METALLIC STRUCTURE

Yves Guyon, Sevres, France

Application September 19, 1935, Serial No. 41,307
In France September 22, 1934

8 Claims. (Cl. 108—1)

In metallic constructions, the walls and carrying surfaces are often constituted by plane corrugated or pressed out sheet metal plates through which the loads directly applied are transferred by flexure on rafters or purlins under bending stress for transferring in their turn the loads on trusses forming the framework proper. In stone or ferro-concrete structures, it is on the contrary attempted, every time it is possible, to use the covering on which the loads are exerted, for directly transmitting these loads to the bearing members. This is particularly true for stone, concrete or ferro-concrete vaults and, generally speaking, for all thin ferro-concrete convex structures. In these structures, the covering is stressed according to a curved surface and the flexure or bending phenomena are eliminated or at least considerably reduced.

It has already been proposed to produce metallic carrying surfaces by utilizing thin sheet metal plates so curved as to cause them to act as a diaphragm; self-carrying surfaces in the form of catenaries have been produced in this manner by means of welded sheet metal plates. In such structures, it is necessary to cause the sheet metal plate to be put only under tensile stress and, consequently, for a single direction of the loads; on the other hand, it is difficult to economically provide devices absorbing the thrusts at the ends of the surface.

The present invention is adapted to provide a metallic wall or carrying surface acting as a thin diaphragm and for which it is possible to choose the shape, in particular shapes having double opposed curvatures, without however it being necessary to have recourse to a pressing operation for obtaining this shape. This surface solely comprises economical elements of types commonly used in metallic structures and, on the other hand, it can be used exactly in the same conditions as thin sheet metal or ferro-concrete convex elements.

The carrying surface according to the invention consists in an assembly of sheet metal plates or other thin elements, and of rafters-purlins, these sheet metal plates being substantially made according to developable surfaces, their intersecting edges or lines being elements of straight lines or curves according as the sheet metal plates are plane or curved, and the elements constituting rafters-purlins being secured according to the junction or bending lines of the sheet metal plates. The carrying power of the system thus provided is obtained, on the one hand, by the polygonal or curved outline of the successive rafters-purlins and, on the other hand, by the resistance to distortion of the system of rafters-purlins owing to their connection with the sheet metal plates. The carrying surface can thus be considered, from a mechanical standpoint, as a reticulated multiple panel-work or as a thin diaphragm.

The accompanying drawings illustrate, by way of example only, various forms of carrying out the subject-matter of the invention.

Fig. 1 shows rafters-purlins of a surface composed of elements in the shape of plane quadrilaterals.

Fig. 2 diagrammatically illustrates a surface composed of elements in the shape of skew quadrilaterals.

Fig. 3 illustrates a form of construction utilizing corrugated sheet metal elements.

Figs. 4 and 5 are diagrams showing the mode of obtaining a surface in which the lines of intersection of the sheet metal surfaces are curved.

Fig. 6 is a perspective view of a curved sheet metal element before placing it in position on the carrying surface.

Fig. 7 is a perspective view of a shed provided with a canvas covering.

The carrying surface according to the invention can be of any shape with polygonal, plane, or skew, cylindrical, conical or more generally developable faces.

When the polygons are plane quadrilaterals, the plane sheet metal plates are arranged according to these quadrilaterals. In the form of construction diagrammatically illustrated in Fig. 1, this surface, fitted for instance on two wall sections P, comprises two rafter-purlin systems C1, C2 which can be constituted in any manner whatever, for instance by section members or by a fold of the sheet metal plate itself and which form a skew reticulated panel-work, each elementary mesh of this panel-work being a plane quadrilateral.

When the polygons are triangles, the sheet metal plates can be cut out according to these triangles. According to a preferred arrangement, each sheet metal plate is given the shape of a quadrilateral folded according to a diagonal as shown in Fig. 2 for instance; the reticulated armature is indicated by the two networks of polygonal lines L1, L2, and the elementary meshes are skew quadrilaterals, each sheet metal plate T being folded according to one of its diagonals x x as to form two triangles T1, T2.

In some cases the superficial dimensions of
the sheet metal plates can be increased, whilst keeping them very thin, by the addition of ribs secured in position; in the arrangement indicated above, a rib can be provided according to the diagonal x x, the system of rafter-purlins then forming a real skew reticulated panel-work, and the sheet metal plates can then be replaced by a pressed sheet metal plate (that is to say warped or curved in any manner whatever).

The pressed sheet metal plates can moreover be replaced by corrugated sheet metal plates of standard manufacture with the diagram by choosing the outline of the polyhedral surface. Fig. 3 diagrammatically illustrates a form of construction of this latter arrangement. It illustrates a portion of a surface in the shape of a thin convex structure, defined by networks of lines Ls Ls, corresponding to the edges of a polyhedral surface having triangular faces, rafters-purlins and ribs 4, 5, 6 being arranged according to these lines. The surface proper is constituted by corrugated sheet metal panels 7 overlapping at the wave end as indicated at 1a.

The determination of the system of sheet metal plates according to which are arranged the elements of a metallic carrying surface according to the invention can be conveniently effected from a fictitious and so-called directing surface suitably chosen and on which is traced either one, or two, or three systems of so-called directing curves. The lines of intersection or edges of the various sheet metal plates, the assemblage of which constitutes the carrying surface, are either the chords of these curves composed between the successive points of intersection of one and the same curve with the others, or these curves themselves, or a combination of the chords and of the curves.

If the curves belong to three networks, the meshes will be triangular if the curves of any of the three networks pass through the knots or respective points of intersection of the curves of the other two; if the curves belong to two networks, the meshes will be quadrangular. In both cases each elementary sheet metal plate can be plane or curved. If there is only one network on the directing surface, each face of the directing surface will be curved, the intersecting of the various faces being the curves of this network. This case is only a particular case of the preceding one, in which the second network is reduced to two curves which limit the surface.

Figs. 4 and 5 illustrate diagrams in which the various sheet metal plates are bounded by curves entirely situated on the directing surface. Fig. 6 is a perspective of a sheet metal element before it has been fitted in position.

The construction according to the partial diagram of Fig. 4 comprises a surface obtained by means of a series of elements 5 each having two rectilinear sides 5a and two curved sides 5b.

The sides 5a, 5b form a reticulated system which can be for instance carried but by rafters-purlins (not shown). This reticulated system is composed of a system of curves 5b entirely situated on the directing surface and of chords 5a of a second system of curves Ls Ls of the same surface; this second system can be limited to two edges of the surface, stiffened or not by tympan frameworks or any other suitable member. The differences between the two surfaces, as well as the differences between the real constructions and those theoretically foreseen, are relatively small.

The construction shown in the partial diagram of Fig. 5 comprises a series of elements 9 having all their sides curved. Some of these sides, 9c, are for instance arranged according to a system of directing curves Ls Ls of the directing surface, the other sides 9b being arranged according to another system Ls, of directing curves of the same sort as those shown in Fig. 3. The surface constituted by the elements 9 can therefore either coincide with the directing surface, or it can constitute a polyhedron provided with curved facets and having its edges 9a, 9b on the directing surface.

The facets such as 8 or 9 (or surface elements if the whole of these elements, such as 9, forms a continuous surface coinciding, or not, with the directing surface) can be either cylindrical, or conical, or skew facets; the cylindrical or conical facets are particularly convenient, as they can be easily obtained by transformation of a plane sheet metal plate into a developable surface.

The sides of the facets can, as previously stated, be reinforced by special members, such as rafters-purlins, resisting to the action of the bending stresses due to the loads transferred on to these rafters by the facets. These flexure or bending stresses are moreover nil in some particular cases, if the joints describe a funicular curve of the stresses applied.

The production of the facets can be rendered particularly simple if use is made of the weight of the sheet metal plates themselves, upon assemblage, for giving to each facet the curved shape it must assume. For instance, in a case such as that diagrammatically shown in Fig. 4, if the lines formed by the sides 8a are formed, during construction, by resistant arches previously in position, it suffices, upon assemblage of the sheet metal plates, to allow strips, such as 8b, to hang between these arches, which strips will then assume the profile either of a catenary, or of any other curve approximating a catenary if slight supplementary stresses are exerted on said strips. In the case of facets or elements having a surface of double curvature, such as the elements 9 of the device diagrammatically illustrated in Fig. 5, these elements can be formed from sheet metal plates which will be curved lines of the intersection of the various faces being the curves of this network. This operation, by which a plane sheet metal plate is given the shape of a developable surface, is easy to carry out. The second curvature can then be obtained, upon assemblage, for instance by the action of gravity.

In the latter case, the rafters-purlins are theoretically unnecessary, the surface thus obtained constituting a real thin convex structure.

The sheet metal can at least partially be replaced by glass or by any other suitable material, such as concrete, fibre, canvas, or the like.

The form of construction shown in Fig. 7 is a shed the roof of which is carried by standards 10 and struts 11 held in position by braces 12.

The armature of this roof comprises rigid arches 13, 14. Its directing surface is, according to the present invention, formed by a system of curves of the hyperbolic type, the construction of a system of hyperboloids of revolution as for example a portion of hyperbolical parabolid, and the armature also comprises rafters-purlins 13a, 13b respectively arranged according to generatrices in both of the systems in the hyperboloid, and other elements working on the roof according to the diagonals of the meshes formed by the elements 15a and 15b. It is to be noted that this form of construction made according
to a predetermined directing surface, at the same time as it includes the use of rectilinear armature elements (5c, 5b), constitutes a particular case of the arrangement described above, according to which these armature elements are entirely on said directing surface.

The covering, in this example, is constituted by means of a canvas 18.

I claim:—

1. In a metallic structure, a wall having two opposed curvatures comprising a reticulated armature having quadrangular meshes and the elements of which are relatively rigid and coincide with the edges of a fictitious polyhedron and sheet metal plates of quadrangular shape filling up the meshes of this armature and rendered rigid with the latter at their four edges.

2. In a metallic structure, a wall comprising a reticulated armature having triangular meshes and the elements of which are relatively rigid and sheet metal plates of quadrangular shape filling up the meshes of this armature and each rendered rigid, at two of their opposed edges, with corresponding elements of said armature.

3. In a metallic structure, a wall comprising a reticulated armature having triangular meshes and the elements of which are relatively rigid and sheet metal plates of quadrangular shape filling up the meshes of this armature and each rendered rigid, at two of their opposed edges, with corresponding elements of said armature, the said sheet metal plates being corrugated.

4. In a metallic structure, a wall having two opposed curvatures comprising a reticulated armature the elements of which are rectilinear and the knots of which coincide with points of a fictitious surface having a double curvatures, and plane sheet metal plates filling up the meshes of said armature.

5. In a metallic structure, a wall having two opposed curvatures comprising a reticulated armature the knots of which coincide with points of a fictitious surface having a double curvature and the elements of which coincide some with curved directrices of said surfaces and the others with fictitious rectilinear chords connecting points of other curved directrices of said surface, and sheet metal plates filling up the meshes of this armature and having the shape of a developable surface.

6. In a metallic structure, the combination of rigid arches a reticulated armature the knots of which coincide with points of a fictitious surface having two opposed curvatures and the edges of which are attached to said arches, and a series of flexible strips entirely covering this armature.

7. In a metallic structure, a wall having two opposed curvatures comprising the combination of rigid arches and of sheet metal strips secured to these arches and directed across the latter, these strips having between the arches the curved shape which is given to them by gravity and being connected together so as to form a continuous surface having concave facets.

8. In a metallic structure, a wall comprising the combination of a series of substantially curved and relatively rigid armatures arranged for constituting a framework having two opposed curvatures, and of thin surface elements attached to these armatures and connected to each other at their edges so as to form a continuous surface.

YVES GUYON.