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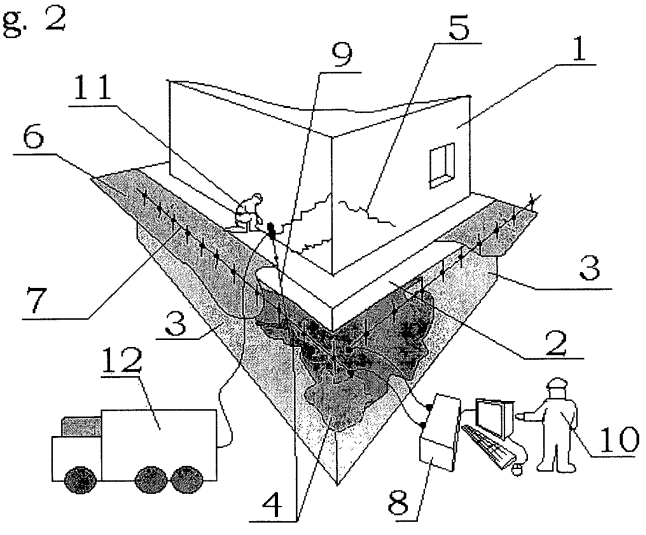
Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **A method for homogenizing and stabilising a soil by way of injections**

(57) A method for homogenizing and/or re-homogenizing the physical and chemical characteristics of foundation grounds and/or building areas in general, to fight the differential sagging of buildings, consists in injections of chemical products, even expanding and effective also in the presence of water and/or moisture (such as polyurethane resins and compounds), aimed at acting over the volumes of grounds that prove to be non-homogeneous and/or uneven compared to adjoining portions that are not affected by sagging and which are taken as reference portions. These portions of ground are localized and monitored according to set frequencies and fixed patterns by means of 3D tomographic geoelectric general detection means allowing the effects obtained in the ground by the mentioned targeted injections to be verified both before and during the work, owing to the nature of the resins/ground dynamic system and the treated volumes to be brought the same conditions of homogeneousness and/or uniformity as those matching the areas that are not affected by any sagging.

Fig. 2



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Description

[0001] This invention refers to a method for homogenizing and/or re-homogenizing the physical and chemical characteristics of foundation grounds and/or building areas in general, aimed at fighting any sagging possibly triggered by the modification of the chemical and physical characteristics of grounds that are particularly sensitive to changes in contents of water or moisture that is related to them.

[0002] It is known that grounds are more or less sensitive to changes in their contents of water or moisture, especially owing to the action of the natural seasonal climatic cycles that promote the occurrence of ground swelling and sagging phenomena. More particularly the correlations between weights/volumes of the various lithotypes are the very ones that may vary and differ as a function of the components making up the grounds at issue, such as: peat, clay, silt, sand, gravel or mixed fractions of them; indeed, they may change in time differently, mainly owing to natural actions such as variations of level conditions, mechanical actions of plants root systems, climatic changes or other effects, or owing to anthropic actions such as: execution of adjoining digging works, vibration, loss of fluids in the ground or other similar effect, and which can intensify or start other subsequent or correlated effects, such as: sagging phenomena, and the ensuing structural collapses of buildings, physical depression of the grounds and structures coming into contact with it, which may show up even in grounds featuring good load-bearing capacities.

[0003] It is also known that, in order to solve problems of differential sagging of foundation or building grounds, various techniques are currently being adopted wherein, more specifically, some tend to transfer the building loads onto lithological horizons featuring a greater supporting capacity, no matter how deep, as in the case of posts, or widening bodies, to increase the imprint of the structural foundation, as this would reduce the unit load that the buildings operate on the ground.

[0004] We also know that if these phenomena occur partially and locally in the foundation grounds under the imprint of buildings, they are technically defined as differential sagging instances.

[0005] Other techniques are based on the concept of pursuing an improvement of the load-bearing capacity of the foundation ground through the injection of cement products or chemical formulations, even expanding, e.g. jet grouting or injections of polyurethane foams and similar products, instead;

[0006] However, cement compounds demand plenty of water and fluidizing agents to be injected in a liquid state at medium-high pressure values and maintenance time values that are considerably longer than those related to expanding resins, and if they are executed in silt, clay or peat grounds, they may easily dispersed in the ground they meet, mixing up with them to the extent of making it difficult to check their location and any immediate effects of the operation, and do not allow any convenient design corrections to be entered with any instrumental monitoring system, even geophysical in nature; especially if geoelectrical surveys are performed directly through the injection holes into the ground, as described in patent EP0786673.

[0007] Differently, with the method described in this disclosure, and right in the specific context of surface application in foundation grounds, advantageous aligned series of electrodes and transmitters can be adopted directly in surfaces surrounding the sagged buildings and/or on prefabricated buildable grounds in general to be tested, without making any expensive digging works and/or drilling. Moreover, in the event of detecting and transmitting elements being spread by location into holes to be made in the ground, the latter will suit this very purpose and will therefore be different from those that are used for injections, since injection resin products, which are considerably resistive in character, once inserted into the very holes that are meant to lodge the detectors, would bar all subsequent and necessary comparison measurements from being taken, as they would isolate the electrodes.

[0008] According to more recent techniques, high-pressure fluidized cement mix injections have been replaced by injections, made at very low pressure values, of expanding chemicals which, in an extremely short time, react and stiffen in the ground until they create hardened columns according to fixed injection levels that are different from one another and arranged in injection points that are three-dimensionally and regularly spaced from one another. However, the disadvantage they bring is that they mainly operate "at random" since injections are applied without using systems that can precisely verify the effects when the work is in progress; indeed, these techniques only resort to out-of-ground instrumental monitoring, with laser levels and fixed erection scanners on walls and floors standing above the ground undergoing treatment which indicate that the treated ground has been strengthened through the successful lifting of the structures towering above, as described in patent EP0851064.

[0009] A development of these techniques consists of the use of resins with an extremely strengthened expanding strength, which is still however more oriented to heightening the mechanical action of compression and tamping of the ground, as described in patent EP1314824. Other more recent techniques, using injections of expanding resins, have been improved owing to empirical calculation systems which, being based on the measurement of electrical resistance between different points in the ground, through detectors that are connected to injection pipes, allow the moisture level to be calculated and, hence, the minimum empirical quality and quantity of expanding resin required for strengthening to be defined, as described in patent EP1536069.

[0010] In any case, today's experience in this field reveals that these assessment parameters (detection of

injected products, lifting of above-standing structures and calculation of the minimum amount of resin) cannot always be considered to suffice in order to guarantee the final balance and the successful reinforcement of the ground being analyzed, nor is it possible to only concentrate the adoption of resins featuring a greater expanding strength, thus pursuing more and more mechanical structure lifting effects, to the detriment of the delicate balances of the volumes of ground located beneath and of safety of the buildings or, as in the case of cement injections, in high pressure values.

[0011] These disadvantages really exist in practice, as the foregoing techniques achieve the solution of the sagging problems through actions that are merely quantitative and mechanical, aimed at the exclusive search for significant increases in load-bearing capacity (called ground reinforcing actions), by operating "random" compression actions, with no direct control while the work is in progress over the effects produced over the treated volumes and over the adjoining volumes not affected by any sagging.

[0012] It is therefore possible to argue that these operating techniques do not guarantee a sufficient level of uniformity of the physical and chemical conditions of the treated portions of grounds, compared to those of present adjoining portions, not exposed to any sagging. These disadvantages prove to be even more marked in the presence of clayey, slimy, peaty grounds or mixed portions of these; as a matter of fact, experience shows that, by modifying hydraulic pressures of water in these grounds and by creating new concentrations and new saturation levels through the injection of even few kilograms of expanding products, a fictitious increase in load-bearing capacity can be immediately achieved, to be verified out-of-ground with the lifting of the structures; if, however, the treated portions of ground were specially exposed to seasonal drying and swelling phenomena owing, for instance, to short- and medium-term variable weather conditions, the sagging problem will show up again, since it will still be affected by a wrong distribution of the contents of water, hollows and injected resins, owing to the lack of an effective monitoring of the effects produced.

[0013] This aspect is most amplified by the fact that the tests and enquiries traditionally adopted for these techniques are mainly point-like and quantitative in type, appointed to verify the increase in load-bearing capacity only of the treated ground, mainly reliable all around the vertical line of the tests themselves and, sometimes, limited to methods of mathematic interpolation among various survey points to possibly formulate subsequent overall assessments over the ground not yet analyzed, with ensuing wide margins of error and interpretation.

[0014] It is also known that a portion of ground where water under pressure has been incorrectly introduced through injections of expanding resins offers, immediately, apparently satisfactory mechanical strength values to the aforementioned point-like test, but which are such as to lead to wrong results. In fact, when the contents of water under pressure that is in the ground is later slowly diluted and dispersed according to time and modes that are mainly a function of the type of lithology and of the local climatic conditions, one may easily find that the differential sagging resumes. It is moreover known that making injections of expanding resins, without performing a careful control over the combination effects and such as to be able to produce possible wrong concentrations of water volumes underground and underneath the foundations, turns out to be extremely dangerous even from the viewpoint of seismic safety, since the right conditions to promote the onset of ground liquefaction phenomena could be generated.

[0015] We may therefore state that these current techniques offer wide margins of interpretation and approximation, as they lack systems for exerting direct control over the effects that the injection of resins produces in the ground, to the detriment of the required accuracy, reliability and duration of operations over time.

[0016] The object of this invention is to offer a method to fight the sagging of the grounds which allows the operating parameters (heights, quantity and sequence of injection cycles, characteristics of the resins and/or resin mixes, consistency of the injected resins, reaction temperatures of the injected products, water absorption capacity, and more) to be actively modified while the work is in progress, by relying extremely carefully and attentively on the direct control over the effects produced by sequential injections into targeted portions of grounds affected by sagging and by advantageously monitoring the changes in chemical and physical characteristics of the treated portions themselves by comparison with those of adjoining portions not affected by any sagging, which are taken as reference portions; this has the sole material purpose to remedy all the disadvantages listed above and which can be found in the operating techniques that are known at present.

[0017] For this reason, the non-homogeneous and/or non-uniform portions of ground are basically detected and monitored by means of known geophysical surveying systems whose diagnostics is not concerned with the search for evidence to increase the load-bearing capacity of grounds, but is used to detect in a sensitive manner the effect of the expanding action of resins injected into targeted points of treated grounds that, at first, showed to be non-uniform and causing sagging, by acting on such qualitative assessment parameters as electric resistivity and conductivity.

[0018] The invention solves the problem through a method for homogenizing and/or re-homogenizing the physical and chemical characteristics of foundation grounds, which can fight all differential ground sagging under the existing buildings or in buildable areas, and which consists of the execution of pluralities of targeted holes in the portion of ground that has sagged or needs to be tested, through which effective expanding chemical substances can be injected, with special pipes and also simultaneously, even in the presence of water and/or

moisture, these substances being such as to be able to: affect the weight/volume correlations of the various phases that make up the ground, homogenize and make uniform the chemical and physical characteristics of the treated portions with those of adjoining portions of grounds taken as reference portions and which are not affected by differential sagging, and check the starting conditions and the effects achieved through the laying on the ground, including the one to be homogenized, of series of geoelectrical instrumental survey electrodes, which are separated and conveniently spaced from the foregoing injection pipes, aimed at measuring electric resistivity and conductivity at preset rates before, during and after each injection, until the desired uniformity of the treated portions of ground is reached. Moreover, the definition of the position of the injection points, the sequence of injections, the quantity of expanding resins and their reaction characteristics are assessed and changed based on the real effects that are detected, while the work is in progress, in the ground portions themselves, during the targeted injections, so that the condition of the treated portions is periodically compared with the condition preceding the last injection made, until the ground is successfully homogenized. The method determines that, when the values of electric conductivity or resistivity previously measured in the portions of ground affected by differential sagging are modified in such a way as to homogenize, as a whole, with those of the adjoining portions of ground not affected by the sagging and taken as reference portions, the aim is deemed to be achieved and the injections of expanding substances are interrupted. In pursuing the reduction or removal of differential sagging of the ground, one may advantageously and cheaply intervene by availing of integrated action systems which add targeted injections of chemical products, even expanding ones and also effective in the presence of water and/or moisture, to direct control, while the work is in progress, over the effects produced by means of three-dimensional tomographic geoelectrical surveys, and which allow the required changes to the starting project to be entered based on the data that are constantly measured in the overall monitoring and compared with those of the adjoining grounds that are not affected by the sagging, so as to directly complete and/or correct the shortcomings of the primitive elements available while the work is in progress. Moreover, since the adopted monitoring reaches the three-dimensional (3D) level, the electric conditions of the ground being analyzed may be detected along with the ensuing effects produced by the targeted injections of expanding resins on it, even and particularly below the imprint of the buildings, without any need to excavate or pull anything down for traditional inspection and diagnostic purposes.

[0019] Ultimately, by means of this invention, significant reduction and/or the total disappearance of differential ground sagging can be obtained, to promote a significant optimization of the final costs and benefits, with lasting results over time, and avoiding unwillingly creating other problems that might cause undesired unbalances in the ground in an attempt to solve individual problems.

[0020] Further advantages envisage:

- highly accurate interventions, with a minimized invasive character of operations and minor disturbance of the balance of the treated grounds;
- the possibility of more accurately defining the required amounts and characteristics of the products and/or product mixes - even expanding in type - that need to be injected, as a function of the real effects that are constantly measured while the work is in progress in the whole set of treated ground portions;
- highly accurate measurements owing to the distribution of electrodes, which are different and separated from the traditional injection pipes;
- optimization of the intervention time;
- no excavation and or demolition;
- reduction of all side effects over the buildings, owing to the expansion of resins and to their mechanical actions.

[0021] The invention is minutely described in examples of applications, which do not limit the invention to the precise forms disclosed by them, with reference to the attached drawings, wherein:

fig.1 is a section view of the building/ground context of an example of partial lack of homogeneity of the ground underneath a building portion, and
fig. 2 is a section view of the typical context of targeted injection technique in accordance with the invention, in association with detection, monitoring and
data processing systems.

[0022] The figures depict a practical example of a building 1 with a foundation 2, located on a ground 3 which is not generally affected by sagging, except for non-homogeneous portions/volumes 4 whose sagging has produced cracks 5 on the concurrent walls of a corner of building.

[0023] The purpose according to the invention is to intervene with targeted injections of chemical products, even expanding in type and effective also in the presence of water and/or moisture, into the mentioned portions/volumes 4 of non-homogeneous and/or non-uniform ground, and to create in them, with monitored sequence stages, equal or basically corresponding physical and chemical characteristics, hence homogeneous and/or uniform, compared to those of the adjoining areas 3 which are already homogeneous and uniform, not affected by sagging.

[0024] To this purpose, through the use of conventional instruments, the behaviour of the ground being analyzed is monitored before, during and after the injections. This is pursued through the location in the ground 3-4, on the surface and/or into drilling holes through the filling

layer 6, of at least one set of electrodes 7 which are preferably but not limitedly made from stainless steel instead of copper, since copper does not allow the electric conductivity to be correctly measured because it is easily oxidizable and, therefore, not suitable for monitoring measurements over time. The electrode sets 7 are connected to multichannel georesistivimeter 8 allowing a number of quadrupole measurements to be made through a progressive energizing of at least an electrode pair and the calculation of the consequent electric potential on other pole pairs. The use of at least a multichannel georesistivimeter 8 is preferential in order to take measurements very quickly, so as to minimize the invasive character of the operations and allowing a three-dimensional covering of the analyzed portions of ground, owing to the several combinations of measurements performed, to be guaranteed with no need to make excavation and/or demolition works, so as to be able to make overall assessments of the changes in resistivity of the treated portions of ground compared to themselves and compared to the adjoining portions of ground, not affected by the sagging and taken as reference portions, even underneath building units.

[0025] The monitoring electrode sets 7 are arranged according to targeted geometrical configurations, next to the portion 4 of ground to be homogenized or re-homogenized, also including those portions 3 that are not affected by sagging, which prove to be useful as elements of comparison. Electrodes 7, which are distributed on the surface or stuck vertically deep, are preferably arranged at a constant distance, and enough to ensure a proper covering of the whole ground being analyzed. The proper execution of the method at issue in this patent disclosure, requires electrodes 7 to be located on and into the ground, distinct, separate and spaced from the holes that are intended to serve (even expanding) product injection pipes 9, such as for instance polyurethane resins and compounds. This is because, on a local level, the injected products cause the contact resistance to rise, which makes it impossible to transmit appropriate currents into the analyzed medium, and should electrodes 7 come into contact with them, they would undergo an unrecoverable loss of the detection force. Hence, electrodes 7 are anchored to the virgin ground and, if necessary, moistened to ensure electric continuity with the ground. Specialized operators 10 process the monitored data, through at least one Personal Computer equipped with dedicated software and, as a function of the results, other operators 11 see to the execution of the product injections required as instructed by the former, in the amounts and combinations as purposely required. The personal Computer(s) may indifferently, be placed directly on site or located in a place located elsewhere and network-connected, e.g. via Internet, to the multichannel detection units 8. The injection system(s) may be placed on self-moving means 12.

[0026] The operating procedure of this method is mainly composed of the following main operating stages:

a) Preparation of at least one set of electrodes 7 anchored to the virgin ground to be analyzed and connected to at least one data monitoring and processing unit which includes at least one multichannel georesistivimeter 8 and at least one Personal Computer, located on site or in a remote place with a network connection.

b) Energizing of the set(s) of electrodes 7 and output voltage registration of profile measurements of the electrical behaviour of the ground to be analyzed, through processing with simulation algorithms.

c) Monitoring before injection, allowing: the initial conditions of the state of volumes, or portions/volumes of ground to be analyzed, the portions that show a suitable homogeneousness characteristics 3 to be found and identified, along with those that might undergo sagging 4, and the causes for such conditions to be found, and then allowing the number and the horizontal and vertical locations of the injection points, the system injection parameters, the type and characteristics of the injection product(s) or mixes to be designed.

d) Making of holes in the ground, aimed at reaching the volumes that are obviously different and non-homogeneous 4, such as for instance portions with different concentrations of hollows and moisture, compared with the remaining portions of homogeneous ground 3 not affected by sagging.

e) Introduction into the mentioned holes of injector pipes 9, which are preferably equipped with static mixers but not in such a way as to limit the invention, and execution of the targeted injections in the ground according to preset sequences as a function of data monitored and processed through a Personal Computer; injection products, even expanding ones, may even be two-component polyurethane foams or equivalent chemical compounds.

f) In the presence of medium-high water concentrations in the treated underground, any excess moisture and/or water can also be removed through an effective controlled draining effect to promote ejection of all excess quantity, avoiding to incorrectly place or concentrate it in other adjoining portions of ground, possibly also using special pipes inserted into injection channels that have not been used yet.

g) While homogenizing and/or re-homogenizing processes are being run, the monitoring system the monitoring system continues to record, on a time basis, the variations of geophysical parameters (resistivity and conductivity) of the concerned ground or ground portion, thus allowing for a continuous and direct *in situ* comparison with the previous readings made and the characteristics of the portions of homogenous ground 3, not affected by sagging, taken as reference units.

h) The recorded data are processed by means of at least one Personal Computer PC which, using dedicated software including algorithms that simulate

electrical magnitudes, generates and makes graphic three-dimensional configurations of the ground volumes being currently homogenized or re-homogenized available directly on site, according to their geophysical and geolithologic characteristics at that time. The interpretation of data is based on three-dimensional processing methods upon the Finished Elements which may provide detailed reconstructions of the underground resistivity and conductivity distributions. The graphic display on site is provided to operators directly through images, even volumetric in type, on the Personal Computer, transferring the isolines of the measured electric parameter so that, in a quick and advantageous manner, the development of the effects produced during execution by the injections into the ground can be easily and intuitively checked by comparing the results with the foregoing images. The dedicated software is also in a position to graphically extrapolate, the percent variations of the measured parameters, thus speeding up understanding and studies.

i) Based on the comparisons among measurements taken at different and sequential times, skilled site technicians can correct and/or modify, during execution, the project injection parameters, through the evaluation of the latest recorded data and the subsequent intervention with more targeted injections, by acting on the physical and mechanical parameters of injection systems, such as: injection points, temperatures, pressure values, time values, amounts of injected products, injection product types, level of mixing (if any), density and so on.

[0027] It is also to be clarified that in the system at issue, the out-of-ground laser level can exclusively be used to monitor any possible deformation affecting the structures and not, wrongly, to consider the primary goal as achieved, since the intervention is only considered as over when the treated ground is successfully homogenized, that is when the physical and chemical characteristics of the treated volume 4 are closer to those measured over the building areas or building grounds that are not affected by sagging 3, or other causes that produce disturbance to the ground underneath the buildings and/or in buildable areas.

[0028] This method at issue does not simply pursue the goal of understanding where the injected products need to be applied, but that of mainly understanding the effects produced during the targeted injections to possibly take, during execution, all actions required to reach the demanded homogenization levels to reduce or eliminate the differential sagging, by conceptually and operatively moving the monitoring while the work is in progress, from "out-of-ground" (common laser level) to "in-ground"; namely within the ground volume treated with three-dimensional tomographic geoelectrical scanning before, during and after the work.

Claims

1. A method for homogenizing and/or re-homogeneizing the physical and chemical characteristics of foundation grounds and/or building areas in general to fight all differential sagging of buildings, consisting of injections into the ground of chemical products, even expanding in type, also effective in the presence of water and/or moisture, **characterized in that** the mentioned injections, even sequential, are targeted and aimed at acting on the portions of ground (4) that prove to be non-homogeneous and/or non-uniform compared to adjoining areas (3), the latter being homogeneous and uniform, which are not affected by sagging and which are taken as reference areas, and at changing the characteristics of the foregoing portions of ground (4) until they are made homogenous and/or uniform as well as matching or similar to those of the mentioned adjoining portions (3); these foundation grounds and/or building areas in general being entirely monitored, at given frequencies and according to fixed patterns before, during and after the mentioned targeted injections, by using integrated electric tomography systems addressed to a preliminary interception analysis over the areas (4) of foundation ground that may cause sagging, followed by a first series of targeted injections, affecting these very areas (4), aimed at changing the chemical and physical characteristics so as to fight the mentioned potential sagging occurrences, and followed by subsequent results control analysis and possibly by subsequent targeted injections, whose heights, quantities and specific characteristics, which may also differ from the previous actions, are a function of the effects that have been observed on the treated ground, until the desired homogeneousness and/or uniformity is reached.

2. A method for homogenizing and/or re-homogeneizing according to claim 1 **characterized in that** the definition of the position of the injection points, the quantity of chemical products, even expanding in type and also effective in the presence of water and/or moisture (such as expanding resins and polyurethane or equivalent compounds), and the reaction characteristics of these products, are assessed and modified based on the effects recorded during execution in the portions of ground (4) before and during the targeted injections, and **in that** the conditions of the treated portions are sequentially compared with the conditions that preceded the last injection made, until the desired homogenizing of the treated portions of ground (4) is reached, which compares with the characteristics of the mentioned portions of ground (3) that are not affected by any sagging, taken as reference areas.

3. A method for homogenizing and/or re-homogeneiz-

ing according to claims 1 and 2 **characterized in that** it is completed when the values of electric resistivity and conductivity measured in the portions of ground (4) that have undergone the injection treatment turn out to be homogeneous and/or comparable to those of the adjoining portions of ground (3) not affected by any sagging.

4. A method for homogenizing and/or re-homogeneizing according to claims 1, 2 and 3 **characterized in that** it uses monitoring and checks of the targeted injections into the ground based on overall analysis and on comparison of the main ground parameters during the dynamic rebalancing stage through an integrated monitoring and injection system that manages the various operating stages: design, executing and final confirmation, by assessing the underground distribution of given physical parameters such as electric resistivity and conductivity, along with their variation in time; this monitoring (7) being three-dimensional (3D) and aimed at the real-time monitoring of the conditions of the ground being analyzed and of the effects brought to the same by the injections, even underneath the imprint of buildings, without any need to excavate or demolish any building for the purpose of inspection and diagnostics.

5. A method for homogenizing and/or re-homogeneizing according to claims 1 to 4 **characterized in that** these checks are performed with in-ground monitoring during execution through three-dimensional tomographic geoelectrical scanning.

6. A method for homogenizing and/or re-homogeneizing according to claims 1 to 5 **characterized in that** the required controlled and targeted injections of the needed chemicals, in the quantities and combinations as specifically assessed, is performed through holes to be made in the ground, for special pipes (9), that are meant to only reach the portions (4) that are manifestly different and non-homogeneous, such as portions featuring different concentrations of hollows and moisture, compared to the remaining portions of homogeneous ground (3) that are not affected by sagging events and are taken as reference areas; these injections being performed, according to preset frequencies as a function of data monitored and processed by an electronic calculator (PC), using injection products like: expanding resins, bicomponent polyurethane foams or equivalent chemical compounds.

7. A method for homogenizing and/or re-homogeneizing according to the previous claims **characterized in that** the mentioned targeted operations are a function of corrections and/or modification, during execution, of the project injection parameters and are obtained and performed based on comparisons with measurements taken at different and sequential times, as a function of the assessments made on the last measurements and based on interventions made on the physical and mechanical parameters of injection systems , such as: injection heights, temperatures, pressure values, time values, quantities of injected products, types of injected products, level of mixing, if any, and density.

8. A method for homogenizing and/or re-homogeneizing according to the previous claims **characterized in that** the monitoring, at frequencies and according to preset patterns before, during and after the mentioned targeted injection operations, includes at least one set of electrodes (7) for geoelectrical instrumental measurement, inserted on the surface or into drilled holes in to grounds to be analyzed and possibly treat (3-4) and connected to at least one multichannel georesistivimeter (8) for the acquisition of set of quadrupole measurements through the progressive energizing of at least one electrode pair and the assessment of the ensuing electric potential on pole pairs; the mentioned multichannel assembly (8) being connected to at least one electronic calculator (PC), equipped with dedicated software comprising algorithms that simulate the electrical characteristics of the grounds, and which operate directly at the assessment of the three-dimensional graphic configuration of grounds or portions of ground undergoing the treatment.

Amended claims in accordance with Rule 137(2) EPC.

1. A method for homogenizing and/or re-homogeneizing the physical and chemical characteristics of portions of ground (3, 4) that prove to be non-homogeneous and/or non-uniform in order to counter differential sagging of buildings standing on said portions of ground (4),
said method providing for:

- drilling a plurality of holes into said ground;
- inserting a plurality of electrodes (7) through the filling laver (6) for obtaining information about said ground;
- injecting into each of said holes a minimum amount of chemical products aimed at changing the ground chemical and physical characteristics so as to counter the mentioned potential sagging occurrences; and monitoring the results of said injections for carrying out further injections;

characterized in that
said information concerning said ground comprises a three-dimensional covering of the ground (3, 4)

obtained through integrated electric tomography systems (8) and based upon the variations of geophysical parameters (resistivity or conductivity) of the concerned ground or ground portion with adjoining areas (3) not affected by sagging being taken as a reference,
and **in that** said monitoring provides for comparing the variations resulting from said injection with the previous readings made and the characteristics of the portions of the ground (3), not affected by sagging;
the injection parameters being modified on the basis of said comparisons by acting on the physical and mechanical parameters of injection systems, until the physical and chemical characteristics of the ground (4) are made homogenous and/or uniform as well as matching or similar to those of the mentioned adjoining portions (3).

2. A method according to claim 1 **characterized in that** the definition of the position of the injection points, the quantity of expanding chemical products (such as expanding resins and polyurethane or equivalent compounds), and the reaction characteristics of these products, are assessed and modified based on the effects recorded during execution in the portions of ground (4) before and during said injections, and **in that** the conditions of the treated portions are sequentially compared with the conditions preceding the last injection made, until the desired homogenizing of the treated portions of ground (4) is reached, which compares with the characteristics of the mentioned portions of ground (3) that are not affected by any sagging, taken as reference areas.

3. A method according to claims 1 and 2 **characterized in that** said injection are stopped when the values of electric resistivity and conductivity measured in the portions of ground (4) that have undergone the injection treatment turn out to be homogeneous and/or comparable to those of the adjoining portions of ground (3) not affected by any sagging.

4. A method according to claims 1, 2 and 3 **characterized in that** it provides for monitoring and checking said injections into the ground based on overall analysis and on comparison of the main ground parameters during the dynamic rebalancing stage through an integrated monitoring and injection system that manages the various operating stages: design, executing and final confirmation, by assessing the underground distribution of given physical parameters such as electric resistivity and conductivity, along with their variation in time; said three-dimensional monitoring (7) aiming at a real-time monitoring of the conditions of the ground being analyzed and of the effects brought to the same by the injections, even underneath the imprint of buildings.

5. A method according to claim 4 **characterized in that** said checks are performed with inground monitoring during execution through three-dimensional tomographic geoelectrical scanning.

6. A method according to claims 1 to 5 **characterized in that** said controlled injections of chemical products, such as expanding resins, bicomponent polyurethane foams or equivalent chemical compounds, is performed through holes drilled in the ground for special pipes (9), that are meant to only reach the portions (4) that are manifestly different and non-homogeneous, such as portions featuring different concentrations of hollows and moisture, compared to the remaining portions of homogeneous ground (3) that are not affected by sagging events and are taken as reference areas; these injections being performed, according to preset frequencies as a function of data monitored and processed by an electronic calculator (PC).

7. A method according to the previous claims **characterized in that** said mentioned operations are a function of corrections and/or modification, during execution, of the project injection parameters and are obtained and performed based on comparisons with measurements taken at different and sequential times, as a function of the assessments made on the last measurements and based on interventions made on the physical and mechanical parameters of injection systems , such as: injection heights, temperatures, pressure values, time values, quantities of injected products, type; of injected products, level of mixing, if any, and density.

8. A method according to the claim 7 **characterized in that** the monitoring, at frequencies and according to preset patterns before, during and after the mentioned injection operations, includes at least one set of electrodes (7) for geoelectrical instrumental measurement, inserted on the surface or into drilled holes in to grounds to be analyzed and possibly treat (3-4) and connected to at least one multichannel georesistivimeter (8) for the acquisition of set of quadrupole measurements through the progressive energizing of at least one electrode pair and the assessment of the ensuing electric potential on pole pairs; the mentioned multichannel assembly (8) being connected to at least one electronic calculator (PC), equipped with dedicated software comprising algorithms that simulate the electrical characteristics of the grounds, and which operate directly at the assessment of the three-dimensional graphic configuration of grounds or portions of ground undergoing the treatment.

Fig. 1

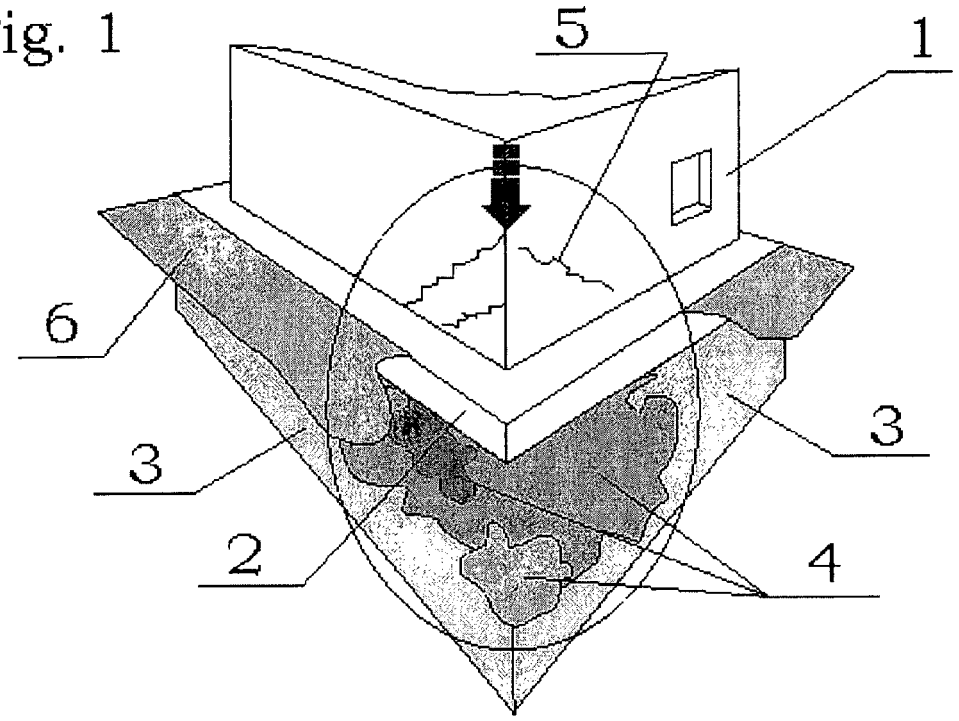
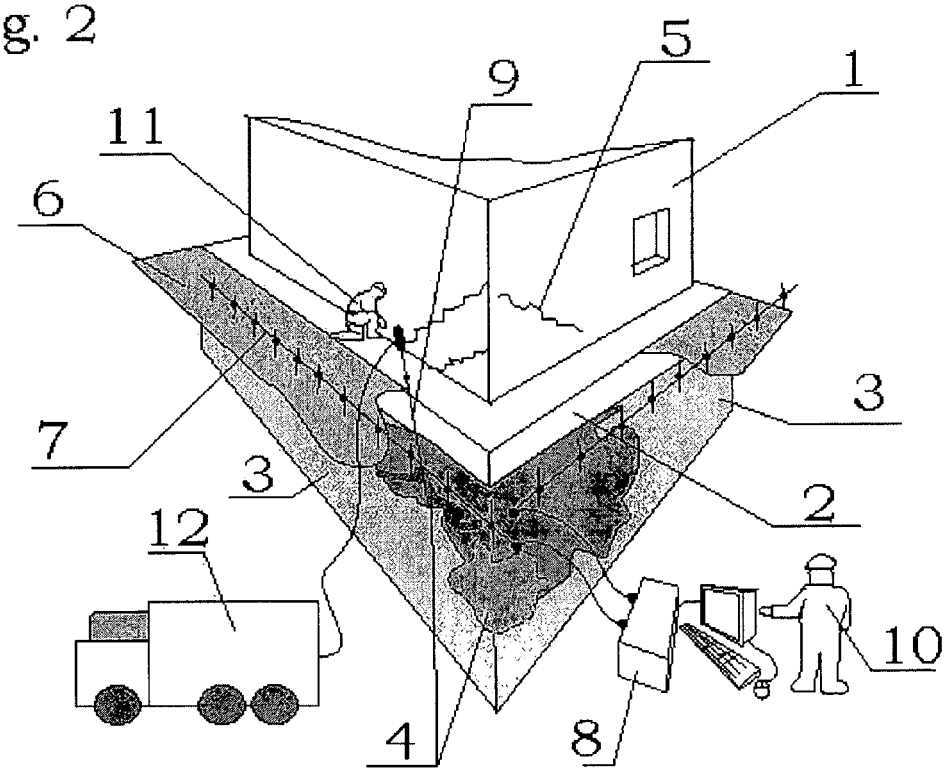


Fig. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5705

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 43 04 816 A1 (GUDEHUS GERD PROF DR ING [DE]) 18 August 1994 (1994-08-18) * column 2, line 2 - column 4, line 34; figures 2,3 *	1-8	INV. E02D3/12
A	DE 26 59 740 A1 (INTEC GES FUER INJEKTIONS ANKE) 13 July 1978 (1978-07-13) * page 9, paragraph 3 - page 17, paragraph 1; figure 11 *	1-8	
A	EP 1 650 356 A (ZUEBLIN AG [DE]) 26 April 2006 (2006-04-26) * the whole document *	1-8	
A	US 6 302 380 B1 (ULTIMO SR FRANK D [US] ET AL) 16 October 2001 (2001-10-16) * column 4, line 57 - column 11, line 63; figure 1 *	1-8	
A	EP 1 536 069 A1 (URETEK S R L [IT]) 1 June 2005 (2005-06-01) * paragraph [0017] - paragraph [0082]; figure 3 *	1-8	TECHNICAL FIELDS SEARCHED (IPC) E02D
A	EP 0 851 064 A1 (URETEK S R L [IT] URETEK S R L [IT]; PURE LIFE FOUNDATION [LI]) 1 July 1998 (1998-07-01) * column 2, line 27 - column 6, line 5; figure 1 *	1-8	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 March 2007	Geiger, Harald

CATEGORY OF CITED DOCUMENTS

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26-03-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 4304816 A1	18-08-1994	NONE	
DE 2659740 A1	13-07-1978	NONE	
EP 1650356 A	26-04-2006	NONE	
US 6302380 B1	16-10-2001	NONE	
EP 1536069 A1	01-06-2005	WO 2005054586 A1	16-06-2005
		ES 2255666 T3	01-07-2006
		PT 1536069 T	31-05-2006
EP 0851064 A1	01-07-1998	AT 181384 T	15-07-1999
		AT 250170 T	15-10-2003
		AU 731637 B2	05-04-2001
		AU 5751998 A	29-06-1998
		CA 2273345 A1	11-06-1998
		DE 69700280 D1	22-07-1999
		DE 69700280 T2	04-11-1999
		DE 69724994 D1	23-10-2003
		WO 9824982 A1	11-06-1998
		EP 0941388 A1	15-09-1999
		ES 2132983 T3	16-08-1999
		GR 3030659 T3	29-10-1999
		HU 0000359 A2	28-06-2000
		IT 1286418 B1	08-07-1998
		JP 2001510514 T	31-07-2001
		PL 186495 B1	30-01-2004
		US 2002098042 A1	25-07-2002

EPO FORM P0459

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0786673 A **[0006]**
- EP 0851064 A **[0008]**
- EP 1314824 A **[0009]**
- EP 1536069 A **[0009]**