Castellated Beams

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Welded construction represents a creative endeavour comprising of two phases, conceptual and implementary. Concept, however brilliant, without the means for its implementation will remain only a dream. Implementary art in the form of welding technology and behavioural analysis has amply proven the adequacy for realization of many a fine concept in welded design. It now stands as a challenge to all potential users of welding technology in structural fabrication, stimulating their imagination in the process of expressing their daring and creative thoughts. Castellated beams will be the motive force for such expression.

Castellating is a process whereby the rolled steel beams or for that matter, channels as well are split into two equal halves in a zig zag fashion along the length of the section. This splitting up of the section has been best achieved by the use of oxy acetlylene flame cutting. The two halves are then separated and one of the halves is set back by half a pitch along axis of cutting and then these two halves are welded together. Fig. 1 shows typical method of cutting out and Fig. 2 shows a welded castellated beam.

This creative thought was as has been reported, put into action first in the United States about the year 1910 by H. E. Horton. Thanks to the development of welding technology, this concept was accepted

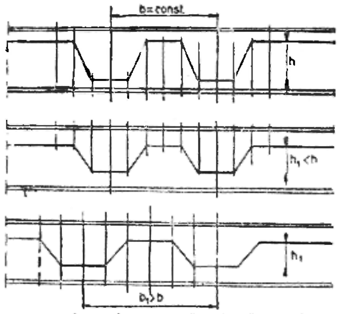
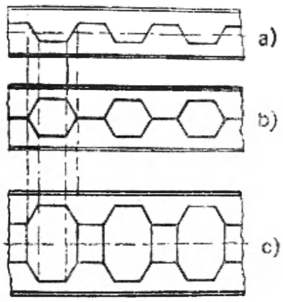


Diagram showing method of cutting-out for open-web beams.



Types of open-web beam.
a) Solid-Web beam after cutting-out process.
b) Castellated beam.
c) Beam with spacing plates.

and steady progress has been made in extensive use of castellated sections, but still the importance that it deserves has been denied. This is primarily due to the fact that research institutions have not put in enough efforts to undertake its behavioural analysis, and there is a large scope for study of the behaviour of the

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castellated sections under different loading conditions. This very neglect has been an obstacle in the free use of these sections since consulting engineers have, generally, resorted to the use of the rolled steel sections which are readily available in the market and whose behaviour has been known for sure.

But today when the entire world is passing through such a critical phase and especially with an international shortage of steel, it is imperative for a developing country like ours to make an opportunity out of this adversity, and work towards saving steel which is the backbone of our industrial growth. I would request engineering research institutions to come forth at this hour and contribute their findings towards behavioural analysis of the castellated sections so that they are popularized and the use of these may result in saving of this scarce item, i.e. steel.

Castellated sections are just ideal for long spans and light super-imposed loads, though these have been frequently used as other structural members as well. Since by castellation, the depth of the section increases by about 50 per cent as compared to the original rolled section from which it has been manufactured, there is a corresponding increase in the moment of inertia and section modulus of the section. The increase in the moment of inertia is as much as 135 per cent and that of section modulus by abour 56 per cent. As a result of this there is an improvement in the carrying capacity of the beam due to the section having acquired properties to resist greater bending moments. Though there is an improvement here, there is no effect in the shear capacity of the section. In fact, at times it is adversely affected and sufficient strengthening is necessary.

On account of this increased carrying capacity of the castellated beam, it is ideally suited for large spans with light loads and thus help to have a structure with reduced dead load resulting in a lighter and more economical design. The foundation costs also of such structures are comparatively low.

Castellated sections have however not been very frequently used under impact and moving loads, though at quite a number of places they have been used as gantry girders for e.o.t. cranes and as chassis frames for trailers etc. It is in this field that more sresss is to be laid and I foresee that very soon one would see these sections being frequently used for gantry girders, bridge girders for cranes and other structures where moving loads are encountered.

On sample studies, it has been found that there has been a saving of around 10 per cent to 25 per cent a saving of around 10 per cent to 25 per cent of saving in steel. Though manufacturing costs are there and have offset the saving, yet there has been a saving of around 15 per cent on costs. So far the castellations had been done using the hand torch for splitting the section and then welding, and this added to costs in manufacturing. If the manufacturing is done by automatic gas cutting machines and produced on a mass scale in a workshop, I am sure that these castellated sections would be available at a reduced cost alongwith quality.

As far as the painting costs are concerned they are also reduced to the extent of 50 per cent to 60 per cent. Another advantage is that one could span the roof trusses at comparatively large distance and thus have more space in between two columns and also have fewer columns resulting in lower foundation costs.

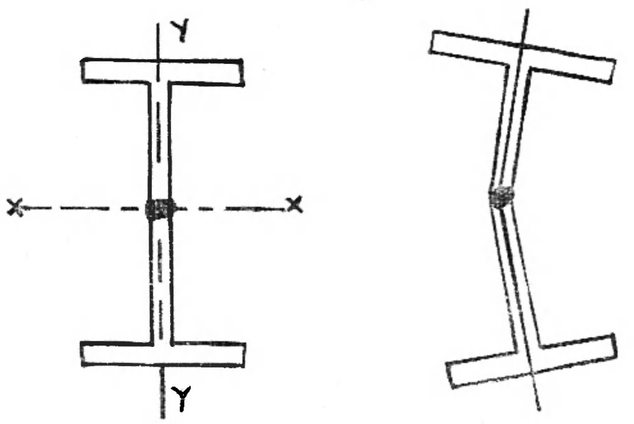
As far as manufacture of the castellated sections are concerned there have been a number of processes used so far. Invariably, the zig zag profile was marked on the web of the beam and using an oxy acetylene blow pipe the beam was split and after separating the two halves they were laid down on a surface and rewelded together, to give the required castellated section. But this method has not produced beams fast enough and also without defects which adversely affect their strength. The gas cutting of these sections could best be achieved by using automatic gas cutting machines on which are mounted multiple torches so that at the same time a number of beams could be split. It is common these days to have automatic machines with 6 torches mounted on it. The speed for cutting being about 15 ins/min for cutting, one could with the aid of 6 torches accomplish 90 ins/min.

Amongst automatic cutting machines, there have also been a great variety. In one type, the machine has a steel template mounted on it to suit the section to be cut and the machine is guided by a magnetic roller, which runs along the template and thereby cuts the web of the beam to the required shape. Improving on the techniques of gas cutting machines, the manufacturers brought in more sophistication such as the electronic eye which is guided by a pencil drawing on the paper. The required shape is drawn on a drawing paper which is then fixed on to the machine. The electronic eye scans the profile and thus repeats the process of cutting. Both these processess involved the making of template or drawing which is a time consuming affair. The use of cams and gears has come out very handy and fast in the production of these castellated sections. The cams and gears are fitted on to the machine and the magnetic roller runs on the cam. As the machine runs it traces the zig zag pattern required for the respective size of the beams.

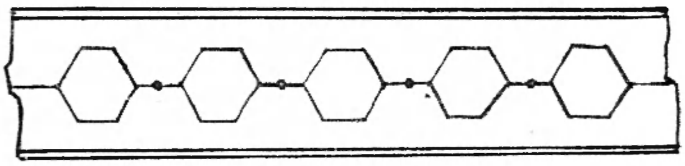
Whilst gas cutting, there are a number of problems that are encountered which need care. The rolled sections normally available are not straight and hence they have to be straightened before cutting. This could be either done by passing through straightening rolls or placing the beams in jigs, which keep the beams in position whilst cutting. In the process of cutting also the right procedure should be adopted since whilst the beams are being split the two halves tend to distort because of the heat generation. One way would be to cut them for some distance and skip off a little portion which would keep both the halves together and repeat this for the full length of beam. After the beam has cooled down these portions could be cut off, using a blow pipe.

Another way would be to put a number of beams together with their flanges adjacent to each other and the beams mounted on a frame. From the sides of the frames, pressure could be given to the beams to be pressed together in alignment so that they could be cut along their longitudinal axis. These beams should not be taken out till they have cooled down sufficiently.

After having been gas cut, the sections are taken up for dressing and cleaning and for proper lay out for welding. It is here that utmost care is needed. The split half sections of the beams should be straightened out and cleaned for any hard crust or slag which may be adhering to the cut surface. The split up sections should then be matched properly in a jig so that uniform depth is maintained and also to be sure there are no bends on either axes of the beam. In case the YY axis of the beams is not straight, under loading the beam will be subject to failure due to web failure.



After having placed these beams in the jigs the two halves should be tack weld together and these tacks should be placed in the middle of length of the weld but not at the end of the weld length as shown below.



The full welding then shall be done. During the course of welding, care should be taken that the proper sequence of welding is adopted since distortion would take place. It would be better if two welders are employed and the welding is done from centre outwards towards the ends.

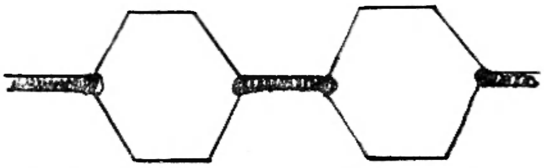
Since the thickness of the web of these beams would be in the vicinity of 5 mm-12 mm, in quite a number of instances there would not be any necessity of making a weld preparation. In such cases, a deep penetration electrode would be most useful.

For thicknesses above 12 mm it would be necessary to make a weld preparation in the shape of a V. When one side of the beam is welded, the root should be properly chipped or gouged to sound metal and then welded.

In the case of these castellated beams, the welding is not a continuous affair, the weld length being about 2″-6″ with a break of about 5″-20″ length which happens to be the castellated portion. In such circumstances, automatic welding such as submerged arc welding will not be suitable, the alternative being to use the age old method of using stick electrodes or semi-automatic process such as CO_2 welding. Though CO_2 welding would be very much convenient and productive, this process would take still some more time to be adopted in our country.

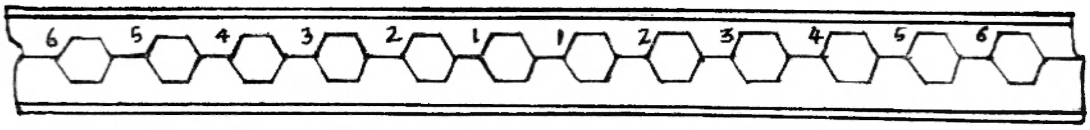
Whilst welding the castella, proper care is to be taken that the ends of the weld length are properly done. If the ends are not properly done, there is every chance of web weld failure taking place because of the force acting at the re-entrant corners.

In the manufacture of the castellated beams utmost care is to be given for the web weld because most of the failures that have occurred have been on account of web buckling and web weld giving in. The webs are quite a number of times stiffened with stiffeners to



avoid the buckling taking place. It would not be out of the way to lay more emphasis on the type of welding to be adopted for the manufacture of the castellated beams. CO_2 welding seems to be the only choice since it will give a comparatively sound weld as compared to use of stick electrodes. Since the manufacture of the beams will have to be done in a shop, the problem of wind blowing away the CO_2 shield will also be minimized and thus this method would be productive.

As indicated earlier, I would not go into the intricacies of welding technology on the subject but list below, in brief, some advantages that accrue by use of these sections.



1. Lighter sections.
2. Higher strength to weight ratio.
3. On site adaptation for utility lines.
4. Opening in the web permits ready passage and concealment of pipes and electrical conduits within the depth of the floor.
5. Lightness of girder permits use of lighter frame work cutting down foundations costs. Where poor soil conditions are encountered such light weight construction makes it particularly desirable.
6. Cuts down painting costs.
7. Top quality of fabrication can be assured and standards maintained by strict quality control at shop.
8. Economy in steel and overall costs.

The following are the best places where castellated beams can be used without any difficulty. They are used in structures like.

1. Commercial and industrial buildings.
2. Warehouses and portable frames.
3. Cranes and towers.
4. Crane girder.
5. Secondary members and deck stiffeners in bridges.
6. Ring beams in storage tanks and vessels.
7. Stiffening girders in ship structures with added advantage of passage for pipes and ducts.
8. Under carriages for railway wagons.
9. Light machine frame.
10. Light duty automobile chassis.
11. Platforms and temporary structures for off-shore sites and also for marine oil drilling etc.