

Dec. 27, 1960

A. KOCH
CONSTRUCTION UNITS

2,966,009

Filed May 19, 1955

2 Sheets-Sheet 1

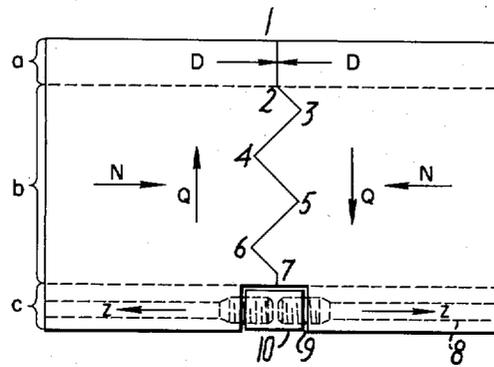


FIG. 1

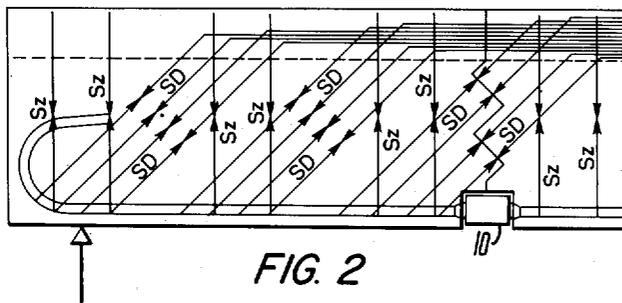


FIG. 2

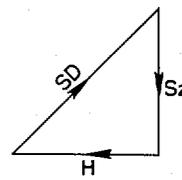


FIG. 3

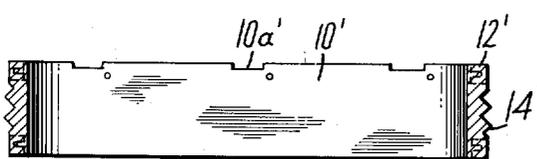


FIG. 7

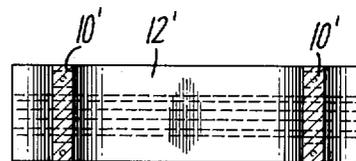


FIG. 8

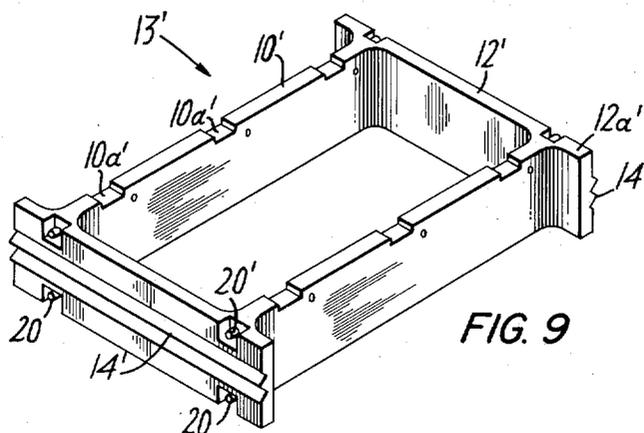


FIG. 9

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2,966,009

CONSTRUCTION UNITS

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Filed May 19, 1955, Ser. No. 509,598

In Germany Oct. 1, 1948

Public Law 619, Aug. 23, 1954

Patent expires Oct. 1, 1968

4 Claims. (Cl. 50-442)

This invention relates to pre-formed construction units and is more particularly concerned with such construction units which are bend-resistant and can be immediately loaded after being positioned in the structure being constructed.

Known construction units formed from reinforced concrete and the like which are intended for use as floor joists, platforms, roofing rafters, and the like are generally very long, unwieldy and extremely difficult to handle even with special equipment, and they often do not have sufficient strength to resist lateral strains when being transported to the site of erection or during the erection procedure itself.

It is the principal object of the present invention to provide pre-formed construction units which are readily transported and assembled at the point of erection without difficulty and avoid the disadvantages and drawbacks of prior construction elements.

In accordance with the invention, there are provided constructional units formed from longitudinally adjacent construction members. These members have their end faces joined at their compression chords and in their shearing zones, and in their tension zones they are interconnected by continuously adjustable connecting devices. Each constructional unit forms a bending-stiffened, uniform section, which is no longer decomposable, and which consists of the compression chord, the shearing zone, and the tension chord within the interior of the constructional unit defined by these members.

The front surface of every constructional member of this invention, viewed in its longitudinal direction, shows the following characteristics.

The shock flange of the compression chord forms at least in its exterior a broad, smooth front transverse to the supporting joist. The interior of the compression chord may be uneven, preferably of zig-zag or wave-form transverse to the supporting joist, and the enclosed field of the shearing zone is formed in that way. The zig-zag or wave-form shock flanges of two adjoining elements are of complementary form, whereby the surfaces of the impacting shearing zones lie on each other and mesh into each other, whereby the sum of the upwardly-inclined surfaces is equivalent to the sum of the downwardly-inclined ones.

The tension chord of the constructional element has at its center of gravity one or several metal bars disposed in parallel to the supporting bar of the joist each of which ending at one end in a right-hand screw thread, and at its other end in a left-hand screw thread in order to enable the opposed bar ends at the shock point to present a right and a left thread. These bar ends are adapted to receive a turnbuckle which permits the two ends of the bars to be joined. By turning the turnbuckle the distance of the bar ends opposed to each other is continuously adjustable in the direction of the supporting joist. The shock point formed in this way in accordance with this invention is fit for plate-webbed or panel-

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worked constructional elements either of steel-concrete or of metal.

Bending-stiffened constructional units which are immediately loadable between their bearing supports are formed from the constructional elements by the engagement of the compression chords and the shearing zones as well as by the joining of the tension chord.

The invention will now be described with particular reference to the specific embodiments shown in the accompanying drawings, wherein:

Fig. 1 is a diagrammatic view of a two-part reinforced concrete girder constructed in accordance with the invention showing the joint between the abutting ends of the parts making up the girder;

Fig. 2 is a corresponding diagrammatic view, on a smaller scale, showing the entire length of one part of the girder;

Fig. 3 is a diagram of stresses in the concrete;

Fig. 4 shows the use of an embodiment of construction units of the invention used in the formation of a ceiling;

Fig. 5 is a perspective view of another embodiment of the invention;

Fig. 6 is a plan view of another ceiling construction;

Figs. 7 to 9 show the application of the invention in the construction of a roof.

As previously mentioned, known construction units in the form of reinforced concrete floor joists, rafters, etc. have been continuous from bearing support to bearing support and, as a result, they are long, unwieldy and difficult to handle.

The finished parts of steel-concrete constructed in accordance with the invention, are formed from manageable, short constructional elements of reinforced concrete abutting in the compression chord zone and in the shearing zone and joined in the tension chord zone. The opposed concrete surfaces of the joint are arranged in an end-to-end pressure relationship, and the steel reinforcements molded in the concrete and provided with means for joining them together coaxially, and the abutting faces of the webs of the reinforced concrete members are at right angles to the neutral plane of the members, and are either of zig-zag or wave-like shape for taking up the transverse forces, or if flat, are indented in order to take up compressive stress resulting from shearing forces at the joint. With this connection, according to the invention, each middle piece of a reinforced-concrete girder may have at its other end a joint-face with a negative zig-zag or wave-shape. The opposed concrete surfaces transmit the compressive stressing resulting from the normal bending, shearing and/or torsional forces acting at the joint, and the steel reinforcements joined together coaxially take up the tensile stresses resulting from the same forces.

The concrete of the constructional or building members will be so formed at the jointing surfaces that it will transmit the compressive and shearing forces arising at this position, either directly or indirectly, and other materials, such as lead or sound-insulating material, may be introduced between the concrete surfaces under compression, which material should be able to take up the high stress in the same manner as, or even better than, concrete, without being subjected to other deformations such as are caused by unevenness or compressions across the edges, i.e. equalizing plastic deformations. On the other hand, the jointing connection is arranged so that it takes up the tensile forces not transmitted by the concrete but taken up by the steel reinforcement.

Referring to Fig. 1, there is illustrated an improved joint for the direct connection of two parts of a reinforced concrete girder of T-section, the abutting ends being under bending, shearing and normal force stresses.

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The compression chord "a" of the girder is cut perpendicularly at the point of connection, the plane of the cut being at right angles to the main central plane of the girder. The surface of the cut may, however, be inclined or dovetailed. The surface may also be corrugated or formed in such manner that small forces perpendicular to the central plane, due for example to torsion, will be transmitted thereby. By the "central plane" of the girder is meant, as generally understood, the plane passing through the longitudinal axis of the girder and also through the vertical axis of its cross-section, which normally contains the center of gravity of the section at every point. The "central plane" is located in such manner with regard to the forces acting upon the girder that the forces determinant for the dimensional calculation of the girder act in this plane.

The web "b" of the T-section is given a zig-zag shape at the joint in such a way that the surfaces lie perpendicular to the central plane but are inclined to the vertical by 45° or less, on alternate opposite sides.

The sum of the parallel surfaces of one inclination is equivalent to the sum of the parallel surfaces of the other inclination. The corners may be rounded to such an extent that the zig-zag line becomes sinuous or wave-like and instead of the statically favorable zig-zag shape, there may be used other toothed or indented shapes. Where intensities of shear per unit of area are of minor importance, especially with reference to simultaneously acting normal intensities of compressive stress, as where they are smaller than the tensions then arising due to friction, or where they do not arise at all, the surface of the cut may form a plane.

In the bottom or tension chord "c" of the girder, the concrete adjacent to the joint is omitted from one or both parts so that the reinforcing bars are exposed for connection within the resulting space, which is shown in Fig. 1 as extending evenly at both sides of the joint, Z being the tensile stress.

In Fig. 1 the static forces determinant for a girder free from torsional stresses are indicated by arrows. The forces to be transmitted by the concrete are taken directly at the joint by surfaces under pressure, viz. the compressive forces D due to bending, which are taken by the compression chord surfaces 1 to 2, the normal compressive forces N taken by the compression chord and web surfaces 1 to 7, and the compressive forces due to transverse shearing forces Q taken by the inclined surfaces 2 to 3, 4—5 and 6—7 of the web. Although the tensile component due to shear cannot be transmitted by the surfaces 3—4 and 5—6, it is contact with the wave hollows of the web surfaces at 4, 6, and 3, 5, respectively. If not too great, the forces will be taken up there by horizontal cross-sections of concrete just as securely as they would be in the case of undivided adjacent parts of the web. Stronger forces of the tensile component due to shear, may, however, be taken up by looped inserts or reinforcements as in the adjacent parts of the web. In that case, the reinforcement framework of compressional or tensional bars will be arranged as indicated in Fig. 2. The surfaces 3—4 and 5—6 remain free from tension. The magnitude and direction of the compressive forces S and tensile forces S_z due to shear are shown in Fig. 3.

If the transverse shearing forces change their direction with reference to the inclined web surfaces 3—4 and 5—6, the forces S_a are then turned through 90°. As the sum of the inclined surfaces taking up the compressive stress is the same, the capacity of the joint for taking up the shearing forces for the inverse direction remains equal. The aforesaid joint may thus be located at any point in the length of the girder, to the right or to the left of a support.

In order to diminish the intensity of compressive stress, the compression chord "a" and the web "b" may be laterally enlarged adjacent the joint or joints. The thickening of the web at the same time diminishes the tensile stress

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due to the component S_z . The lateral enlargement may be designed in such a way that the joint becomes stronger than the adjacent cross-sections. The enlargement may also project laterally to such an extent that it assumes the form of a transverse plate or disk.

After erection of the girder, cement grouting or the like may be injected through small channels provided at suitable points in order to fill up the joints.

The tensile forces due to bending, and any simultaneously-acting normal tensile forces, will be transmitted between the reinforcements of the joint, for example by means of a coupling with right and left hand screw threads. The reinforcements may consist of one or more bars or rolled steel sections joined together, for instance, in the case of heavily-loaded girders. The reinforcements, consisting preferably of round steel bars 8, will be swaged or upset at their ends and formed with screw threads 9, the ends having a cross-sectional area at least equal to and preferably larger than that of the steel bars enclosed in the tension zones, and being screwed into a coupling member 10. The latter is so dimensioned that its net sectional area remains larger than that of the bars, making it stronger than the calculated continuous reinforcement.

The spaces around the nuts are plastered in order to protect the nuts against corrosion. By means of these nuts steels of different qualities or steels of different thicknesses may be joined, if their ends are upset for the same thread. In this way degrees of reinforcement can be developed from one constructional part to be joined to the other, as for example, in the direction of the support.

Constructional parts of girders of pressure and reinforcement in different zones, required for the transfer of power with changeable loads from different sides, are naturally joined in several zones.

The above-described short constructional elements are, in the following embodiments, in a form which will be referred to as "lamellas."

Such constructions of lamellas may be erected more easily than has been possible hitherto with the known long, unwieldy and heavy units disposed from support to support or from hinge to hinge. The erection of the lamellas is very simple. Beginning with the lamella of support, a lamella is connected to a lamella, and the last-connected lamella will be connected by a provisional support until the next lamella, which is supported by a second provisional support, is connected. Another advantage of importance results from this construction. Each joint may be increased by adjusting the coupling nuts and thus the entire framework, latticework, ceiling, or like construction may be saddle backed, i.e. the bending or sagging of the construction due to erection and the useful load applied to it, which may be found by calculation, may be compensated and the ceiling or other construction may further be given a desired and continuing saddle backing. The bending of the supporting construction of the lamella is cancelled by the tension of the locks.

The lamella-joints interrupt or at least interfere with sound waves and thus have a sound-deadening action, especially if sound-deadening materials which may take up the high intensities of compressive stress of the concrete without any detrimental deformations are incorporated. A further sound-proofing may be obtained if the support lamellas and the building up lamellas coming into contact with the support are provided with sound-proofing courses which may be cast at the factor or fastened in some other way. Hollow bodies and other materials for heat-and-sound-insulation may be provided for in the lamella constructions.

Lamella constructions may be dismantled and may be erected at another location even in different architectural relationships.

A finished beam joist or other unit of conventional

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construction extending over a room does not have a manifold possibility of application. For this finished unit there is only one span and one useful load under always equal supporting- and fixing-conditions. Therefore, the hitherto known finished units extending over a room are only economical for type-construction, where one building is constructed exactly like another, because their manufacture in a factory is only economical in multiple constructions. Their use has, therefore, been exclusively by large scale contractors with special workers.

Due to the manifold possibilities of using them for all spans and for different loads, the lamellas of the invention may be manufactured in large quantities and stored. This working in advance allows long storage. In this case any shrinking which may occur will be finished long ago before erection.

The application of lamella building in above-ground construction will now be explained by means of a ceiling with a low, normally-permanent useful load, e.g. by means of a dwelling house ceiling. The girder lattice-construction of the ceiling is sub-divided into grate-shaped lamellas by the provision of lamellas of different sizes for various requirements of erection, span and conditions of load. Such a disjointing in lamellas is shown by the horizontal projection of the ceiling of Fig. 4. In this construction two neighboring longitudinal girders 10, i.e. lamellas, and two transverse bars 12 are rigidly connected in the manner of a frame-work 13, and are conveniently called a "frame-work lamella." The ends 12a of the transverse bars 12 project laterally by $\frac{1}{2}$ the distance of the girders 10 each time. The opposite surfaces 14 of the ends of the transverse bars are of complementary zig-zag shape. The outwardly opposite surfaces of the two transverse bars of each frame-work lamella are of zig-zag shape throughout their length. Fig. 5 shows such a frame-work-lamella in parallel perspective. Frame-work-like girder pairs are constructed by connecting the right-hand tension chord of the frame-work-lamella to the right-hand tension chord of the adjacent frame-work-lamella and the left-hand one to the adjacent left-hand one, the zig-zag surfaces 14 being pushed together and positive engagement being effected by means of the threaded units 20. The end surfaces 16 of the bars are notched with the end-surfaces of the transverse bars of the adjacent girder pair. In this case, the transverse bars are able to receive transverse forces only.

Fig. 6 shows in horizontal projection the same frame-work-lamellas in lateral bracing, wherein the right-hand tension chord of the frame-work-lamella is connected to the left-hand one and the left-hand tension chord of the frame-work-lamella to the right-hand one of the following frame-work-lamella. In this case the transverse bars overlap from frame-work-lamella to frame-work-lamella laterally by $\frac{1}{2}$ the distance of a girder. As they engage at their side-faces over their entire length, there is produced a concrete structure substantially equal to a girder cast as a monolith over its entire length. In the event the transverse girders are also equipped with upper and lower reinforcement, this reinforcement will also overlap after erection in such a way that there arises a continuous transverse reinforcement at each frame-work-lamella-end effective to receive the bending stresses in the longitudinal direction, as well as the transverse forces. Owing to this kind of lamella-structure, the distribution of load transverse to the girders will be improved considerably.

The afore-described lamella-ceilings are at once walkable after erection and then bear the whole useful load. They may be covered with a wooden floor or plates, they may be plastered, and they may contain heat and sound insulating filling bodies or loose filling material. All these variations may be effected at the time of erection or later, depending upon the stocks of material, financial means of the contractor, or the like, without any influence on the stability of the construction.

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In the case of lamella-casting, hollow bodies of brick sand, pumice-concrete or other light concrete, or other light material may be used as lagging body and may become a heat and sound insulating component of the lamella. This lagging body will give the lamella a plane upper and lower surface as a base for continuous floor and as a bearer of plaster.

In the same manner as explained above in connection with ceiling constructions, lattice like lamellas for steep roof constructions, for instance, may be developed. Fig. 7 shows a longitudinal section and Fig. 8 shows a cross-section through such a lamella shaped as a rafter with end transverse discs. Fig. 9 is a perspective of a lamella. Roof lamellas may be assembled for most common roof inclinations, if only the ridge- and eaves-lamellas are shaped to correspond to the desired inclination.

In the embodiment seen in Figs. 7-9, the "frame-work-lamella" 13' is formed with longitudinal girders 10' having notches 10a', and transverse bars 12' having ends 12a' and zig-zag end surfaces 14', along with threaded means 20 for positive interconnection.

Sheds, garages or huts, for instance, may be constructed in the same manner as described above and may be formed from lamellas, to have one upper and one lower, one outer and one inside mounting, to have plates closed on one side or on both sides, and to have one or more webs, mounted with or without load-distributing transverse ribs, and with or without lateral bracing. In the case of building vaults in the form of a segment of a circle, it is to be understood that the height of the crown and the span must be harmonized with a vault-radius which remains unchanged, if vaults of different spans and heights with same lamellas are to be produced.

With the lamella constructions set forth hitherto, the lamellas produce after their connection the statically necessary skeleton of the building construction, which without any further grouting of concrete, is complete and bears the full load.

The elements according to the invention facilitate the disjointing of supporting systems in their main supporting plane as well as in direction vertical to it, into lamellas of different lengths. If, for instance, a wide struss girder is subdivided into different length of lamellas, of, for example, 70, 80, 90 and 100 cm. in length, a span of 1.40 m. and more, graduated from cm. to cm. may be bridged over, if the support-ends of the end lamellas may be displaced on the support by 1-5 cm.

What I claim and desire to secure by Letters Patent is:

1. A pre-formed constructional member effective to take up all stresses resulting selectively from normal bending, shearing and torsional forces, composed in its longitudinal direction of at least two constructional elements, each of said elements being in the form of a framework with longitudinally spaced apart frontal area defined by two cross beams interconnected by longitudinally-extending girder portions, said cross beams extending laterally beyond said girder portions, said elements being engaged at their joints within the constructional member by engagement of a cross beam of one element along its entire surface with the corresponding entire surface of a cross beam of an adjoining element whereby said elements are engaged with their opposed frontal areas in their upper chords as well as in the adjacent webs, and means connecting said elements with each other in their tension chords permitting a continuous adjustment of the longitudinal support force, each connecting means being arranged within the joint and each constructional element itself forming an integral bending-resistant uniform section consisting of the upper chord, the adjacent web, and the tension chord, the upper chord of the constructional element being cut perpendicularly at the joint, the plane of the cut being at right angles to the main central plane passing through the longitudinal axis of the element and through the vertical axis of its cross-section, the frontal area of the adjacent web

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having a zig-zag shape at the joint so that the surfaces lie perpendicularly to the central plane, but are inclined to the vertical by at most 45° on alternate opposite sides, the sum of the parallel surfaces of one inclination being equivalent to the sum of the parallel surfaces of the other inclination, the frontal area of the elements having a greater surface area than the corresponding cross-sectional areas of the elements between the frontal areas, reinforcements extending at least partly through said elements and said connecting means comprising a screw body having a cross section greater than the central cross-section of the reinforcements, a screw body being externally threaded on the end of each reinforcement, the element being formed with a recess near the end of the tension chord thereof into which said reinforcement protrudes.

2. A pre-formed constructional member effective to take up all stresses resulting selectively from normal bending, shearing and torsional forces composed in its longitudinal direction of at least two constructional elements, each of said elements being in the form of a framework with longitudinally spaced apart frontal areas defined by two cross beams interconnected by longitudinally-extending girder portions, said cross beams extending laterally beyond said girder portions, said elements being engaged at their joints within the constructional member by engagement of a cross beam of one element along half its length with a corresponding half length of a cross beam of one adjoining element and along the other half of its length with a half length of another adjoining element to provide a staggered inter-relationship among adjoining elements with said elements being engaged with their opposed frontal areas in their upper chords as well as in the adjacent webs, and means connecting said elements with each other in their tension chords permitting a continuous adjustment of the longitudinal support force, each connecting means being arranged within the joint and each constructional element itself forming an integral bending resistant uniform section consisting of the upper chord, the adjacent web, and the tension chord, the upper chord of the constructional element being cut perpendicularly at the joint of connection, the plane of the cut being at right angles to the main central plane passing through the longitudinal axis of the element and through the vertical axis

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of its cross-section, the frontal area of the adjacent web having a zig-zag shape at the joint so that the surfaces lie perpendicularly to the central plane, but are inclined to the vertical by at most 45° on alternate opposite sides, the sum of the parallel surfaces of one inclination being equivalent to the sum of the parallel surfaces of the other inclination, the frontal areas of the elements having a greater surface area than the corresponding cross-sectional areas of the elements between the frontal areas, reinforcements extending at least partly through said elements and said connecting means comprising a screw body having a cross section greater than the central cross-section of the reinforcements, a screw body being externally threaded on the end of each reinforcement, the element being formed with a recess near the end of the tension chord thereof into which said reinforcement protrudes, each of said elements being in the form of a frame-work with said opposed surfaces being provided by two cross beams interconnected by longitudinally-extending girder portions.

3. A constructional member as defined in claim 1 wherein said constructional elements are formed from reinforced concrete.

4. A constructional member as defined in claim 2 wherein said constructional elements are formed from reinforced concrete.

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