METHOD AND INSTALLATION FOR LIMITING THE DIFFERENTIAL SETTLEMENTS OF A CONSTRUCTION ON A MIXED FOUNDATION

BACKGROUND OF THE INVENTION

The present invention relates to a method for constructing a neighboring construction in a ground close to a pre-existing building standing on a mixed foundation. Mixed foundation is commonly known to designate a foundation which comprises a deep foundation as well as shallow foundation, both bearing the same building structure.

Mixed foundation is generally found in buildings that have been constructed in several phases, at different periods of time.

In some cases, the building is originally constructed on shallow foundation, such as wall footing or mat foundation. Such shallow foundation transfers the structural load of the building close to the ground surface. Then, in a subsequent phase, for instance several years later, an additional building or construction can be added, such as a lift shaft or a utility room for instance. In some cases, the additional construction is built on deep foundation, such as piles for instance.

Generally the additional construction is solidly fixed to the original construction and thus they form together a single mechanical unit. As deep foundation and shallow foundation do not have generally the same mechanic behaviors, differential vertical displacements between the original construction and the additional construction may occur, for instance due to a neighboring construction, which in some cases might damage the pre-existing building.

SUMMARY OF THE INVENTION

The purpose of the invention is to provide a method for constructing a neighboring construction in a ground close to a pre-existing building having a first building structure standing on a shallow foundation and a second building structure standing on a deep foundation, said method comprising:

modifying the deep foundation of the second building structure into a shallow foundation type with at least one hydraulic jack bearing the second building structure;

constructing the neighboring construction in the ground in the vicinity of the pre-existing building;

adjusting the vertical position of the second building structure by controlling the hydraulic jack in case of a vertical displacement of the first building structure during the construction of the neighboring construction so as to reduce differential vertical displacements between the first building structure and the second building structure.

The modified deep foundation, namely the shallow foundation type, can be viewed as a "synthetic" shallow foundation which behaves as a classical shallow foundation.

As a result of this modification, both first and second building structures of the pre-existing building settle as if they were standing on shallow foundation. The whole pre-existing building is therefore standing on shallow foundation as the hydraulic jack is controlled, preferably via a passive hydraulic system, by the possible settlement of the second building structure.

Consequently, the second building structure settles, or more generally moves vertically, together with and as the first building. As a result, undesirable differential vertical displacements are reduced and the risk of damages is lowered.

In one aspect, the step of constructing the neighboring construction comprises a step of making an excavation in the ground.

The neighboring construction may be a building, a tower, a metro station, a tunnel, a shopping center, or any other massive constructions.

In one aspect, a plurality of hydraulic jacks is used to modify the deep foundation of the second building structure. The hydraulic jacks can be controlled independently to each other, or together by a unique hydraulic circuit.

In one aspect, the step of controlling the hydraulic jack comprises a step of adjusting hydraulic pressure of the hydraulic jack with a pressure regulator.

According to one embodiment, the pressure regulator comprises a passive pressure limiter for reducing the hydraulic pressure of the hydraulic jack during a settlement of the first building structure.

If a settlement of the first building structure occurs during the construction of the neighboring construction, then the pressure regulator adjusts the pressure in the hydraulic jack so that the force exerted by the jack on the second building structure remains equal to its initial value. As a result the second building structure also settles with the same displacement values as the first building structure, and without transferring efforts to the interior of the second building structure. Hence, structural stresses, and hence damages are avoided.

According to another embodiment, the pressure regulator comprises a pump. If the first building structure tends to heave during construction of the neighboring construction, then the pump will inject oil in the hydraulic jack so as to maintain the pressure at a constant value. The effect of this pressurization of the hydraulic jack is that the second building structure will heave together with the first building structure, whereby reducing the differential vertical displacement between first and second building structures.

In one aspect, the deep foundation comprises at least one pile and wherein the step of modifying the deep foundation of the second building structure of the pre-existing building comprises:

excavating the ground around the pile so as to expose the pile;

propping the deep foundation;

trimming the top end part of the pile;

installing the hydraulic jack between the pile and the second building structure; and

pressurizing the hydraulic jack.

The pile might be a micro pile.

In one aspect, the deep foundation comprises a plurality of piles. The top ends of piles are trimmed, at a time, one after the other and hydraulic jacks are also installed one after the other. The deep foundation is therefore progressively modified into a foundation behaving as a shallow foundation.

In one aspect, the hydraulic jack is first pressurized to about 50% of the capacity of the pile, or any other pressure defined by designer

In one aspect, the method according to the invention further comprises placing a sliding plate between the hydraulic jack and the pile.

The purpose is to allow a possible horizontal displacement of the hydraulic jack in respect of the pile body.

It is understood that the hydraulic jacks are controlled during all the duration of the construction of the neighboring construction.

In one aspect, the method according to the invention further comprises the step of removing the hydraulic jack and remaking a head of the pile after construction of the neighboring construction.

When there are several hydraulic jacks, the steps of removing the jacks and remaking the heads of the piles are preformed sequentially.

After reconstruction of the piles, the excavation is preferably, but not necessarily, filled up.

In one aspect, the first building structure is connected to the second building structure. Alternatively, the hydraulic jacks could be grouted.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be apparent from the following detailed description of the preferred embodiment of the invention in conjunction with the accompanying drawings, in which:

FIG.**1** illustrates a pre-existing building comprising a first building structure standing on shallow foundation fixed to a second building mounted on deep foundation;

FIG.**2** illustrates a step of excavating the ground around the piles and modifying the deep foundation with hydraulic jacks;

FIG.**3** illustrates the pre-existing building with the modified foundation of the second building structure, while boring an excavation in the vicinity of the pre-existing building; and

FIG.**4** illustrates the pre-existing building after the construction of the neighboring construction, the pile heads being rebuilt and excavation being filled up.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figures **1** to **4** schematically illustrate an example of a method for constructing a neighboring construction **C** in a ground **S** close to a preexisting construction **10**.

In this example, the neighboring construction **C** is an underground station. In other examples, the neighboring construction could be a tower, a station, a shopping center, the construction steps of which may cause vibrations in the ground or soil movement. Such vibrations are likely to damage nearby existing buildings.

The pre-existing building **10** comprises a first building **12** having a first building structure **14**, which is a tower with accommodation in this example. The first building structure **14** stands on shallow foundation **16**, for instance a mat foundation.

After the construction of the first building, a second building **18** has been built close to the first building structure so as to extend the first building. In this example, the second building comprises a second building structure **20** which is a lift shaft. It could also be a utility room, or other types of extension later built. As schematically illustrated in the figures, the second building structure can have a height similar to the one of the first building.

The second building structure **20** stands on deep foundation **22**, which, in this example, comprises a plurality of vertical piles **24**. Such piles can be made out of reinforced concrete.

One purpose of the invention is to modify the mechanical behavior of the foundation system of the pre-existing building.

The initial steps comprise a step of excavating the ground so as to expose the piles **24**at a time. More precisely, the excavation is performed so as to access to the connection between the top portions of the piles **24** and the base foundation **30** with is located on the top of the piles.

As illustrated in figure **2**, the deep foundation is propped (if required) by using propping equipment **32** which are for instance installed between the pile **24** (below the jack) and the base foundation **30**.

Then, according to the invention, the deep foundation of the second building structure is modified so as to transform it into a synthetic shallow foundation, namely of foundation type which behave as a shallow foundation.

In step (i), the top end part **24**a of the exposed pile is trimmed. As a result, the trimmed pile does not connect the base foundation **30**. Accordingly, the propping equipment then bears the base foundation.

In step (ii), a hydraulic jack **40** is then installed between the pile body and the base foundation of the second building structure. In this example, a sliding plate **42** is also placed between the hydraulic jack and the pile **24**.

The hydraulic jack **40** is then connected to a pressure regulator **44** and pressurized to about half of the bearing capacity of the pile **24** or whatever value imposed by the designer.

These steps (i) and (ii) are repeated for each pile **24**.

In the illustration of figure **3**, all the piles **24** are equipped with hydraulic jacks **40**, each being connected to a pressure regulator **44**. Alternatively, the hydraulic jacks **40** could be connected to a unique pressure regulator or to several group of jacks. Hydraulic jacks **40** therefore bear the second building structure **20**.

Preferably, a watertight platform **45** is provided at the ground level for the entire duration of work to secure the excavation and prevent the excavation from filling with rainwater.

Figure **3** illustrates the step of constructing the neighboring construction **C**, and in particular the initial step of realizing an excavation **E** in the ground. During this excavation, ground may smove. Such movement might cause a vertical displacement (settlement) of the first building structure **12**. In this example, the vertical displacement is a settlement illustrated with arrows **T**. As the first and second building structures are fixed to each other in a solid manner, the vertical displacement of the first building structure causes the vertical displacement of the second building structure.

The vertical position of the first building structure is adjusted by controlling the hydraulic jacks **24** with the pressure regulators **44**, which reduces the differential vertical displacement between the first and second building structures **12**,**18**.

The pressure regulators **44** can be passive pressure limiters which maintain oil pressure constant in the hydraulic jacks during the settlement of the second building. The bearing force exerted on the second building structure is thus maintained at a constant value during the settlement of the second building structure. Thus, no effort is transferred to the interior of the second building and there is no differential vertical displacement between first and second building structures **14**,**20**.

As a result, the whole pre-existing building, with such modified foundation, is on shallow foundation as the hydraulic jacks **40** are passively controlled by the settlement of the first building which stands on real shallow foundation.

If a part of the base foundation tends to heave during a phase of construction of the neighboring construction, the pressure limiters can be replaced by active system as a hydraulic pump for injecting oil so as to maintain constant the pressure in the hydraulic jacks during heave.

After the neighboring construction **C** is completed, as illustrated in figure **4**, the hydraulic jacks and slide plated are removed at a time, one after the other. New heads **27** of piles **24** are made to as to connect the piles **20** to the base foundation **30** again.

After the construction of the neighboring construction, the second building structure is on its deep foundation again.

CLAIMS

1. Method for constructing a neighboring construction in a ground close to a pre-existing building having a first building structure standing on a shallow foundation and a second building structure standing on a deep foundation, said method comprising:

   modifying the deep foundation of the second building structure into a shallow foundation type with at least one hydraulic jack bearing the second building structure ;

   constructing the neighboring construction in the ground in the vicinity of the pre-existing building;

   adjusting the vertical position of the second building structure by controlling the hydraulic jack in case of a vertical displacement of the first building structure during the construction of the neighboring construction so as to reduce differential vertical displacements between the first building structure and the second building structure.

2. The method according to claim **1**, wherein the step of controlling the hydraulic jack comprises a step of adjusting hydraulic pressure of the hydraulic jack with a pressure regulator.

3. The method according to claim **2**, wherein the pressure regulator comprises a passive pressure limiter for reducing the hydraulic pressure of the hydraulic jack during a settlement of the first building structure.

4. The method according to any one of claims **1** to **3**, wherein the deep foundation comprises at least one pile and wherein the step of modifying the deep foundation of the second building structure of the pre-existing building comprises:

   excavating the ground around the pile so as to expose the pile;

   propping the deep foundation ;

   trimming the top end part of the pile;

installing the hydraulic jack between the pile and the second building structure; and
pressurizing the hydraulic jack.

5. The method according to claim **4** further comprising placing a sliding plate between the hydraulic jack and the pile.

6. The method according to any one of claims **1** to **5**, further comprising the step of removing the hydraulic jack and remaking a head of the pile after construction of the neighboring construction.

7. The method according to any one of claims **1** to **6**, wherein the first building structure is connected to the second building structure.

8. The method according to any one of claims **1** to **7**, wherein the step of constructing the neighboring construction comprises a step of making an excavation in the ground.