(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 308 774 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
16.04.2025 Bulletin 2025/16

(21) Application number: **22717453.9**

(22) Date of filing: **18.03.2022**

(51) International Patent Classification (IPC):
E04H 6/08 *(2006.01)* ***E02D 27/01*** *(2006.01)*
E02D 27/02 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
E04H 6/08

(86) International application number:
PCT/IT2022/050058

(87) International publication number:
WO 2022/195642 (22.09.2022 Gazette 2022/38)

(54) FOUNDATION SYSTEM FOR THE REALISATION OF PREFABRICATED STRUCTURES, IN PARTICULAR FOR THE REALISATION OF MODULAR PARKING LOTS

FUNDAMENTSYSTEM ZUR HERSTELLUNG VORGEFERTIGTER STRUKTUREN, INSBESONDERE ZUR HERSTELLUNG MODULARER PARKPLÄTZE

SYSTÈME DE FONDATION POUR LA RÉALISATION DE STRUCTURES PRÉFABRIQUÉES, EN PARTICULIER POUR LA RÉALISATION DE PARCS DE STATIONNEMENT MODULAIRES

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **18.03.2021 IT 202100006563**

(43) Date of publication of application:
24.01.2024 Bulletin 2024/04

(73) Proprietor: **Spellucci, Gianfranco**
00133 Roma (RM) (IT)

(72) Inventor: **Spellucci, Gianfranco**
00133 Roma (RM) (IT)

(74) Representative: **Santi, Filippo et al**
Barzanò & Zanardo S.p.A.
Via Piemonte 26
00187 Roma (IT)

(56) References cited:
EP-A1- 0 698 700
EP-A2- 1 355 020
JP-A- H10 280 545
US-A- 4 442 989
US-A1- 2008 120 925
US-A1- 2020 048 892

EP 4 308 774 B1

Description

[0001] The present invention concerns a foundation system for the realisation of modular parking lots with one or more raised levels.

[0002] In the following, the specification will be particularly addressed to the use of the foundation system according to the invention in a modular parking structure, but it is well clear that the same can also be used in modular systems for the realisation of prefabricated structures of another type or intended for a different use.

[0003] It is known that, starting from 1990, we witnessed the emergence and the gradual affirmation on the market of various modular parking systems with one and subsequently more raised levels, designed to be installed on existing asphalt pavements, without the need for foundations of traditional type. Such a modular parking system is disclosed in JP H10 280545 A.

[0004] Columns of this type of prefabricated modular structures are mounted on steel bases simply resting on the pavement. Such bases receive the concentrated loads of the columns and transmit pressures to the underlying yard which, for design purposes, must be checked from time to time applying the principles of geotechnics (and the reference standards) compatible with the bearing capacity of the soil of the yard in question. For convenience of reference, in the rest of the present specification, this type of structure will be defined as "without foundations".

[0005] Multilevel car parks with standard dimensions of the lane and of the parking space can be more or less comfortable to use depending on the number and position of the columns that may be present at the side of the lane, such columns interfering with the manoeuvres to enter/exit the parking space.

[0006] Car parks without foundations were born in the 90s, arranged on a 5.0 x 5.0 m structural grid. A 5.0 x 5.0 m module can operate both as a lane (a 5.0 m long portion of a 5.0 m wide lane) and as a parking space (two parking spaces measuring 5.0 x 2.5 m). With such structural mesh, each column receives the loads, both permanent and accidental, collected by 25 m^2 of floor slab for the internal columns, 12.5 m^2 for the perimeter columns, 6.25 m^2 for the corner columns (Fig. 1).

[0007] Such grid makes it difficult for the inexperienced driver to park, due to the large number of columns and the reduced width of the lane. Partially sacrificing the modularity of the structure, modules of different dimensions were subsequently introduced for the lane (6.0 x 5.0 m) and for the parking space (4.5 x 5.0 m), in order to mitigate the interference of the lane column on the manoeuvre, while increasing the loads on each column.

[0008] Another issue with the original design of the car park without foundations consists in the way in which the horizontal actions (wind and/or earthquake) are counteracted. Given the reduced shear resistance of the base-yard interface, equal to about 50% of the vertical force applied to the base, even modest seismic actions require the introduction of a large number of braces. These braces must be installed in two orthogonal directions; in particular, the braces orthogonal to the lane will be installed between the lane column and the column at the end of the parking space, coming into conflict with the correct opening of the door of the parked car (Fig. 2).

[0009] The two issues described above have been strongly mitigated by the introduction, in recent times, of the patented system called "twin column" (Fig. 3), according to which, in correspondence with the lane support, two columns are placed side by side, equipped with two bases resting on the ground instead of just one, allowing to almost double the load that can be unloaded in correspondence of the lane support. Such system allows the transition from the module with two parking spaces (5.0 m = 2 parking spaces measuring 5.0 m x 2.5 m) to a module with three parking spaces (7.5 m = 3 parking spaces measuring 5.0 m x 2.5 m), as well as the "encasement" of the brace transverse to the lane in the space included within the "twin column".

[0010] By maintaining, instead, the original dimensions of the module (5.0 m instead of 7.5 m), the twin-column system allows to realise two-level raised structures (Fig. 4).

[0011] It is also known that structural meshes with columns positioned only at the end of the parking spaces (called "clear span" and shown in Fig. 5) are to be preferred from the point of view of comfort of use and in fact this type of structural mesh is rapidly supplanting other types that provide for the presence of columns near the lane. The transition to "clear-span" meshes, for a parking system without foundations, is not immediate: even using a mesh with columns spaced only 2.5 m apart (Fig. 5), the load on each column, and therefore on the underlying base, increases by 50% compared to the system which also makes use of columns along the lane.

[0012] For this reason, the solutions currently known for car parks of clear span type without foundations are of two types:

- those that limit the loads by adopting a lightweight-type floor slab;
- those that double the number of support plates, by adding columns near those positioned at the end of the parking spaces, as shown in the figure (Fig. 6).

[0013] However, the lightweight floor slab solves the issue of vertical loads but not the issue of horizontal loads and of lifting due to the wind. In order to counteract the lifting induced by horizontal loads, in the absence of the structure's own weight, it is necessary to have the anchorage on the ground by a number of columns which is higher the higher the seismic action or the action of the wind is in the area where the structure is installed. The structure will therefore be equipped with foundations in the form of anchorages.

[0014] A further drawback of this type of structure consists in the fact that the lightweight-type floor slab is considered of lower quality of use by users/parking managers and presents maintenance issues.

[0015] As regards the structure with the addition of columns in the proximity of those positioned at the end of the parking spaces, the following technical issues are instead encountered:

- a waste of space as regards the strip between the two rows of central columns, as the parking space will be completely outside the strip identified by the two rows of columns;
- the absence of braces, which implies an additional burden at the knots level, since it requires a framed structure, which also involves important momentum in the columns, which therefore cannot contain height adjustment devices;
- the limitation to a single raised level, since the circular bases are already fully loaded and since, if it were built on two raised levels, the framed system would have problems of excessive deformation in response to horizontal actions.

[0016] However, none of the structures described above is able to satisfactorily deal with an issue that often arises at the time of the check, by calculating, on the basis of the survey campaign performed, the suitability of the system "without foundations". Very often, in fact, in these asphalted areas, already used for parking, it is possible to notice even significant differences in the mechanical characteristics of the ground surface, found even at a small distance from each other. The unhomogeneities that are found can be considerably higher than those normally found for deeper ground layers, where the traditional foundations rest.

[0017] With a foundation system having separate bases, such as all those described up to now, there is no possibility of a load redistribution, from areas where the ground is softer to areas where the ground is firmer. This circumstance could give rise to situations of significant differential subsidence or local breakages, with the result that many existing street level car parks, where the average parameters of the ground on the areas involved are good, must be discarded as unsuitable for the use of a system "without foundations" every time an excessive variability is required according to the designer's judgment.

[0018] Therefore, all the systems described above suffer from an important limitation: they are designed to unload vertical and horizontal loads on bases independent from each other, thus lacking of "redistribution capacity" in case of localized weaknesses in the ground which, as mentioned, can be frequent on surface and backfill grounds.

[0019] This aspect forces designers to adopt particularly conservative parameters for grounds, limiting the number of cases where these construction systems can be used.

[0020] The solution according to the present invention fits in this context, which proposes a system without foundations capable, in the presence of localized weaknesses of the ground, under one or more support bases, to redistribute part of the load originally applied to the aforementioned bases, to those surrounding bases that are resting on firmer and/or more resistant portions of ground.

[0021] These and other results are obtained according to the present invention by proposing a foundation system for the realisation of modular parking lots which allows to:

- increase the unloading surface on the ground in a manner compatible with the efficient and safe use of the parking structure by both cars and pedestrians;
- create a "safety net" that allows to limit, in the presence of "soft spots", excessive subsidences in conditions of serviceability limit state (SLS) and/or localized breakages in conditions of ultimate limit state (ULS).

[0022] In this perspective, the foundation system proposed for the realisation of prefabricated structures should make it possible to realise a modular car park that can be used in the largest possible number of areas (therefore influenced as little as possible by the variability of the ground on the site and/or by the mediocre or even scarce characteristics thereof).

[0023] In particular, such foundation system for the realisation of prefabricated structures must include a foundation system capable of:

- having sufficiently rigid support elements, capable of collecting the point loads of the structure in its elevation and distributing them over a sufficiently large portion of the support surface, without creating an obstacle to the normal use of the car parking, both by cars and pedestrians;
- having a transfer mechanism, to surrounding support elements, of the portion of the load that would generate excessive subsidence, or localized breakages of the ground, in correspondence with a given support element, due to the greater load applied by the structure in its elevation on the element in question than the surrounding elements, or with the same load, but with a smaller unloading surface of the given element than the surrounding elements, or, finally, in conditions of lower rigidity and/or resistance of the ground underlying the given element than the surrounding elements.

[0024] The aim of the present invention is therefore to provide a foundation system for the realisation of prefabricated structures, in particular for the realisation of modular parking lots, which allows to overcome the limits of the structures according to the known art and to obtain the technical results previously described.

[0025] A further aim of the invention is that said foundation system can be achieved with substantially low costs, both in terms of production costs and in terms of management costs.

[0026] Last but not the least aim of the invention is to propose a foundation system for the realisation of prefabricated structures, in particular for the realisation of modular parking lots, which is simple, safe and reliable.

[0027] Therefore, the specific object of the present invention is a foundation system for the realisation of prefabricated structures, in particular for the realisation of modular parking lots, consisting of

- a first framework, comprising at least a first level of a prefabricated structure, comprising at least three columns arranged aligned at a predetermined distance along a direction, a diagonal rod (21) being arranged between the head of each column (20) and the foot of the adjacent column (20), a lower beam (19) being arranged between the foot of each column (20) and the foot of the adjacent column (20), each lower beam (19) being coupled at the head to the adjacent lower beam (19) and to the foot of the column (20), an upper beam (22) being arranged between the head of each column (20) and the head of the adjacent column (20), each upper beam (22) being coupled at the head to the adjacent upper beam (22) and to the head of the column (20);
- a second framework comprising a plurality of support elements, in a number corresponding to the number of said columns, each support element being arranged under a corresponding column, each support element being adapted to receive the concentrated/-point loads of the corresponding column and to distribute these concentrated/point loads over a wider, whereby said support elements are support beams, the centre of each support beam being arranged under a corresponding column, each support beam being adapted to receive the concentrated/point loads of the corresponding column and to distribute such concentrated/point loads along its length. Preferably said support beams are arranged parallel to the alignment direction of the columns and even more preferably each support beam is provided with sufficient flexural stiffness, so as to adequately distribute over the support surface the point load received by the column, and coupled at the head to the adjacent support beam, to form the lower stringer of the prefabricated structure. In particular, according to the invention, said support beams are double-T support beams, made of steel and stiffened at the centre by means of ribbings.

[0028] Furthermore, said diagonal rods are preferably made of steel and preferably the angle of each diagonal rod with the vertical is not greater than 45 degrees.

[0029] Preferably, again according to the present invention, the foundation system can further comprise a third framework consisting of a plurality of orthotropic plates for each support element, said third framework being adapted to receive the distributed loads of the overlying second framework and to distribute them over a larger area of the underlying ground, in particular, when said support elements are support beams, in a direction transverse to the axis of the support beams.

[0030] In particular, according to the invention, said plates can be made of steel and can be stiffened by means of stiffening elements, in particular, when said support elements are support beams, adapted to stiffen said plates transversely to the axis of the support beams.

[0031] Furthermore, according to the present invention, the foundation system can comprise a fourth framework, arranged under said third framework and made with a buried concrete slab, equipped with a reinforcement, with the function of further extending the surface on which the load is distributed in a direction transverse to the direction of the first framework, where for reasons related to the function of the building it is not possible to further extend the orthotropic plate.

[0032] Alternatively, again according to the present invention, said third framework can consists of a concrete slab, possibly buried, with a reinforcement predominantly transverse to the direction of alignment of the columns.

[0033] The present invention will now be described, for illustrative but not limitative purposes, according to a preferred embodiment thereof, with particular reference to the figures of the attached drawings, in which:

- Figures 1-6 show schematic drawings for realising modular parking lots according to the known art;
- Figure 7 shows a perspective view of a support beam and of the corresponding orthotropic plates of a foundation system for the realisation of prefabricated structures according to a first embodiment of the present invention,
- Figure 7a shows a perspective view of a support plate of a foundation system for the realisation of prefabricated structures according to the present invention,
- Figure 8 shows a perspective view of a support beam (also called foundation base) of a foundation system for the realisation of prefabricated structures according to the present invention,
- Figure 9 shows a representation of the distribution of pressures at the interface of the orthotropic plates with the ground for known values of the elastic constant of the ground, having fixed the stiffness characteristics of the orthotropic plates and of the support beam of a foundation system for the realisation of prefabricated structures according to an embodiment of the present invention,
- Figure 10 shows a schematic representation of a section of the foundation system for the realisation of prefabricated structures according to an embodiment of the present invention,
- Figure 11 shows a schematic representation of a section of the foundation system for the realisation

of prefabricated structures according to a further embodiment of the present invention, and

- Figures 12-30 show a representation obtained using a program for calculating the distribution of the loads on a section of a prefabricated structure realised using the foundation system according to the present invention, in the presence of different conditions of the supporting ground; and
- Figure 31 shows a cross-sectional view of a reinforced concrete beam of a foundation system according to the present invention.

[0034] With reference to figures 7 and 8, according to a preferred embodiment of the invention, the foundation system for the realisation of prefabricated structures, in particular for the realisation of modular parking lots according to the present invention comprises a double-T support beam 10, made of steel and of a length equal, by way of example but not by way of limitation, to 2.0 m or 2.5 m, stiffened in the centre by means of ribbings 11, in correspondence with the area below the support point of a column (not shown) of the prefabricated structure. The inertia (and therefore the height) of the support beam 10 is fixed on the basis of the elastic constant of the ground that results from the geotechnical study preliminary to the activity realising the structure.

[0035] In particular, the support beam 10 rests on three orthotropic plates 12, made of steel, whose longitudinal dimension (i.e. according to the axis of the support beam 10) is such that a succession of plates 12 is able to follow the altimetric evolution of the ground, with each plate 12 in a condition of complete and optimal support, despite any possible undulation and irregularity of the ground/-yard.

[0036] The perfect contact of the support beam 10 with the underlying plates 12 is ensured, where necessary, by means of paddings (not shown); the fixing between the support beam 10 and the underlying plates 12, and any possible padding that is present, takes place by means of bolting.

[0037] The size of each plate 12, in a direction orthogonal to the axis of the support beam 10, is fixed on the basis of the geotechnical study, taking into account the applied loads, the compressibility characteristics of the ground affected by the pressure bulb.

[0038] Each plate 12 is stiffened transversely to the direction of the support beam 10 by means of a plurality of stiffening elements 13.

[0039] In particular, with reference to Fig. 7a, it is shown a plate having dimensions of 0.8 x 0.8 m stiffened with four stiffening elements 13 of the UPN 120 type.

[0040] In Fig. 9 it is represented the distribution of pressures at the interface of the orthotropic plates 12 with the ground, for known values of the elastic constant of the ground, the stiffness characteristics of the orthotropic plates 12 and of the double-T support beam 10 being fixed.

[0041] With reference to Figure 10, the prefabricated structure made using the foundation system of the present invention must have a plurality of columns 20 arranged aligned with each other at a predetermined distance; a lower stringer, formed by a plurality of lower beams 19, to connect the foot of each column 20 together with that of the adjacent column 20, each lower beam 19 being coupled at the head to the adjacent lower beam 19 and to the foot of the column 20 at least by means of a hinge joint; and an upper stringer, formed by a plurality of upper beams 22, to connect the heads of the columns 20 together, each upper beam 22 being coupled at the head to the adjacent upper beam 22 and to the head of the column 20 by means of a hinge joint, the upper and lower stringers being capable of withstanding traction/compression. Diagonal rods 21 made of steel are installed between the head of a column 20 and the foot of the adjacent column 20, the angle of each diagonal rod 21 with the vertical having preferably to be not greater than 45 degrees, in order to guarantee an efficient possible counteraction against vertical loads from one column 20 to the adjacent column 20. Furthermore, at the foot of each column 20, the foundation system according to the present invention provides for the presence of a support element 10', so as to distribute the load of each column 20 over a larger portion of the underlying ground.

[0042] With reference to Figure 11, it is shown an embodiment according to which each support element is formed by a double-T support beam 10, of the type described in relation to Figures 8 and 9, the central part of each support beam 10 being arranged in a position below a corresponding column 20.

[0043] More generally, therefore, the foundation system according to the present invention can be described as comprising a structure consisting of a first framework, comprising the columns 20, the diagonal rods 21, the lower beams 19, i.e. the longitudinal beams of the lower stringer and the upper beams 22, i.e. the longitudinal beams of the upper stringer, with high longitudinal stiffness, which transmits concentrated/point loads at more or less regular intervals along its length to an underlying second framework, formed by the support elements 10' and in particular by the support beams 10, the aforementioned second framework being provided with flexural stiffness and therefore capable of distributing such concentrated/point loads along its length and preferably transmitting the loads thus distributed to an underlying third framework, consisting of a plurality of plates 12 for each support beam 10, the aforementioned third framework receiving the loads distributed along the length of the overlying support beam 10 and distributing them on the ground transversely to the axis of the support beam 10.

[0044] Preferably, a prefabricated structure made using the foundation system according to the present invention is a reticular structure whose second framework forms the lower side.

Application examples

[0045] In Figures 12-31 it is shown the operation of the foundation system according to the present invention in various situations, as specified in the following.

[0046] With reference to Figure 12, a foundation system realised according to the criteria of the present invention consists of fifteen columns with an interaxis of 2.5 m, according to a typical configuration for a parking structure with two raised levels.

[0047] Each column insists on a foundation base which, by way of example, corresponds to that shown in Fig. 8. All the bases are of the same dimensions, equal to 2.5 x 0.6 m, which are the maximum dimensions allowed for compatibility with the function, in the case for example of a parking for cars.

[0048] In the situation represented, it is considered that the ground below the bases is heterogeneous: as shown by the vectors represented in the figure, all the bases having the same size, there are different resistances of the system consisting of the base and the ground, with greater resistances where the ground has better mechanical characteristics and lower resistances where the ground has worse mechanical characteristics.

[0049] In the case shown in figure 12, of the fifteen bases below the fifteen columns, the first five from the left are placed on a ground/yard of high-performance asphalt, having an ultimate unitary resistance equal to 4 kg/cm^2 and therefore a resistance of the base and ground system equal to 600 kN, the central group of five bases is placed on poorer ground, with an ultimate unitary resistance of 2 kg/cm^2 and therefore with a resistance of the base and ground system of only 300 kN, the last five bases on the right are also placed on the ground with a resistance of 4 kg/cm^2 and therefore 600 kN for the entire base.

[0050] These resistances are noted in Figure 12 in the proximity of the column foot.

[0051] In the absence of a redistributive mechanism between the bases, the ULS (Ultimate Limit State) actions on the bases are those shown in Fig. 13. In case the bases are not connected to each other by the foundation system according to the present invention, and therefore behave as independent plinths, the five bases under the five central columns would therefore not be checked (300 kN < 371.52 kN).

[0052] In the case of the system object of the present invention, on the other hand, the bases are simulated in a calculation program as elastic-plastic springs which, having reached the maximum resistance respectively equal to 300 and 600 kN, pass to a perfectly plastic behavior, i.e. they continue to maintain the maximum resistance, but the deformation continues indefinitely.

[0053] Figure 14 shows the redistributive effect of the foundation system object of the present invention. By applying the ULS loads (and therefore in the conditions of ultimate limit state) we can see how the system is in equilibrium, despite the achievement of the maximum resistance of 300 kN for the five central columns. This is achieved by transferring the excess load (about 70 kN per base for a total of about 350 kN) on the five central columns. Such load migrates towards the right and left ends of the foundation system. Given the important difference in resistance (double resistance on the sides than on the centre), the "migrating" load stops on the first base it encounters (fifth base from the right and fifth base from the left) which is however checked with a load of approximately 547 kN. The maximum subsidence from the calculation model is equal to 5 mm under the five central bases, and therefore widely acceptable.

[0054] Figure 15 shows a case similar to the previous one except for a lower resistance of the ground under the five bases on the right and the five bases on the left, which this time have a maximum resistance of 450 kN.

[0055] In this case, Fig. 16 shows how the system is still in equilibrium, and the migrating load migrates beyond the fifth column from the right and left, reaching the third column from the right and left.

[0056] In Fig. 17 it is shown an amplified deformation for the two cases described above.

[0057] Fig. 18 considers the same foundation system situation of a two-level raised parking lot, in a case where the ground is highly heterogeneous, with significant and sudden changes in resistance. The figure shows a resistance equal to 600 kN for the first two bases from the left, equal to 300kN for the third and fourth, and so on as shown in figure 18.

[0058] Also in this case, an independent-plates system would not be usable, as the ultimate resistance for the bases carrying 300kN would be lower than the ultimate load limit imposed on them (300 kN < 371.52 kN).

[0059] In Fig. 19 it is shown instead that the foundation system according to the invention is in equilibrium and all the bases below the knots are checked. The maximum subsidence according to the calculation model used is equal to 2 mm (the amplified deformation is shown in Fig. 20).

[0060] Another case to illustrate the operation of the foundation system according to the present invention is one where all the foundations offer the same resistance (homogeneous ground), but the structure in its elevation imposes higher loads on the five central columns. In the example in question, for which figure 21 shows the ULS load drops in the absence of redistribution, the effects of accidental loads (live loads) equal to three times those insisting on groups of five columns on the right and on the left are considered on the three central columns. This simulates a situation where the central parking area is also accessible to heavy vehicles. The ultimate resistance of the bases, as in the previous cases, is equal to 600 kN, in this case for all the bases. In the absence of redistribution, the ULS loads on the three central columns, shown in Fig. 21, would be equal to N = 725 kN > 600 kN and therefore the structure would not be checked.

[0061] In Figure 22 it is shown the effect of redistribution: the load on the five central columns reaches the yield point of 600kN (resistance of the plate/ground system). Furthermore, the fifth column from the right and the fifth column from the left load up to 511 kN, bringing the system in equilibrium. The maximum subsidence in this case is equal to 6 mm (deformation in fig. 23).

[0062] Another case of non-homogeneous distribution where the overloaded columns are those at the ends is shown in figure 24. In this case, an ultimate resistance for the bases equal to 600 kN, and an increase in load on the first two columns from the right and from the left equal to F = 400 kN are still considered. The load on the corner columns is equal to N = 797 kN > 600 kN, the load on the second column from the right and from the left is 941 kN > 600 kN. The ULS vertical action in foundation is shown in Fig. 25 for independent bases, where it is clear that the first two bases from the right and from the left are not checked.

[0063] In figure 26, due to the redistribution, the first four columns from the right and the first four columns from the left reach the maximum value of 600 kN and the system is in equilibrium (maximum subsidence equal to 12 mm). Figure 27 shows the amplified deformation (maximum subsidence of 19 mm from the calculation model).

[0064] It is possible to compare the case analysed in figures 12 to 14 with a traditional solution, as shown in Fig. 28, consisting of a system of beams and columns non-connected to each other having a reticular structure, superimposed on a buried foundation beam made of reinforced concrete. For the ULS loads shown in Fig. 13, and for a width of the foundation system equal to 60 cm (equal to the width of the base as in Fig. 8, used in all the previous elements), neglecting the increase in resistance of the foundation due to deepening of the support surface, the momentum and shear diagrams for the reinforced concrete foundation beam are shown respectively in figures 29 and 30. The section of such reinforced concrete beam to check the shear and momentum of figs. 29 and 30 is equal to 60 cm wide by 1.0 m high, reinforced as in Fig 31.

[0065] It is therefore clear that the system object of the present invention allows to use a system without foundations in a much more extensive number of situations than the known art.

[0066] The present invention has been described for illustrative, but not limitative purposes, according to its preferred embodiments, but it is to be understood that variations and/or changes may be made by those skilled in the art without thereby departing from the relevant scope of protection, as defined by the attached claims.

Claims

1. Foundation system for the realisation of prefabricated structures, in particular for the realisation of modular parking lots, consisting of

   - a first framework, comprising at least a first level of a prefabricated structure, comprising at least three columns (20) arranged aligned at a preset distance along a direction, a diagonal rod (21) being arranged between the head of each column (20) and the foot of an adjacent column (20), a lower beam (19) being arranged between the foot of each column (20) and the foot of the adjacent column (20), each lower beam (19) being coupled at the head to the adjacent lower beam (19) and to the foot of the column (20), an upper beam (22) being arranged between the head of each column (20) and the head of the adjacent column (20), each upper beam (22) being coupled at the head to an adjacent upper beam (22) and to the head of the column (20);
   - a second framework comprising a plurality of support elements (10'), in a number corresponding to the number of said columns (20), each support element (10') being arranged below a corresponding column (20), each support element (10') being configured to receive the concentrated/point loads of the corresponding column (20) and to distribute such concentrated/point loads over a wider area,

   characterised in that said support elements (10') are support beams (10), the centre of each support beam (10) being arranged under a corresponding column (20), each support beam (10) being adapted to receive the concentrated/point loads of the corresponding column (20) and to distribute these concentrated/point loads along its length.

2. Foundation system according to claim 1, **characterised in that** said support beams (10) are arranged parallel to the direction of alignment of the columns (20).

3. Foundation system according to claim 1 or 2, **characterised in that** said support beams (10) are double-T support beams (10), made of steel and stiffened in the centre by means of ribbings (11).

4. Foundation system according to claim 2, **characterised in that** each support beam (10) is coupled at the head to the adjacent support beam (10).

5. Foundation system according to any one of the preceding claims, **characterised in that** said diagonal rods (21) are made of steel.

6. Foundation system according to claim 5, **characterised in that** the angle of each diagonal rod (21) with the vertical is not greater than 45 degrees.

7. Foundation system according to any one of claims 1-6, **characterised in that** it further comprises a third

framework constituted by a plurality of plates (12) for each support element (10'), said third framework being adapted to receive the distributed loads of the overlying second framework and to distribute them over a greater area of the ground below, in particular, when said support elements (10') are support beams (10), in the direction transverse to the axis of the support beams (10).

8. Foundation system according to claim 7, **characterised in that** said plates (12) are made of steel.

9. Foundation system according to claim 8, **characterised in that** said plates (12) are stiffened by means of stiffening elements (13), in particular, when said support elements (10') are support beams (10), adapted to stiffen said plates (12) transversely to the axis of the support beams (10).

10. Foundation system according to any one of claims 7-9, **characterised in that** it comprises a fourth framework, arranged below said third framework and made with a slab (16) made of concrete provided with a reinforcement (17), in particular, when said support elements (10') are support beams (10), said reinforcement being prevalently transverse to the axis of the support beams (10).

11. Foundation system according to any one of claims 1-6, **characterised in that** it further comprises a third framework consisting of a concrete slab (14) with reinforcement (15) prevalently transverse to the direction of alignment of the columns (20), said third framework being adapted to receive the loads distributed along the length of the overlying second framework and to distribute them on the underlying ground in a direction transverse to the direction of alignment of the columns (20).

Patentansprüche

1. Gründungssystem für die Realisierung von vorgefertigten Strukturen, insbesondere für die Realisierung von modularen Parkplätzen, bestehend aus

- einem ersten Gerüst, das mindestens eine erste Ebene einer vorgefertigten Struktur umfasst, die mindestens drei Säulen (20) umfasst, die in einem vorgegebenen Abstand entlang einer Richtung ausgerichtet sind, wobei ein Diagonalstab (21) zwischen dem Kopf jeder Säule (20) und dem Fuß einer benachbarten Säule (20) angeordnet ist, wobei ein unterer Träger (19) zwischen dem Fuß jeder Säule (20) und dem Fuß der benachbarten Säule (20) angeordnet ist, wobei jeder untere Träger (19) am Kopf mit dem benachbarten unteren Träger (19) und mit dem Fuß der Säule (20) verbunden ist, ein oberer Träger (22) zwischen dem Kopf jeder Säule (20) und dem Kopf der benachbarten Säule (20) angeordnet ist, wobei jeder obere Träger (22) am Kopf mit einem benachbarten oberen Träger (22) und mit dem Kopf der Säule (20) verbunden ist;

- ein zweites Rahmenwerk, das eine Vielzahl von Stützelementen (10') in einer Anzahl umfasst, die der Anzahl der Säulen (20) entspricht, wobei jedes Stützelement (10') unter einer entsprechenden Säule (20) angeordnet ist, wobei jedes Stützelement (10') so konfiguriert ist, dass es die konzentrierten/punktuellen Lasten der entsprechenden Säule (20) aufnimmt und solche konzentrierten/punktuellen Lasten über eine größere Fläche verteilt, **dadurch gekennzeichnet, dass** die Stützelemente (10') Stützbalken (10) sind, wobei die Mitte jedes Stützbalkens (10) unter einer entsprechenden Säule (20) angeordnet ist, wobei jeder Stützbalken (10) so ausgelegt ist, dass er die konzentrierten/punktweisen Lasten der entsprechenden Säule (20) aufnimmt und diese konzentrierten/-punktweisen Lasten entlang seiner Länge verteilt.

2. Gründungssystem nach Anspruch 1, **dadurch gekennzeichnet, dass** die Stützbalken (10) parallel zur Fluchtrichtung der Säulen (20) angeordnet sind.

3. Gründungssystem nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Stützbalken (10) Doppel-T-Stützbalken (10) sind, die aus Stahl bestehen und in der Mitte durch Rippen (11) ausgesteift sind.

4. Gründungssystem nach Anspruch 2, **dadurch gekennzeichnet, dass** jeder Stützbalken (10) am Kopf mit dem benachbarten Stützbalken (10) verbunden ist.

5. Gründungssystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die diagonalen Stäbe (21) aus Stahl hergestellt sind.

6. Gründungssystem nach Anspruch 5, **dadurch gekennzeichnet, dass** der Winkel jeder Diagonalstange (21) mit der Vertikalen nicht größer als 45 Grad ist.

7. Gründungssystem nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** es darüber hinaus ein drittes Gerüst umfasst, das aus einer Vielzahl von Platten (12) für jedes Stützelement (10') besteht, wobei das dritte Gerüst so beschaffen ist, dass es die verteilten Lasten des darüber liegenden zweiten Gerüsts aufnimmt und sie auf eine größere Fläche des darunter liegenden Bodens verteilt, insbesondere, wenn es sich bei den Stützelementen (10') um Stützbalken (10) handelt, in der Richtung quer zur Achse der Stützbalken (10).

8. Gründungssystem nach Anspruch 7, **dadurch gekennzeichnet, dass** die Platten (12) aus Stahl hergestellt sind.

9. Gründungssystem nach Anspruch 8, **dadurch gekennzeichnet, dass** die Platten (12) mit Hilfe von Versteifungselementen (13) versteift sind, insbesondere wenn die Stützelemente (10') Stützbalken (10) sind, die geeignet sind, die Platten (12) quer zur Achse der Stützbalken (10) zu versteifen.

10. Gründungssystem nach einem der Ansprüche 7-9, **dadurch gekennzeichnet, dass** es ein viertes Gerüst umfasst, das unter dem dritten Gerüst angeordnet ist und aus einer Betonplatte (16) besteht, die mit einer Bewehrung (17) versehen ist, insbesondere wenn die Stützelemente (10') Stützbalken (10) sind, wobei die Bewehrung überwiegend quer zur Achse der Stützbalken (10) verläuft.

11. Gründungssystem nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** es außerdem ein drittes Gerüst umfasst, das aus einer Betonplatte (14) mit einer Bewehrung (15) besteht, die überwiegend quer zur Ausrichtungsrichtung der Stützen (20) verläuft, wobei das dritte Gerüst so beschaffen ist, dass es die über die Länge des darüber liegenden zweiten Gerüsts verteilten Lasten aufnehmen und sie auf den darunter liegenden Boden in einer Richtung quer zur Ausrichtungsrichtung der Stützen (20) verteilen kann.

Revendications

1. Système de fondation pour la réalisation de structures préfabriquées, en particulier pour la réalisation de parkings modulaires, composé de

- une première ossature, comprenant au moins un premier niveau d'une structure préfabriquée, comprenant au moins trois colonnes (20) alignées à une distance prédéfinie le long d'une direction, une tige diagonale (21) étant disposée entre la tête de chaque colonne (20) et le pied d'une colonne adjacente (20), une poutre inférieure (19) étant disposée entre le pied de chaque colonne (20) et le pied de la colonne adjacente (20), chaque poutre inférieure (19) étant couplée en tête à la poutre inférieure adjacente (19) et au pied de la colonne (20), une poutre supérieure (22) étant disposée entre la tête de chaque colonne (20) et la tête de la colonne adjacente (20), chaque poutre supérieure (22) étant couplée en tête à une poutre supérieure adjacente (22) et à la tête de la colonne (20);
- une deuxième ossature comprenant plusieurs éléments de support (10'), en nombre correspondant au nombre desdites colonnes (20), chaque élément de support (10') étant disposé sous une colonne correspondante (20), chaque élément de support (10') étant configuré pour recevoir les charges concentrées/pointues de la colonne correspondante (20) et pour répartir ces charges concentrées/pointues sur une zone plus large, **caractérisé en ce que** lesdits éléments de support (10') sont des poutres de support (10), le centre de chaque poutre de support (10) étant disposé sous une colonne correspondante (20), chaque poutre de support (10) étant adaptée pour recevoir les charges concentrées/pointues de la colonne correspondante (20) et pour distribuer ces charges concentrées/pointues sur sa longueur.

2. Système de fondation selon la revendication 1, **caractérisé en ce que** lesdites poutres de soutien (10) sont disposées parallèlement à la direction d'alignement des colonnes (20).

3. Système de fondation selon la revendication 1 ou 2, **caractérisé par le fait que** lesdites poutres de soutien (10) sont des poutres de soutien en double T (10), fabriquées en acier et raidies au centre au moyen de nervures (11).

4. Système de fondation selon la revendication 2, **caractérisé par le fait que** chaque poutre de support (10) est couplée à la tête de la poutre de support adjacente (10).

5. Système de fondation selon l'une quelconque des revendications précédentes, **caractérisé en ce que** lesdites tiges diagonales (21) sont en acier.

6. Système de fondation selon la revendication 5, **caractérisé en ce que** l'angle de chaque tige diagonale (21) avec la verticale n'est pas supérieur à 45 degrés.

7. Système de fondation selon l'une quelconque des revendications 1 à 6, **caractérisé en ce qu'**il comprend en outre une troisième ossature constituée d'une pluralité de plaques (12) pour chaque élément de support (10'), ladite troisième ossature étant adaptée pour recevoir les charges réparties de la deuxième ossature sus-jacente et pour les répartir sur une plus grande surface du sol en dessous, en particulier, lorsque lesdits éléments de support (10') sont des poutres de support (10), dans la direction transversale à l'axe des poutres de support (10).

8. Système de fondation selon la revendication 7, **caractérisé en ce que** lesdites plaques (12) sont en acier.

9. Système de fondation selon la revendication 8, **caractérisé en ce que** lesdites plaques (12) sont raidies au moyen d'éléments de raidissement (13), en particulier, lorsque lesdits éléments de support (10') sont des poutres de support (10), adaptés pour raidir lesdites plaques (12) transversalement à l'axe des poutres de support (10).

10. Système de fondation selon l'une quelconque des revendications 7 à 9, **caractérisé en ce qu'**il comprend une quatrième ossature, disposée sous ladite troisième ossature et constituée d'une dalle (16) en béton pourvue d'une armature (17), en particulier, lorsque lesdits éléments de support (10') sont des poutres de support (10), ladite armature étant majoritairement transversale à l'axe des poutres de support (10).

11. Système de fondation selon l'une quelconque des revendications 1 à 6, **caractérisé en ce qu'**il comprend en outre une troisième ossature constituée d'une dalle en béton (14) avec armature (15) principalement transversale à la direction d'alignement des colonnes (20), ladite troisième ossature étant adaptée pour recevoir les charges réparties sur la longueur de la deuxième ossature sus-jacente et pour les répartir sur le sol sous-jacent dans une direction transversale à la direction d'alignement des colonnes (20).

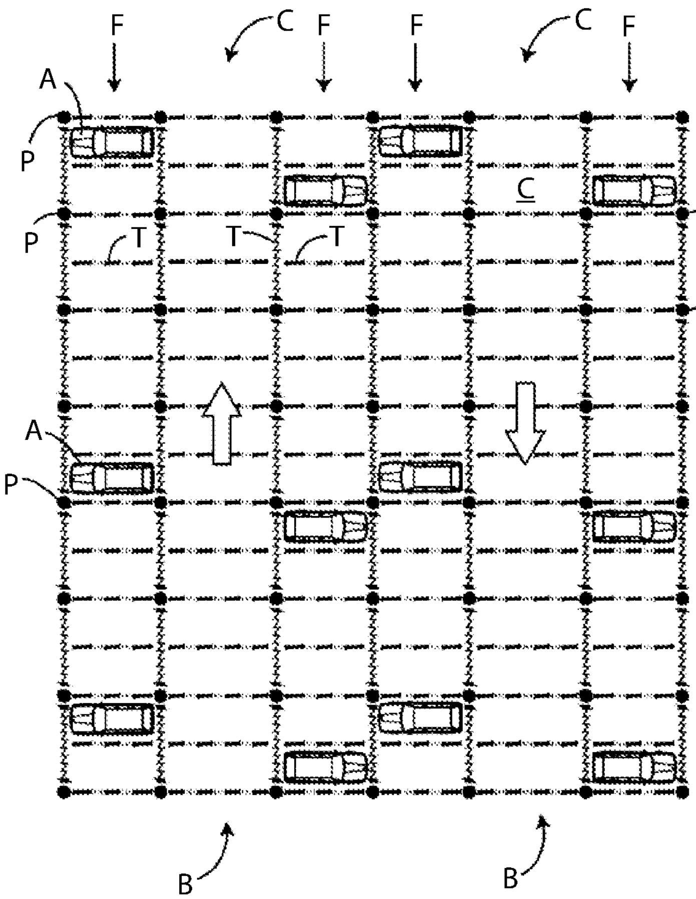

Fig. 1

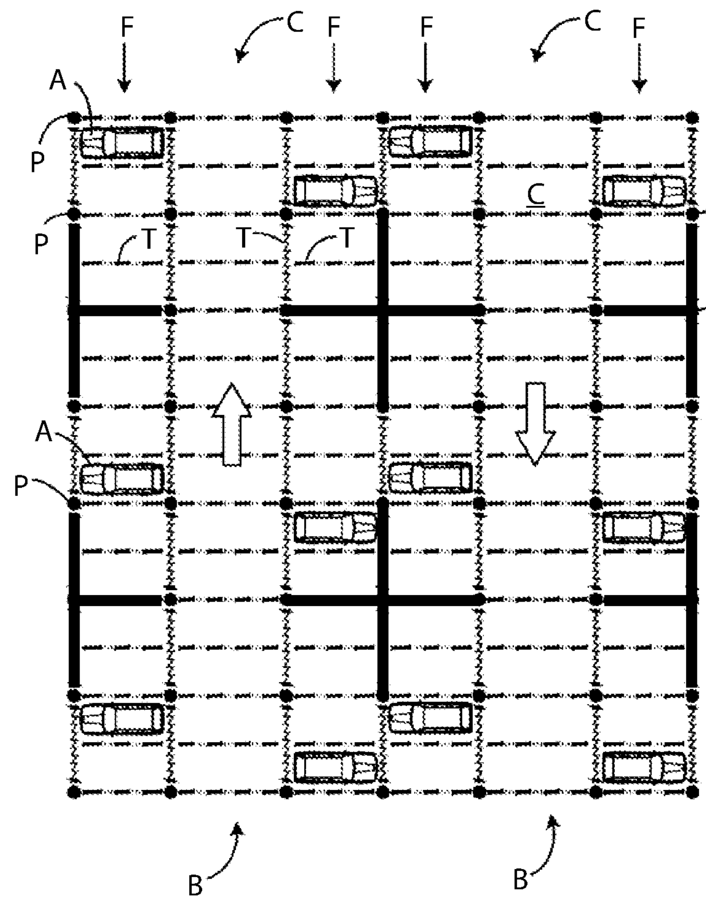

Fig. 2

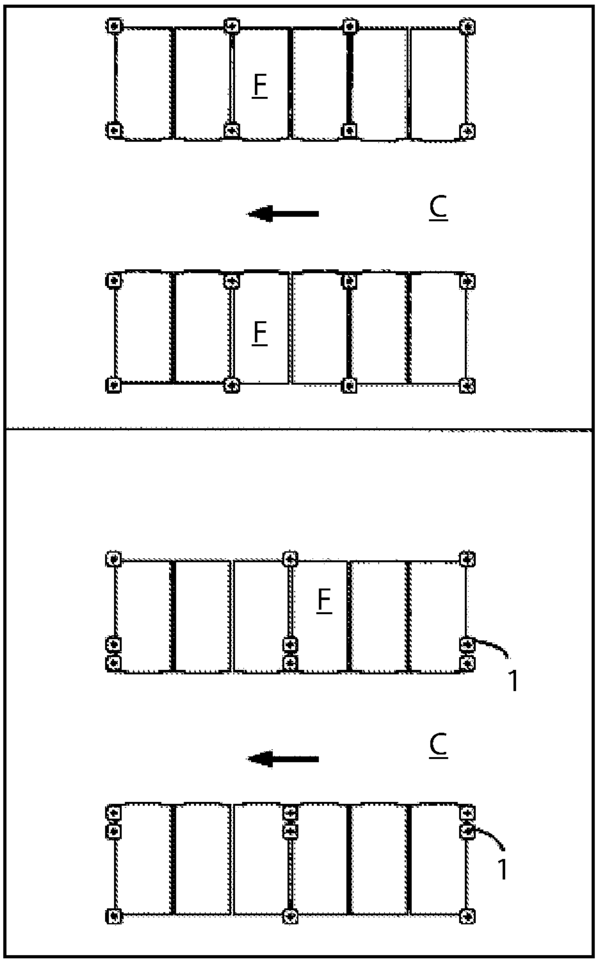

Fig. 3

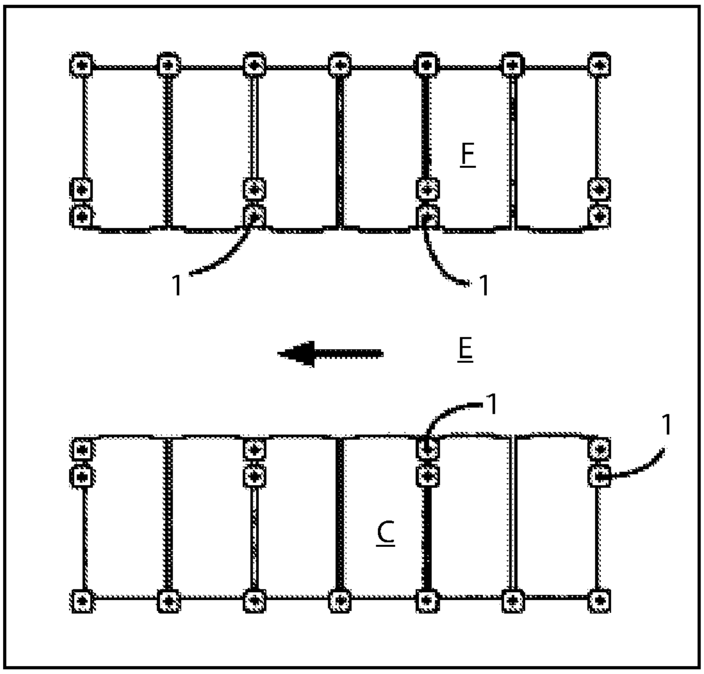

Fig. 4

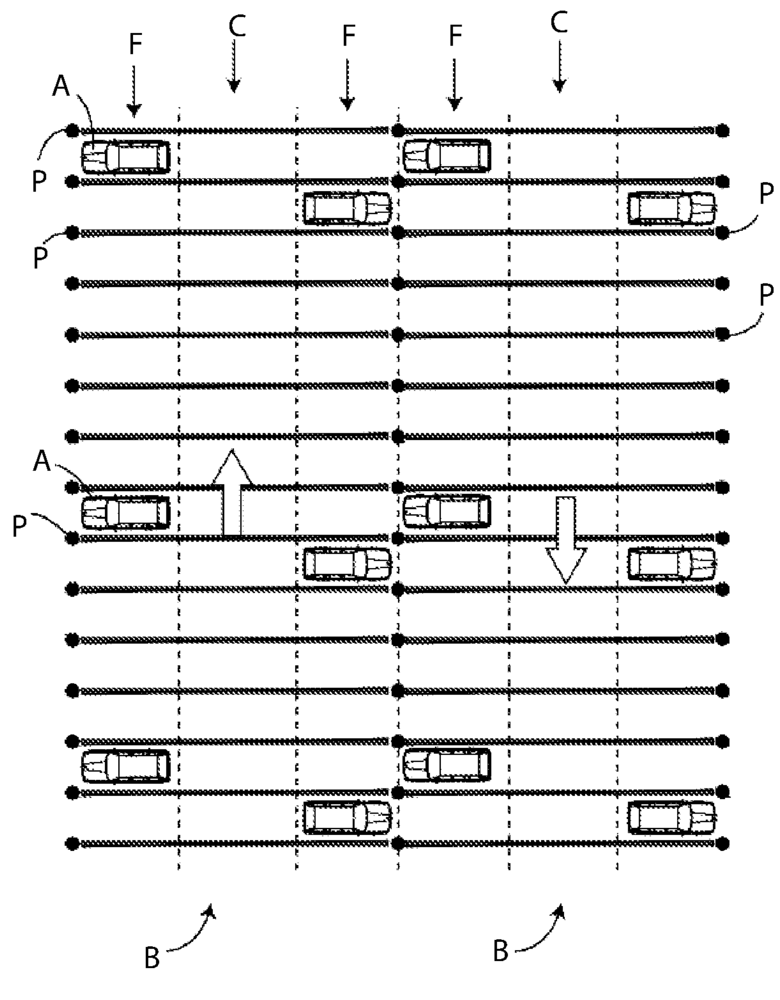

Fig. 5

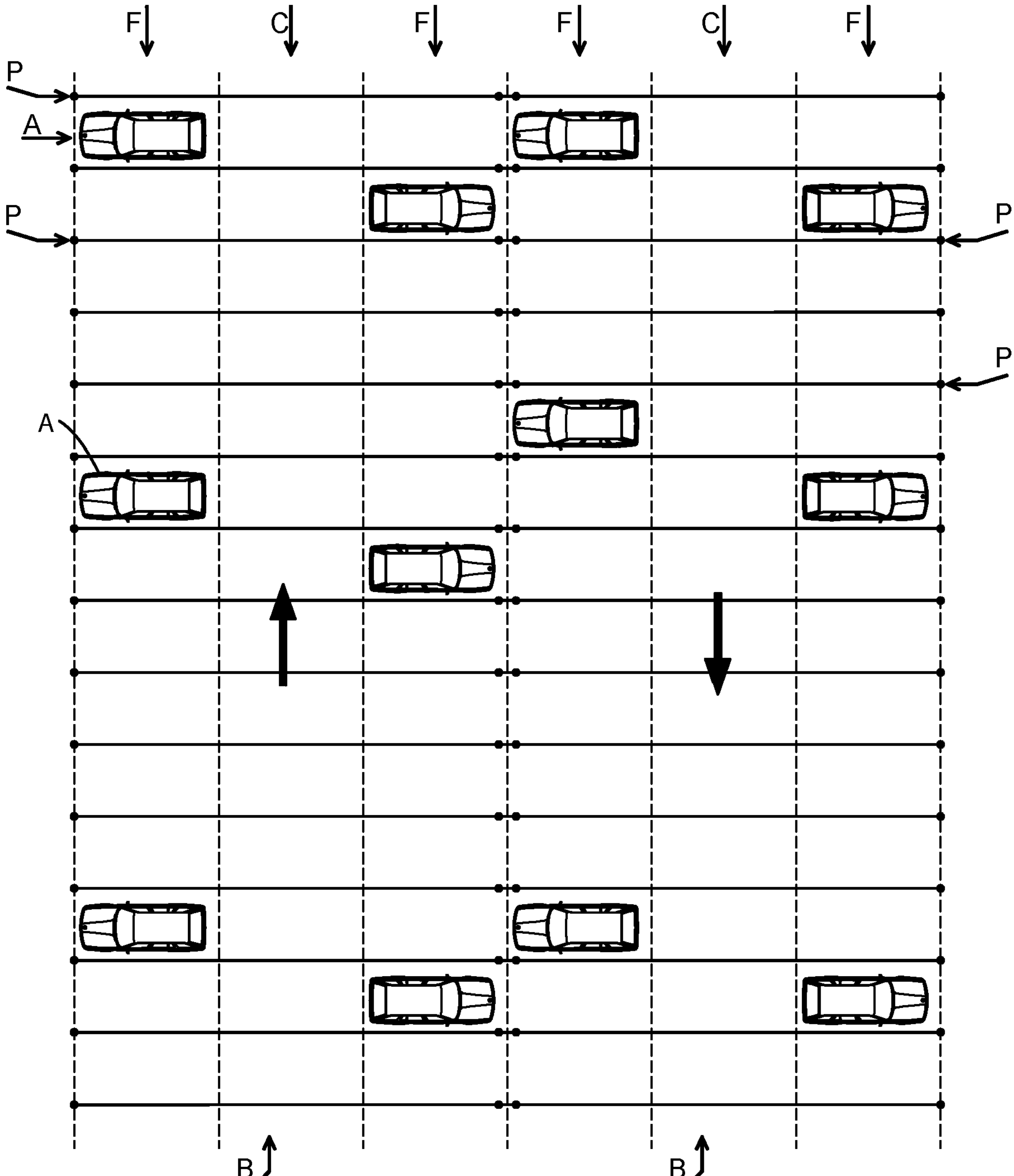

Fig. 6

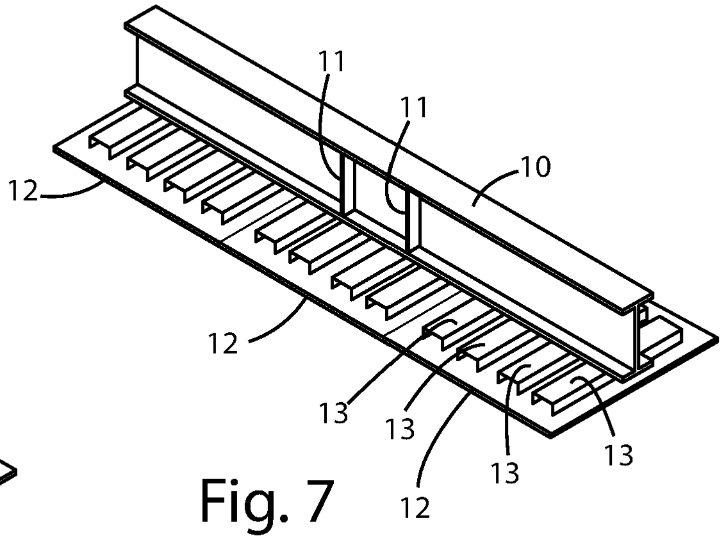

Fig. 7

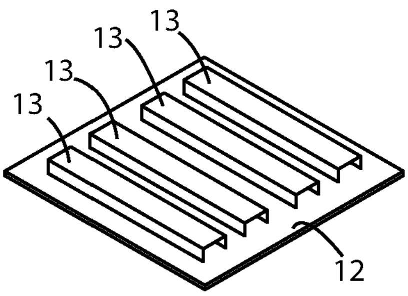

Fig. 7a

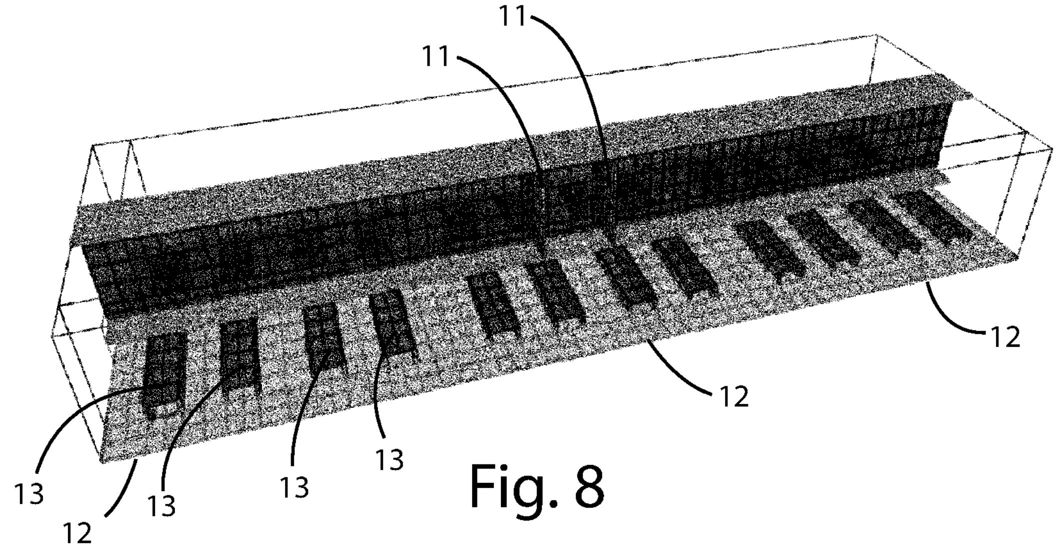

Fig. 8

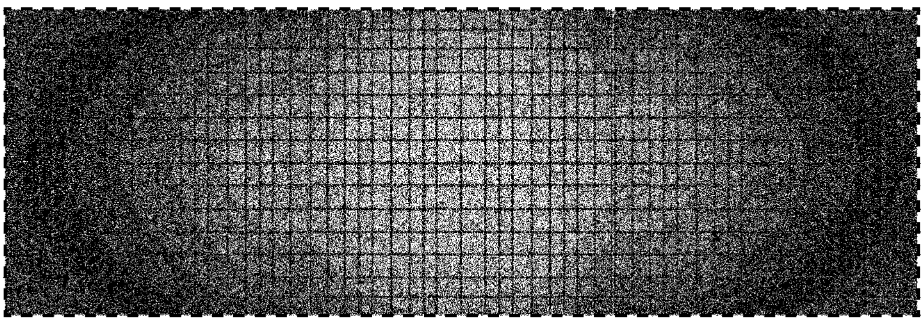

Fig. 9

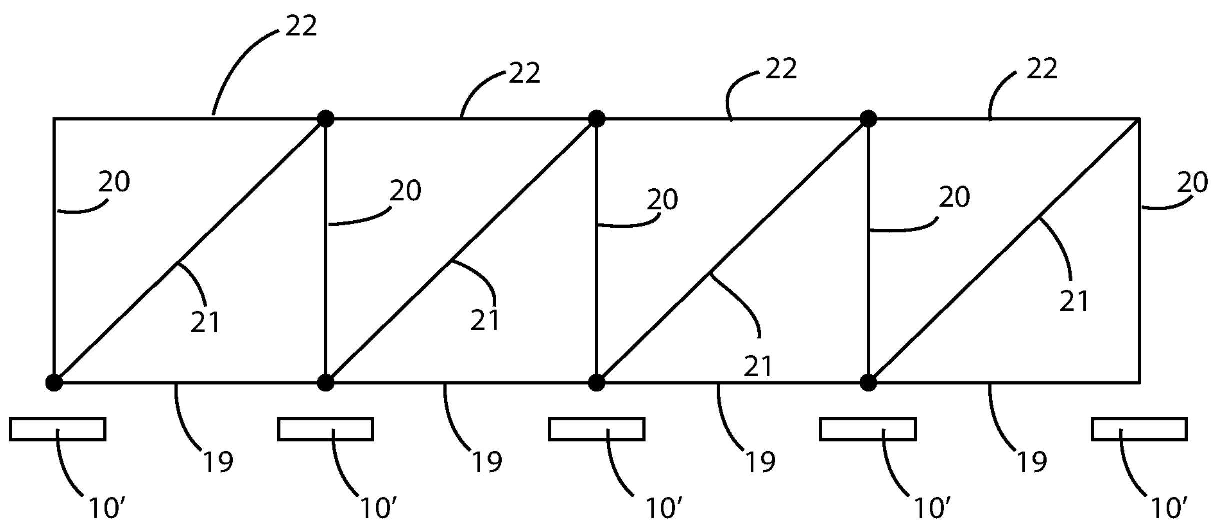

Fig. 10

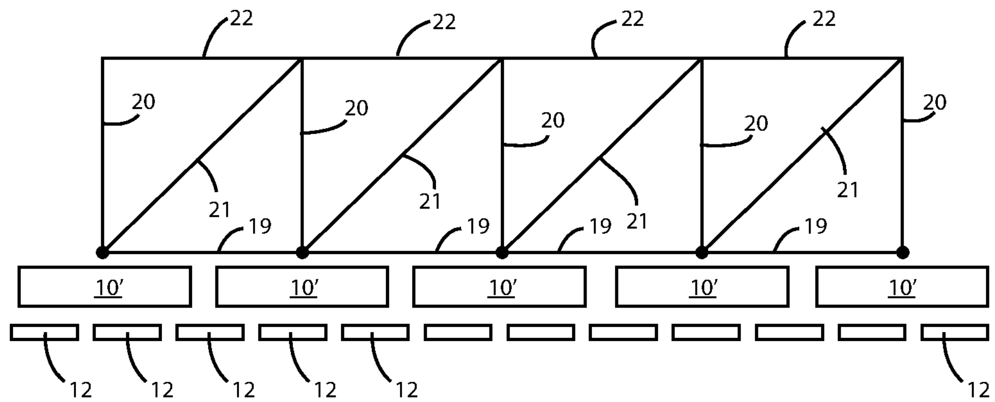

Fig. 11

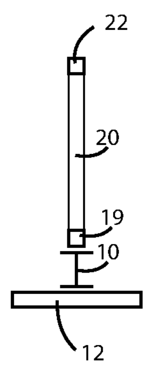

Fig. 11a

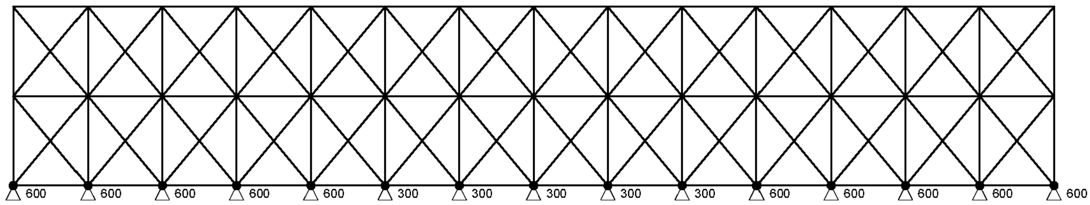

Fig. 12

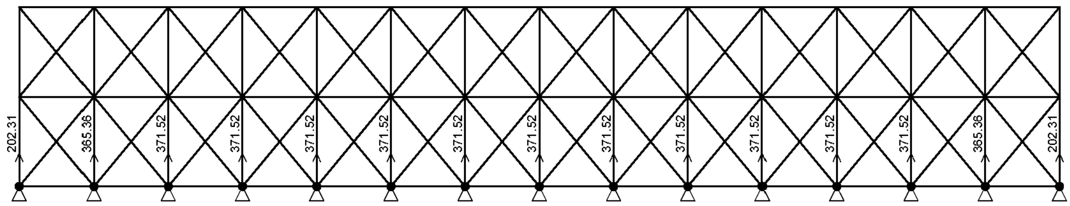

Fig. 13

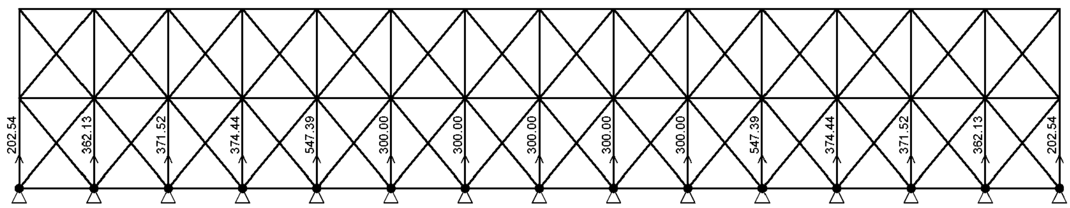

Fig. 14

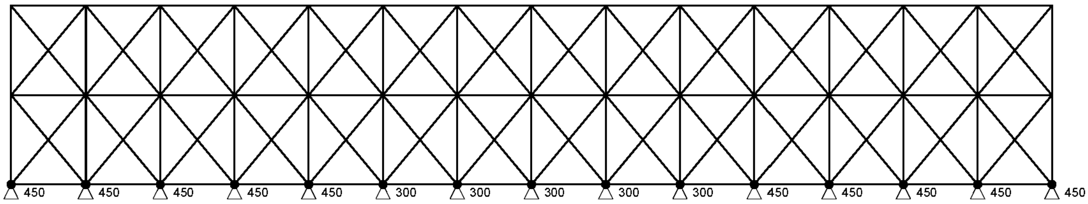

Fig. 15

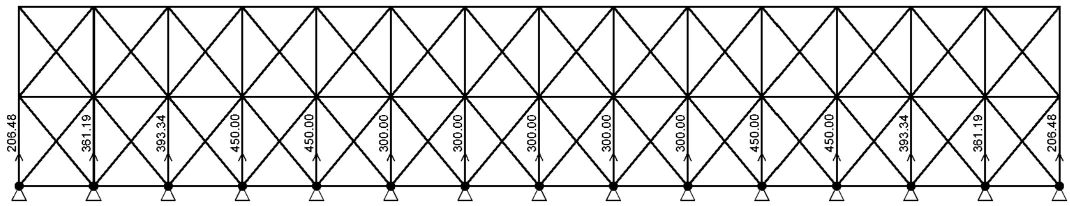

Fig. 16

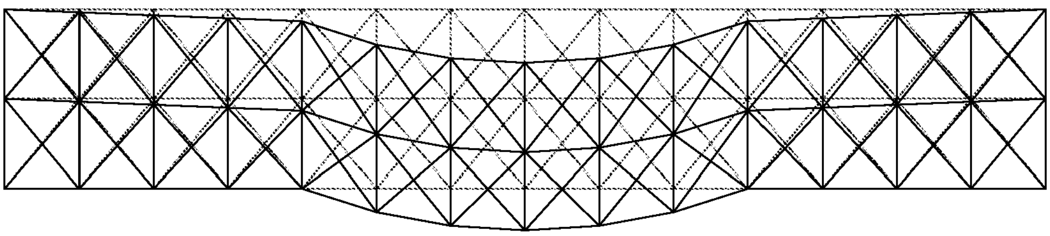

Fig. 17

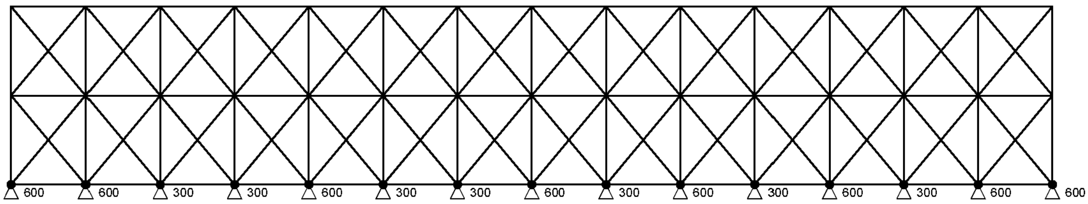

Fig. 18

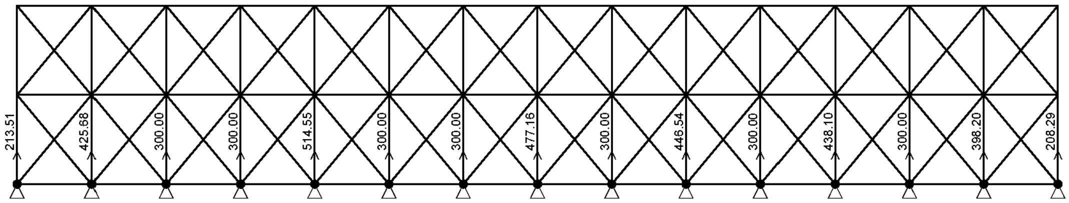

Fig. 19

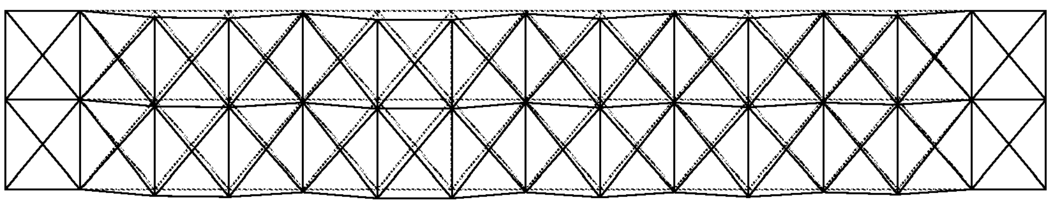

Fig. 20

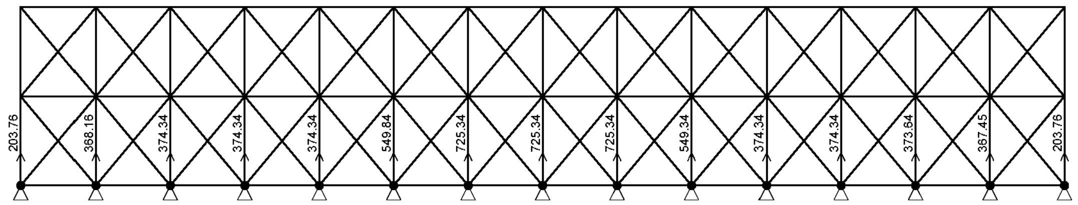

Fig. 21

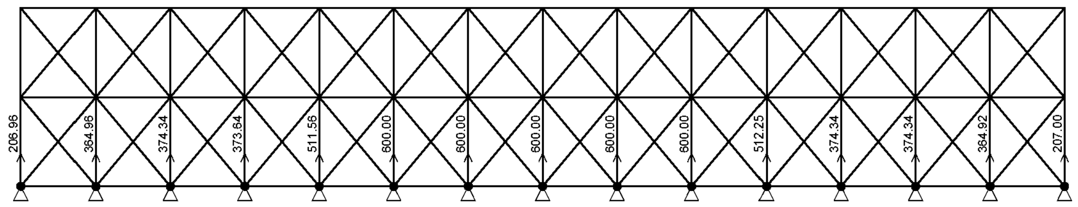

Fig. 22

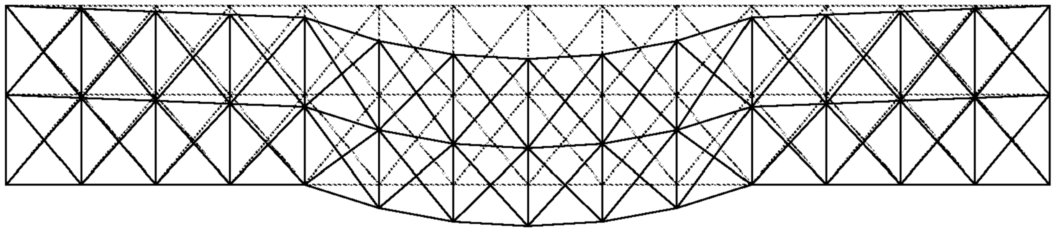

Fig. 23

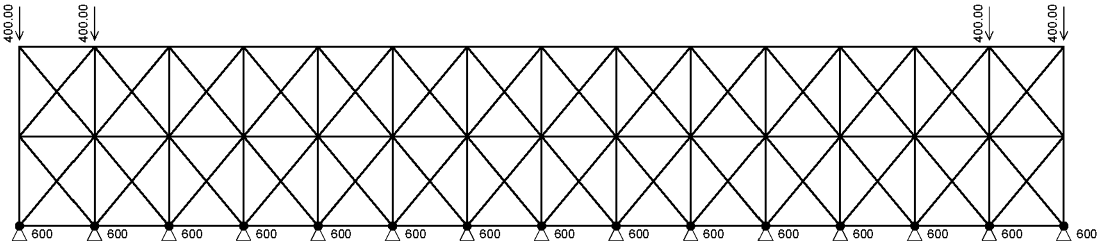

Fig. 24

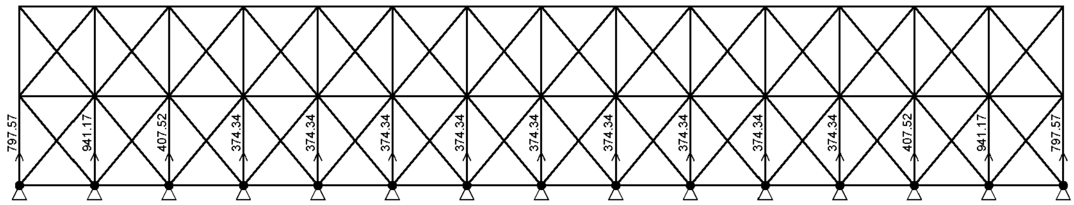

Fig. 25

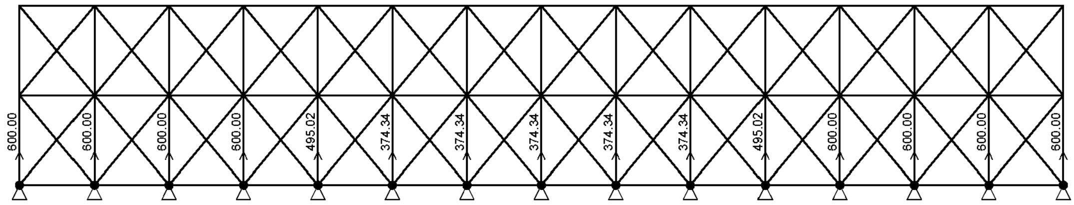

Fig. 26

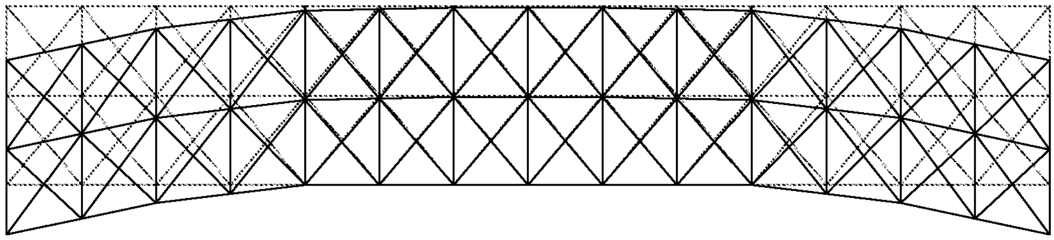

Fig. 27

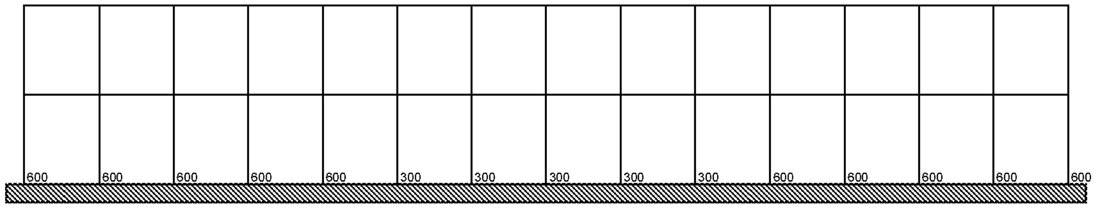

Fig. 28

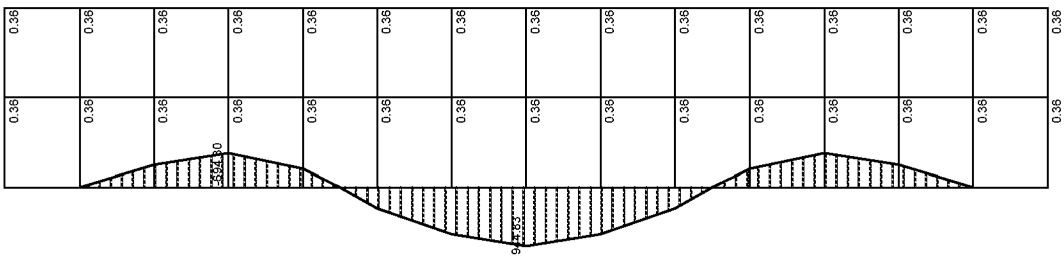

Fig. 29

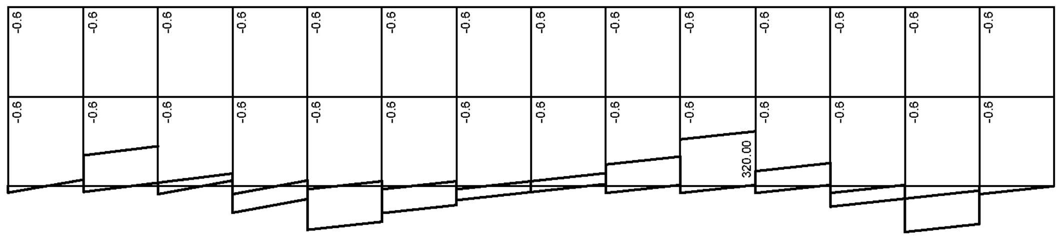

Fig. 30

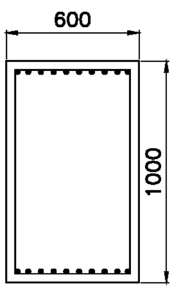

Fig. 31

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP H10280545 A **[0003]**