Settlements of Buildings on Preconsolidated Clay Layers

Tassements de bâtiments sur couche d'argile préconsolidée

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Summary

The actual recorded settlements, of buildings resting on clays preconsolidated by an earlier older building, or simply by the weight of upper layers, removed to suit the new building, raise some questions about the possibility of using the voids-ratio pressure curves of laboratory samples, to determine the theoretical settlements. In sites where the full elastic rebound is possible, the theoretical and actual settlements compare favourably. In other sites, where part of the old stress is maintained, the old raft being kept, the actual settlements are less than half the theoretical.

We are not yet in a position to give full explanation of the reasons. This fact however, gives rise to a great economy in the design of foundation because it permits using the old raft for the new building in spite of the increased stress.

Sommaire

Les mesures de tassement obtenues pour des bâtiments reposant sur des argiles préalablement consolidées soit par le poids d'un bâtiment démoli, soit, simplement, par le poids des couches supérieures excavées pour permettre la construction du bâtiment nouveau, soulèvent certaines questions touchant l'application des courbes indice des vides-contraintes obtenues au laboratoire sur échantillons aux fins de déterminer les tassements théoriques. Sur les emplacements où un gonflement élastique entier du sol est possible, les courbes de tassements mesurées et théoriques présentent une concordance satisfaisante. Sur d'autres emplacement où une partie des anciennes contraintes sont maintenues – à savoir l'ancien radier – les tassements mesurés s'élèvent à moins de 50% des tassements théoriques.

Nous ne sommes pas encore en mesure de fournir une complète explication des raisons de ce phénomène, cependant, ce fait constaté permet de réaliser une sensible économie dans le projet des fondations et il justifie l'utilisation de l'ancien radier pour le bâtiment nouveau, en dépit de l'augmentation des contraintes.

Introduction

This paper deals with four cases of foundation on clay layers which have been preconsolidated either by a previous building which occupied the same site or simply by the excavated weight of upper layers. In the last two cases, the pressure from the foundation was in one case slightly higher than the pressure due to the weight of upper layers. In the second case the preconsolidation pressure was small compared to the pressure from the foundation of the building above.

These four cases represent certain behaviour in raft foundations observed amongst the 150 buildings studied by the S.M.R. Laboratory of the Faculty of Engineering of Fouad 1st University and are not merely special cases.

In each of these four cases the foundation rested on clay layers of different depths and consistency and underlaid by very dense sand. In all cases, the clay layers also were below subsoil water. Tests were carried on samples taken from the site after the preconsolidation pressure had been totally or partly removed. In the latter case, this represented the pressure due to the weight of the old raft foundation. Comparative studies of the actual and the theoretical settlements divided these cases to two groups:

First Group

It was observed that in cases where the old raft was used to support the new foundation, and where the site was excavated just within the area of the old raft, and having areas around the excavated area supporting neighbouring existing buildings, the actual settlements were not more than 48% of the theoretical settlements as determined from the consolidation test carried out with an initial stress equal to the preconsolidation pressure.

Second Group

On the other hand, when the preconsolidation pressure is removed over a wide area in the site in which the new building is to be placed, the full elastic rebound of the clay layers can take place, and the actual settlements will be very nearly equal to the calculated settlements.

Of the two examples of this group, one is that of a barrage and lock, the other is that of a reinforced concrete skeleton building.

In all cases the samples were extracted by and tested in the Ring sampler cedometer devised by *Hanna* (1948).

In the first two cases the pressure on the soil was very definite, and the buildings were of the type in which the rigidity of the superstructure would not materially influence the theoretical stresses calculated.

The clays referred to here are clays deposited by the Nile, and subjected to annual drying and saturation. The preconsolidation pressure referred to here is that due to the weight of upper layers or that due to an old building. The brown clays have high elastic properties (*Hanna*, 1950).

The phenomenon represented by the first group has an important practical and economical bearing on the design of foundations in Egypt. In most parts of the business area of Cairo and other cities, old buildings of three storeys (generally having a basement), and consisting of thick bearing walls and steel joist floors are being replaced by higher and heavier buildings consisting of reinforced concrete skeletons. In the new buildings the loads are concentrated at point instead of forming closely spaced strip loads. In most cases these buildings had for a foundation a puzzolana lime concrete raft under the whole built area. Because of the lower level of subsoil water 50 years ago, and the traditional foundation design prevalent at that time, the underside of the raft was from 3 to 7 m below ground level and of 1 to 3 m in thickness, and just above the lowest subsoil water level.

In normal sites pile foundations descending to the dense sands, 10 to 20 m below, would be the best solution. But excavation of the site, pumping of subsoil water, and the partial or complete demolition of the old raft is very costly. Further there is the danger of cracking the neighbouring old buildings, (built on similar foundations), as a result of pumping and lowering of subsoil water. The use of the old raft would represent a considerable economy.

Cases of First Group

The first case is that of the S.O.P. Building, a printing house, built on the site of an older building which was constructed on a general raft 1 m thick (Fig. 1). The original pressure was 0.68 kg/cm², the pressure due to the raft is 0.22 kg/cm². The pressures on the new foundation ranged between 1.20 and 1.45 kg/cm². The settlements observed were only 0.48 of the calculated settlement. The raft was left for a period of six months before the new building was started.

In designing this building I allowed for moments and shears due to differential settlements almost double the calculated values based on laboratory tests, carried out on a large number of samples from each layer.

The second example is that of the Helvetia-Vie Building, Cairo (Fig. 2). With the experience gained in the first building and a few others, the foundation of this building was designed on the old raft of 3 m, the top of which was 3 m below ground level.

The old pressure was 0.88 kg/cm², that due to the raft 0.52 (including buoyancy), the new building gave a pressure of 1.45 kg/cm².

Again the values of the recorded settlements and the shape of the time—settlement curves, are approximately 45% of the theoretical settlements.

We are not yet in a position to give definite explanations. It is true that in the laboratory tests, the last stretch of the $e - p$ rebound curve generally has a greater slope than the stretch before, but it seems so far, that the laboratory tests on the samples do not reproduce what actually happens to the soil when pressure is reduced.

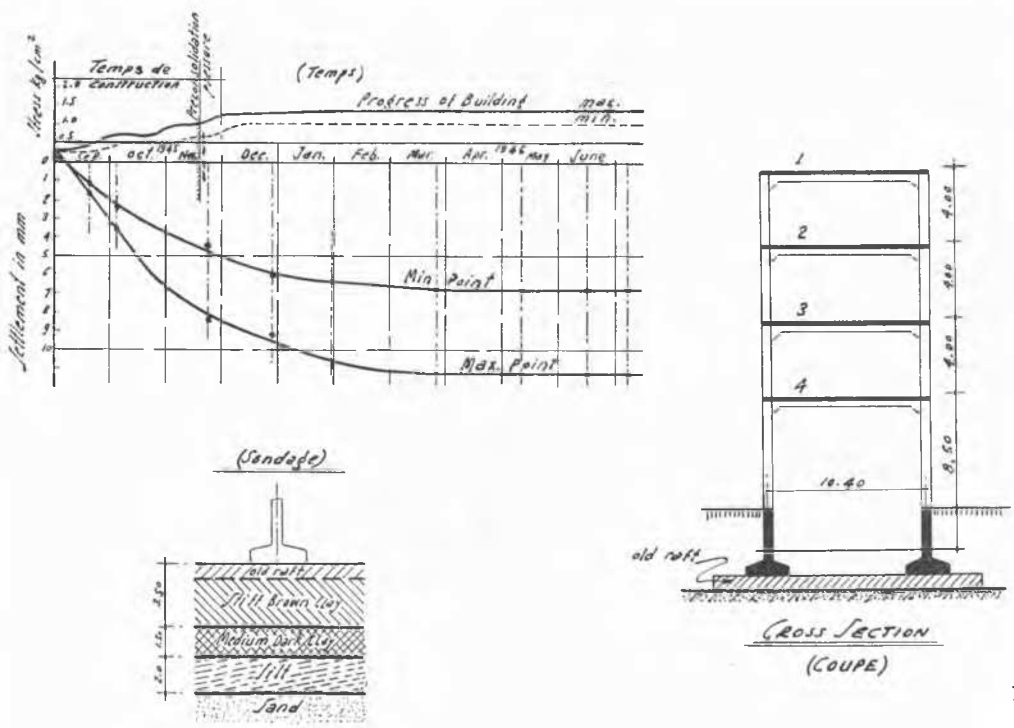

Fig. 1 S.O.P. Building
Immeuble de la S.O.P.

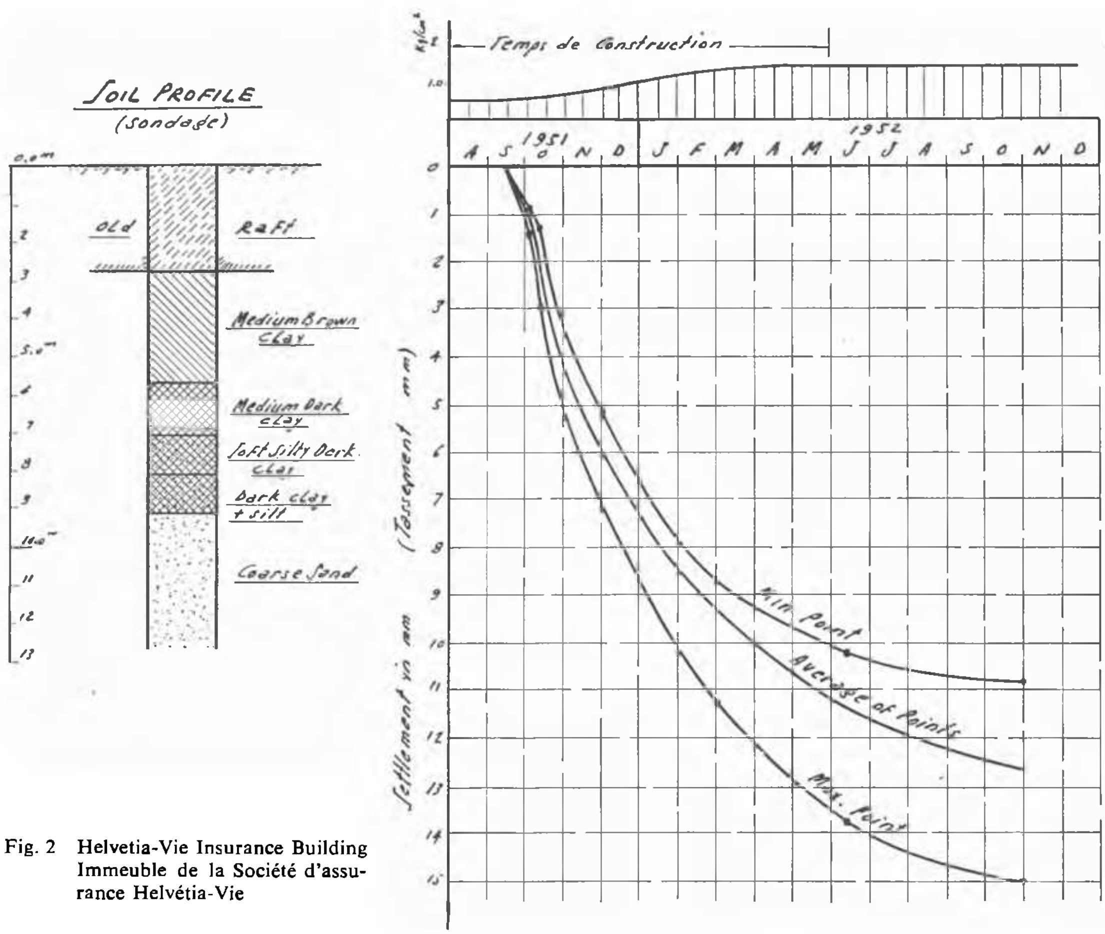

Fig. 2 Helvetia-Vie Insurance Building
Immeuble de la Société d'assurance Helvétia-Vie

Cases of Second Group

The first building, Tewfikieh Regulator and Lock the foundation rests at a level, in which the pressure due to upper layers was 0.64 kg/cm², and the pressure from the building varied between 0.34 and 0.78 kg/cm² (Fig. 3). The theoretical settlement, based on samples taken from borings before excavation, and borings at foundation level, after excavation, were from 12 to 20% higher than the actual values observed. Of special interest is the effect of refill behind the end walls which acted as new—extra loads.

The second, is Talaat—Harb Building, in which the original pressure due to overburden before the building was 0.79 kg/cm² and the pressure from the new building was 1.4 kg/cm². The observed and theoretical curves are self explanatory (Fig. 4).

Conclusions

The two cases of the last group are given to illustrate the time settlement curves of buildings erected on the second compression curves of clays met with in Egypt to form a basis of comparison with the first group.

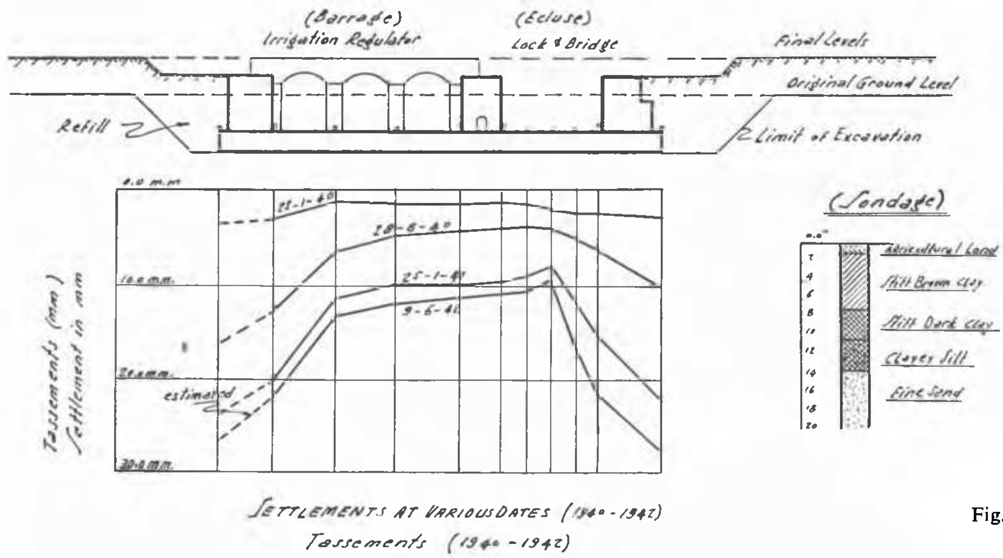

Fig. 3 Tewfikieh Lock and Regulator
Ecluse et régulateur à Tewfikieh

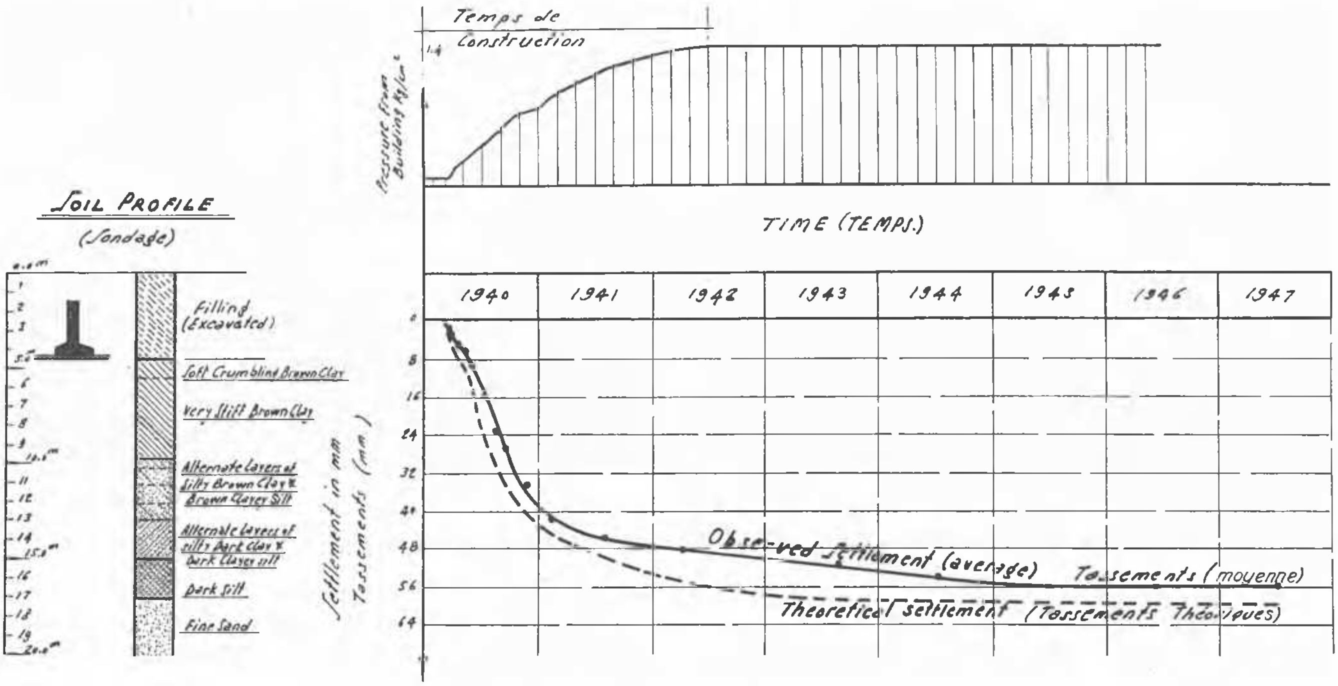

Fig. 4 Talaat-Harb Building
Immeuble à Talaat-Harb

Clays met with here have been subject to preconsolidation due to drying, but are all under subsoil water level now. The saturation has been due to the gradual rise of subsoil water until it reached its present level, a process, similar to that carried out in the oedometer of the laboratory.

For certain reasons still not clear, it seems that under certain conditions, when the pressure on certain clays is partly removed a condition could arise in which the corresponding elastic strains cannot develop. This influences the change in the voids ratio when a new pressure is applied.

References

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