REINFORCED CONCRETE CEILING AND PROCESS FOR THE MANUFACTURE THEREOF

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ABSTRACT
A reinforced concrete ceiling is characterized by a combination of the following features:

- a concrete slab (1) the thickness (D) of which falls short of the total thickness of the reinforced concrete ceiling, and
- intersecting ribs (2) which are each connected with an end region (3) to the concrete slab (1) in a force-transmitting manner and project freely upwards from the concrete slab (1), i.e., without being integrated in a further supporting surface structure, wherein their top end regions (4) are designed to absorb compressive and/or tensile forces and wherein the ribs (2) are connected to each other in a frictional manner at the respective intersection points (9), and

their regions lying in each case between the top and bottom end regions (3,4) have at least one aperture (6).
The invention relates to a reinforced concrete ceiling as well as to a process for the manufacture thereof. In the building trade, concrete is indisputably the best suited material for making planar supporting frameworks of any desired shape. In addition, the design of reinforced concrete ceilings is extremely simple and economical. Architects particularly like to use flat ceilings, since they permit easy installment of lines because of the flat ceiling sublayer. Massive cores are required merely for reinforcement. Said flat ceilings may be designed as a ceiling with a solid cross-section (GB 1 284 402 A), as a hollow ceiling (DE 4 113 028 A1) or as a ceiling with reinforcements over the supports. The ceiling with a solid cross-section is made of in-situ concrete or a partially prefabricated ceiling (element ceiling). Since the dead weight accounts for nearly 50% of the ceiling load, one has begun to produce hollow ceilings. The hollow bodies can be produced during the manufacturing process (hollow board ceiling) or by displacers during concreting (e.g. EP 1 350 898 A1). Ranges can be increased by minimizing the weight. On the assumption of a ceiling of a thickness of 25 cm, savings of dead weight of 35-45% (Cobiax hollow board ceiling) can be achieved in comparison to a ceiling with a solid cross-section.

Ceiling systems are expected to provide large ranges with a small overall height, fast and easy manufacture, very good properties in the fields of fire protection, protection against moisture and noise control, a pleasing visual appearance, low maintenance and repair costs, a high degree of flexibility and much more. Thereby, however, not only the flexibility during manufacture is kept in mind, but the ceiling is also expected not to lose any flexibility during the entire useful life. In buildings, new devices are integrated again and again, which have to find room also in the ceiling systems. This begins with energy, data and communication lines via heat exchangers and air conditioners whose component parts and lines must find room in the ceiling structure. In addition, easy retrofitting should be possible also for future fixtures. In order to ensure these possibilities, it is known to install double bottom systems or suspended ceilings, since, with those elements, also a later change of use is easily possible. However, such double bottom systems or suspended ceilings require relatively large thicknesses of the ceiling.

The invention aims at combining the supporting structure with the advantages of the double bottom. It is a specific object of the invention to permit easy accommodation of supply lines, thus reducing the total thickness of the ceiling, so that a larger number of floors can be provided at a predetermined height of construction. Furthermore, the structure according to the invention is supposed to enable a significant saving of dead weight in comparison to known structures, with the load-bearing capacity being the same. This is to be accomplished by material savings and also by reductions in the work to be performed.

According to the invention, said object is achieved by a combination of the following features:

- a concrete slab the thickness of which falls short of the total thickness of the reinforced concrete ceiling, and
- intersecting ribs which are each connected with an end region to the concrete slab in a force-transmitting manner and project freely upwards from the concrete slab, i.e., without being integrated in a further supporting surface structure, wherein their top end regions are designed to absorb compressive and/or tensile forces and wherein the ribs are connected to each other in a frictional manner at the intersection points, namely at least with their top end regions, and
- their regions lying in each case between the top and bottom end regions have at least one aperture.

According to the invention, only a thin concrete slab is provided. Intersecting ribs are provided thereon which absorb compressive forces and optionally tensile forces in a concentrated fashion. Due to this loosened structure, the dead weight can be minimized considerably (>55%) and, in addition, a large space in the supporting structure becomes free. The free space can be used for installations of any kind: from electric lines to supply lines and to ventilation and air-conditioning lines. Since the ribs have recesses, being designed, for example, in a framework style, lines and pipes can run without problems from one ceiling field to the next. Instead of, as is usual, accommodating the installations in the floor area or attaching them to the ceiling with dowels, the lines can be inserted in the supporting structure. If large cross-sections are to be accommodated, the supporting structure becomes higher, whereby the range of the structure can be increased as well. Instead of creating a separate line level, the height of the supporting structure can be utilized. The result is a reduction in the total ceiling height. However, apart from the combination of the supporting structure level with the installation level, the most important advantage is the flexibility of the system. Since primarily only the narrow ribs are used for the load-bearing capacity, covers can be applied in between, which are detachable anytime since they are not used for the structural conditions of, e.g., a ceiling. Said covers may be conventional double bottom elements with which a lot of experience has already been gained. With this system, the flexibility of use will thus remain for the entire lifetime. If installations are relocated or re-laid, the covers are removed by hand and reapplied, and after the laying work no change is visible anymore.

Preferred variants are defined in the dependent claims.

Furthermore, it is the object of the invention to develop further a reinforced concrete ceiling of this kind such that it is particularly easy to manufacture, namely by using semifinished parts. As a result, it should be possible to omit complex connecting and shuttering operations on site.

According to the invention, said object is achieved in that the concrete slab comprises at least two semifinished plates arranged directly next to each other which are covered by a reinforced topping layer of concrete and are interconnected in a frictional manner.

It is known to connect semifinished plates by welding, screwing, reinforcement splices in casting pockets or pretensioning. However, said joining techniques involve a large effort on site, whereby it is also necessary to work with sufficient precision for the force transmission from one semifinished plate to the next.

What is special about the invention is that a simple connection between semifinished plates can be achieved by the reinforced topping layer of concrete, which joining technique has to be regarded as the standard for concrete construc-
tion, wherein, however, said connection method is used only for establishing the connection between semifinished plates and not, as is otherwise customary, for the production of the entire concrete slab.

According to a preferred embodiment, the ribs rest with base parts on the semifinished plates, with the base parts being circumferentially enclosed by the topping layer of concrete.

Suitably, the reinforcement of the topping layer of concrete penetrates the apertures of the ribs.

A further preferred embodiment is characterized in that the base parts of the ribs are anchored in the topping layer of concrete via a reinforcement, wherein, advantageously, the base parts of the ribs are anchored in the semifinished plates via a reinforcement and wherein, furthermore, the ribs and the semifinished plates suitably have a common reinforcement.

Preferably, the ribs along with a semifinished plate are designed as a semifinished product, whereby the ribs no longer have to be shuttered on site.

Depending on the demand on the apertures, i.e., the lines to be laid in the ceiling, or, respectively, depending on the demand on the load-bearing capacity, the apertures can diverge or converge from above to below.

If the reinforced concrete ceiling is carried on supports, it is characterized in that a slab element resting on a support is advantageously provided above the support, wherein ribs extending radially outwards in a star-shaped manner from a centre, which ends up lying above the support, are provided, which ribs are attached to ribs of adjacent elements on the edge side of the slab element, wherein the ribs extending in a star-shaped manner are suitably provided with a reinforcement which is attached to a reinforcement of adjacent elements or changes into the reinforcement of adjacent elements.

In order to increase the stiffness of the slab element resting on a support, ribs extending in a star-shaped manner are connected to ribs extending in the peripheral direction of the slab element.

An essential aspect of the invention is that the topping layer of concrete is statically contributive, with its reinforcement extending beyond a semifinished plate to at least a second adjacent semifinished plate.

The thickness of the semifinished plate preferably ranges between 2 and 20 cm, in particular between 4 and 16 cm, and the thickness of the topping layer of concrete ranges between 2 and 20 cm, preferably between 4 and 8 cm.

A preferred process for the manufacture of a reinforced concrete ceiling according to the invention is characterized in that formwork elements for forming the ribs are placed on the concrete slab and the reinforced concrete ceiling is manufactured by installing a reinforcement in the cavity provided for the ribs between the walls of the formwork elements and by grouting said cavity with concrete.

A further suitable approach for producing a reinforced concrete ceiling according to the invention is characterized in that thin-walled plate-shaped elements are placed vertically on a reinforcement applied to a semifinished plate, a layer covering the semifinished plate is concreted and, subsequently, the space between the thin-walled plate-shaped elements is filled with concrete, with the ribs being formed.

A particularly efficient process for the manufacture of a reinforced concrete ceiling is characterized in that the semifinished plates are produced in a factory for prefabricated parts along with rib bodies provided on them, wherein the rib bodies have channels located at the top or are designed so as to be hollow, that said semifinished plates are transported to the construction site and are placed there in correct position according to the building to be constructed, that subsequently a reinforcement extending across at least two adjacent semifinished plates is applied to the semifinished plates and a reinforcement extending into cavities of rib bodies of adjacent semifinished plates is provided in the cavities of the rib bodies, whereupon the topping layer of concrete is applied and the rib bodies are grouted with concrete.

Below, the invention is explained in more detail on the basis of several exemplary embodiments, wherein FIGS. 1 and 2 depict oblique view illustrations of a biaxially prestressed ceiling in a schematized manner. FIG. 3 is a top view of such a ceiling. FIGS. 5 and 6 depict cross-sections of the variants illustrated in FIGS. 1 and 2. FIGS. 7 to 10 show, in section, various designs of the ribs, and FIGS. 11 to 14 illustrate different types of mounting reinforced concrete ceilings according to the invention with the respective cut-size charts. FIGS. 15 and 16 show floorings for ceilings according to the invention. In FIG. 17, a variant of the reinforced concrete ceiling according to the invention formed from prefabricated parts is shown, FIG. 18 depicts a section taken along line XVIII-XVIII of FIG. 17. FIG. 19 shows a top view of the variant illustrated in FIG. 17. FIG. 20 is a section taken along line XX-XX of FIG. 19. FIG. 21 depicts a detail of FIG. 20 on an enlarged scale.

FIGS. 22 to 25 illustrate an embodiment at different stages of manufacture, in each case in oblique view. FIG. 26 shows a side view in which the positions of the reinforcements are plotted. FIG. 27 shows a top view of a reinforced concrete ceiling composed of several elements. FIGS. 28 and 29 show sections taken along line VII-VII of FIG. 27, again at different manufacturing stages. FIGS. 30 and 31 depict further embodiments in an illustration analogous to FIG. 29. FIG. 32 shows a section taken along line XI-XI of FIG. 27. FIGS. 33 to 36 show details of the reinforced concrete ceiling, in each case in top view.

The reinforced concrete ceiling according to the invention is basically formed from a concrete slab 1 from which ribs 2 project upwards. Said ribs 2 are each connected with one of their end regions 3—in the following also referred to as base parts—to the concrete slab 1 in a force-transmitting manner and project freely upwards with their top end regions 4, i.e., they are not integrated in a further supporting surface structure, as is customary, e.g., in case of hollow ceilings. Said ribs 2 absorb compressive and/or tensile forces with their top end regions 4 and, in this regard, may be designed so as to be reinforced at those top end regions, comprising, for example, top chords 5. The ribs 2 are provided with apertures 6 between the top end regions 4 and the bottom end regions 3 which are anchored in the concrete slab 1 in a force-transmitting manner. This provides the possibility to connect the fields 7 delimited by the ribs 2 with regard to lines, i.e., to lay lines from field 7 to field 7.

FIGS. 1 and 2 exemplify ceilings supported on vertical supports or columns 8, respectively, and the individual fields 7 delimited by the ribs 2 are visible. These are biaxially prestressed ceilings.

The ribs 2 are preferably all of the same height and, in case of biaxially prestressed reinforced concrete ceilings, they are preferably arranged at right angles to each other. Of
course, a different arrangement of the ribs 2 is also possible according to the ground plan shape of the reinforced concrete ceiling to be formed.

[0033] The ribs 2 are interconnected in a force-transmitting, e.g., frictional, manner at their intersection points 9 and also on supporting strips 10 defining a ceiling, which supporting strips are provided optionally. Such a supporting strip can be designed along the lines of the ribs 2.

[0034] FIGS. 1, 5 and 8 show ribs 2 comprising an all-over web 11, with each rib 2 having at least one aperture 6 with the top end region 4 being left, which aperture preferably reaches the top side of the concrete slab 1 so that an installation of lines by putting them on the concrete slab 1 is easily possible.

[0035] FIG. 2 illustrates ribs 2 of the type of a framework structure, wherein diagonals 12 project as far as into the concrete slab 1, starting from a top chord 5 of the ribs 2, and are connected to the concrete slab 1 in a force-transmitting manner. Of course, the diagonals 12 could lead to a separate bottom chord, starting from the top chord 5, and the bottom chord could be connected to the concrete slab 1 in a force-transmitting manner.

[0036] FIGS. 7 to 10 illustrate various designs of the ribs 2. For example, FIG. 7 shows a rib 2 the diagonals 12 of which are formed from steel pipes which are integrally cast in a concrete slab 1 provided with a reinforcement 13. The top chord 5 of said rib 2 is formed from a steel profile 14 which is open toward the top, wherein a reinforcement 15 is inserted in the open cavity of the steel profile 14 and said cavity is filled with in-situ concrete 16.

[0037] FIG. 8 illustrates a rib 2 which is made entirely of concrete and whose top end region 4 is also provided with a reinforcement 15—secured by means of a stirrup 15'. Said rib 2 is integrally cast in a concrete slab 1 provided with a reinforcement 13 and is preferably manufactured concurrently with the concrete slab 1.

[0038] FIG. 9 shows a prefabricated rib 2 manufactured from concrete, which is initially provided with a cavity open toward the top in the top end region 4, which cavity is grouted with concrete 16 after the rib 2 has been arranged on a formwork not illustrated, with a reinforcement 15 being inserted. Said rib 2 is prefabricated as a semifiinished part and is connected in a frictional manner to the concrete slab 1 using in-situ concrete, which concrete slab likewise comprises a reinforcement 13 which projects through a diagonal recess 18 of the rib 2.

[0039] FIG. 10 shows a similar rib 2 prefabricated as a semifiinished part, with the concrete slab 1 being formed from prefabricated individual elements 1', 1" which rest on bottom flanges 17 of the rib 2. After placing a reinforcement on the individual elements 1', 1", in-situ concrete 16 is applied to those individual elements 1', 1", whereby the concrete slab 1 is formed in its total thickness and the rib 2 is connected to the concrete slab 1 in a frictional manner. For safety purposes, the rib 2 is provided with a diagonal recess 18 through which the reinforcement 13 protrudes, which reinforcement also projects into the in-situ concrete. Furthermore, according to FIG. 10, also the bottom end region 13 of the rib 2 is reinforced by a reinforcement 15.

[0040] FIGS. 11 to 13 show various ways of designing a reinforced concrete ceiling according to the invention, namely in a projecting manner according to FIG. 11, mounted on two end supports 14 according to FIG. 12, mounted on three supports according to FIG. 13, with a diagram of moments being added to each of the figures in which the compressive and/or tensile forces occurring at the top chord 5 or at the top end region 4 of the ribs 2, respectively, are in each case illustrated for a stress caused by an evenly distributed load. It is evident that the structure according to the invention is suitable both for a cantilever plate and for a single-field or two-field plate with a centre support.

[0041] FIG. 14 shows an example with a framework effect in the middle region of the structure, in which only small transverse forces are to be transmitted, namely for a single-field plate, with the upper chart showing the moment distribution and the lower chart showing the transverse force path of an evenly distributed load. Said variant provides the advantage of very large apertures 6 in midspan, which permits particularly easy installation also of bulky lines and/or channels, respectively, on the concrete slab 1.

[0042] FIGS. 15 and 16 show the construction of bottoms 19 on reinforced concrete ceilings according to the invention, wherein FIG. 15 shows a variant in which a bottom 19 is directly applied to the ribs 2 in the manner of a double bottom. FIG. 16 illustrates a variant according to which a bottom 19 is elevated on the concrete slab 1 also in the manner of a double bottom.

[0043] Among other things, it is essential for the invention that the concrete slab 1 has a thickness D which falls significantly short of the total thickness of the reinforced concrete ceiling, preferably the thickness D of the concrete slab is at most approx. ½ of the thickness of the reinforced concrete ceiling. In case of a reinforced concrete ceiling according to the invention, about 50 to 85% of the ceiling cross-section is available for installations; for example, the total thickness of the structure may be 40 cm and the thickness D of the concrete slab 1 may be about 6 cm.

[0044] The ribs 2 or at least their top chord 5 may be formed from a high-strength or ultrahigh-strength concrete, respectively. Thereby, high-strength concrete is a concrete with a compressive strength of from 60 to 120 N/mm², ultrahigh-strength concrete is a concrete with a compressive strength of between 120 and 250 N/mm².

[0045] It may be advantageous to provide the concrete slab 1 and, respectively, optionally also the top chords 5 of the ribs 2 with a steel reinforcement 15, a textile reinforcement or a fibre reinforcement.

[0046] As can be seen in particular in FIG. 25, the concrete slab 1 is formed from a semifiinished plate 21 lying at the bottom as well as a topping layer of concrete 22 applied thereon and provided with a reinforcement 23. The semifiinished plate 21 is likewise provided with a reinforcement 24. Preferably, the ribs 2 also have a reinforcement 25 which projects into the semifiinished plate 21 where it is anchored. The reinforcement 25 of the ribs 2 is shown in side view in FIG. 26 and in an oblique view illustration, but without ribs, in FIG. 23.

[0047] FIG. 22 illustrates the semifiinished plate 21 with hollow rib bodies 26 anchored therein via the reinforcement 25, which rib bodies are formed from concrete shells and are already provided with the reinforcements 25. Such a semifiinished plate 21 with hollow rib bodies 26 constitutes a semifiinished product which can be used particularly advantageously for the manufacture of a planar reinforced concrete ceiling according to the invention. Advantageously, said semifiinished product is made in a factory, i.e., remote from the construction site where the reinforced concrete ceiling is to be constructed.
FIG. 24 shows the arrangement of the reinforcement 23 for the topping layer of concrete and a reinforcement 27 connecting the ribs 2 of adjacent semifinished plates 21, which reinforcement is installed in the cavities of the rib bodies 26. The reinforcement 23 applied to the semifinished plate likewise extends across at least two semifinished plates 21 arranged directly next to each other or across the entire planned reinforced concrete ceiling, respectively, as shown, for example, in FIG. 27.

After arranging the semifinished products 21 forming the outlines of the reinforced concrete ceiling, e.g., on the supports 8—as shown in FIG. 27—and after installing the reinforcement 23 or 27, respectively, on the semifinished plates 21 to be connected and in the channel-like cavities of the rib bodies 26, concrete is poured into the rib bodies 26, and all semifinished plates 21 are covered with a topping layer of concrete 22 so that the final result is a reinforced concrete ceiling, which is illustrated in FIG. 25 with a single semifinished plate 21 and, however, in FIGS. 25 to 31 with semifinished plates 21 lying next to each other. The base parts 3 are thereby surrounded, i.e., enclosed, by the topping layer of concrete 22 but may project beyond it with regard to height, as shown in FIGS. 30 and 31.

According to the variant illustrated in FIG. 29, the ribs 2 project with base parts 3 directly into the topping layer of concrete 22. However, according to FIG. 30, the base parts 3 extend on a level 28 above the topping layer of concrete 22 so that the base parts 3 are not only stressed by transverse forces but are also subject to a bending stress. This results in apertures 6 which have larger cross-sections.

FIG. 31 shows a variant according to which the apertures 6 of the ribs 2 do not widen but taper downwards, i.e., towards the topping layer of concrete 22, in contrast to the variants illustrated in FIGS. 28 to 30. For proper attachment of a reinforcement 23 to the semifinished plate, the base parts 3 exhibit openings 31 which are filled with concrete after the application of the topping layer of concrete 22.

As can be seen in FIG. 27, the reinforced concrete ceiling formed from ten semifinished products rests on four columns 8 which each are arranged centrically between intersecting ribs 2. As shown in FIG. 32, said region between the ribs 2 above the columns 8 is filled with concrete. According to FIGS. 33 to 36, the regions between the ribs 2 and above the columns 8 are provided with ribs 29 arranged in a star-shaped manner which are likewise provided with a reinforcement 27, wherein, as shown, e.g., in FIG. 33, the reinforcements 27 of the ribs 2 and 29 extend beyond those regions from one semifinished plate 21 to the next semifinished plate 21. According to FIG. 34, the reinforcements 27 of the ribs 2 and 29 are interconnected by means of reinforcement connections 30. The reinforcements arranged on the ribs provided in a star-shaped manner are attached, e.g., welded, preferably to a steel element, such as a steel plate, provided centrally above the column 8, wherein the reinforcement 27 may be incorporated as well.

The thickness of the semifinished plates 21 suitably ranges between 2 and 20 cm, preferably between 4 and 6 cm; the thickness of the topping layer of concrete ranges between 2 and 20 cm, preferably between 4 and 8 cm. The connection between the individual semifinished plates 21 may thereby be effected in an easy manner by the reinforcement 23 installed in the topping layer of concrete 22.

Different variants are possible for the manufacture of a reinforced concrete ceiling according to the invention, for example, the concrete slab 1 may be formed from in-situ concrete and the diagonals 12 and top chords 5 of the ribs 2 may be formed as prefabricated elements with or without jointing concrete in the diagonals 12 and top chords 5. The diagonals 12 and top chords 5 may thereby serve as shell moulds in which reinforcements 15 are inserted, whereupon the diagonals 12 and top chords 5 are grouted with concrete. If the diagonals 12 are formed from reinforced concrete or steel, only the top chords 5 might serve as shell moulds in which a reinforcement 15 is inserted and grouted. If the diagonals 12 are formed from reinforced concrete or steel and the top chords 5 are formed only from steel, the top chords 5 may be connected with the diagonals 12 using connection methods employed in structural steel engineering.

Furthermore, it is possible to form the reinforced concrete ceiling according to the invention entirely from finished elements which are interconnected by in-situ concrete, optionally with a reinforcement being provided beforehand, so that a frictional connection between the component parts is provided. As has already been described above, also the concrete slab 1 may be designed as a semifinished element 1', 1" onto which a reinforcement 13 is placed, whereupon grouting with in-situ concrete 16 takes place, with the bottom end regions 3 of the ribs 2 being integrated simultaneously. In that case, the concrete slab 1 is thus finished by the in-situ concrete 16 applied to the semifinished elements 1', 1" (cf. FIG. 10), wherein also the top chords 5 have to be connected in a frictional manner.

The known methods of prestressing reinforced concrete ceilings may be used advantageously for the reinforced concrete ceiling according to the invention (bonded post-tensioning, unbonded post-tensioning, pretensioning of finished parts, external prestress beside the ribs).

According to the variant illustrated in FIGS. 17 to 21, a reinforced concrete ceiling is depicted which is formed from finished parts F, F" placed side by side. Each of the finished parts F, F" comprises a concrete slab 1 as well as ribs 2 which, in the illustrated exemplary embodiment, are arranged in an intersecting manner—since the structure is a biaxially prestressed structure.

The concrete slabs 1 are each formed integrally with the ribs 2, namely in a maximum size, so that transport of the finished parts F, F" by truck is possible. In order to produce a reinforced concrete ceiling with a large range, the finished parts F, F" are arranged side by side and interconnected, the connection between the finished parts F, F" being established, on the one hand, by a grouting joint 20 and, on the other hand, by prestressed reinforcements 15, in the following referred to as prestressing elements 15. After the arrangement of the finished parts F, F", the prestressing elements 15 are threaded through channels provided in those finished parts during manufacture for the prestressing elements, preferably as illustrated in FIGS. 21 and 22, according to which variant the prestressing elements 15 end up lying in the tensile zones of the reinforced concrete ceiling.

![Supporting Structure](image-url)

Reduction of dead weight by more than 55% (in comparison to a solid cross-section).
[0061] almost the entire height of the structure may be used for installations.

Manufacture
[0062] The individual elements may be produced as finished parts. Pressure surges and jointing concrete as well as prestressing elements or a topping layer of concrete are used as connection means.
[0063] Therefore, only little concreting is necessary on site.
[0064] No or only minor shuttering operations are required.
[0065] Working time and integrated material are saved, and less auxiliary means are required for the manufacture.

Installations
[0066] Easy insertion of installations, fastening is not required.
[0067] Access to the installations is possible anytime from the flooring.
[0068] Installation of lines is possible without any auxiliary technical devices. Upon completion, covers are applied.

Covers
[0069] Well-proven covers of double bottom systems are usable.
[0070] from a static point of view, strong concrete slabs are not required since ranges are small.

Building Physics
[0071] Improvement of sound insulation by elastomer supports,
[0072] mass-spring-mass-spring-mass system,
[0073] enhancement of sound suppression by the cavity,
[0074] fire protection is ensured by the thin concrete slab at the bottom side.

Subsequent Reinforcement in Case of Changed Usage
[0075] The pressure and tensile zone as well as shear connections may be reinforced separately from each other according to a changed usage.
[0076] The reinforcement covers only a selected region.
[0077] No impairment of the aesthetic appearance.
[0078] Neighbours are hardly affected.

Economic Efficiency
[0079] is provided because of the smaller dead weight, a shortened time of construction and a quality assurance,
[0080] structural alteration works are possible anytime with little effort.

Flexibility
[0081] Installations are accessible anytime through detachable covers.
[0082] All supporting parts can be reinforced individually and independently of each other at any position.
[0083] Raising of the double bottom by conventional distance pieces for additional installations which find no room is possible anytime.

1. A planar concrete supporting structure, in particular a reinforced concrete supporting structure such as a reinforced concrete ceiling, characterized by a combination of the following features:
   a concrete slab (1) the thickness (D) of which falls short of the total thickness of the concrete supporting structure, and
   intersecting ribs (2) which are each connected with an end region (3) to the concrete slab (1) in a force-transmitting manner and project freely upwards from the concrete slab (1), i.e., without being integrated in a further supporting surface structure, wherein their top end regions (4) are designed to absorb compressive and/or tensile forces and wherein the ribs (2) are connected to each other in a frictional manner at the intersection points (9), namely at least with their top end regions (4), and their regions lying in each case between the top and bottom end regions (3, 4) have at least one aperture (6).

2. A concrete supporting structure according to claim 1, characterized in that ribs (2) are designed in the style of a framework structure, namely with a top chord (5) and diagonals (12) starting from the top chord (5) which are directly or indirectly connected via a bottom chord to the concrete slab (1) in a force-transmitting manner.

3. A concrete supporting structure according to claim 1, characterized in that an all-over web (11) connecting the top end region (4) with the bottom end region (3) of the ribs (2) is provided with at least one aperture (6).

4. A concrete supporting structure according to claim 1, characterized in that at least the top end region (4) of the ribs (2), optionally also the bottom end region (3) of the ribs (2), is provided with a reinforcement, in particular made of steel (13).

5. A concrete supporting structure according to claim 1, characterized in that ribs (2) with diagonals (12), preferably formed from steel pipes, are provided.

6. A concrete supporting structure according to claim 1, characterized in that ribs (2) having at least a top end region (4) made of high-strength or ultrahigh-strength concrete, preferably of concrete with a compressive strength of from 60 to 250 N/mm², are provided.

7. A concrete supporting structure according to claim 1, characterized in that ribs (2) are connected in a frictional manner to the concrete slab (1) using in-situ concrete.

8. A concrete supporting structure according to claim 1, characterized in that a web of the ribs (2) as well as optionally a top chord (5) or a bottom chord, respectively, are made of steel.

9. A concrete supporting structure according to claim 1, characterized in that a top chord (5) of the ribs (2) is formed from a steel profile (14) filled with concrete.

10. A concrete supporting structure according to claim 1, characterized in that the concrete slab (1) exhibits at last one layer of high-strength, preferably ultrahigh-strength concrete.

11. A concrete supporting structure according to claim 10, characterized in that the concrete slab (1) exhibits a steel reinforcement, a textile reinforcement or a fibre reinforcement.

12. A concrete supporting structure according to claim 1, characterized in that the concrete slab (1) is formed from a thin semifinished plate (1', 1'') made of reinforced concrete on which a planar reinforcement (13) is applied and which is
grouted with the semifinished plate (1', 1") with in-situ concrete (16), with the bottom end regions (3) of the ribs (2) being integrated simultaneously.

13. A concrete supporting structure according to claim 1, characterized in that the total height of the concrete supporting structure ranges between 12 and 120 cm, preferably between 20 cm and 50 cm.

14. A concrete supporting structure according to claim 1, characterized in that the thickness (D) of the concrete slab (1) ranges between 4 cm and 40 cm, preferably between 8 cm and 20 cm.

15. A concrete supporting structure according to claim 1, characterized in that the concrete slab (1) is integrally connected with the rib or ribs (2), respectively, as a finished part.

16. A concrete supporting structure according to claim 15, characterized in that several prefabricated concrete slabs (1) are connected with their ribs to a concrete supporting structure, with grouting joints and prestressing elements (15) being provided for the connection.

17. A concrete supporting structure according to claim 16, characterized in that the prestressing elements (15) in the ribs (2) and in the concrete slabs (1) are in each case provided in the tensile zones.

18. A concrete supporting structure according to claim 1, characterized in that the concrete slab (1) comprises at least two semifinished plates (21) arranged directly next to each other which are covered by a reinforced topping layer of concrete (22) and are interconnected in a frictional manner.

19. A concrete supporting structure according to claim 18, characterized in that the ribs (2) rest with base parts (3) on the semifinished plates (21), with the base parts (3) being circumferentially enclosed by the topping layer of concrete (22).

20. A concrete supporting structure according to claim 18, characterized in that the reinforcement (23) of the topping layer of concrete (22) penetrates the apertures (6) of the ribs (2).

21. A concrete supporting structure according to claim 18, characterized in that the base parts (3) of the ribs (2) are anchored in the topping layer of concrete (22) via a reinforcement (25).

22. A concrete supporting structure according to claim 18, characterized in that the base parts (3) of the ribs (2) are anchored in the semifinished plates (21) via a reinforcement (25).

23. A concrete supporting structure according to claim 22, characterized in that the ribs (2) and the semifinished plates (21) have a common reinforcement (25).

24. A concrete supporting structure according to claim 23, characterized in that the ribs (2) along with a semifinished plate (21) are designed as a semifinished product.

25. A concrete supporting structure according to claim 21, characterized in that the apertures (6) of the ribs (2) diverge from above to below.

26. A concrete supporting structure according to claim 18, characterized in that the apertures (6) of the ribs (2) converge from above to below.

27. A concrete supporting structure according to claim 18, characterized in that a slab element resting on a support is provided above the support (8), wherein ribs (29) extending radially outwards in a star-shaped manner from a centre, which ends up lying above the support (8), are provided, which ribs are attached to ribs (2) of adjacent elements on the edge side of the slab element.

28. A concrete supporting structure according to claim 27, characterized in that the ribs (29) extending in a star-shaped manner are provided with a reinforcement which is attached to a reinforcement (27) of adjacent elements or changes into the reinforcement of adjacent elements.

29. A concrete supporting structure according to claim 27, characterized in that ribs (29) extending in a star-shaped manner are connected to ribs extending in the peripheral direction of the slab element.

30. A concrete supporting structure according to claim 18, characterized in that the topping layer of concrete (22) is statically contributive, with its reinforcement (23) extending beyond a semifinished plate (21) to at least a second adjacent semifinished plate (21).

31. A concrete supporting structure according to claim 18, characterized in that the thickness of the semifinished plate (21) ranges between 2 and 20 cm, preferably between 4 and 16 cm, and the thickness of the topping layer of concrete (22) ranges between 2 and 20 cm, preferably between 4 and 8 cm.

32. A process for the manufacture of a concrete supporting structure according to claim 1, characterized in that formwork elements for forming the ribs (2) are placed on the concrete slab (1) and the concrete supporting structure is manufactured by installing a reinforcement (13) in the cavity provided for the ribs (2) between the walls of the formwork elements and by grouting said cavity with concrete (16).

33. A process for the manufacture of a concrete supporting structure according to claim 1, characterized in that thin-walled plate-shaped elements are placed vertically on a reinforcement (13) applied to a semifinished plate (1', 1") made of a layer covering the semifinished plate (1', 1") and the concrete supporting structure is manufactured by installing a reinforcement (13) in the cavity provided for the ribs (2) between the walls of the formwork elements and by grouting said cavity with concrete (16).

34. A process for the manufacture of a concrete supporting structure according to claim 15, characterized in that concrete slabs (1) are manufactured integrally with ribs (2) as finished parts (1', 1") which are interconnected after transport to a construction site, preferably by grouting joints (20) and prestressing elements (15).

35. A process for the manufacture of a concrete supporting structure according to claim 18, characterized in that the semifinished plates (21) are produced in a factory for prefabricated parts along with rib bodies (26) provided on them, wherein the rib bodies (26) have channels located at the top or are designed so as to be hollow, that said semifinished plates (21) are transported to the construction site and are placed therein in correct position according to the building to be constructed, that subsequently a reinforcement (23) extending across at least two adjacent semifinished plates (21) is applied to the semifinished plates (21) and a reinforcement (27) extending into cavities of rib bodies (26) of adjacent semifinished plates (21) is provided in the cavities of the rib bodies (26), whereupon the topping layer of concrete (22) is applied and the rib bodies (26) are grouted with concrete.