

TITLE

"HOLLOW FLANGE SECTION"

FIELD OF THE INVENTION

5 This invention relates to a hollow flange section and a method of making same. The invention also relates to a composite structural member incorporating the hollow flange section.

BACKGROUND TO THE INVENTION

10 A diverse range of structural components have been developed in the building industry over an extended number of years. The components include joists, purlins, rafters and beams. Most of these components can be formed in steel and include rolled hollow sections (R.S.), rolled steel joists (RAJ), I-beams, C-sections and the like.

15 I-beams have been found useful in a wide range of applications because of their relative ease of manufacture and structural efficiency in load bearing situations. Conventional I-beams (or universal beams) typically consist of a pair of opposed parallel flanges joined by a single flat intermediate web. In order to provide the required strength and resistance to bending, the flanges are substantially thicker than the web.

20 Although useful, I-beams do have a number of disadvantages including :

- (1) Exposed surface area to mass and strength ratios are high which lead to increased costs for both corrosion protection and fire proofing;
- (2) Flange widths to thickness ratios are generally limited to avoid
25 reductions in load bearing section capacity due to local buckling considerations;
- (3) Web widths to thickness ratios are generally limited to avoid reductions in section load bearing capacity due to local buckling considerations;

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(4) The hot rolling method of manufacture commonly used leads to production of substantial mill scale and rust as well as providing a limited minimum thickness; and

5 (5) Prime painting during manufacture is not a practical proposition.

The applicants have developed an alternate structural member which comprises a pair of hollow end sections and intermediate web characterised in that each hollow end section is welded to the intermediate web so as to form two weld lines or joins extending along the structural member. The structural member is described in detail in International Patent Application
10 PCT/AU89/00313. This patent application also describes a number of prior art structural members that are alternatives to conventional I-beams.

The known structural members are pre-formed and delivered to a building site in set lengths. This can cause problems if long beams must be
15 transported appreciable distances. There is advantage to providing modular beams that can be more easily transported and assembled on-site.

A known approach to construction of composite structural members is to knit together a number of beams welded to a pair of opposed angle brackets at the top and bottom. In order to achieve sufficient strength a
20 complex web of struts and braces must be provided within each structural member and between structural members.

An improved form of the basic design of a composite structural member is disclosed in United States patent number 5644888 in the name of Johnson. In the Johnson arrangement the angle brackets are replaced by
25 a hollow I-beam having a scalloped internal surface. The beams (or posts) have complimentary surfaces that interlock with the I-beam. The interfitting elements form a complex post and brace structure. The disadvantage of the Johnson arrangement is the complexity of the elements leads to expense in manufacture and difficulty of assembly.

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An approach to solving this problem is the Davis truss described in Australian Patent Numbers 230690 and 250131. The Davis truss is formed from a CHS (circular hollow section) web that is captured between an opposed parallel pair of decapitated coat hanger shaped flanges. The flanges are folded steel plate and therefore need to be particularly heavy gauge in order to provide the required strength and resistance to skew. In order to capture the web a lower portion of the CHS web is crushed so as to form a neck which fits between the sides of the open mouth of the flange. The Davis truss fails to achieve the properties necessary for an effective modular structural member.

OBJECT OF THE INVENTION

It is an object of the present invention to provide a hollow flange section useful in forming a composite structural member.

It is a further object of the invention to provide a composite structural member incorporating the hollow flange section.

It is a yet further object to provide a method of making the hollow flange section and composite structural member.

Further objects will be evident from the following description.

DISCLOSURE OF THE INVENTION

In one form, although it need not be the only or indeed the broadest form, the invention resides in a hollow flange section comprising :

a base member;

a pair of opposed cavity walls and a cavity base defining a cavity;

two opposing lateral support members extending from the base member to the cavity walls such that each lateral support member forms an enclosed volume with an adjoining one of the opposed cavity walls and an adjoining portion of the base member;

wherein the cavity base and the base member form an integral structure that resists skew deformation of the cavity.

The cavity base may be a portion of the base member or may be a separate element that is joined to the base member to form the integral structure.

5 The enclosed volume may suitably be square or rectangular. In preference the lateral support members are linear and extend from the base member at an angle to form enclosed volumes having a triangular cross-section.

The angle between the base member and an adjoining lateral support member is suitably in the range 20° to 45° and is most suitably 30°.

10 The cavity is suitably rectangular having parallel opposed walls and an open mouth opposite the base. The size of the cavity is selected to suit a web used to form a composite structural member.

In preference the hollow flange section comprises a unitary structure, suitably manufactured of carbon steel.

15 The base member and the cavity base are preferably welded to form an integral structure. The weld is preferably selected from the following : high frequency induction weld, metal inert gas weld, tungsten inert gas weld; carbon dioxide shielded arc weld; atomic hydrogen gas weld, spot weld; electron beam weld; laser weld or other suitable welding.

20 In one form the lateral support members join the cavity walls at the top of the cavity walls.

In another form the hollow flange section further comprises lugs extending beyond an intersection of the lateral support members and the cavity walls. The lugs preferably terminate in a bead. In preference a plurality
25 of apertures are formed in the lugs to facilitate fixing of a web to the hollow flange section for formation of a composite structural member.

In a further form, the invention resides in a process of forming a hollow flange section comprising the steps of :

30 passing a strip through a plurality of forming stations to successively deform the strip to provide a cavity and a pair of substantially hollow adjoining support volumes;

further forming the deformed strip so that the base of the cavity contacts a base member connecting the adjoining support volumes; and welding the base of the cavity to the base member.

In preference the stations are roll forming stations.

5 The process may suitably be performed in two phases. In the first phase the strip is formed into a tube. In the second phase the tube is formed into the hollow flange section.

The process may further include the step of forming lugs extending beyond the adjoining support volumes. A further step of forming apertures
10 in the lugs may also be included.

In a yet further form, the invention resides in a composite structural member comprising :

at least two opposed hollow flange sections, said hollow flange sections comprising a base member; a pair of opposed cavity walls and a
15 cavity base defining a cavity; two opposing lateral support members extending from the base member to the cavity walls such that each lateral support member forms an enclosed volume with an adjoining one of the opposed cavity walls and an adjoining portion of the base member; wherein the cavity base and the base member are joined to form an integral structure
20 that resists skew deformation of the cavity; and

an intermediate web;

wherein the hollow flange sections are joined to opposing ends of the intermediate web such that distal ends of the web are seated in a respective cavity of the hollow flange section.

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BRIEF DETAILS OF THE DRAWINGS

To assist in understanding the invention preferred embodiments will now be described with reference to the following figures in which :

FIG 1 shows a perspective view of a first embodiment of a
30 hollow flange section;

FIG 2 shows an end view of a composite structural member formed from an R.S. web and a pair of the flanges of FIG 1;

FIG 3 shows a perspective view of the composite structural member of FIG 2;

5 FIG 4 shows a perspective view of a second embodiment of a hollow flange section;

FIG 5 shows an end view of a composite structural member formed from an R.S. web and a pair of the flanges of FIG 4;

10 FIG 6 shows a perspective view of the composite structural member of FIG 5;

FIG 7 shows a flowchart of a roll forming process for forming the hollow flange section;

FIG 8 shows an end view of a third embodiment of a hollow flange section;

15 FIG 9 shows an end view of a fourth embodiment of a hollow flange section;

FIG 10 shows an end view of a fifth embodiment of a hollow flange section;

20 FIG 11 shows an end view of a sixth embodiment of a hollow flange section;

FIG 12 shows an end view of a seventh embodiment of a hollow flange section;

25 FIG 13 shows a graphical comparison of the bending capacity of prior art joists compared to joists formed using hollow flange sections according to the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

In the drawings, like reference numerals refer to like parts.

30 Referring to FIG 1 there is shown a hollow flange section 1 having a base member 2 and opposing lateral support members 3. The lateral support members 3 are separated by a cavity 4 having opposed cavity walls 5 and

cavity base 6. The cavity base 6 is welded to the base member 2. The lateral support members 3, cavity walls 5 and base member 2 form opposing enclosed volumes 7.

The cavity 4 is sized and shaped to receive web members for formation of a composite structural member as described in detail below with reference to FIG 2.

The lateral support members 3 provide structural strength to the flange 1 by supporting the cavity walls 5. The inventors have found that between 20° and 45° is a suitable choice for the angle θ between the base member 2 and the lateral support members 3. In the preferred embodiments an angle of 30° is selected as being most appropriate. Smaller angles do not have sufficient enclosed volume to provide the required strength. Larger angles require additional metal without improving performance.

A composite beam 8 can be formed by welding a web member 9 between opposing hollow flange sections 1, as shown in FIG 2. The flange sections 1 are welded to the web 9 at 10. The resultant composite beam 8 can be used in situations previously requiring I-beams. The inventors have conducted comparative tests between a conventional universal beam and composite beams of the form shown in FIG 2. The following table shows that equivalent strength is achieved at substantial reduction in mass.

	Universal beam	composite beam
material	grade 300 plus	grade 450
length	200mm	200mm
strength	1	1
mass	1	.81

	Universal beam	composite beam
material	grade 300 plus	grade 450
length	310mm	310mm
strength	1	1
mass	1	.77

A composite structure incorporating the hollow flange section is shown in FIG 3. The composite structure 11 comprises vertical beam members or posts, such as 12, and inclined beam members or braces, such as 13, assembled between a top flange 14 and a bottom flange 15. The beam members 11, 12 are welded to the flange sections 14, 15 in the manner described above.

A substantial advantage of the composite structure of FIG 3 is the reduced mass compared to prior art construction methods. Furthermore, transport of components to a construction site is significantly easier since the structure can be assembled on-site rather than transported complete.

A further embodiment of a hollow flange section is shown in FIG 4. The hollow flange section 21 comprises a base member 22 and opposing lateral support members 23. The lateral support members 23 are separated by a cavity 24 having opposed cavity walls 25 and cavity base 26. The cavity base 26 is welded to the base member 22.

The cavity walls 25 extend beyond the lateral support members 23 to provide lugs 27 terminating in beads 28. The lugs 27 facilitate mechanical fixing of web 30 and flanges 21, as shown in FIG 5. Suitable forms of mechanical fixing include Tek™ screws 31 and bolts 32. The hollow flange section 21 may be made with pre-punched apertures to facilitate on-site assembly of the structure 33 shown in FIG 6.

As with the embodiment of FIG 1 the lateral support members 23 provide support to the cavity walls 25 thereby giving structural strength to the flange 21. The combination of the lateral support members 23 and the weld of the cavity base 26 to the base member 22 resists skew deformation of the cavity 24.

The composite structure 33 has a similar construction to the embodiment of FIG 3 and comprises vertical beam members or posts, such as 34, and inclined beam members or braces, such as 35, assembled between a top flange 36 and a bottom flange 37. The beam members 34, 35 are joined to the flange sections 36, 37 by bolts 38. For ease of assembly,

apertures may be pre-formed in the flanges and beams.

The embodiments of FIG 1 and FIG 4 described above are conveniently manufactured by roll forming a metal strip according to the steps depicted in FIG 7. The step of forming a tube is optional since the
5 hollow flange section can be formed directly from the strip. There may be advantage in forming tube on a separate roll forming line prior to formation of the hollow flange section.

After forming of the profile the base member and cavity base are welded in a welding station. The formed hollow section then passes a
10 finishing section where it is painted and cut to length, as required.

It will be appreciated that a different set of roll forming rollers will be required for the embodiment of FIG 1 and the embodiment of FIG 4.

A third embodiment of the hollow flange section is shown in FIG 8. This hollow flange section 40 can be conveniently formed by a similar
15 process as described above. A flat strip or tube is rolled to form enclosed volumes 41. The enclosed volumes are defined by the base member 42, lateral support members 43 and cavity walls 44. The cavity 45 is defined by the cavity base 46 and cavity walls 44. The cavity base 46 and base member 42 are welded at 47 to complete the hollow flange section. Other shapes for
20 the enclosed volume are also possible.

A fourth embodiment of the hollow flange section is shown in FIG 9. The hollow flange section 50 is conveniently formed from a flat strip by the process described above, although the optional step of tube forming is not available. The flat plate is bent in a series of roll forming stations to turn the
25 extremities over to form enclosed volumes 51. The enclosed volumes are defined by the base member 52, lateral support members 53 and cavity walls 54. The cavity 55 is defined by the base member 52 and cavity walls 54. Welds 56 complete the hollow flange section 50.

Welding of a terminating edge of a strip to a continuing face of a strip,
30 as required by weld 56 in FIG 9, has proven problematic. The preferred method of welding two strip edges together is induction welding. However,

induction welding is less successful for welding a strip edge to a strip face due to dissipation of current and heat in the face. The inventors have solved the problem by pre-heating the face.

5 The hollow flange section can also be formed from two components as shown in FIG 10. A hollow flange section 60 comprises a base component 61 that is roll formed to make a base member 62 and lateral support members 63. A separate cavity 64 is formed as a U section having cavity walls 65 and cavity base 66. The base component 61 and cavity 64 are then welded at 67 to form the hollow flange section 60.

10 Embodiments of the hollow flange section of FIG 4 can also be formed from a flat plate. Two examples are shown in FIG 11 and FIG 12. In both examples a flat plate is shaped in a series of roll forming stations and then welded to complete a hollow flange section.

15 Composite structural components fabricated from two hollow flange sections and an interconnecting web provide better strength for mass characteristics than existing components and therefore represent a significant economic benefit for the building industry. The advantage of the composite structural component is exemplified in FIG 13 which plots the bending capacity of a standard joist and a joist utilizing the hollow flange section for a range of standard joist sizes. As is clearly seen in the plot, the composite structural component always outperforms the conventional component.

20 Throughout the specification the aim has been to describe the preferred embodiments of the invention without limiting the invention to any one embodiment or specific collection of features.

CLAIMS

1. A hollow flange section comprising :
a base member;
a pair of opposed cavity walls and a cavity base defining a cavity;
5 two opposing lateral support members extending from the base member to the cavity walls such that each lateral support member forms an enclosed volume with an adjoining one of the opposed cavity walls and an adjoining portion of the base member;
wherein the cavity base and the base member form an integral
10 structure that resists skew deformation of the cavity.
2. The hollow flange member of claim 1 wherein the cavity base is a portion of the base member.
- 15 3. The hollow flange member of claim 1 wherein the cavity base is separate from the base member but joined to form the integral structure.
4. The hollow flange member of claim 1 wherein the lateral support members are non-linear and extend from the base member to form enclosed
20 volumes having a rectangular cross-section.
5. The hollow flange member of claim 1 wherein the lateral support members are linear and extend from the base member at an angle to form enclosed volumes having a triangular cross-section.
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6. The hollow flange member of claim 5 wherein the angle between the base member and the adjoining lateral support member is in the range 20° to 45°.
- 30 7. The hollow flange member of claim 5 wherein the angle between the base member and the adjoining lateral support member is 30°.

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SUBSTITUTE SHEET (Rule 26)



8. The hollow flange member of claim 1 wherein the cavity has a rectangular cross-section with parallel opposed walls and an open mouth opposite the cavity base.

5 9. The hollow flange member of claim 1 having a unitary structure.

10. The hollow flange member of claim 1 having a non-unitary structure wherein the base member and the cavity base are welded to form an integral structure.

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11. The hollow flange member of claim 10 wherein the weld is selected from the following : high frequency induction weld, metal inert gas weld, tungsten inert gas weld; carbon dioxide shielded arc weld; atomic hydrogen gas weld, spot weld; electron beam weld; and laser weld.

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12. The hollow flange member of claim 1 wherein the lateral support members join the cavity walls at the top of the cavity walls.

13. The hollow flange member of claim 1 wherein the hollow flange section further comprises lugs extending beyond an intersection of the lateral support members and the cavity walls.

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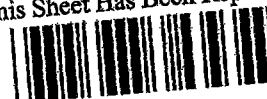
14. The hollow flange member of claim 13 wherein the lugs terminate in a bead.

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15. The hollow flange member of claim 13 having a plurality of apertures formed in the lugs to facilitate fixing of a web to the hollow flange section for formation of a composite structural member.

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16. A process of forming a hollow flange section comprising the steps of:
passing a strip through a plurality of forming stations to successively deform
the strip to provide a cavity and a pair of substantially hollow adjoining
support volumes;
- 5 further forming the deformed strip so that a base of the cavity contacts
a base member connecting the adjoining support volumes; and
welding the base of the cavity to the base member.
17. The process of claim 16 wherein the stations are roll forming stations.
- 10 18. The process of claim 16 further including the step of forming lugs
extending beyond the adjoining support volumes.
19. The process of claim 18 further including the step of forming apertures
- 15 in the lugs.
20. A process of forming a hollow flange section comprising the steps of:
passing a strip through a tube forming station to form a tube;
passing the tube through a plurality of forming stations to successively
- 20 deform the tube to provide a cavity and a pair of substantially hollow
adjoining support volumes;
- further forming the deformed tube so that a base of the cavity contacts
a base member connecting the adjoining support volumes; and
welding the base of the cavity to the base member.
- 25 21. The process of claim 20 further including the step of forming lugs
extending beyond the adjoining support volumes.
22. The process of claim 21 further including the step of forming apertures
- 30 in the lugs.

23. A composite structural member comprising :

at least two opposed hollow flange sections, said hollow flange sections comprising a base member; a pair of opposed cavity walls and a cavity base defining a cavity; two opposing lateral support members
5 extending from the base member to the cavity walls such that each lateral support member forms an enclosed volume with an adjoining one of the opposed cavity walls and an adjoining portion of the base member; wherein the cavity base and the base member form an integral structure that resists skew deformation of the cavity; and

10 an intermediate web;

intermediate web such that distal ends of the web are seated in a respective cavity of the hollow flange section.



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