Abstract: Formwork (1) for pouring a concrete slab (21), which (1) contains a membrane (17) consisting of a foil or tarpaulin or the like made of plastic, whereby the membrane (17) forms the bearing surface that bears the concrete (33) to be poured for the concrete slab (21) while it cures.
Formwork for pouring a concrete slab, construction for pouring a floor, roof or ceiling, method for pouring a concrete slab, as well as a concrete slab.

First of all, the present invention concerns a formwork for pouring a concrete slab.

Without limiting the invention thereto, the present invention in particular relates to such a formwork designed to be mounted on an underlying supporting structure, whereby overhanging portions of the concrete slab to be formed form a span between supporting parts of the bearing structure and whereby a reinforcement is provided in the concrete slab to be formed.

Typically, a formwork according to the invention is designed for pouring a concrete slab to cover a water management facility, such as for example an underground facility for the infiltration of rain water, a facility for buffering rain water or an underground water storage or the like, or to cover a crawl space or the like in house-building, but the invention is not restricted to these applications.

Due to the increasing rain intensity as a result of the changing climate, and as open spaces are increasingly being built over and large paved areas are constructed such as car parks, roads and so on, more and more measures are being taken to prevent flooding when it rains.
To this end, provisions are set up under paved areas in the form of underground cavities or wells in which the rain water can be collected temporarily or, in the long term, for example to drain it to a sewer in a controlled manner later on, to use it in other applications or to allow it to infiltrate locally in the underground.

Many ways are already known to create such water management facilities.

In many cases, infiltration units or buffer units are provided in a building pit to that end, which are comparable to a kind of plastic crates or supports with an open structure and which are often stackable and/or can be mutually coupled to form large, underground open constructions in which water can be collected.

These underground constructions also form a bearing structure on which a concrete slab can subsequently be poured or on which a footing or the like can be provided.

In many cases, on top of the infiltration units and/or buffer units is provided a cover in the shape of a layer of sand or some foundation package, and only then is provided a reinforced road hardening, for example made of concrete, asphalt, clinkers or other materials, selected as a function of the load class or on any other basis.

The manufacturers of the infiltration units and buffer units indicate which traffic class corresponds to which minimum cover.
However, there are also applications whereby the concrete is poured directly on the upper side of the plastic infiltration units or buffer units, so that these infiltration units or buffer units in a sense can be regarded as parts of a formwork. This is rather rare.

A disadvantage of these known methods for constructing underground water management facilities is that the used plastic infiltration units are very expensive.

Another disadvantage associated with the use of said plastic infiltration units is that their installation requires great precision, since the different infiltration units should closely connect.

This requires among others also a very precise finish and alignment of the bottom of the building pit itself.

Consequently, applying such plastic infiltration units in the building pit is a labour-intensive and time-consuming job, which further increases the costs associated with the installation of the underground water management facility. Moreover, it is also known that the plastic crates cannot be cleaned, resulting in a huge constraint for such systems.

Also, the present invention aims to provide a solution to one or more of the aforesaid and/or other disadvantages.

More specifically, the invention aims to provide a solution which makes it possible to pour a concrete slab on top of a bearing structure in a very simple, extremely fast and efficient manner.
Another object of the invention is to simplify the construction of the actual bearing structure for the concrete slab as much as possible.

In particular, it is an object of the invention to offer a technique that allows a less precise alignment of the different parts of this bearing structure, as well as of the building pit.

Yet another aim of the invention is to make as much use as possible of relatively inexpensive materials which are widely available in the building industry and which can be easily assembled with conventional techniques and connecting means.

To this end, the present invention concerns a formwork for pouring a concrete slab, which contains a membrane made of a plastic foil or tarpaulin or the like, whereby the membrane forms a supporting part of the formwork which can bear concrete to be poured while it cures.

The strength of the invention lies in the fact that it goes against all currently prevailing thoughts, which leads to some surprising effects which moreover strengthen one another.

According to the present state of the art, invariably rigid elements are used for assembling a formwork in the assumption, on the one hand, that this is necessary to absorb the large pressures under the weight of the concrete, and on the other hand because non-rigid elements
inevitably have a certain deflection, as a result of which the measurements which are usually imposed on the construction cannot be respected or the result which is finally obtained will be considered to be unpredictable.

A first major advantage of a formwork according to the invention is indeed that its membrane is bendable or flexible, and possibly even elastic and stretchable, as a result of which certain alignment errors are easily, by itself as it were, absorbed in the bearing structure for the concrete slab, so that larger tolerances in the finishing of this bearing structure are more acceptable than is the case with the conventional techniques, which moreover makes it possible to speed up the building process.

However, the membrane not only adjusts to possible deviations in the bearing structure, of course it also deflects under the pressure of the concrete in locations where it is not supported by the bearing structure.

In contrast to what is generally thought, this deflection is surprisingly not detrimental to the construction, but precisely adds to the stability of the construction.

Indeed, due to the bending and possible stretching of the membrane, the supporting parts of the bearing structure on which the formwork rests are laterally anchored in the poured concrete slab, so that lateral (typically horizontal) forces can be absorbed.
The fact that the side of the concrete slab adjacent to the membrane is not 100% flat is irrelevant in the aimed applications, since underground facilities are concerned which have no aesthetic function whatsoever once the construction is finished and which are supposed to be exclusively accessible for inspection and maintenance.

Another major advantage of such a formwork according to the invention is that it can be installed very quickly and efficiently.

Indeed, it is sufficient to roll the membrane of the formwork over the bearing structure and to fix it.

This moreover allows to obtain a seamless finish of the poured concrete slab on the side of the membrane.

In short, the use of a flexible membrane in a formwork, which is usually considered to be impossible or disadvantageous, on the contrary appears to be a simpler and faster solution for the aimed applications here, whereby moreover a more stable construction is obtained.

The invention also concerns a construction for pouring a floor, ceiling or roof, whereby the construction comprises a formwork according to the invention as described above.

In such a construction according to the invention, the formwork is provided on a bearing structure, whereby the formwork is designed for pouring a concrete slab on the bearing structure, whereby overhanging portions of the concrete slab to be poured form a span between supporting
parts of the bearing structure and whereby a reinforcement is provided in the formwork, whereby the membrane of the formwork at least partially spans the bearing structure and is designed for bearing poured concrete for the concrete slab, in particular in the overhanging portions, and for making it rest on the supporting parts.

It is clear that such a construction according to the invention has all the advantages mentioned above and is particularly suitable for the construction of for example underground water management facilities.

According to a preferred embodiment of such a construction in accordance with the invention, the bearing structure comprises one or several of the following elements:
- a PP infiltration unit;
- a concrete or brickwork column or foundation strip provided with a pad;
- a plastic column provided with a pad; and/or
- a retaining wall element.

Naturally, the aforesaid elements are just a few of the possible examples and it is not excluded according to the invention to apply many other possible elements in order to achieve a bearing structure.

Moreover, it is clear that it is not excluded to use pre-existing elements, such as the known infiltration units and retaining wall elements, to build the bearing structure according to the invention.
Also, a major advantage of applying for example concrete or brickwork columns is that it is very inexpensive and they can be easily placed by any construction worker.

The invention also relates to a method for pouring a concrete slab to cover a water management facility, whereby the concrete slab must rest on an underlying supporting structure and whereby overhanging portions of the concrete slab form a span between supporting parts of the bearing structure.

More specifically, the invention relates to such a method including at least the following steps:
- applying or building the supporting parts of the bearing structure;
- applying a formwork on the bearing structure by applying a membrane over the bearing structure;
- fixing the membrane to a portion of the formwork itself and/or to a portion outside the formwork;
- applying a reinforcement over the membrane;
- pouring concrete on the membrane, whereby the poured concrete is borne by the membrane, in particular in the overhanging portions, and rests on the supporting parts, and whereby the membrane undergoes a stretch or deformation, so that a certain sag of the poured concrete is obtained around the supporting parts; and,
- the curing of the concrete.

Obviously, such a method is very efficient and makes it possible to build a water management facility very fast.
Finally, the invention also relates to a concrete slab covering a water management facility, whereby the concrete slab rests on an underlying supporting structure, whereby overhanging portions of the concrete slab form a span between supporting parts of the bearing structure and whereby the concrete slab shows a certain deflection between the supporting parts of the bearing structure amounting to at least 1/200, better still at least 1/100 and preferably at least 1/50 of the distance between the corresponding supporting parts nearby.

The deflection is obtained in a simple manner with a formwork according to the invention which is provided with a flexible membrane and which makes sure that the supporting parts are firmly anchored in the concrete slab.

In order to better explain the characteristics of the invention, the following preferred embodiments of a formwork for pouring a concrete slab, a construction for pouring a floor, roof or ceiling, a method for pouring a concrete slab, as well as a concrete slab according to the invention are described by way of example only without being limitative in any way, with reference to the accompanying drawings, in which:

figure 1 is a cross-section through a first embodiment of a formwork according to the invention, whereby the middle portion is omitted;
figure 2 shows the portion indicated by F2 in figure 1 to a larger scale;
figure 3 shows a top view of a portion of the formwork indicated by F3 in figure 2;
figure 4 shows a cross-section through a construction according to the invention for pouring a floor, whereby the formwork from figure 1 has been provided on a bearing structure;

figure 5 shows the portion indicated by F5 in figure 4 to a larger scale;

figure 6 shows the condition, in an analogous manner as in figure 5, after the concrete for the floor has been poured;

figure 7 shows a top view of a bearing structure provided in a building pit;

figure 8 is a side view according to arrow F8 in figure 7, whereby the middle portion has been omitted for clarity's sake;

figure 9 shows a view according to arrows F9 of a portion of the building pit after a second embodiment of a formwork according to the invention has been provided and concrete has been poured in the formwork;

figure 10 shows the portion indicated by F10 in figure 9 to a larger scale;

figure 11 is a top view according to arrow F11 in figure 12 of a portion of a construction according to the invention whereby a third possible embodiment of a formwork according to the invention has been applied;

figure 12 shows a cross-section through the above-mentioned construction after the concrete has been poured in this formwork;

figures 13 and 14 show the portions indicated by F13 and F14 in figures 11 and 12 respectively to a larger scale; and,
figures 15 and 16 show the portions indicated by F15 and F16 in figures 11 and 12 respectively to a larger scale.

5 The first embodiment of a formwork 1 in accordance with the invention represented in figures 1 to 3 has a rectangular shape in a plan view, whereby its perimeter is formed of lateral elements 2 which in this case consist of concrete support blocks 3.

10 These concrete support blocks 3 may for example be concrete blocks having a length of 50 cm, a height of 30 cm and a thickness of 14 cm.

15 As an alternative, also small reinforced concrete beams can be used having a length of 1 m to 2 m and a square cross-section of 14 cm by 14 cm.

To this end, for example standard lintels can be used.

20 Naturally, it is not excluded according to the invention to use other dimensions and/or other materials to this end.

25 Between two opposite sides 4 and 5 of the formwork 1, opposite lateral elements 2 are mutually connected by means of transverse elements 6.

In the case of figure 1, these transverse elements 6 are formed of hollow steel pipes 7, but other types of transverse elements 6, for example in the shape of a steel
reinforcement or the like, are not excluded either according to the invention.

The steel pipes 7 may for example typically have a diameter of about 35 mm, but other dimensions are not excluded of course.

For the application of the steel pipes 7 between a pair of support blocks 3 has been provided, in this case, an insert 9 in each far end 8 of the steel pipe 6 concerned which can be inserted with its far end 10 fitting in the cavity 11 of the steel pipe 7.

The inserts 9 are not rigidly connected to the hollow steel pipes 7 in this case, but it is not excluded to apply such a rigid connection, for example by means of a welded joint or the like.

Such an insert 9 is further provided with a support piece 12 against which a far end 8 of the steel pipe 7 can rest and with which a force can be transmitted onto a support block 3.

The other far end 13 of the inserts 9 is anchored in the concrete support block 3 concerned.

To this end, the far end 13 of said insert 8 can be provided directly in the uncured substance during the manufacture of the concrete support block 3, or it may be anchored in the support block 3 later on, for example by boring and applying a plug or chemical anchor or the like.
Naturally, many other possible techniques and embodiments are not excluded from the invention either.

On either side of the steel pipes 7 has been provided a reinforcement mesh 15.

Naturally, these reinforcement meshes 14 are dimensioned such that the concrete slab to be poured can handle the required load, for example the load of traffic passing over the concrete slab to be poured.

Typically, for example reinforcement meshes 14 with an aperture 15 of 150 mm could be used and with reinforcement bars 16 having a diameter of for example 6 mm, but other dimensions are not excluded either.

What makes a formwork 1 according to the invention special is that it includes a membrane 17 formed of a plastic foil or tarpaulin or the like, whereby the membrane 17 forms a supporting part of the formwork 1 which can support the concrete to be poured while it cures.

The membrane 17 may for example be a PE film (polyethylene) which is at least pliable and flexible and it may also exhibit a certain elasticity, depending on the application .

As already explained in the introduction, the aim is that, after the concrete has been poured, the membrane 17 of the formwork 1 undergoes a certain sag due to its bendability or elasticity, such that alignment errors can easily be
absorbed and a large stability of the construction is obtained.

The membrane 17 is fixed and to this end, in the given example of figures 1 to 3, it adheres with its edges 18 to a portion of the formwork 1 itself, more specifically to the support blocks 3.

In order to fasten the membrane 17 to the support blocks 3, concrete anchors 19 are used in this case, but of course many other means can be used to that end.

The membrane 17 is hereby stretched between the two opposite sides 4 of the perimeter of the formwork 1.

The lateral elements 2 of support blocks 3 are held at a fixed distance from each other by the hollow steel pipes 7 and the inserts 9.

The tension force for stretching the membrane 17 is thus absorbed by the hollow steel pipes 7.

An advantage of the use of hollow steel pipes 7 consists in that such hollow pipes 7 are able to absorb proportionally larger bending moments than full pipes or reinforcement bars of the same weight.

On the other hand, the aim is for the whole steel frame formed of the steel pipes 7 to be embedded along in the concrete to be poured.
However, for safety reasons, the use of hollow steel pipes 7 as a reinforcement is not necessarily readily accepted, as a result of which the contribution of the hollow steel pipes 7 to the reinforcement of the concrete slab may be excluded from the strength calculation.

Thus, a design in which the hollow steel pipes 7 are excluded from the strength calculation will usually contain more steel than a similar design, whereby the support blocks 3 are connected by means of transverse elements 6 consisting of reinforcement bars.

In the latter case, however, the use load on the concrete slab as well as the forces acting on the reinforcement bars as a result of the membrane being stretched will be taken into account for the dimensioning of the reinforcement bars.

It is clear that, depending on the case, by an appropriate choice of the design parameters, the amount of steel used can be minimised.

Figures 4 to 6 represent a construction 20 in accordance with the invention for pouring a concrete slab 21, more specifically a floor or a roof 21 to cover a water management facility, in this case an infiltration basin 22.

The concrete slab 21 hereby forms a paved area and may for example be a parking lot, a road, a square or the like.
In a square or rectangular building pit 23 is provided a bearing structure 24 to this end which includes a regular pattern of concrete poles 25 in the middle and whereby the edges 26 of the building pit 24 are bordered with a belt made of plastic (for example PP) infiltration units 27.

The poles 25 are poles 25 built of concrete blocks 28, whereby a concrete pad 29 forms the foot of each pole 25 and in this case each time two concrete blocks 28 are cemented on said concrete pad 29.

Naturally, the pads 29 of the poles 25 are intended to better spread the load which is to be transferred to the ground via the poles 25 over the ground surface and thus prevent sagging of the poles 25.

Of course, many other elements can be used to build a bearing structure 24, such as for example plastic columns provided with a pad, prefab concrete cones, retaining wall elements, steel frames and the like.

The building pit 23 is provided beforehand with a coating 30 which in this case consists of a geotextile 30.

In the given example, the aim is that rain water which ends up in the infiltration basin 22 after a rain shower can penetrate in the soil through the geotextile 30.

In other applications, however, the aim may be for example to prevent this infiltration of rain water into the ground and to temporarily store the rain water in the well 22 for
other use or to discharge it in a controlled manner from the well 22 to a sewer or drain or the like.

In such an application, the building pit 23 may for example be coated with a waterproof layer.

The construction 20 further comprises a formwork 1 as discussed above with reference to figures 1 to 3.

The formwork 1 is hereby provided on the bearing structure 24, whereby the formwork 1 is of course designed for pouring the concrete slab 22 on top of the bearing structure 24.

The aim is not to make the formwork 1 beforehand and to then put it over the bearing structure 24.

A practical way of working is to roll the membrane 17 over the bearing structure 24 and to then fix it and possibly tighten it, either to portions of the formwork 1 itself which are provided afterwards, or to the bearing structure 24 or other fixed elements in the building pit 23 and the like.

As is represented in greater detail in figure 6 for example, overhanging portions 31 of the concrete slab 21 to be poured form a span 31 between supporting parts 32 of the bearing structure 24.

The supporting parts 32 are in this case formed of the poles 25 and the infiltration units 27.
The reinforcement meshes 14 which are provided in the formwork 1 make sure that the concrete slab 22 is able to support the load in the overhanging portions 31 and can transmit it to the ground via the poles 25.

The membrane 17 of the formwork 1 spans the entire bearing structure 24 and is designed to bear poured concrete 33 for the concrete slab 21, in particular in the overhanging portions 31, and to make it rest on the supporting parts 32.

Indeed, it is in these overhanging portions 31 that the membrane 17 forms a bearing portion of the formwork 1, and consequently the membrane 17 must be sufficiently rigid to be able to bear the weight of the liquid concrete until this concrete has cured.

It is clear that an improper alignment of the tops of the poles 25 and the infiltration units 27 is not problematic in this respect since, thanks to the bendability and the elasticity of the membrane 17 of the formwork 1, the formwork 1 will deform under the weight of the concrete 33, and the poured concrete will be automatically supported by the supporting parts 32.

In this manner is also obtained a very even distribution of the force to be transmitted onto the bearing structure.

As is represented in greater detail in figure 6, after the concrete 33 has been poured, a sag D of the membrane is moreover obtained in the overhanging portions 31.
According to the invention, said sag D amounts to at least 1/200, better still at least 1/100, preferably more than 1/50 and even more than the distance L between the nearby supporting parts 32 concerned, i.e. the length L of the span 31.

In this manner is obtained a solid anchoring of the poles 25 and the infiltration units 27 in the concrete slab 21, whereby any lateral thrusts or other lateral or horizontal forces acting on parts of the bearing structure 24 can be easily absorbed.

In the example discussed here, the membrane 17 of the formwork 1 is fixed in the formwork 1 itself.

As an alternative or additionally, it is not excluded however to fix the membrane 17 by fastening it to a portion outside the formwork 1.

The membrane 17 of the formwork 1 may for example be additionally fixed to one or several supporting parts 32 of the bearing structure 24.

In order to obtain a good deflection of the membrane 17 while pouring the concrete 33, a membrane 17 with a certain elasticity may be used, but this is not necessarily the case.

It may be sufficient to use a membrane 17 with a certain degree of bendability without being stretchable however.
Indeed, the membrane 17 can be fixed to two opposite sides 4 and 5 and be provided with a certain 'extra length', whereby the distance between the opposite sides 4 and 5 is thus shorter than the corresponding dimensions in the direction concerned of the membrane 17.

In this manner, the membrane 17 may obtain the required deflection between the supporting parts 32 while the concrete 33 is being poured.

In order to achieve an equal distribution of deflections in the different overhanging portions 31, a reinforcement may be applied for example with protruding parts which already deform the membrane 17 in accordance with the deflection to be achieved in the overhanging portions 31 before the concrete 33 is poured.

The membrane 17 of the formwork 1 may be stretched before the concrete 33 is actually poured, which may benefit the practical feasibility and execution speed.

However, it is not necessary to stretch the membrane 17 before the concrete 33 is being poured, since the membrane 17 will automatically stretch under the load of the liquid concrete 33 on the membrane 17 while the concrete 33 is being poured.

Figure 7 shows a top view of another embodiment of a bearing structure 24, whereby this time the building pit 23 is bordered by poles 34 instead of infiltration units 27, as was the case in the previous example.
The infiltration basin 22 is further sealed by means of sheet material 35 provided on the poles 34 forming the perimeter of the infiltration basin 22.

Figures 9 and 10 represent the situation after a concrete slab 21 has been poured on said bearing structure 24 with the aid of a formwork 1 according to the invention, although carried out differently this time.

The formwork 1 of figures 9 and 10 includes lateral elements 2 which have the shape of a steal beam or girder 36 this time, with an L-shaped cross-section in the given example.

The transverse elements 6 of the formwork 1 are made of reinforcement steel 37 and are no longer formed of hollow steel pipes 7, as was the case in the preceding example.

Transversely to the steel girders 36, sleeves 38 have been welded in which said reinforcement steel can be tightly fit.

In this way, the lateral elements 2 are again maintained at a fixed distance from one another.

The aim hereby is that the reinforcement steel 37 is made sufficiently heavy to absorb the tension force for stretching the membrane 17 of the formwork 1.

The membrane 17 is stretched between the metal girders 36 and fastened to these girders with appropriate means 39.
For example, when using a membrane 17 made of HDPE (high density polyethylene), a HDPE extrusion weld 30 can be used as a fender.

The formwork 1 is further surrounded by lateral panels 40 to form a shell in which the concrete 33 can be poured.

In the preceding example, this function was carried out by the support blocks 3.

The lateral panels 40 are mounted fixed to the sheet material 35 of the bearing structure 24.

The edges 18 of the membrane 17 also cover the inside of the lateral panels 40, such that the entire membrane 17 forms the actual shell for the concrete 33.

The obtained result as represented in figures 9 and 10 can be compared to that of figure 6 in which, in the overhanging portions 31, the concrete slab 21 represents a certain sag D which contributes to the stability of the construction 20.

Figures 11 to 16 illustrate yet another possible working method.

In a building pit 23 is provided a bearing structure 24, similar to that of the situation represented in figure 7.

On this bearing structure 24 is provided a formwork 1 according to the invention, but carried out differently and whereby a concrete 33 is poured in the formwork 1.
The formwork 1 of figures 11 to 16 includes lateral elements 2 which, as in the preceding example of figures 9 and 10, are formed of a steel beam or girder 36 having again an L-shaped cross-section in this example.

In the direction transverse to the lateral elements 2, the situation is rather similar to the embodiment of figures 1 to 6, since use is again made among others of transverse elements 6 formed of hollow steel pipes 41 designed to absorb the tension force of the membrane 17 of the formwork 1.

In contrast to what was the case with the preceding embodiments of a formwork 1 according to the invention, the aim here is not that these steel transverse elements 41 remain permanently in the concrete 33, but the purpose is precisely to take them away after the concrete 33 has cured.

In order to make this possible, holes 42 have been provided in the metal girders 36 and, through opposite holes 42 in the pair of girders 36, plastic transverse elements 43 are first provided extending between the two opposite girders 36.

These plastic transverse elements 43 are designed as hollow wall duct tubes 43, made for example of PVC or HDPE, and they do form a part of the formwork 1 which remains permanently in the concrete 33, and they are designed to form a shield between the concrete 33 to be poured and the steel transverse elements 41 which are
provided in the wall duct tubes 43 after these plastic wall duct tubes 43 have been put in place in order to temporarily absorb the tension force.

In order to form a sealed entity in the formwork 1 for the liquid concrete 33, the plastic wall duct tubes 43 must of course have a diameter corresponding to the holes 42 in the metal girders 36.

The diameter of the hollow steel pipes 41 is preferably sufficiently smaller than the diameter of the wall duct tubes 43 in order to facilitate the insertion of the steel pipes 41 in the wall duct tubes 43.

In a practical embodiment, which is also illustrated in figures 11 to 16, the hollow steel pipes 41 consist of short segments 44 of for example 1 to 2 metres that are coupled to one another.

As is represented in greater detail in figures 15 and 16, said coupling of the segments 44 is in this case achieved with intermediate steel pins 45, each time provided between two segments 44, but other methods are not excluded either.

The use of such short segments 44 can prevent that the underground building pit 23 must assume large dimensions to allow the steel transverse elements 41 to be inserted and removed again.

The hollow steel pipes 41 extend through the girders 36 and rest on either side on a flange 46 which can be
screwed down on the steel girder 36 concerned by means of nuts 47, which is represented in greater detail in figures 13 and 14.

In this manner, the segments 44 can be firmly pressed together to thus absorb the tension force of the membrane 17.

The membrane 17 is introduced under the girders 36 and fixed on the outside of the girders 36.

Above and under the wall duct tubes 43 are again provided reinforcement meshes 14 as in the case of figure 1, for example.

After the concrete 33 has been poured and cured, the aim is not only to remove the segments 44 and pins 45, but also the metal girders 36.

This can be done in a simple manner in this case by first loosening the membrane 17 and then further tightening the nuts 47, as a result of which the girders 36 will move apart and be peeled away from the formed concrete slab 21, which considerably facilitates the formwork removal.

Naturally, formwork oil should be provided on the metal frame of the formwork 1.

It is clear that the steel transverse elements 41 in this case only form a temporary construction.
Also, the formwork 1 according to the invention contains parts which are left behind after the pouring of the concrete 33 and thus form parts of a formwork 1, but also temporarily provided parts.

This third embodiment has as a major advantage that the actual reinforcement formed by the reinforcement meshes 14 can be used more effectively.

As already discussed above, the first embodiment of figures 1 to 6 is indeed disadvantageous in that the hollow steel pipes 7 which remain permanently in the concrete 33 do not actually count as reinforcement, which increases the price of the solution and makes the construction relatively heavy.

Moreover, these pipes 7 are situated in the central zone of the concrete 33, where they are least effective to absorb bending moments.

This third embodiment of a formwork 1 according to the invention therefore offers an even more practical and more economical solution and also offers all the advantages of the preceding embodiments, for example with regard to the achievement of a sag D and the like.

In general it can be said that a formwork 1 according to the invention is used for pouring a concrete slab 21 and to that end includes a membrane 17 consisting of a foil or tarpaulin or the like made of plastic, whereby the membrane 17 forms the support that bears the concrete 33 to be poured for the concrete slab 21 while it cures.
The membrane 17 is preferably made of a plastic without reinforcement or fibres, for example a non-fibre-reinforced PE foil (polyethylene) with a certain elasticity. This provides for a sag D of the concrete 33 to be poured.

The formwork 1 preferably has a perimeter provided on at least two opposite sides with lateral elements 2, and whereby the membrane 17 is fixed and to this end is fastened to the lateral elements 2 of the formwork 1.

Just fastening the membrane 17 may be sufficient in certain cases, but depending on the nature of the membrane 17, it may be necessary to stretch the membrane 17.

More specifically, in a preferred embodiment of a formwork 1 according to the invention, the membrane 17 is prestretched before the concrete 33 is being poured.

Naturally, the membrane 17 which serves to bear the concrete 33 will also stretch under the weight of the concrete 33, which may be associated with an excessive sag which can be avoided by prestretching the membrane 17.

The membrane 17 is preferably prestretched between at least two opposite sides 18 of its perimeter.

To this end, the formwork 1 is provided on opposite sides 4 and 5 with one or several lateral elements 2, whereby opposite lateral elements 3 or 36 on the opposite sides 18 of the membrane 17 are mutually connected by transverse elements 6.
These transverse elements 6 keep the lateral elements 2 at a distance from one another and absorb the tension force for prestretching the membrane 17, as well as the additional tension force which is present after the concrete 33 has been poured until this concrete 33 has cured.

The transverse elements 6 are preferably formed of pipes 7 or tubes or the like, such that they are highly resistant to bending.

Indeed, as is known, full bars have the disadvantage that they are much less resistant to bending and torsion for the same weight.

It is not excluded according to the invention to use full bars, however.

Transverse elements in the shape of pipes 7 preferably have a minimal diameter of 30 mm or even 45 mm and a wall thickness between 2 mm and 5 mm, or even between 2.5 mm and 3 mm.

In a preferred embodiment of a formwork according to the invention, retaining means 19 are provided on opposite sides 18 of the membrane 17 for retaining the membrane 17, as well as tightening means with which the retaining means 19 can be moved in relation to one another for stretching the membrane 17.
The retaining means may be formed of concrete anchors which are anchored in the lateral elements, whereby in this case the tightening means may consist for example of means with which the length of the transverse elements can be adjusted and thus also the distance between the lateral elements, such that the membrane is stretched more or less, according to the case.

In another embodiment, the retaining means themselves can be arranged in a movable manner, whereby more or less tension is put on the membrane by moving the retaining means towards one another or by moving them apart, as appropriate.

In general, it can be said that the tension force resulting from the stretching of the membrane during the prestretching and the subsequent load under the pressure of the poured concrete results in a buckling load on the separate transverse elements.

The transverse elements should hereby be manufactured and dimensioned such that they are able to resist said buckling load, or in other words:

\[
P < \frac{\pi^2 \cdot E \cdot I}{L}
\]

whereby:

- \( E \) is the modulus of elasticity of the material out of which a transverse element is made;
- \( I \) is the area moment of inertia of the cross-section of a transverse element; and,
- \( L \) is the buckling length.
Usually, the transverse elements 6 according to the invention extend in a plane parallel to the membrane 17 at a distance from the plane of the membrane 17, for example at a distance which typically amounts to 15 to 20 mm.

The far ends of the transverse elements 6 are hereby anchored in the lateral elements 2, in such a way that they are connected in a non-sliding manner to the lateral elements 6.

The anchoring of the transverse elements 6 in the lateral elements 2 is further such that the lateral elements 2 cannot undergo a tilting movement as a result of the tension force exerted by the membrane 17 on the lateral elements 2 on the one hand, and the pressure force exerted by the transverse elements 6 on the lateral elements 2 on the other hand, taking into account the distance between the planes in which said forces occur.

In a preferred embodiment of a formwork 1 according to the invention, the transverse elements 6 are reusable, for example for pouring a concrete slab 21 at a different location.

Such reusable transverse elements 6 may for example be metal pipes 7 or tubes that are encased in surrounding lost pipes of the formwork 1, such as for example lost pipes made of a plastic such as PVC.

In another embodiment, the reusable transverse elements 6 are provided such on the lateral elements 2 that they do
not end up in the concrete 33 to be poured, so that they can be smoothly removed after the concrete 33 has been poured.

5 In a typical dimensioning which can be advantageously used according to the invention, the transverse elements 6 are formed of steel pipes 7 with a diameter of at least 30 mm and with a wall thickness between 2 and 5 mm, whereby successive transverse elements 6 are provided between the lateral elements 2 on a centre to centre distance of 30 cm or even 90 cm or more, and whereby the bottom of the pipes is situated 10 mm to 100 mm or even 15 mm to 20 mm above the membrane 17.

10 In a very general manner, we can say that the invention also concerns a construction 20 for pouring concrete 33 to form a predominantly horizontal span 31, such as a floor, a roof or a ceiling or the like.

15 This span 31 is provided between supporting parts 32 of an underlying supporting structure 24 formed of vertical elements such as walls, vertical columns 25 and the like.

According to the invention, a formwork 1 in accordance with the invention is provided on the bearing structure 24.

20 This formwork 1 is designed for pouring a concrete slab 21 on the bearing structure 24, whereby the membrane 17 of the formwork 1 extends over the underlying supporting structure 24 and forms the bearing surface to bear the
concrete 33 to be poured for the concrete slab 21 while it cures.

A typical feature of the invention is that it is characterised in that the membrane 17 is freely suspended and is not supported at the location of the span 31 between the supporting parts 32, but rests directly on the supporting parts 32 formed by the vertical elements 25.

The bearing structure 24 may for example include several columns 25, whereby the end faces of these columns 25 form the above-mentioned supporting parts 32.

The membrane 17 of the formwork 1 extends over the end faces of said columns 25, whereby the membrane 17 rests directly on the above-mentioned supporting parts 32 of the columns 25.

In a typical embodiment of a construction 20 according to the invention, the supporting parts 32 of the underlying supporting structure 24 are formed of several vertical elements situated at a mutual centre to centre distance from one another amounting to at least 40 cm and maximally 120 cm, or even at least 50 cm and maximally 100 cm.

The supporting parts 32 of the underlying supporting structure 24 consist for example of several vertical elements whose width amounts to at least 6 cm and maximally 30 cm, or even at least 10 cm and maximally 20 cm.
The invention also concerns a method for pouring concrete to form a predominantly horizontal span 31, such as a floor, a roof or a ceiling or the like, between supporting parts 32 of an underlying supporting structure 24 formed of vertical elements 25 such as walls, vertical columns 25 and the like.

In such a method according to the invention, use is made of a formwork 1 in accordance with the invention as described above.

Further, the method according to the invention includes at least the following steps:
- applying or building the supporting parts 32 of the bearing structure 24;
- applying the formwork 1 on the bearing structure, whereby a bearing surface is formed to bear the concrete 33 to be poured while it cures by applying a membrane 17 which extends over the bearing structure 24;
- fixing the membrane 17 to a part of the formwork 1 itself and/or to a portion outside the formwork 1;
- letting the membrane 17 suspend freely and not supporting it at the location of the span 31 between the supporting parts 32;
- directly supporting the membrane 17 on the supporting parts 32 formed by the vertical elements 25;
- providing a reinforcement 14 over the membrane 17;
- pouring concrete 33 on the membrane 17, whereby the poured concrete 3 is borne by the membrane 17, in particular in the overhanging portions 31, and rests on the supporting parts 32, and whereby the membrane 17 undergoes a stretch or deformation, such that a certain
sag D of the poured concrete 33 is obtained around the supporting parts 32; and,
- allowing the concrete 33 to cure.

5 In a particular method according to the invention, the membrane 17 is prestretched before the concrete 33 is being poured, and in order to fix the membrane 17 to at least two opposite sides 4 and 5 of the formwork 1, a series of concrete support blocks 3 are provided in between which are provided steel pipes 3 or reinforcement bars 37 which hold the concrete support blocks 3 at a fixed distance from one another and which absorb the tension force for prestretching the membrane 17, as well as the additional tension force which is present as soon as the concrete 33 has been poured, until the concrete 33 has cured.

The invention is by no means restricted to the embodiments of a formwork 1, a construction 20 and a concrete slab 21 according to the invention, described by way of example and illustrated in the accompanying drawings; on the contrary, such formworks 1, constructions 20 and concrete slabs 21 can be achieved in many other ways while still remaining within the scope of the invention.

25 The invention is not restricted either to the examples of methods according to the invention for pouring a concrete slab, described by way of example; on the contrary, other methods can be applied as well while still remaining within the scope of the invention.
Claims

1. Formwork (1) for pouring a concrete slab (21), characterised in that the formwork (1) includes a membrane (17) formed of a foil or tarpaulin or the like made of plastic, whereby the membrane (17) forms the bearing surface that bears the concrete (33) to be poured for the concrete slab (21) while it cures.

2. Formwork (1) according to claim 1, characterised in that the formwork (1) has a perimeter, provided on at least two opposite sides with lateral elements (2,3,36), and whereby the membrane (17) is fixed and has been fastened to the lateral elements (2,3,36) of the formwork (1) to that end.

3. Formwork (1) according to claim 1 or 2, characterised in that the membrane (17) is stretched, more specifically is prestretched before the concrete (33) is being poured, between at least two opposite sides (18) of its perimeter, whereby the formwork (1) is provided with one or several lateral elements (2) on opposite sides (4,5) and whereby opposite lateral elements (3,36) on the opposite sides of the membrane (17) are mutually connected by transverse elements (6) which hold the lateral elements (2) at a distance from one another and which absorb the tension force for prestretching the membrane (17), as well as the additional tension force which is present as soon as the concrete (33) has been poured, until this concrete (33) has cured.
4. Formwork (1) according to claim 3, characterised in that the transverse elements (6) are formed of pipes (7) or tubes or the like.

5. Formwork (1) according to claim 3, characterised in that the transverse elements (6) are formed of pipes (7) or tubes or the like having a minimal diameter of 30 mm and a wall thickness between 2.5 and 3 mm.

6. Formwork (1) according to one or several of claims 3 to 5, characterised in that on opposite sides of the membrane (17) are provided retaining means to hold the membrane (17) and tightening means with which the retaining means can be moved in relation to one another in order to stretch the membrane (17).

7. Formwork (1) according to one or several of the preceding claims, characterised in that the transverse elements (6) extend in a plane parallel to the membrane (17) at a distance from the plane of the membrane (17) and whereby the far ends of the transverse elements (6) are anchored in the lateral elements (2), in such a way that the transverse elements (6) are connected in a non-sliding manner to the lateral elements (2), and the lateral elements (2) cannot undergo a tilting movement as a result of the tension force exerted by the membrane (17) on the lateral elements (2) on the one hand, and the pressure force exerted by the transverse elements (6) on the lateral elements (2) on the other hand, and taking into account the distance between the planes in which these forces occur.
8. Formwork (1) according to one or several of the preceding claims, characterised in that the formwork (1) is provided with reusable transverse elements (6).

9. Formwork (1) according to claim 9, characterised in that the reusable transverse elements (6) are metal pipes (7) or tubes which are encased in surrounding lost pipes of the formwork (1) which are made for example of a plastic or whereby the reusable transverse elements (6) are provided such on the lateral elements (2) that they do not end up in the concrete (33) to be poured and can be smoothly removed once the concrete (33) has been poured.

10. Formwork (1) according to one or several of the preceding claims, characterised in that the transverse elements (6) are formed of steel pipes (7) with a diameter of at least 30 mm and with a wall thickness between 2.6 and 3 mm, whereby successive transverse elements (6) are provided between the lateral elements (2) at a centre to centre distance of 30 cm or more and whereby the bottom of the pipes (7) is situated 10 to 100 mm above the membrane (17).

11. Formwork (1) according to one or several of the preceding claims, characterised in that the membrane (17) is made of a plastic without any reinforcement or fibres, for example of a non-fibre-reinforced PE foil (polyethylene) having a certain elasticity so as to allow for a sag (D) of the concrete to be poured.
12. Construction (20) for pouring concrete (33) so as to form a predominantly horizontal span (31), such as a floor, a roof or a ceiling or the like between supporting parts (32) of an underlying supporting structure (24) consisting of vertical elements such as walls, vertical columns (25) and the like, comprising a formwork according to one or several of the preceding claims, characterised in that the formwork (1) is provided on a bearing structure (24), whereby the formwork (1) is designed for pouring a concrete slab (21) on the bearing structure (24), whereby the membrane (17) extends over the underlying supporting structure (24) and forms the bearing surface to bear the concrete (33) to be poured for the concrete slab (21) while it cures, whereby the membrane (17) is freely suspended and is not supported at the location of the span (31) between the supporting parts (32), but rests directly on the supporting parts (32) formed by the vertical elements (25).

13. Construction (20) according to claim 13, characterised in that the bearing structure (24) includes several columns (25), whereby the end faces of these columns (25) form supporting parts (32), whereby the membrane (17) of the formwork (1) extends over the end faces of these columns (25) and whereby the membrane (17) rests directly on the above-mentioned supporting parts (32) of said columns (25).

14. Construction (20) according to claim 13 or 14, characterised in that the supporting parts (32) of
the underlying supporting structure (24) consist of several vertical elements situated at a mutual centre to centre distance from one another amounting to at least 40 cm and maximally 120 cm.

15. Construction (20) according to claim 15, characterised in that the supporting parts (32) of the underlying supporting structure (24) consist of several vertical elements whose width amounts to at least 6 cm and maximally 30 cm.

16. Method for pouring concrete (33) in order to form a predominantly horizontal span (31), such as a floor, a roof or a ceiling or the like between supporting parts (32) of an underlying supporting structure (24) formed of vertical elements (25) such as walls, vertical columns (25) and the like, whereby use is made of a formwork (1) according to one or several of claims 1 to 11, characterised in that the method comprises the following steps:
- applying or building the supporting parts (32) of the bearing structure (24);
- applying the formwork (1) on the bearing structure, whereby a bearing surface is formed to bear the concrete (33) to be poured while it cures by applying a membrane (17) which extends over the bearing structure (24);
- fixing the membrane (17) to a part of the formwork (1) itself and/or to a part outside the formwork (1);
- letting the membrane (17) suspend freely and not supporting it at the location of the span (31) between the supporting parts (32);
- directly supporting the membrane (17) on the supporting parts (32) formed by the vertical elements (25);
- providing a reinforcement (14) over the membrane (17);
- pouring concrete (33) on the membrane (17), whereby the poured concrete (33) is borne by the membrane (17), in particular in the overhanging portions (31), and rests on the supporting parts (32), and whereby the membrane (17) undergoes a stretch or deformation, such that a certain sag (D) of the poured concrete (33) is obtained around the supporting parts (32); and,
- allowing the concrete (33) to cure.

17. Method according to claim 14, characterised in that the membrane (17) is prestretched before the concrete (33) is being poured and whereby, in order to fix the membrane (17) to at least two opposite sides (4,5) of the formwork (1), a series of concrete support blocks (3) is provided in between which steel pipes (3) or reinforcement bars (37) are provided which hold the concrete support blocks (3) at a fixed distance from one another and which absorb the tension force for prestretching the membrane (17), as well as the additional tension force which is present once the concrete (33) has been poured, until this concrete (33) has cured.

18. Method according to claim 15 or 16, characterised in that after the concrete (33) has been poured, a sag (D) of the membrane (17) is achieved which amounts to
at least 1/200, better still 1/100 and preferably at least 1/30 of the distance $L$ between the nearby supporting parts (32) concerned.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. E94B5/38
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC:

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
E04B E04G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronica database consulted during the international search (name of database and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Further documents are listed in the continuation of Box C. X See patent family annex.

Date of the actual completion of the international search
25 September 2015

Date of mailing of the international search report
05/10/2015

Name and mailing address of the ISA/
European Patent Office, P.O. Box 5018 Patentlan 2 NL-2280 HV Rijswijk
Tel. (+31-70) 940-2040, Fax (+31-70) 940-3018

Authorized officer
Righetti, Roberto
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