this note, area of minimum capacity of soft soils massiv in tops of cross section under corner of the reactor building is located where in interval of depth 5 m gradient zone of sharp difference of Vp velocity is observed (from 1000 to 2300 m/s). The availability of such gradient's may be can caused by zones of large stress and determines type of potential shear in case of loss of stability of foundation.

RESULTS

Obtained picture of wave field reflects the particular stress-stran condition of foundation of the Crimea nuclear power station.

The structure of wave field under reactor building indicates probability of critical condition of foundation.

Additional static or dynamic loading can inforse transition of soils into stage of unelastic deformations and even infringe its state.

Obviously, that in other conditions (availability other geotechnical structure and change of hydro-geological conditions) and at change of external factors (increase of static load, shock wave, earthquake) wave picture will be modified. It is confirmed by results of work on Bashkirija site.

Hence, it is possible to ascertain, that the application of "Cross-hole" method on long distance base is rather effective for monitoring of foundation conditions of reactor buildings and development of recommendations for safe operation of object.

Periodic control of wave field as compressional, as shear waves allows to receive the authentic information about process of consolidation of natural basement, possible abnormal deviations in its development and enables to adjust preliminary evaluations of stability of basement and its reaction on various external effects and to recommend engineering decisions concerning of stability and up grading of object. Safety, influenced by mentioned problems.

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