CHARACTERISTIC ASPECTS OF INTERACTION STRUCTURE-FOUNDATION-FOUNDATION SOIL FOR CONSTRUCTIONS TYPE HALL WITH LARGE SPANS

ASPECTE CARACTERISTICE ALE INTERACȚIUNII STRUCTURĂ-FUNDAȚIE-TEREN DE FUNDARE LA CONSTRUCȚII TIP HALĂ CU DESCHIDERI MARI

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Abstract: *Inter-working between structure - foundation - foundation soil is a complex issue that must be taken into account during planning, design and execution of constructions, aiming not to reach in any of the phases the limit state of bearing capacity and deformations. The foundations of these constructions must be adapted to each location, depending on the nature and deformability of the soil, the size and reactive pressure distribution on the contact surface and on the general deformation of construction. In the case of halls with large spans, redistribution of the efforts due to differential settlements is influenced by the rigidity and static indeterminate structures being able to lead to a state of effort and deformation of constructions different than that obtained with conventional analysis in the current design.*

Rezumat: *Conlucrarea dintre suprastructură – fundație – teren de fundare reprezintă o problemă complexă de care trebuie să se țină cont în faza de concepere, proiectare şi execuție a construcțiilor, urmărindu-se ca în nici una dintre fazele menționate să nu se atingă stările limită de capacitate portantă şi de deformații. Fundațiile acestor construcții trebuie adaptate fiecărui amplasament, în funcție de natura şi deformabilitatea terenului, de mărimea şi distribuția presiunii reactive pe suprafața de contact şi de deformația generală a construcției. În cazul construcțiilor tip hală cu deschideri mari, redistribuirea eforturilor datorată tasărilor diferențiate este influențată de rigiditatea şi nedeterminarea statică a structurilor, putând conduce la o stare de efort şi deformație a construcțiilor mult diferită de cea obținută cu analiza convențională din proiectarea curentă.*

Key words**:** *halls with large spans, state of effort and deformation, deep foundations*
Cuvinte cheie: *hale cu deschideri mari, stare de efort şi deformație, fundații de adâncime*

INTRODUCTION

The continuous concern to achieve solid constructions and at the same time economic, led to the need of finding ways of calculation, which would allow a design more economical and appropriate. The constructions behaviour during and after their erection, under constant or accidental load depend on many parameters, whose influence is more or less appropriate to the particular situation of each construction individually.

To establish general principles for selection of structures and foundations, in relation to certain categories of soil, will be dangerous and void if the design engineer does not understand primarily a physical phenomenon of interaction construction-soil and the influence way of each parameter.

Trying to clarify these issues is actually an attempt to link the two lines on which have been developed the researches in this domain, theoretical and applied. The theoretical researches have solved partially the complicated problem of elastic contact, but the parameters

introduced in calculations were not analyzed such as their results to lead at their direct application in the design engineering. The researches and the applied studies were aimed to find constructive solutions to design types of structures and foundations as appropriate to practical situations, but still so different, based on the analysis of behaviour of existing constructions, the influence of certain parameters, drawing up useful and valuable lessons in accidents of the construction that took place.

Applied researches were not developed as a result of the application of theoretical results, but they tried as far as could, more than to justify, explain or understand why certain types of constructions located on certain categories of soils produce better results and others have led to accidents. Experimental tests have somehow bond the two related guidelines of research that developed the analysis of constructions located on deformable soils.

MATERIALS AND METHOD

In the case of halls with large spans, redistribution of the efforts due to differential settlements is influenced by the rigidity and static indeterminate structures being able to lead to a state of effort and deformation of constructions different than that obtained with conventional analysis in the current design.

Determining the state of efforts and deformation of indeterminate static structures, due to the simultaneous influence of external loads and progressive settlements of foundations, is a major problem both in terms of technical and economical implications that arise in terms of theoretical problems to be solved.

It is known that a statically indeterminate structure made from reinforced concrete presents a particular importance and it has a stiffness that depends on a number of parameters, including speed of growth of unequal settlements of the supports and concrete age at the time of application of imposed loads and displacements.

If the rate of settlements growth occurs suddenly, the reinforced concrete structure, static indeterminate will behave elastic. If the rate of unequal settlements growth is very small, concrete structure will behave viscid-elastic, the construction adapting to the deformations produced by displacements of isolated foundations, especially if they begin to occur immediately after pouring the concrete. The settlements that occur in the case of reinforced concrete structures with viscid-elastic behaviour will be higher than the steel structures with elastic behaviour. Located on the same type of soil that settles in time, first structures adapt more easily to displacements imposed by relaxation phenomenon.

Conventional analysis is far removed from the real state of effort and deformation of constructions located on deformable soils. When the reserves of structure strength are used strictly as a result of a spatial or elastic-plastic calculus disregarding the interaction, the construction no longer has the capacity to adapt to uneven settlements occurred and the consequences are known.

Analyzing the results of research carried out on accidents in construction, it is shown better the practical side of this complex problem of inter-working between structure - foundation - soil.

RESULTS AND DISCUSSION

In tests conducted by the Service de Pathologie du Bureau Securitas in France, a number of 1,200 cases of expertise in construction accidents due to foundations, could find that from seven cases of prevailing of disaster, three are due to mistakes that could have been avoided, if the problem of constructions located on deformable soils, of interaction construction-soil and mechanical problems of soil, would have been better known by the designers.

Noted that 4/10 of the total number of accidents due to the following causes:

- the non-uniformity of the soil in the area of contact between foundation and foundation soil, having as a result unequal settlements, particularly dangerous for static indeterminate structures, with the average stiffness and isolated foundations, or not allowed inclinations of rigid constructions, resulting in their removal from service;
- heterogeneous foundations and structures encountered in a number of important works, where parts of different construction are founded on different depths to which the land has modified physical and mechanical characteristics.

These types of works that have a double heterogeneity, that of soil and foundation solution, have led most often to serious and frequent accidents in construction works. For example in Figure 1 and 2, there is presented a Gymnasium in France, of 35.00 x 54.00 m, which cost about 100 million francs, and that collapsed in 1956. Produced accident showed how dangerous it is to build on a soil of rubbish, even old, works with various types of foundations, at different depths, without taking the elementary precaution dissociated their joints by marking;

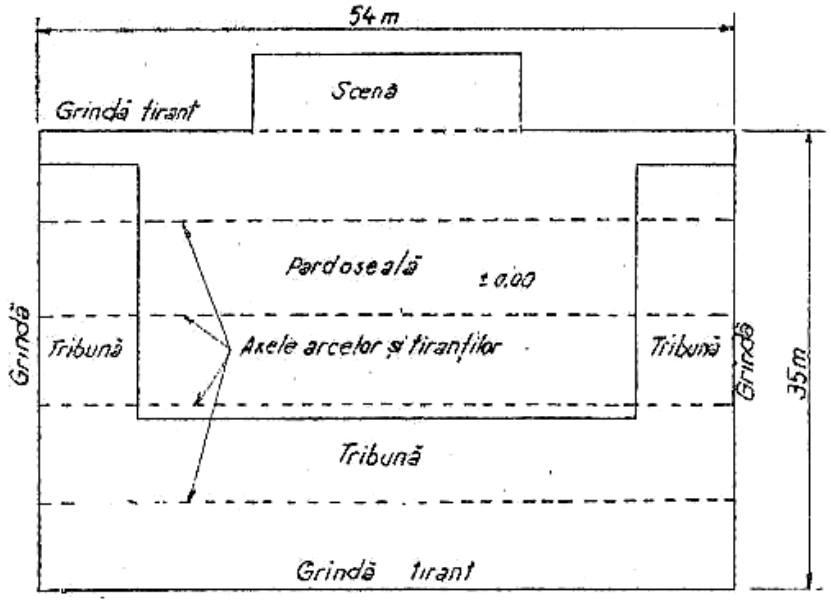

Figure 1. Sport center in France. View plan

Tribunes made of reinforced concrete were placed on 3 sides of the gym. On the 4th side was provided a large stage. Construction was covered by a metal roof framing consisting of 6 arcs of 54.00 m spans, placed at 7.00 m away from each other and articulated at base. Stratification soil on which the construction is located is shown in figure 4.6. The foundation was made from s drilled up to the layers of sand and gravel, with a precarious stability due to the presence of a layer of soft shale, located below.

Tribunes and stage, however, on economy considerations, have been founded on soles, at level - 1.13 m, meaning in a stuffing layer, two years old that suffered settlements of 35 cm. All these considerations, led to led to the degradation and separation of the facade elements and the significant degradation of the walls of this area and thus at the removal from service of the gym.

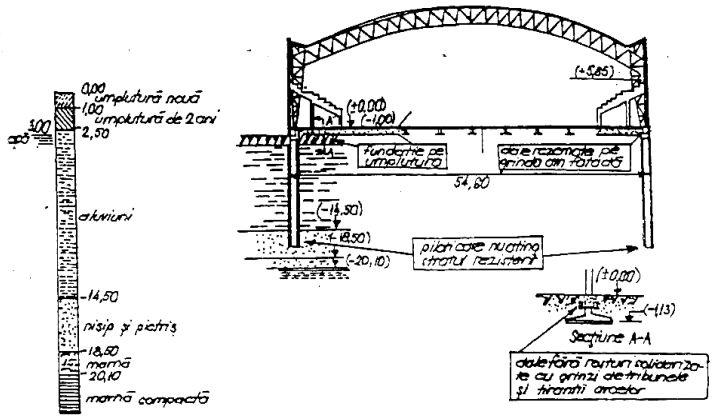

Figure 2. Sport Centre: a - cross section through the construction; b - section A-A

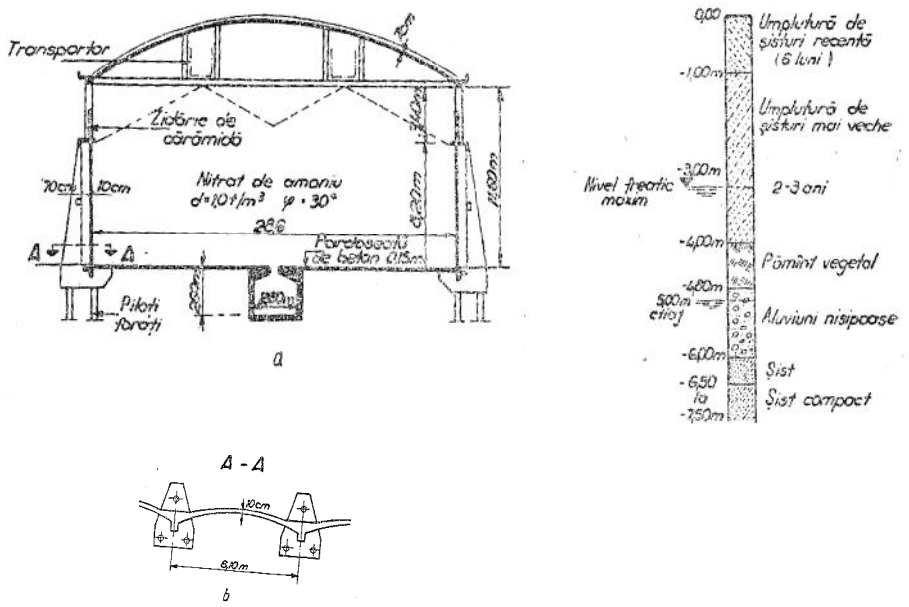

Figure 3: Grain storehouse: a cross-section through the storehouse, b-section AA, c-soil stratification

Another example is the accident occurred in 1961 in France of a building used as warehouse-store fertilizers (figure 3), at which the consolidation works value was 50 million

francs. The deposit has a span of 30.00 m and is covered by a thin surface ribbed reinforced concrete. Inside, the warehouse has a concrete floor of 15.00 cm thickness; placed on a padding layer of 4.00 m thick, situated over a layer of vegetation soil (see stratification in figure 3 c). Construction foundation is conducted on drilled s embedded in the layer of slate, as detailed in figure 3 a, b.

In short time when the first available fertilizers were stored, the front wall was leaning inwards. Deformed building scheme is shown in figure 4.

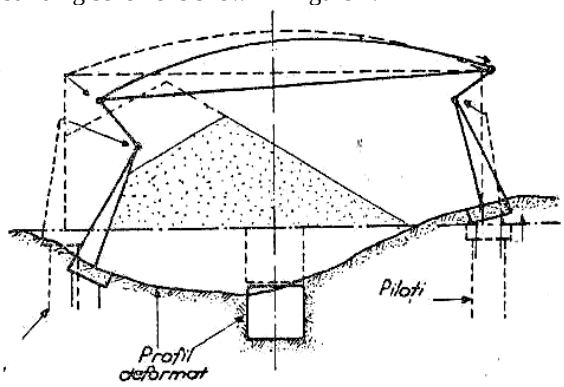

Figure 4. Grain storehouse after accident

Among the causes that brought the building in this state, remember that ammonium nitrate being hygroscopic is increasing a lot in weight, transmitted directly to the filling layer. Thus, the developed pressures involved through negative friction, an increase of the efforts on the inner s. The foundations of counter forts have been calculated assuming that the fertilizers exert on piles the maximum thrusting. All these causes produced the breaking of inner s, which resulted in damage to the construction, as shown in Figure 4.

- construction of a new construction alongside an old one, the effects of foundation soil settlements under the action of the new construction through interaction can produce cracks and disorders in the old construction. The old faith that in designing the providing of a simple foundation joint and the assurance of a pressure lower than the admissible solve this problem, led to a great number of accidents (1/10);
- construction on compressible foundation soils or on soils that modify in time their physical and mechanical characteristics, being unable to adapt to uneven settlements even if they were dimensioned at equal pressure.

For instance it was found that a workshop of 120.00 m x 120.00 m dimensions, having foundations of 4.00 m^2 located from 15.00 m to 15.00 m, was settled less than a tower of 9 floors with a supporting area of 20.00 m x 20.00 m and the settlements of a flexible mat foundation of 150.00 m^2 were much higher than the previous settlements for the same computed pressure.

Also, it was found that the adoption of deep foundations, with particularly high cost of erection, for constructions located on deformable soils, does not always provide, as it is believed, the necessary safety. Adopting surface foundations more economical is possible if the interaction of structure-foundation-soil is sufficiently known, and mechanical properties of the foundation soil are determined adequately, in this case it can be chosen the type of foundation and structure appropriate to the soil on which the construction is located, taking care to take necessary constructive measures.

CONCLUSIONS

Research worldwide has shown that efforts between the structures calculated with conventional methods of design and those that have been taken account of interaction of constructions with soil; there may be differences even up to 200% - 300%. Therefore, to achieve a real design in optimal conditions of safety must be taken into account the interaction between the construction and the soil it is located, may obtain a clear picture on the status of efforts and deformation of the whole assembly of structure-foundation-soil, highlighting the parameters that influence it. Optimization on this base of the structures and foundations, conducted once by choosing a solution in principle the most appropriate and then followed by a calculation and dimensioning based on interaction, will certainly lead to good calculated and effective settlements, measured on field, foundations of buildings and structures will be economical, will correspond to the technical operation conditions and will present the desired safety grade.

General treatment of inter-working problem construction-soil hits the big difficulties encountered in addressing theoretical contact problems and those resulting from the multitude of parameters and factors characteristic for each element of the whole assembly structure-foundation-foundation soil that has to be determined and introduced into the calculation. Numerical calculation methods and electronic computers make possible the approach of this complex issue in the current development state of construction and soil mechanics.

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