What's the story with the 'zigzagging' of those diagonal tubes in a truss?

Some people say it should really be done this way, others tell you it doesn't matter at all.

Answer:

Both answers are correct, as the question completely depends on the brand and especially the type of truss. In other words, the question does not have a straight answer, and that's what causes confusion. This means that (technical) reasons have to be given.

"Beautiful"

Unless the person from whom you heard the remark about zigzag diagonals meant that it was *beautiful*. Some people like to see that **zigzag** pattern because they think it *looks beautiful*.

Riggers are often not that interested in beauty, so we will not go into aesthetics here, as there are many other things that we think look *beautiful*. Even if figure 1 on the right ⇨ shows something that looks like a truss (because it has 'zigzags'), it's not the first thing you think of when you hear the word *beautiful*.[1]

The diagonal and vertical tubes or posts referred to here are officially called 'web braces', comparable in function with the 'web plate' of a steel section. In it the top and bottom are called 'flanges', whose function can in turn be compared with the 48-51 mm outer diameter main tubes of a truss, which are officially called 'chords'.

What is the function of these diagonals?

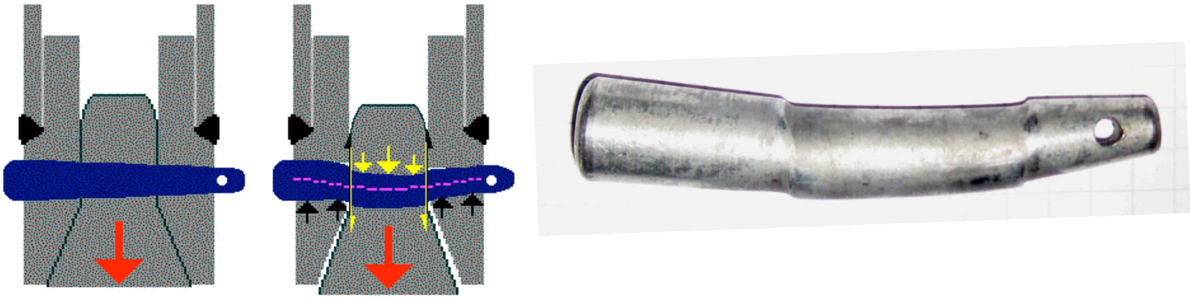
Diagonals: their function in the truss

Shearing and bending

These are the two main sets of forces in a truss. If you place a load on a 'truss girder' (or any other horizontal beam), it will have the tendency to bend (sag) in the middle and slide down along the supports. The latter is called the ***shear force*** and the diagonals are used to absorb it. The shear force is perpendicular (here ⇅ vertical) to the direction of the truss (as we take that to be ⇆ horizontal). The shear is greatest in places where point loads are applied and where the truss is supported. That process of shearing and bending can also be seen in the steel truss

[1] The colour or length of ladies' hair, the print on their lingerie, the colour of their shoes, or the height of their heels, the length of their legs, naturally also the ladies themselves, or the shape of their 'bottom areas' ;-) All of these can be classified as "beautiful". And that truss can certainly wait a while.

pin pictured in figures 2 & 3, which has been overloaded



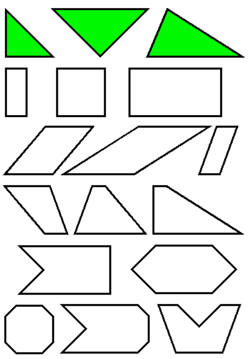
and has been distorted by the (aluminium) connection pieces due to the bending and shearing effect of the forces, as depicted in the diagram.
The same principle also applies in a truss, which for a uniform load mainly shows the bending forces, but the shear force will occur at a support (albeit less visibly). Here, half of that total uniform load must be transferred to a vertical direction at once. The diagonals should prevent the chords from being pressed together or pushed apart. Within the truss construction they connect the bottom and top braces. The distance between these bottom and top braces determines the 'height' of the truss, which is one of the important factors that determine the strength of a truss. This means that these diagonal and straight web braces should not "just give up" by buckling under an excessive compressive force or by breaking (at the weld) under an excessive tensile force. The amount of tension or compression that a brace can withstand can be calculated by the structural engineer based on the length, shape and diameter of such a brace, and based on the material type and quality.
By arranging these web braces in a triangular pattern, the resulting strength of the truss girder can be easily calculated.

So what's going on with these triangles?

Triangle: dimensionally stable geometry

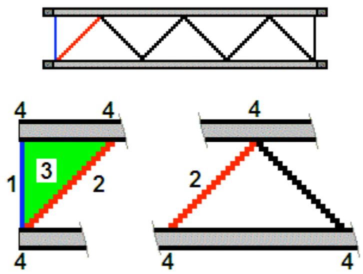
Triangles:

For a structural engineer the (allowable) compressive and tensile forces are especially easy to calculate if they are applied to a triangular brace system ('*framework*'). This means that **triangles** must be present in the truss sections. A rectangle, square, trapezium or parallelogram is much less predictable and requires a much more complex design in terms of construction.



Let's not even start about geometric shapes with more angles and sides ('braces'). However, if you look closely, you can see that these types of unfavourable shapes (still) appear in all sorts of truss products.

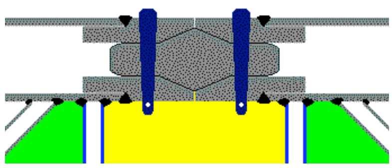
As stated above, the properties of the brace to be loaded axially in a triangle (in the direction of the longitudinal axis) depend on the material type and tensile strength, its length, width and thickness, and the surface area of the cross-section.



1 - shortest brace = vertical
2 - longest brace = diagonal
3 - smallest triangle
4 - node

The brace will only fail under an excessive tensile force (= failure at the weld) or an excessive compressive force (= buckling in the centre). This in turn depends on the length and girth of the brace: the 'relative slenderness'. A thinner and longer brace (diagonals are longer than verticals) will buckle and fail sooner under pressure.
The properties of this repeating triangle mean that construction of supports and the application of large point loads are only allowed in the nodes.

Let's return to the truss. As long as there are triangles in there, it will not matter to the truss *how* they are present, the structural engineer has had to calculate them all for both compression and tension anyway. For the trusses that contain a vertical 'end post' – which is not loaded in any other way – this is the smallest triangle and it connects to the smallest triangle of the next truss section / corner piece (?). Here the small rectangle between these two triangles becomes an almost fixed-moment connection, as the main braces are clamped together there and cannot move independently.

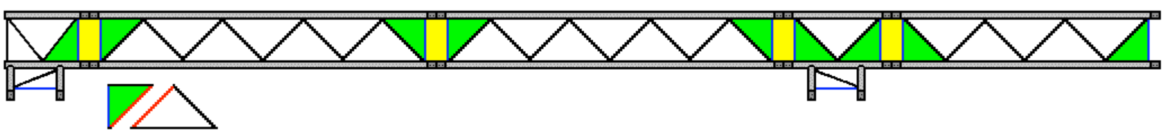


What is the effect of the connecting coupling system?

Coupling: dimensionally (moment) stable or pivoting

Conical couplings + end posts = '*no problemo for zigzagging…*'

The smallest (and strongest) triangle is then located at the end of the truss section.



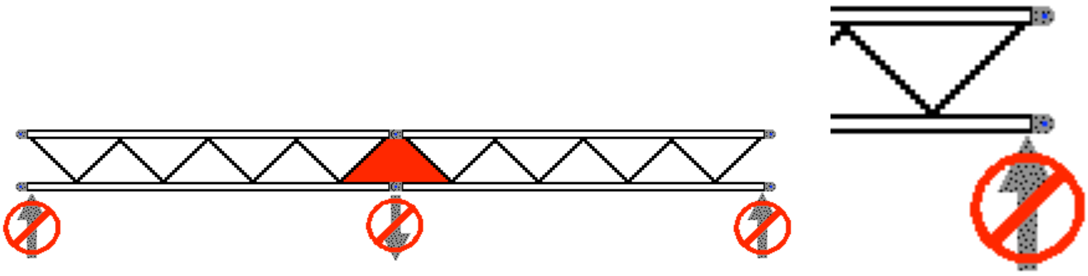
In other words, it makes no difference for brands such as Prolyte, Eurotruss, Interal, etc. These manufacturers all (?) make trusses with a vertical end post, which means that a triangle connects to the next triangle, whether they zigzag or not.

Incidentally, for quite a few manufacturers a lot of comments can be made on the corner pieces associated with the truss (in this context a rather embarrassing lack of triangles), but that is not the question being answered here.
But there are obviously other trusses **for which this zigzagging is important**, otherwise this myth would not have come into existence.

In which cases is 'non-zigzag' a problem then?

No vertical 'end posts'? = Oops!

Many truss types of Slick (Litebeam, Minibeam, Maxibeam) and Camco (and all sorts of other 'variations' or copies of these) do not have the vertical web braces at the end, which means that no 'final triangle' can be formed in a truss section. For some types it is impossible to mount the truss 'incorrectly', such as for ALC trusses, but the missing vertical end post is interesting there for a whole other reason. You cannot simply hook up ("pick up") the underside of this truss close to the couplings, as a hinge is present in the main tube in those locations and there is no vertical support at all!

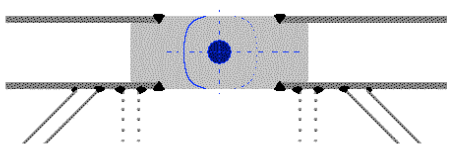


And other types of trusses, such as those with fork/lug and end-plate couplings?

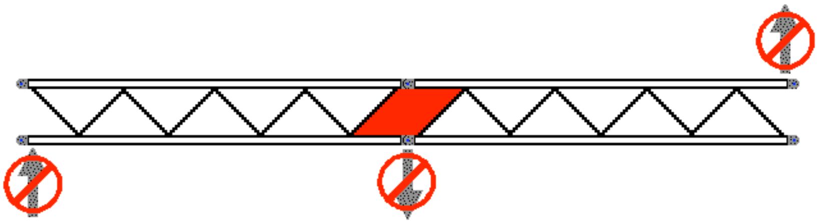
Fork/lug pivot or end plate?

Mounting fork/lug truss the wrong way round (1 x 'upside-down') = Oops!

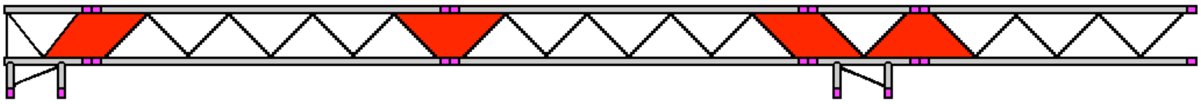
Especially for systems in which pivoting 'fork/lug' couplings are used, the edge braces are much more sensitive to buckling under compression.



And if the triangles are also missing, and a parallelogram or trapezium can be identified, this weakening under pressure is in fact inevitable. The figure below applies to a few types of trusses (incl. those from Slick). The places where no (or very limited) support is allowed or where no (or only minimal) point loads may be applied are marked in the figure.



The level of weakening is related to the series of factors mentioned above (type of material and its quality, thickness and diameter, brace lengths, etc.) and can only truly be given by the manufacturer.



Slick (and Camco, which is derived from it) have resolved this for a number of truss types by applying a sort of internal end cross. But this solution is incomplete and the figure above continues to apply for these brands in terms of the parallelograms.

In the 'endplated' truss designs (especially in the US), where the 'end posts' are incorporated into the coupling system – the connecting plates are welded to the end posts - , the 'zigzagging' must also continue, as those end posts are not only subject to axial forces, but also to bending forces in the location of this endplate.

The reasons for the answer to the original question

'To zigzag or not to zigzag' depends on the type of truss

Conclusion:

1) For the truss types with the 'biconical' couplings and a vertical end post, it does not matter (for strength/safety) whether the zigzag continues.

2) For all trusses that lack 'vertical end posts' this does matter.

3) Whenever the end post is subjected to a load by the coupling system, such as for the endplated truss, it is definitely important to continue the zigzag. Add to this the fact that an endplated truss is also a much weaker construction type. The fact

that this is the most widely sold system in the US proves once again that the most widely sold type does not always have to be the best type.

4) The only party who can provide definitive information about whether zigzagging is necessary or not is the manufacturer itself. This is because some manufacturers make (or copy) all types of coupling systems. This is like ordering a Fiat, Ford or Volkswagen from Tata and feeling confident about it.
If a manufacturer fails to provide any of this type of information, it may be better to avoid its products altogether. The same applies to information about the correct method for supporting or hooking up, or applying a dynamic load, or...