

Z-SECTION STRUCTURAL MEMBERFIELD OF THE INVENTION

This invention relates to a structural member which has a Z-shaped cross-section and which is intended to be used as a load bearing element in a skeletal structure. The invention has been developed as a purlin for use in a roof-supporting building structure and the invention is hereinafter described in the context of a purlin. However, it will be understood that the invention does have broader application, to a structural member which is suitable for use in any load bearing structure.

BACKGROUND OF THE INVENTION

So-called Z-section purlins currently are cold formed from roll-reduced steel and, as viewed in cross-section, a typical Z-section purlin comprises a near-central web, two oppositely directed parallel flanges projecting outwardly from opposite ends of the web and a lip at the outer edge of each flange. The lips lie approximately parallel to the web and, in order to permit two purlin lengths to be connected in overlapping relationship, the purlin is formed with one flange narrower than the other.

The present invention has been developed with the object of providing a section configuration that provides for increased strength relative to that obtained from the above described basic Z-section purlin configuration and, importantly, which has regard for factors that influence bending strength under different load and/or support conditions. In progressing toward this development the inventors recognised that an improvement in bending strength might be obtained by providing each of the lips with a lip return, that is with a lip portion that returns in a direction toward the web. However, it was also recognised that, by providing a lip return in a conventional way, the length of the narrower flange would need be reduced by an amount equal to or approaching the width of the lip return on the wider flange. As a consequence, any gain derived from inclusion of a lip

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return would tend to be negated by the required reduction in width of the narrower flange.

Therefore, the present invention has been developed as a Z-section purlin which is formed with a cross-section which incorporates lip returns and which also is configured to permit maximisation of the width of the narrower flange.

SUMMARY OF THE INVENTION

The present invention provides an elongate structural member which is cold formed from steel and which has a Z-shaped cross-section comprising a web, two oppositely directed parallel flanges projecting outwardly from respective ends of the web and a lip at the outer edge of each flange. A first of the flanges has a width which is narrower than that of the second flange whereby two of the structural members may be joined in overlapping relationship, and the structural member is characterised in that:

(a) each lip is formed with a lip return which is disposed at an included angle θ less than 180° to the lip, and

(b) the lip on the second flange projects in a direction to form an obtuse angle ϕ greater than 90° but not greater than 180° with respect to the second flange.

In forming the lip on the second, wider flange at an angle ϕ greater than 90° , the lips on both of the flanges may be provided with lip returns without imposing an unacceptable reduction on the width of the first, narrower flange.

The lip on the first, narrower flange may also be disposed at an angle ϕ greater than 90° to the first flange, and it will normally (but not necessarily) be disposed at an angle which is equal to or less than the angle ϕ which lies between the second, wider flange and its lip. To distinguish between the two angles ϕ , that which is associated with the second, wider flange is hereinafter referred to as ϕ_2 and that which is

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associated with the first, narrower flange is referred to as ϕ_1 .

The angle ϕ_2 may be selected to be significantly greater than the angle ϕ_1 as one way of providing for
5 maximisation of the width of the narrower flange.

The included angle θ between the lip and the lip return associated with the second, wider flange may be equal to or different from that which is provided between the lip and the lip return which is associated with the
10 first, narrower flange.

Given that the two included angles θ may be equal or different, that which is associated with the second, wider flange is hereinafter referred to as θ_2 and that which is associated with the first, narrower flange is
15 referred to as θ_1 .

For any given application of the structural member, the various angles ϕ_1 , ϕ_2 , θ_1 and θ_2 will be selected to provide for optimisation of the strength of the structural member whilst permitting interconnection of
20 two of the members in overlapping relationship.

PREFERRED FEATURES OF THE INVENTION

The obtuse angle ϕ_2 between the second, wider flange and its associated lip would normally be not greater than 135° . However, the structural member is preferably
25 formed so that the obtuse angle ϕ_2 lies within the range 95° to 125° and most preferably within the range 105° to 120° .

The angle ϕ_1 between the first, narrower flange and its associated lip also would normally be not greater than 135° . However, the angle ϕ_1 preferably lies within
30 the range 85° to 95° and most preferably is approximately 90° .

The lip return angle θ_2 preferably lies within the range 55° to 85° and most preferably is in the order of
35 60° .

The lip return angle θ_1 preferably lies within the range 85° to 95° and most preferably is approximately 90°.

5 The widths of the lips and the lip returns will be determined in part by other sectional dimensions of the structural member and by load bearing requirements of the member. However, each lip preferably has a width equal to 20% to 60% of the width of the associated flange and most preferably has a width equal to 30% to 60% of the
10 width of the associated flange. Also, each lip return preferably has a width equal to 30% to 100% of the associated lip width and most preferably has a width equal to 30% to 80% of the associated lip width.

15 The lip which is associated with the first, narrower flange may have a width which is the same as or different from the width of the lip which is associated with the second, wider flange.

The lip return which is associated with the first, narrower flange may have a width which is the same as or
20 different from the width of the lip return that is associated with the second, wider flange. However, it is preferred that the lip return which is associated with the first, narrower flange will have a width which is equal to or greater than that of the lip return that is
25 associated with the second, wider flange.

When two of the structural members are fitted together in overlapping relationship, the adjacent lips and lip returns may fit together in near-parallel relationship, but it is likely in most cases that such a
30 relationship will not exist.

The web preferably is formed with at least one channel-shaped recess that extends in the longitudinal direction of the web. The or each channel-shaped recess preferably has a depth which is equal to 0.5 to 5.0 times
35 the thickness of the material forming the web. The depth of the channel-shaped recess most preferably is within the range 0.5 to 3.0 times the thickness of the material forming the web.

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A plurality of parallel channel-shaped recesses preferably is formed within the web and, most preferably, four such recesses are provided. The channel-shaped recesses may have any desired cross-sectional form but they preferably have an arcuate form. Also, the channel-shaped recesses preferably are orientated so that, when two of the structural members are connected in overlapping relationship, the channel-shaped recesses in the respective webs form complementary portions of longitudinally extending tunnels.

The invention will be more fully understood from the following description of a preferred embodiment of a Z-section purlin which is illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings -

Figure 1 shows a perspective view of one of the purlins,

Figure 2 shows an end view of a portion of two of the purlins located in overlapping relationship,

Figure 3 shows dimensional aspects of lip and lip return portions of the second, wider flange of one of the purlins,

Figure 4 shows graphs of buckling stress versus buckle half-wavelength for two different purlin sections when subjected to bending in a manner to place the wider flanges of the purlins in compression, and

Figure 5 shows graphs which are similar to those of Figure 4 but when the same purlin sections are subjected to bending in a manner to place the narrow flanges of the purlins in compression.

DETAILED DESCRIPTION OF THE INVENTION

As illustrated, the purlin is cold formed from roll-reduced steel and it has a Z-shaped cross-section that comprises a web 10 and two oppositely projecting flanges 11 and 12 which extend outwardly from opposite ends of the web. The flange 11 is referred to herein as a "first" flange and it has a width which is narrower

than the "second" wider flange 12, as can best be seen from Figure 2.

5 The first, narrower flange 11 is formed with a lip 13 which is inclined at an angle ϕ_1 of approximately 90° to the plane of the flange 11, and the second, wider flange 12 is formed with a lip 14 which is inclined at an angle ϕ_2 of approximately 120° to the plane of the flange 12.

10 In the case of a purlin having a web of 200 mm nominal depth, the first flange 11 might typically have a nominal width in the order of 65 mm to 70 mm and the second flange 12 might have a nominal (overall) width in the order of 75 mm to 80 mm. The lip 13 associated with the first flange 11 might then have a nominal (overall)
15 width in the order of 20 mm to 30 mm, and the lip 14 associated with the second flange 12 might have a nominal width in the order of 25 mm to 30 mm.

Each of the lips 13 and 14 is formed with a respective lip return 15 and 16. The lip return 15 is
20 inclined at an angle θ_1 of approximately 90° with respect to the lip 13, and the lip return 16 is inclined at an angle θ_2 of approximately 60° with respect to the lip 14.

Thus, as can best be seen from Figure 2 the respective flanges, associated lips and lip returns are
25 dimensioned and angularly disposed so that the narrower flange 11 nests within the wider flange 12 when two of the purlins are joined together in overlapping relationship.

The lip return 15 might typically have a nominal
30 (overall) dimension in the order of 10 mm to 15 mm and the lip return 16 might typically have a nominal (overall) dimension in the order of 5 mm to 10 mm so as to permit maximisation of the width of the first, narrower flange 11.

35 Although the lips and associated lip returns are shown in the drawings (particularly in Figure 3) as including arcuate portions and flat portions, one or the other or both of the flat portions A and B (as shown in

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Figure 3) may be minimised to an extent such that the lips and lip returns are, in the limit, defined solely by arcuate portions having radii R_A and/or R_B .

Therefore, the references made in this specification
5 to "lip width" and "lip return width" will be understood as being references to overall widths (sometimes referred to as "overall depths") as determined by the following relationships:

$$\text{Overall lip width} = A + R_A \tan (\beta_A/2) + R_B$$

10 $\text{Overall lip return width} = B + R_B$

where, as shown in the drawings and as would normally be the case, the angle β_B is equal to or greater than 90° .

The web 10 is formed with four longitudinally extending channel-shaped recesses 17. Each recess has an
15 arcuate form and each recess has a depth in the order of 0.5 to 3.0 times the thickness of the metal from which the purlin is formed. Also, the recesses 17 are orientated such that, when two of the structural members are connected in overlapping relationship as shown in
20 Figure 2, the channel-shaped recesses in the respective webs 10 form complementary portions of longitudinally extending tunnels 18.

Reference is now made to Figures 4 and 5 of the drawings in which:

25 Curve A in Figure 4 is a graph of buckling stress against buckle half-wavelength for a standard (prior art) Z-section purlin when subjected to bending in a manner to place the wider flange of the purlin in uniform compression and the narrower flange in uniform tension.

30 Curve B in Figure 4 is a graph of buckling stress against buckle half-wavelength for a Z-section purlin of the type shown in Figure 1 when subjected to bending in a manner to place the wider flange of the purlin in uniform compression and the narrower flange in uniform tension.

35 Curve A in Figure 5 is a graph of buckling stress against buckle half-wavelength for a standard (prior art) Z-section purlin when subjected to bending in a manner to

place the narrow flange of the purlin in uniform compression and the wider flange in uniform tension.

Curve B in Figure 5 is a graph of buckling stress against buckle half-wavelength for a Z-section purlin of the type shown in Figure 1 when subjected to bending in a manner to place the narrow flange of the purlin in uniform compression and the wider flange in uniform tension.

Comparable purlin sections having nominal dimensions shown in the following Table have been analysed for the purpose of deriving the graphs shown in Figures 4 and 5.

TABLE

DIMENSION	PURLIN TYPE	
	STANDARD Z-SECTION	FIG 1 Z-SECTION
Metal thickness	1.5 mm	1.5 mm
Depth	200 mm	200 mm
Narrow flange	74 mm	69 mm
Wide flange	79 mm	77 mm
Narrow flange lip	15.5 mm	28 mm
Wide flange lip	15.5 mm	29.5 mm
Narrow flange lip return	-	14.5 mm
Wide flange lip return	-	10 mm
Lip angle ϕ_1 -narrow flange	90°	90°
Lip angle ϕ_2 -wide flange	90°	120°
Lip return angle θ_1 -narrow flange	-	90°
Lip return angle θ_2 -wide flange	-	60°

In curves A and B in the two Figures 4 and 5, local buckling occurs at short half-wavelengths, distortional buckling at intermediate half-wavelengths and flexural-torsional buckling at longer half-wavelengths. In respect of the Z-section purlin as shown in Figure 1 and

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referred to in the above Table, the local, distortional and flexural-torsional buckling stresses indicated by Curves B in Figures 4 and 5 are higher than for the standard (prior art) Z-section purlin indicated by
5 Curves A in Figures 4 and 5. Hence, the buckling resistance of the Z-section purlin in accordance with the present invention, when subjected to bending which puts one flange in compression and the other in tension, is superior to the buckling resistance of the standard
10 (prior art) purlin when subjected to the same stress distribution.

THE CLAIMS

1. An elongate structural member which is cold formed from steel and which has a Z-shaped cross-section comprising a web, two oppositely directed parallel flanges projecting outwardly from respective ends of the web and a lip at the outer edge of each flange, a first of the flanges having a width which is narrower than that of the second flange whereby two of the structural members may be joined in overlapping relationship; and the structural member being characterised in that:

- (a) each lip is formed with a lip return which is disposed at an included angle (θ_1 or θ_2) less than 180° to the lip, and
- (b) the lip on the second flange projects in a direction to form an obtuse angle (ϕ_2) greater than 90° but not greater than 180° with respect to the second flange.

2. The structural member as claimed in claim 1 further characterised in that the lip on the first flange projects in a direction to form an angle (ϕ_1) with respect to the first flange which is not greater than the angle (ϕ_2) between the second flange and the lip on the second flange.

3. The structural member as claimed in claim 1 or claim 2 further characterised in that the lip on the second flange projects in a direction to form an obtuse angle (ϕ_2) which is not greater than 135° with respect to the second flange.

4. The structural member as claimed in claim 1 or claim 2 further characterised in that the lip on the second flange projects in a direction to form an obtuse angle (ϕ_2) falling within the range 95° to 125° with respect to the second flange.

5. The structural member as claimed in claim 1 or claim 2 further characterised in that the lip on the second flange projects in a direction to form an obtuse angle (ϕ_2) falling within the range 105° to 120° .

6. The structural member as claimed in claim 2 further characterised in that the lip on the first flange



projects in a direction to form the angle (ϕ_1) with respect to the first flange which is not greater than 135° .

5 7. The structural member as claimed in claim 6 further characterised in that the angle (ϕ_1) between the first flange and the lip on the first flange falls within the range 85° to 95° .

10 8. The structural member as claimed in claim 6 further characterised in that the angle (ϕ_1) between the lip and the first flange is approximately 90° .

9. The structural member as claimed in any one of claims 1 to 8, further characterised in that the included angles (θ_1 and θ_2) between the respective lips and the associated lip returns are different.

15 10. The structural member as claimed in claim 9 further characterised in that the included angle (θ_2) between the lip return and the lip associated with the second flange lies within the range 55° to 85° .

20 11. The structural member as claimed in claim 9 further characterised in that the included angle (θ_2) between the lip return and the lip associated with the second flange is approximately equal to 60° .

25 12. The structural member as claimed in claim 9 further characterised in that the included angle (θ_1) between the lip return and the lip associated with the first flange lies within the range 85° to 95° .

30 13. The structural member as claimed in claim 9 further characterised in that the included angle (θ_1) between the lip return and the lip associated with the first flange is approximately equal to 90° .

14. The structural member as claimed in any one of claims 1 to 13 further characterised in that each lip has a width equal to 20% to 60% of the width of the associated flange.

35 15. The structural member as claimed in any one of claims 1 to 14 further characterised in that each lip return has a width equal to 30% to 100% of the width of the associated lip.



16. The structural member as claimed in claim 15 further characterised in that the lip return associated with the first flange has a width not less than that of the lip return associated with the second flange.

5 17. The structural member as claimed in any one of the preceding claims further characterised in that the web is formed with at least one channel-shaped recess that extends in the longitudinal direction of the web.

10 18. The structural member as claimed in claim 17 further characterised in that the or each channel-shaped recess has a depth which is equal to 0.5 to 5.0 times the thickness of the material forming the web.

15 19. The structural member as claimed in any one of claims 1 to 16 further characterised in that the web is formed with a plurality of parallel channel-shaped recesses that extend in the longitudinal direction of the web.

20 20. The structural member as claimed in any one of claims 1 to 16 further characterised in that the web is formed with four spaced-apart parallel channel-shaped recesses that extend in the longitudinal direction of the web.

25 21. The structural member as claimed in claim 19 or claim 20 further characterised in that each of the channel-shaped recesses has an arcuate cross-sectional form.

30 22. The structural member as claimed in any one of claims 19 to 21 further characterised in that each channel-shaped recess has a depth which is equal to 0.5 to 3.0 times the thickness of the material forming the web.

35 23. The structural member as claimed in any one of claims 19 to 22 further characterised in that the channel-shaped recesses are orientated in a manner such that, when two of the structural members are connected in overlapping relationship, the channel-shaped recesses in the respective webs form complementary portions of longitudinally extending tunnels.



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24. The structural member substantially as shown in the accompanying drawings and substantially as hereinbefore described with reference thereto.