US 20020184850A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0184850 A1**
Kamenomostski (43) **Pub. Date: Dec. 12, 2002**

(54) **THIN-WEBBED PROFILE MEMBER AND PANEL BASED ON IT (VARIANTS)**

(76) Inventor: **Alexandre Ilich Kamenomostski**, Bronx, NY (US)

Correspondence Address:
THE FIRM OF KARL F ROSS
5676 RIVERDALE AVENUE
PO BOX 900
RIVERDALE (BRONX), NY 10471-0900 (US)

(21) Appl. No.: **10/149,049**

(22) PCT Filed: **Dec. 1, 2000**

(86) PCT No.: **PCT/RU00/00494**

Publication Classification

(51) **Int. Cl.**[7] **E04C 3/30**; E04C 2/38
(52) **U.S. Cl.** **52/800.1**; 52/731.7

(57) **ABSTRACT**

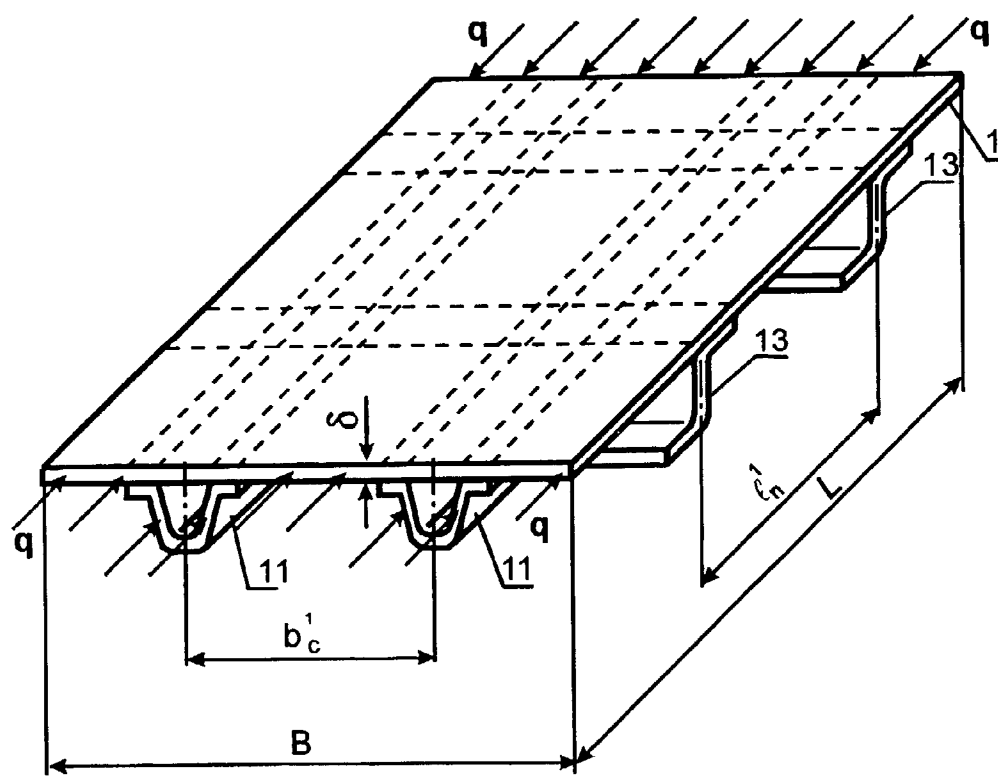
The present group of inventions pertains to building and mechanical engineering and can be implemented in structural load-carrying components.

Thin-webbed profile member is intended for reacting primarily compressive load and is embodied with shape and cross-section dimensions constant along its length. Three variants of thin-webbed profile members are proposed.

The novelty is embodiment of the shapes with optimum relation of cross-section dimensions corresponding to minimum mass.

Two variants of panel are based on all three variants of thin-webbed profile members installed in longitudinal or in longitudinal and transversal directions. Thin-webbed profile members installed longitudinally form with the sheet the open or closed cross-section configuration.

The novelty is embodiment of he panels with optimum relation of cross-section dimensions of thin-webbed profile members, thickness of the sheet, pitch of longitudinal and transversal installation corresponding to minimum mass of the panel.



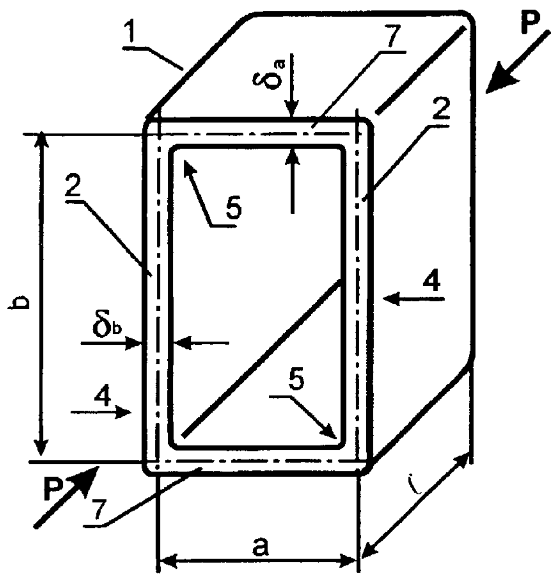


FIG.1

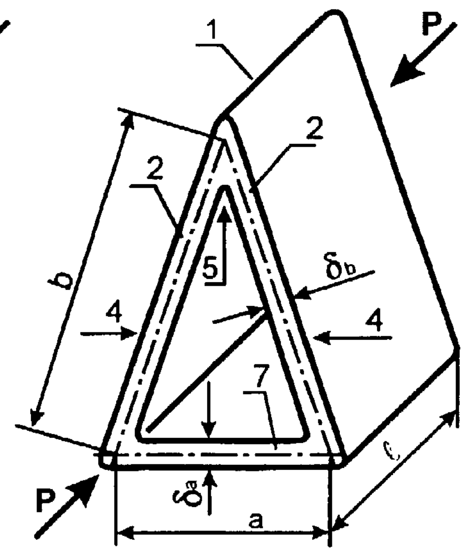


FIG.2

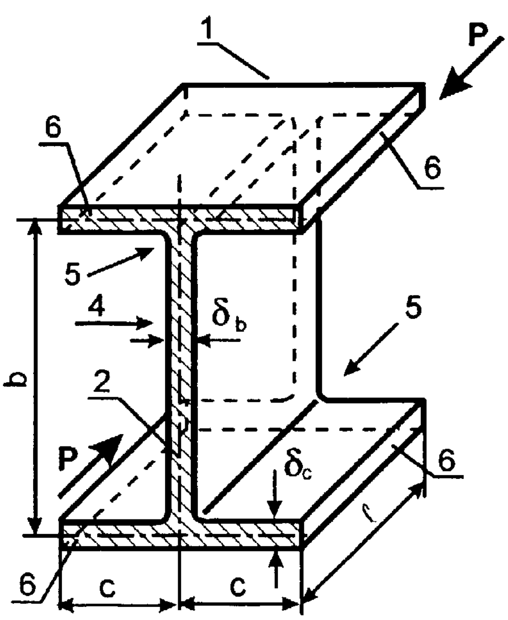


FIG.3

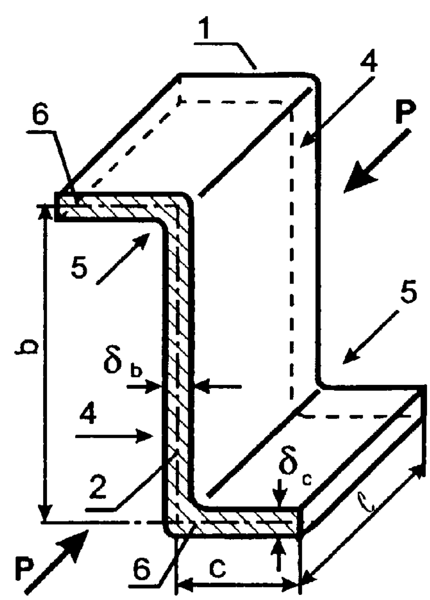


FIG.4

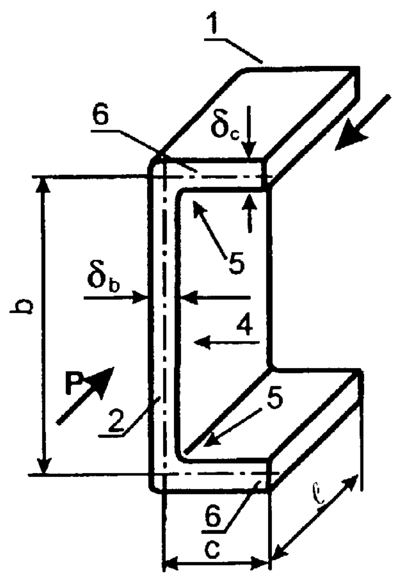


FIG.5

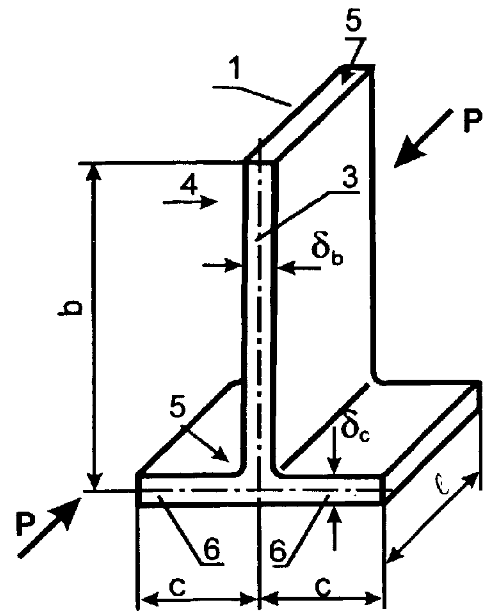


FIG. 6

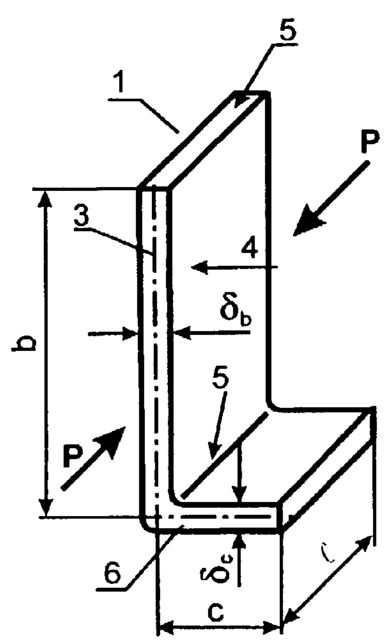


FIG.7

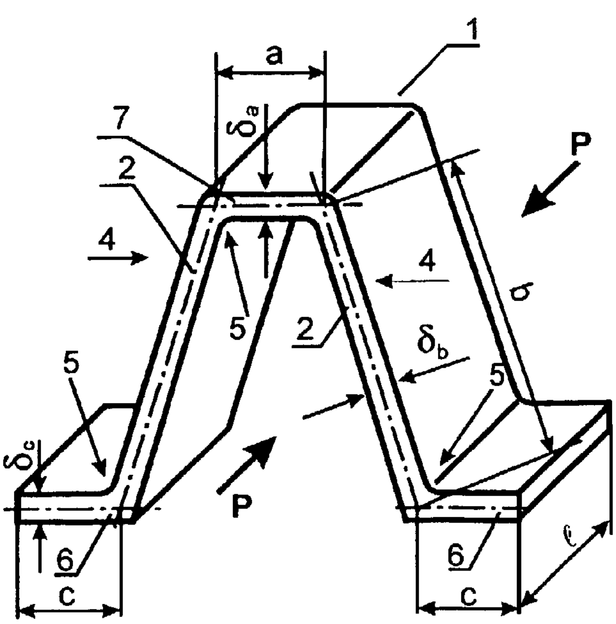


FIG.8

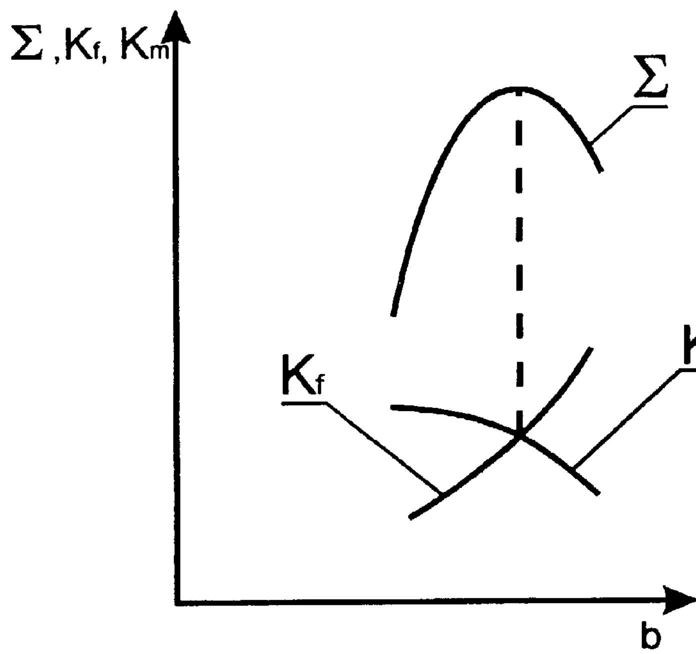


FIG. 9

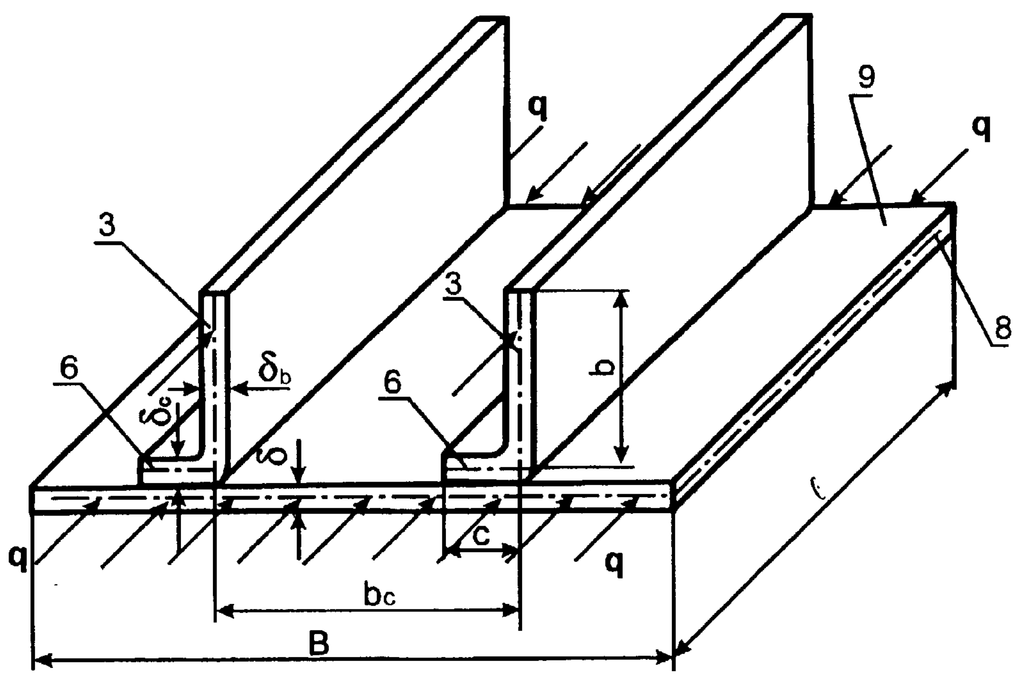


FIG. 10

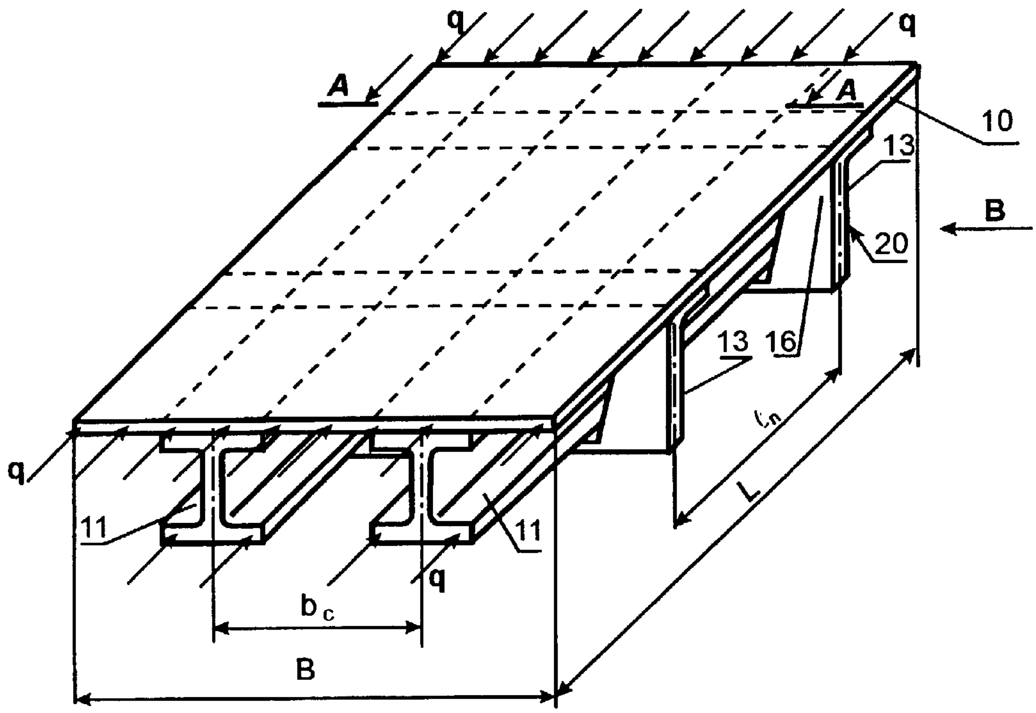


FIG. 11

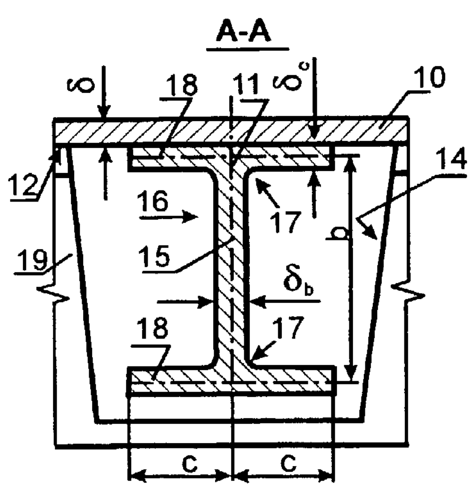


FIG. 12

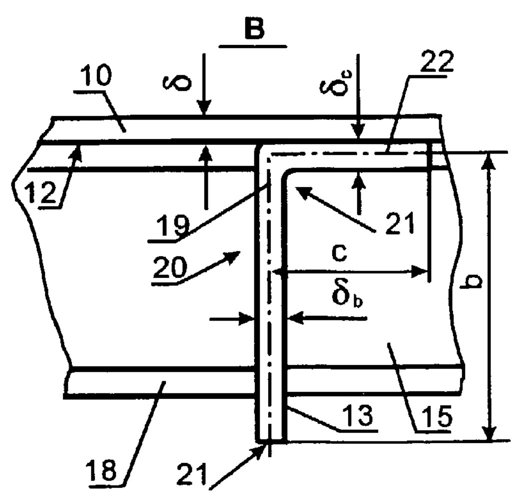


FIG. 13

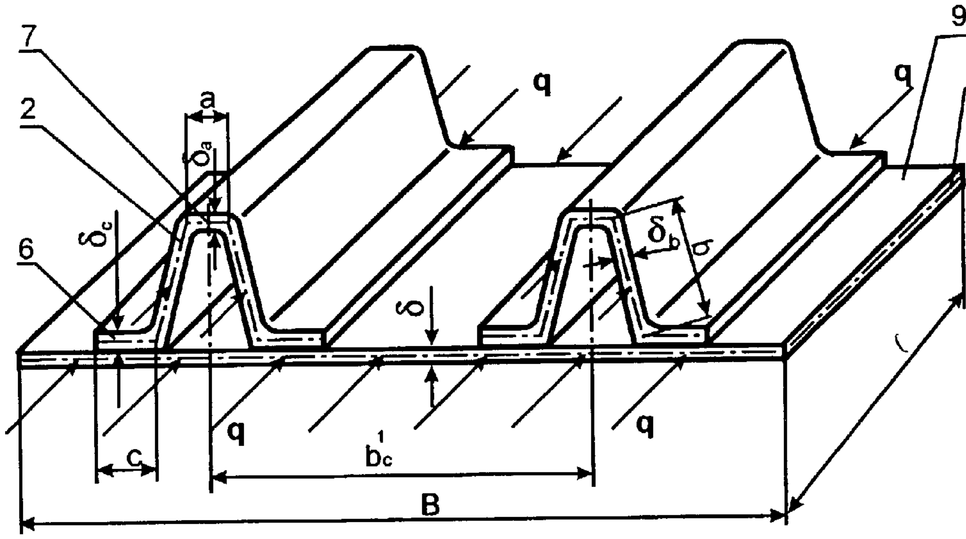

7
2
a
δ_a
δ_c
6
q
9
8
δ_b
δ
q
b_c^1
c
B

FIG.14

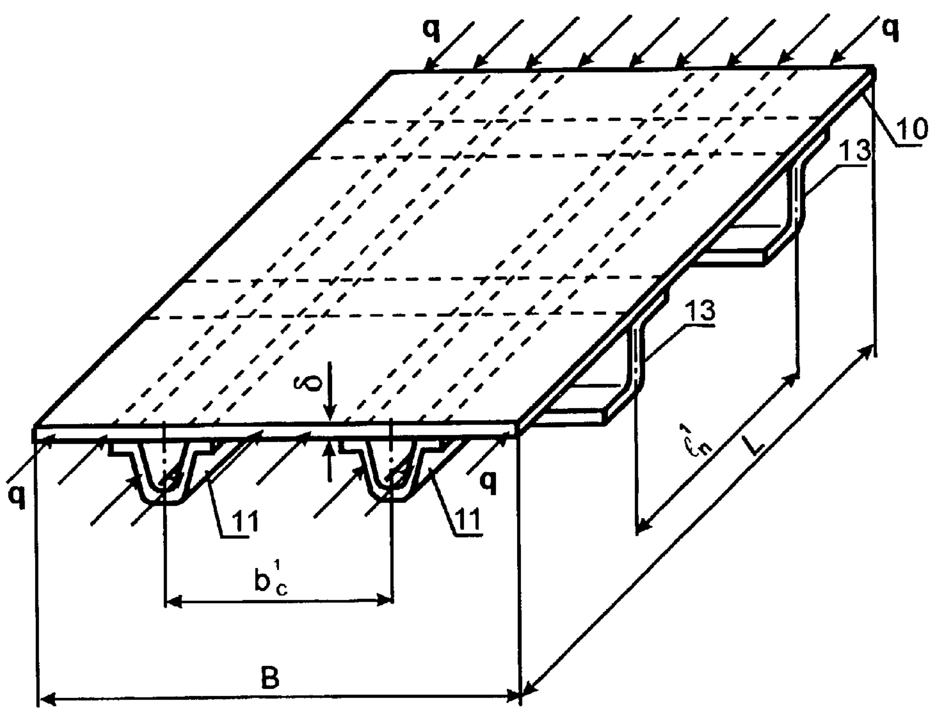

q
q
10
13
13
δ
q
q
11
11
b_c^1
L
B

FIG.15

THIN-WEBBED PROFILE MEMBER AND PANEL BASED ON IT (VARIANTS)

FIELD OF THE INVENTION

[0001] The present group of inventions pertains to building and mechanical engineering and can be implemented in load-carrying components of building structures with strict qualifying requirements to reliable operation provided minimum mass of the structure.

BACKGROUND OF THE INVENTION

[0002] Widespread types of structural units applied in building and in mechanical engineering are compressed thin-webbed structure members constituting thin-walled bars (profile members), plates and shells (panels) reinforced with thin-walled bars. They enable to meet strict operational requirements with respect to articles provided resolution of the "mass—strength" compromise, viz., stability and stiffness under compressive force provided minimization of mass. Minimization of the mass of thin-webbed structures encounters the issue of lack of a single dependence interconnecting multitude of parameters, in particular, rated limiting stress, external load, material, dimensions and shape of cross-section of a thin-webbed profile member and panels based on it.

[0003] There is a prior art thin-webbed profile member (hereinafter, TPM) with the shape and cross-section dimensions constant along its length, for example, of a closed triangular or rectangular shape comprising main strip(s) and additional strip(s) with common reinforcing ribs [1]; [2, p. 33, **FIG. 20**].

[0004] The drawback of this known TPM is the narrow range of its applicability related to the restrictions brought about by its specific shape. Besides, the relations of dimensions of the cross-section of this TPM are not optimal from the viewpoint of its mass minimization.

[0005] There is another prior art TPM with the shape and cross-section dimensions constant along its length comprising main strip(s) and additional strip(s) with common reinforcing rib(s) and free reinforcing ribs [3]; [4]; [2, p. 32, **FIG. 18**; p. 122, **FIG. 111**; p. 153, **FIG. 142**].

[0006] As TPM of such kind, the most common types of TPM can be considered, for example, T-shaped, double-T-shaped, L-shaped, Z-shaped, etc.

[0007] Embodiment of TPM of these shapes with the known ratio of cross-section dimensions is not optimal either, regarding the mass minimization.

[0008] There is another prior art TPM with the shape and cross-section dimensions constant along its length comprising main strip(s) and additional strip(s) with common reinforcing ribs and free reinforcing rib(s) [5]; [6]; [7]; [8]; [2, p. 110, **FIG. 101**; p. 111, **FIG. 102**].

[0009] Belonging to these are, for example, trough-shaped TPM.

[0010] In selection of cross-section dimensions for these TPM in [1-8], the effect of "spacing" of cross-section material was not accounted for accurately enough: at higher moment of inertia, the respectively higher overall stability is achieved, while the local stability is thereby reduced. Due to this, it proves impossible to establish how close is the selected version of cross-section dimensions to the one with the minimum area, hence with the minimum TPM mass.

[0011] There is a prior art panel comprising a sheet and a number of TPM installed across its width longitudinally with even pitch; with this, the main strip(s) and additional strip(s) are forming with the sheet an open cross-section configuration [4]; [2, p. 221, **FIG. 207**].

[0012] There is another prior art panel selected by the author as the closest analogue comprising a sheet and a number of TPM installed across its width longitudinally with even pitch; with this, the main strip(s) and additional strip(s) are forming with the sheet a closed cross-section configuration [5]; [2, p. 8, **FIG. 1**].

[0013] Cross-section and longitudinal section dimensions of the known panels in [2], [4], [5] are selected by the variant method requiring calculations of strength and stiffness performance of these sections and verifying each variant for compliance with the normative requirements. However, the normative requirements do not provide recommendations for selection of the optimal variant of dimensions of sections possessing the minimum area, which inevitably brings about the excessive material intensity of the panel.

SUMMARY OF THE INVENTION

[0014] The claimed group of inventions comprises the new embodiment of dimensions of cross-section shape of TPM and of panels on its base ensuring their reliable operation provided the minimum mass.

[0015] The proposed group of inventions pertains, in respect of the problem formulation, to the class of primal analytic problems: given load, material, pattern of axes and overall dimensions of the structure, dimensions of cross-section shape (hereinafter, the shape dimensions) of members are found corresponding to the minimum mass of structures. The present group of inventions relating to the mass minimization problem is aimed at reduction of the number of parameters varied simultaneously, which cuts down the amount of calculations, entails reduction of man-hour and, eventually, reduces time and cost of design and development work.

[0016] The first type of subject of the group of the inventions is TPM of various shapes. The proposed TPM according to the variant I (hereinafter, TPM I) is characterized in that the ratio of the width of the additional strip with common reinforcing ribs to the width of the main strip satisfies the expression:

$$a/b=0.3\div0.7 \quad (1),$$

[0017] and the ratio of the thickness of additional strip with common reinforcing ribs to the thickness of the main strip satisfies the expression:

$$\delta_a/\delta_b=1.0\div3.0; \quad (2),$$

[0018] where:

[0019] a is the width of the additional strip with common reinforcing ribs;

[0020] b is the width of the main strip;

[0021] δ_a is the thickness of the additional strip with common reinforcing ribs;

[0022] δ_b is the thickness of the main strip;

[0023] with this, the stiffness of the main strip does not exceed the stiffness of the additional strip; specifically, $\delta_a/a \geqq \delta_b/b$.

[0024] The proposed TPM according to the variant II (hereinafter, TPM II) is characterized in that the ratio of the width of the additional strip with the free reinforcing rib and the common reinforcing rib to the width of the main strip satisfies the expression:

$$c/b=0.05\div 0.3 \quad (3),$$

[0025] and the ratio of the thickness of the additional strip with the free reinforcing rib and the common reinforcing rib to the thickness of the main strip satisfies the expression:

$$\delta_c/\delta_b=1.0\div 3.0 \quad (4),$$

[0026] where:

[0027] b is the width of the main strip;

[0028] c is the width of the additional strip with the free reinforcing rib and the common reinforcing rib;

[0029] δ_b is the thickness of the main strip;

[0030] δ_c is the thickness of the additional strip with the free reinforcing rib and the common reinforcing rib;

[0031] with this, the stiffness of the main strip does not exceed the stiffness of the additional strip; specifically, $\delta_c/c \geqq \delta_b/b$.

[0032] The proposed TPM according to the variant III (hereinafter, TPM III) is characterized in that the ratio of the width of the additional strip with common reinforcing ribs to the width of the main strip satisfies the expression:

$$a/b=0.3\div 0.7 \text{ (1)}, \quad (1),$$

[0033] and the ratio of the thickness of the additional strip with common reinforcing ribs to the thickness of the main strip satisfies the expression:

$$\delta_a/\delta_b=1.0\div 3.0 \quad (2),$$

[0034] with this, the ratio of width of the additional strip with the free reinforcing rib and the common reinforcing rib to the width of the main strip satisfies the expression:

$$c/b=0.05\div 0.3 \quad (3),$$

[0035] and the ratio of the thickness of the additional strip with the free reinforcing rib and the common reinforcing rib to the thickness of the main strip satisfies the expression:

$$\delta_c/\delta_b=1.0\div 3.0 \quad (4),$$

[0036] where:

[0037] a is the width of the additional strip with common reinforcing ribs;

[0038] b is the width of the main strip;

[0039] c is the width of the additional strip with the free reinforcing rib and the common reinforcing rib;

[0040] δ_a is the thickness of the additional strip with common reinforcing ribs;

[0041] δ_b is the thickness of the main strip;

[0042] δ_c is the thickness of the additional strip with the free reinforcing rib and the common reinforcing rib;

[0043] with this, the stiffness of the main strip does not exceed the stiffness of the additional strip; specifically, $\delta_a/a \geqq \delta_b/b$ and $\delta_c/c \geqq \delta_b/b$.

[0044] Besides, in this variant of the TPM, the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib; specifically, $\delta_b/b \leqq \delta_a/a \leqq \delta_c/c$, which follows from expressions (1), (2), (3) and (4).

[0045] The second type of subject of the group of inventions is two variants of panel embodiment, IV and V (hereinafter, panel IV and panel V), based on all said variants of TPM, I, II and III.

[0046] The technological result of the panel according to the variant IV is achieved by that the panel comprises a sheet and a number of TPM, having relations between the shape dimensions complying with the expressions (1)-(4), which are installed across its width longitudinally with even pitch; with this, the main strip(s) and additional strip(s) are forming with the sheet an open cross-section configuration, wherein the thickness of the sheet of the panel according to the invention satisfies the following expression:

$$\delta=(0.0006\div 0.0035)l \quad (5),$$

[0047] and the pitch of the longitudinal installation satisfies the expression:

$$b_c=(20\div 65)\delta \quad (6),$$

[0048] where:

[0049] δ is the thickness of the sheet of the panel;

[0050] l is the length of the TPM forming with the sheet the open cross-section configuration;

[0051] b_c is the pitch of the longitudinal installation of TPM forming with the sheet the open cross-section configuration;

[0052] with this, the stiffness of the main strip does not exceed the stiffness of the additional strip, and the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib; specifically, $\delta_b/b \leqq \delta_a/a \leqq \delta_c c$.

[0053] Besides, the panel IV can be additionally equipped with the TPM installed transversally and having the above relations of the shape dimensions (1)-(4). With this, it is expedient to install these TPM with the pitch of transversal installation

$$l_n=(10\div 60)b_c \quad (7),$$

[0054] where:

[0055] l_n is the pitch of transversal installation of TPM for the case of longitudinally installed TPM forming with the sheet the open cross-section configuration;

[0056] b_c is the pitch of the longitudinal installation of TPM forming with the sheet the open cross-section configuration.

[0057] The technological result of the panel V is achieved by that the panel comprises a sheet and a number of TPM, having relations between the shape dimensions complying with the expressions (1)-(4), which are installed across its width longitudinally with even pitch; with this, the main strip(s) and additional strip(s) are forming with the sheet a closed cross-section configuration, wherein the thickness of the sheet of the panel according to the invention satisfies the following expression:

$$\delta=(0.0006\div 0.0035)l \quad (5),$$

[0058] and the pitch of the longitudinal installation satisfies the expression:

$$b^1_c=(40\div 130)\delta \quad (8),$$

[0059] where:

[0060] δ is the thickness of the sheet of the panel;

[0061] l is the length of the TPM forming with the sheet the closed cross-section configuration;

[0062] b^1_c is the pitch of longitudinal installation of TPM forming with the sheet the closed cross-section configuration;

[0063] with this, the stiffness of the main strip does not exceed the stiffness of the additional strip, and the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib, specifically, $\delta_b/b \leqq \delta_a/a \leqq \delta_c/c$.

[0064] Besides, the panel V can be additionally equipped with the TPM installed transversally and having the above relations of the shape dimensions (1)-(4). With this, it is expedient to install these TPM with the pitch of transversal installation

$$l^1_n=(1.5\div 10)b^1_c \quad (9),$$

[0065] where:

[0066] l^1_n is the pitch of transversal installation of TPM for the case of longitudinally installed TPM forming with the sheet the closed cross-section configuration;

[0067] b^1_c is the pitch of the longitudinal installation of TPM forming with the sheet the closed cross-section configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] The design of the TPM and panels on its base in accordance with the present group of inventions is explained in connection with the figures, wherein for better understanding main strips and additional strips will be illustrated as main and additional webs and flanges. With this, a web strip possesses two common longitudinal reinforcing ribs, while the flange strip possesses one common longitudinal reinforcing rib and one free longitudinal reinforcing rib.

[0069] **FIGS. 1 and 2** illustrate variant I of the invention.

[0070] **FIG. 1** shows TPM I of the closed rectangular shape with two main webs and two additional webs;

[0071] **FIG. 2** shows TPM I of the closed triangular shape with two main webs and one additional web.

[0072] FIGS. **3** to **7** illustrate variant II of the invention.

[0073] **FIG. 3** shows the double-T-shaped TPM II with one main web and four additional flanges;

[0074] **FIG. 4** shows the Z-shaped TPM II with one main web and two additional flanges;

[0075] In FIGS. **3-4**, for the purpose of more clear perception, shapes of the TPM cross-section are emphasized;

[0076] **FIG. 5** shows the channel-shaped TPM II with one main web and two additional flanges;

[0077] **FIG. 6** shows the T-shaped TPM II with one main flange and two additional flanges;

[0078] **FIG. 7** shows the L-shaped TPM II with one main flange and one additional flange.

[0079] **FIG. 8** illustrates variant III of the invention.

[0080] **FIG. 8** shows the trough-shaped TPM III with two main inclined webs, one additional web and two additional flanges;

[0081] **FIG. 9** shows the diagram of the shape efficiency factor Σ versus the width of the main strip of the TPM (b).

[0082] FIGS. **10** to 13 show the panel IV.

[0083] **FIG. 10** shows the panel based on the L-shaped TPM forming with the sheet an open cross-section configuration;

[0084] **FIG. 11** shows the panel based on double-T- and L-shaped TPM reinforcing the sheet in longitudinal and transversal directions, respectively;

[0085] **FIG. 12** is a sectional view taken along line "A-A" of **FIG. 11**;

[0086] **FIG. 13** is a view taken along line "B" of **FIG. 11**;

[0087] **FIGS. 14 and 15** show the panel V.

[0088] **FIG. 14** shows the panel V based on the trough-shaped TPM forming with the sheet a closed cross-section configuration;

[0089] **FIG. 15** shows the panel V based on trough- and Z-shaped TPM reinforcing the sheet in longitudinal and transversal directions, respectively.

THE BEST EMBODIMENT OF THE INVENTION

[0090] The subject matter of the present inventions may best be understood by reference to the following descriptions taken in connection with the accompanying drawings.

[0091] In FIGS. **1** to **8**, various shapes of TPM I, II, III, denoted by pos. **1**, are shown, dimensions of which are selected in accordance with the recommended ratios stipulated in the present invention.

[0092] The TPM are intended for reacting the compressive load P and can be embodied, for example, as closed rectangular (**FIG. 1**), closed triangular (**FIG. 2**), double-T—(**FIG. 3**), Z—(**FIG. 4**), channel—(**FIG. 5**), T—(**FIG. 6**), L—(**FIG. 7**), trough—(**FIG. 8**) shapes.

[0093] TPM comprise the main web(s) **2** (FIGS. **1** to **5**, **8**); or main flange **3** (FIGS. **6**, **7**); embodied as main strip(s) **4**, possessing two common longitudinal reinforcing ribs or one free longitudinal reinforcing rib and one common longitudinal reinforcing rib **5**, respectively. Additional flange(s) **6** (FIGS. **3** to **8**) and web **7** (**FIGS. 1, 2, 8**) are embodied with the width less than that of the main strip **4** and with the thickness not less than that of the main strip **4**.

[**0094**] With this, the stiffness of the main strip **4** does not exceed that of the additional strip (flanges **6**, webs **7**), specifically, $\delta_a/a \geqq \delta_b/b$ and $\delta_c/c \geqq \delta_b/b$. And the stiffness of the additional strip with two common longitudinal reinforcing ribs, web **7** (**FIG. 8**), does not exceed the stiffness of the additional strip with one free longitudinal reinforcing rib and one common longitudinal reinforcing rib, flange **6** (**FIG. 8**), specifically, $\delta_a/a \leqq \delta_c/c$.

[**0095**] The additional flange **6** or the additional web **7** can be located with respect to main strip **4** both at the angle 90° (**FIGS. 1, 3** to **7**) and at a different angle (**FIGS. 2, 8**).

[**0096**] Width and thickness of main webs **2**, flanges **3** and additional webs **7**, flanges **6** in the cross-sections of TPM (FIGS. **1** to **8**) satisfy expressions (1), (3), (10):

$$a/b=0.3\div0.7 \quad (1),$$

$$c/b=0.05\div0.3 \quad (3),$$

$$\delta_a/\delta_b=\delta_c/\delta_b=1.0\div3.0 \quad (10).$$

[**0097**] where: a, b, c, δ_a, δ_b, δ_c are, respectively, width and thickness of the additional web, the main web or flange and the additional flange.

[**0098**] For example, width a of the additional web **7** is defined as a length measured along the cross-section medial line (the line equidistant from longitudinal edge lines of cross-section) of the web **7** between the respective lines of main webs **2** adjacent to the web **7** (**FIGS. 1, 2, 8**).

[**0099**] Width b of the main web **2** or flange **3** is defined as a length measured along the medial line of the cross-section of the main web **2** or flange **3** between the respective lines of adjacent strips (FIGS. **1** to **8**).

[**0100**] Width c of the additional flange **6** is defined as a length measured along the medial line of the cross-section of this flange **6** from the medial line of the main web **2** or flange **3** to the free longitudinal reinforcing rib of the additional flange **6** (FIGS. **3** to **8**).

[**0101**] Thickness δ_a, δ_b, δ_c corresponding to dimensions a, b, c is defined as the distance measured between the edges of cross-sections of webs and flanges.

[**0102**] The above expressions (1), (3), (10) can be applied in case of implementation of TPM I to III in the form of the following shapes: double-T—with one main web **2** and four additional flanges **6** (**FIG. 3**); Z (**FIG. 4**)—with two additional flanges **6** located both sides from the main web **2**; or channel—with additional flanges **6** located the same side of the main web **2** (**FIG. 5**); or trough—with main webs **2**, additional web **7** and additional flanges **6** (**FIG. 8**); or T (**FIG. 6**) and L (**FIG. 7**)—with the main flange **3** and additional flange(s) **6**; or closed rectangular (**FIG. 1**) and triangular (**FIG. 2**); as well as shapes with other arrangement and quantity of main and additional webs and flanges.

[**0103**] The range of values of ratios of widths and ratios of thicknesses of main webs **2** and flanges **3**, additional flanges **6** and webs **7** is obtained using the generalizing parameter for various shapes of TPM, which the author introduced and called the shape efficiency factor Σ:

$$\Sigma=K_f \cdot K_m,$$

[**0104**] where:

[**0105**] $K_f=(i^2/F)^{2/5}$,

[**0106**] $K_m=K^{1/5}/(b/\delta_b)^{2/5}$,

[**0107**] b, δ_b are the width and the thickness of the main web **2** or flange **3**, respectively;

[**0108**] i, F are the inertia radius and the area of shape of TPM in FIGS. **1** to **8**, respectively;

[**0109**] K is the coefficient in the known formula for local stability critical stresses, depending on said ratios of TPM shape dimensions.

[**0110**] The graphic illustration of the shape efficiency factor Σ versus width of the main strip (b) is shown in **FIG. 9**. As one can see from this plot, the factor Σ possesses, for each shape, a maximum value. For various TPM I, II, III shapes, these maximum values correspond to the ranges of ratios of dimensions specified by (1), (3), (10).

[**0111**] Various shapes of TPM can be compared in mass, viz.: the greater the maximum value of the factor Σ for a particular shape, the less is the TPM mass.

[**0112**] At the same time, within the specified ranges, maintaining the values of the above ratios, variation of shape absolute dimensions is possible which enables to provide for design/technological restrictions not entailing a considerable increase of the mass of TPM. Beyond these ranges, the mass of TPM increases.

[**0113**] Similar relations for shape dimensions of TPM according to the invention can also be used in designing panels based on these TPM.

[**0114**] **FIG. 10** shows panel IV based on the TPM II of the L-shape. In the course of operation the panel is subjected primarily to compressive load q directed along the length of l and distributed across the width B of the panel. The panel comprises the sheet **8** and TPM II attached to one of the sides **9** of the sheet **8** across its width and installed longitudinally with even pitch. Each of the TPM II forms with the sheet **8** the open cross-section configuration. Each TPM II of the panel has the L-shape comprising one main flange **3** and one additional flange **6**.

[**0115**] Width b and c of main flanges **3** and of additional flanges **6** and the thickness of these, δ_b and δ_c, respectively, satisfy the expressions:

$$c/b=0.05\div0.3 \quad (3),$$

$$\delta_c/\delta_b=1.0\div3.0 \quad (4).$$

[**0116**] The other dimensions of panel IV cross-section in **FIG. 10** satisfy the following expressions:

$$\delta=(0.0006\div0.0035)l \quad (5),$$

$$b_c=(20\div65)\delta \quad (6),$$

[**0117**] where:

[**0118**] δ is the thickness of the sheet **8**;

[**0119**] b_c is the pitch of the longitudinal installation of TPM forming with the sheet **8** the open cross-section configuration;

[**0120**] l is the length of TPM II.

[0121] With this, the stiffness of the main strip does not exceed the stiffness of the additional strip; specifically, $\delta_c/c \geqq \delta_b/b$.

[0122] **FIG. 14** shows panel V based on the TPM III of the trough-shape (**FIG. 8**) forming with the sheet **8** the closed cross-section configuration. Each of TPM III has the main webs **2**, the additional web **7** and the additional flanges **6**.

[0123] The values of width a, b, c of additional webs **7**, main webs **2**, and additional flanges **6** and values of thickness corresponding to these dimensions, δ_a, δ_b, δ_c, of the shape of TPM III of the panel V satisfy the following expressions:

$$a/b=0.3\div0.7 \quad (1),$$

$$c/b=0.05\div0.3 \quad (3),$$

$$\delta_a/\delta_b=\delta_c/\delta_b=1.0\div3.0 \quad (10).$$

[0124] The other dimensions of the panel V cross-section (**FIG. 14**) satisfy the following expressions:

$$\delta=(0.0006\div0.0035)l \quad (5),$$

$$b^1_c=(40\div130)\delta \quad (8),$$

[0125] where:

[0126] δ is the thickness of the sheet **8**;

[0127] b^1_c is the pitch of the longitudinal installation of trough-shaped TPM III forming with the sheet **8** the closed cross-section configuration;

[0128] l is the length of TPM III.

[0129] With this, the stiffness of the main strip does not exceed the stiffness of the additional strip, and the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib, specifically, $\delta_b/b \leqq \delta_a/a \leqq \delta_c/c$.

[0130] To reinforce panels IV and V in longitudinal direction, TPM I, II, III embodied as other configuration profiles, for example, Z-, T-, channel-, rectangular, or triangular shapes, can be also employed.

[0131] The panels IV and V, shown in **FIGS. 10, 14**, function as follows.

[0132] The distributed compressive load q is reacted by both TPM I, II, III and the sheet of the panel **8**. The load-bearing capacity of the panels IV, V is provided for by virtue of selection of optimal dimensions of cross-section of the panel: dimensions of shapes of TPM are selected basing on the expressions (1), (3), (4), (10); the thickness of the sheet and the pitch of TPM longitudinal installation are selected basing on the expressions (5), (6), (8), respectively.

[0133] FIGS. **11** to **13** and **15** show panels IV, V with TPM II, III installed both longitudinally and transversally.

[0134] FIGS. **11** to **13** show panel IV based on longitudinally installed double-T-shaped TPM II and transversally installed L-shaped TPM II.

[0135] In the course of operation the panel IV reacts primarily the compressive load q directed along the length L of longitudinally installed TPM (see pos. **11** in **FIGS. 11 and 12**). These TPM are attached to one of the sides **12** of the sheet **10** across its width and installed longitudinally with even pitch forming with the sheet the open cross-section configuration.

[0136] TPM **13** are installed transversally with even pitch across the length of the same side **12** of the sheet **10** and are embodied with cut-outs **14** in which the longitudinally installed TPM **11** are located (FIGS. **11-13**).

[0137] TPM **11** possesses the main web **15** embodied as the main strip **16**; at each of its longitudinal reinforcing ribs **17**, an additional flange **18** is formed with the width less than that of the strip **16** and with thickness not less than that of the strip **16** (**FIG. 12**).

[0138] The width b and c of main webs **15** and additional flanges **18**, and thickness corresponding to these dimensions, δ_b,δ_c,respectively, of longitudinally installed TPM **11** satisfy the expressions:

$$c/b=0.05\div0.3 \quad (3),$$

$$\delta_c/\delta_b=1.0\div3.0 \quad (4)$$

[0139] With this, the stiffness of the main strip does not exceed the stiffness of the additional strip, specifically, $\delta_c/c \geqq \delta_b/b$.

[0140] Each of the transversally installed TPM **13** is embodied as an L-shape and possesses a main flange **19** embodied as a main strip **20** across the width of which, at one of its longitudinal reinforcing ribs **21**, an additional flange **22** is formed (**FIG. 13**). Relations of shape dimensions of TPM **13** also satisfy the expressions (3), (4).

[0141] The other dimensions of the cross-section of panel IV satisfy the expressions:

$$\delta=(0.0006\div0.0035)L/n_n \quad (5),$$

$$b_c=(20\div65)\delta(6),$$

[0142] where:

[0143] L is the length of the panel;

[0144] n_n is the number of transversally installed TPM **13**;

[0145] δ is the thickness of the sheet **10**;

[0146] b_c is the pitch of the longitudinal installation of TPM **11** forming with the sheet **10** the open cross-section configuration.

[0147] In the panel IV with longitudinally installed TPM **11** of double-T-shape forming with the sheet **10** the open cross-section configuration, the pitch l_n of the transversal installation of L-shaped TPM **13** (shown in **FIG. 11**), satisfies the expression:

$$l_n=(10\div60)b_c \quad (7).$$

[0148] **FIG. 15** shows the panel V based on the longitudinally and transversally installed members **11** and **13**, respectively. The longitudinally installed TPM **11** is embodied as a trough-shape and forms with the sheet **10** the closed cross-section configuration. The transversally installed member **13** is of a Z-shape.

[0149] The width a, b, c of additional webs, main webs, and additional flanges and thickness corresponding to these dimensions δ_a, δ_b, δ_c of the longitudinally and transversally installed TPM **11**, **13** of the panel V shown in **FIG. 15** satisfy the following expressions:

$$a/b=0.3\div0.7 \quad (1),$$

$$c/b=0.05\div0.3 \quad (3),$$

$$\delta_a/\delta_b=\delta_c/\delta_b=1.0\div3.0 \quad (10).$$

[0150] With this, the stiffness of the main strip does not exceed the stiffness of the additional strip, and the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib, specifically, $\delta_b/b \leqq \delta_a/a \leqq \delta_c/c$.

[0151] The other cross-section dimensions of the panel V (**FIG. 15**) satisfy the expressions:

$$\delta=(0.0006\div0.0035)L/n^1_n \quad (5),$$

$$b^1_c=(40\div130)\delta \quad (8),$$

[0152] where:

[0153] δ is the thickness of the sheet **10**;

[0154] b^1_c is the pitch of longitudinal installation of trough-shaped TPM **11** forming with the sheet **10** the closed cross-section configuration;

[0155] L is the length of the panel;

[0156] n^1_n is the number of transversally installed TPM **13**.

[0157] The pitch l^1_n of transversal installation of TPM **13** of the panel V provided longitudinal installation of TPM **11** forming with the sheet **10** the closed cross-section configuration satisfies the expression:

$$l^1_n=(1.5\div10)b^1_c. \quad (9).$$

[0158] The width B of the panels IV, V shown in **FIGS. 10, 11, 14, 15** is determined from the following expressions:

$$B=n_c \cdot b_c=n^1_c \cdot b^1_c \quad (11),$$

[0159] where n_c, n^1_c are the numbers of longitudinally installed TPM of panels IV, V forming with the sheet the open and closed cross-section configuration, respectively.

[0160] The length L of the panels IV, V shown in **FIGS. 11 and 15** is determined from the following expressions:

$$L=n_n \cdot l_n=n^1_n \cdot l^1_n \quad (12),$$

[0161] where n_n and n^1_n are the number of transversally installed TPM for the longitudinal TPM forming with the sheet the open and closed cross-section configurations, respectively.

[0162] For transversal and longitudinal reinforcing of panels IV and V, TPM of other shapes can also be employed.

[0163] In the course of operation of panels IV and V under the compressive load q, the load-bearing capacity of the panel is provided for by virtue of selection of the optimal shapes and dimensions of cross-sections of longitudinally and transversally installed TPM, thickness of the sheet, pitches of longitudinal and transversal installation corresponding to the minimum mass of the panel.

[0164] The presented example and drawings illustrate only the most common types of panels with TPM attached to one of the sides of the sheet which naturally does not limit the scope and spirit of application of the variants of the present invention.

[0165] In case of embodiment of panels with other attachment of TPM to the sheet, which is far more rare in practice, the relations of the shape dimensions of TPM (1), (3), (10) are preserved.

[0166] Implementation of the claimed group of inventions enables to unitize various variants of loads and overall dimensions, materials, TPM shapes, as well as design/technological restrictions on the cross-section dimensions with lower man-hour and design cost.

Industrial Applicability

[0167] The TPM and panels based on it proposed in accordance with the present group of inventions can be embodied out of any known grades of structural metallic alloys or non-metals similar to those in mechanical characteristics.

[0168] The recommendations given in the present inventions can be also applied for industrially manufactured profiles of various shapes, monolithic panels, sandwich panels with longitudinal load-bearing filler, corrugated components and other shapes depending on specific conditions.

[0169] Employing TPM and panels based on these instead of other similar structural members used in mechanical engineering and building is capable of providing the reduction of the structure mass by 5 to 35 percent.

REFERENCES

[0170]

1.	U.S. Pat. No. 4,912,903,	E04C 3/04,	03.04.90
2.	Hertel, H, Thin-slab structures. - Moscow, "Mashinostroyeniye", 1965. - 527 p. [in Russian; translation from: Hertel, H, Leichtbau: Bauelemente, Bemessungen und Konstruktionen von Flugzeugen und anderen Leichtbauwerken. - Springer-Verlag, Berlin]		
3.	WO 92/09767,	EO4C 3/04,	11.06.92
4.	U.S. Pat. No. 5,518,208,	B64C 1/06,	21.05.1996
5.	WO 91/05925,	E04C 2/08,	02.05.91.
6.	U.S. Pat. No. 5,842,318,	E04C 3/07,	01.12.98
7.	WO 96/30606,	E04C 3/07, 3/09, 3/292,	03.10.96
8.	WO 00/17463,	E04C 3/07,	30.03.2000

1. The thin-webbed profile member with cross-section shape and dimensions constant along its length comprising main strip(s) and additional strip(s) with common reinforcing ribs

characterized in that the ratio of the width of the additional strip with common reinforcing ribs to the width of the main strip satisfies the expression:

$$a/b=0.3\div0.7 \quad (1),$$

and the ratio of the thickness of the additional strip with common reinforcing ribs to the thickness of the main strip satisfies the expression:

$$\delta_a/\delta_b=1.0\div3.0 \quad (2),$$

where:

a is the width of the additional strip with common reinforcing ribs;

b is the width of the main strip;

δ_a is the thickness of the additional strip with common reinforcing ribs;

δ_b is the thickness of the main strip;

with this, the stiffness of the main strip does not exceed the stiffness of the additional strip.

2. The thin-webbed profile member with cross-section shape and dimensions constant along its length comprising main strip(s) and additional strip(s) with common reinforcing rib(s) and free reinforcing ribs

characterized in that the ratio of the width of the additional strip with the free reinforcing rib and the common reinforcing rib to the width of the main strip satisfies the expression:

$$c/b=0.05\div0.3 \quad (3),$$

and the ratio of the thickness of the additional strip with the free reinforcing rib and the common reinforcing rib to the thickness of the main strip satisfies the expression:

$$\delta_c/\delta_b=1.0\div3.0 \quad (4),$$

where:

b is the width of the main strip;

c is the width of the additional strip with the free reinforcing rib and the common reinforcing rib;

δ_b is the thickness of the main strip;

δ_c is the thickness of the additional strip with the free reinforcing rib and the common reinforcing rib;

with this, the stiffness of the main strip does not exceed the stiffness of the additional strip.

3. The thin-webbed profile member with cross-section shape and dimensions constant along its length comprising main strip(s) and additional strip(s) with common reinforcing ribs and free reinforcing rib(s)

characterized in that the ratio of the width of the additional strip with common reinforcing ribs to the width of the main strip satisfies the expression:

$$a/b=0.3\div0.7 \quad (1),$$

and the ratio of the thickness of the additional strip with common reinforcing ribs to the thickness of the main strip satisfies the expression:

$$\delta_a/\delta_b=1.0\div3.0 \quad (2),$$

with this, the ratio of width of the additional strip with the free reinforcing rib and the common reinforcing rib to the width of the main strip satisfies the expression:

$$c/b=0.05\div0.3 \quad (3),$$

and the ratio of the thickness of additional strip with the free reinforcing rib and the common reinforcing rib to the thickness of the main strip satisfies the expression:

$$\delta_c/\delta_b=1.0\div3.0 \quad (4),$$

where:

a is the width of the additional strip with common reinforcing ribs;

b is the width of the main strip;

c is the width of the additional strip with the free reinforcing rib and the common reinforcing rib;

δ_a is the thickness of the additional strip with common reinforcing ribs;

δ_b is the thickness of the main strip;

δ_c is the thickness of the additional strip with the free reinforcing rib and the common reinforcing rib;

with this, the stiffness of the main strip does not exceed the stiffness of the additional strip.

4. The thin-webbed profile member according to Clause **3**,

characterized in that the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib.

5. The panel comprising a sheet and thin-webbed profile members installed across its width longitudinally with even pitch; with this, the main strip(s) and additional strip(s) are forming with the sheet an open cross-section configuration,

characterized in that the thickness of the sheet of the panel satisfies the following expression:

$$\delta=(0.0006\div0.0035)l \quad (5),$$

and the pitch of the longitudinal installation satisfies the expression:

$$b_c=(20\div65)\delta \quad (6),$$

where:

δ is the thickness of the sheet of the panel;

l is the length of the thin-webbed profile member forming with the sheet the open cross-section configuration;

b_c is the pitch of the longitudinal installation of thin-webbed profile members forming with the sheet the open cross-section configuration;

with this, the stiffness of the main strip does not exceed the stiffness of the additional strip, and the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib.

6. The panel according to Clause **5**,

characterized in that it is additionally equipped with thin-webbed profile members installed transversally.

7. The panel according to Clause **6**,

characterized in that the pitch of transversal installation of thin-webbed profile members satisfies the expression:

$$l_n=(10\div60)b_c \quad (7),$$

where:

l_n is the pitch of transversal installation of thin-webbed profile members for the case of longitudinally installed thin-webbed profile member forming with the sheet the open cross-section configuration;

b_c is the pitch of the longitudinal installation of thin-webbed profile members forming with the sheet the open cross-section configuration.

8. The panel comprising a sheet and thin-webbed profile members installed across its width longitudinally with even pitch; with this, the main strip(s) and additional strip(s) are forming with the sheet a closed cross-section configuration,

characterized in that the thickness of the sheet of the panel satisfies the following expression:

$$\delta=(0.0006\div0.0035)l \quad (5),$$

and the pitch of the longitudinal installation satisfies the expression:

$$b^1{}_c=(40\div130)\delta \quad (8),$$

where:

δ is the thickness of the sheet of the panel;

l is the length of the thin-webbed profile member forming with the sheet the closed cross-section configuration;

$b^1{}_c$ is the pitch of longitudinal installation of thin-webbed profile members forming with the sheet the closed cross-section configuration;

with this, the stiffness of the main strip does not exceed the stiffness of the additional strip, and the stiffness of the additional strip with common reinforcing ribs does not exceed the stiffness of the additional strip with the free reinforcing rib and the common reinforcing rib.

9. The panel according to Clause **8**,

characterized in that it is additionally equipped with thin-webbed profile members installed transversally.

10. The panel according to Clause **9**,

characterized in that the pitch of transversal installation of thin-webbed profile members satisfies the expression:

$$l^1{}_n=(1.5\div10)b^1{}_c \quad (9)$$

where:

$l^1{}_n$ is the pitch of transversal installation of thin-webbed profile members for the case of longitudinally installed thin-webbed profile member forming with the sheet the closed cross-section configuration;

$b^1{}_c$ is the pitch of the longitudinal installation of thin-webbed profile members forming with the sheet the closed cross-section configuration.

* * * * *