Behavior of Plate Girders with Web Cut-outs

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***Abstract*: This paper discusses about the size and shape of the openings in the webs of plate girders which would give the most optimum cross-section of the plate girder. A comparison between different plate girders with varying, spans, loads and element sizes and varying shapes--- hexagonal, square and circular, and sizes of web cut outs was done. As a conclusion, a value of web depth percentage is arrived at, at which the efficiency of the cross section is maximum. Moreover, this percentage of cutout remains constant for any combination of spans, loadings and element sizes.**

Key words: Plate Girders, web-cutouts.

INTRODUCTION

Steel is a costly resource and its use needs to be done judiciously. In huge industrial set-ups where frequency of repetitive use of similar elements is high, optimization of elements can result in huge savings.

Plate Girders are an inevitable part of industries due to its versatility in its utility. However, an attempt needs to be made to reduce its self weight while still maintaining its functionality. One way to reduce the self weight is to introduce openings in the webs. Also, many a times, in industries utility pipes need to cross beams and girder, thus making introduction of web cut cuts inevitable.

However, a fine balance needs to be struck while introducing such web cut outs, such that the cross-section of the plate girder should be utilized to its optimum without compromising on the safety aspect.

Also, while introducing openings in the web, one has a wide range of options in front—from hexagonal, circular, squares and rectangular—openings. Therefore, in addition to the most economical size, one should also be select the most economical shape as well.

This study makes an attempt to find out the most economical shape and size of web cut out for optimum utilization of the plate girder cross section..

PROBLEM STATEMENT

To study the behavior of plate girders with different shaped and sized openings in their webs.

Hexagonal, square and circular openings in the webs are analyzed with varying sizes and the results are compared on criteria of strength and deflection to evaluate the most optimum size and shape of the web cut out Plate Girders of varying spans and different sizes and thicknesses of flanges and webs are analyzed.

METHODOLOGY

To achieve the objectives following step by step procedure is followed.
Input data:
Span
Live load
Dead load
Flange width
Flange thickness
Web depth
Web thickness

A 12 m span simply supported plate girder of flange width of 150 mm, flange thickness of 17.4 mm, web depth of 640 mm and web thickness of 9.4 mm with Live load of 7.5 KN/m and Dead load of 9 KN/m was considered. A hexagonal web cut out of 35% of the web depth was considered in the first case.

The plate girder was checked for bending stresses, combined shear stresses and deflection at the most critical section.

In the next case, the same plate girder with same parameters but the web cutout size increased to 40% was checked.

The variation in the stresses was observed. The sizes of web cuts were gradually increased to observe a pattern.

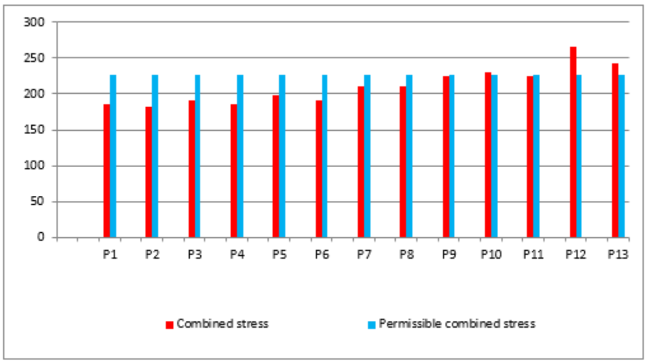

Figure 1.1: Stress-strength comparison for plate girders with hexagonal web cut-outs

In the above set, thirteen plate girders with varying sizes of hexagonal web cut outs. It can be observed that there is a huge gap between the bending stress and bending strength for smaller sizes of web cut outs, indicating that there is reserve strength in the cross-section and the full potential is not utilized. In the above graph, for plate girders P1 to P13, there is a huge difference between the values of bending stress and bending strength. However, for plate girders P9 and P11, there is hardly any gap between the two values, indicating that the cross-section is utilized to its optimum capacity. The size of web cut out at which cross-section is utilized to its optimum is 54% of the web depth.

Figure 1.2: Stress Opening size comparison for plate girders with hexagonal web cut-outs

Now a second set of plate girders with different set of parameters was checked for varying sizes of hexagonal cut-outs was checked for stresses and deflection.

And then a third set was checked for hexagonal web cut-outs to affirm the results.

Now, the plate girders were studied for square cut-outs in the webs. The same set of ten plate girders which was studied for hexagonal cut-outs was studied, was studied for square web cut outs.

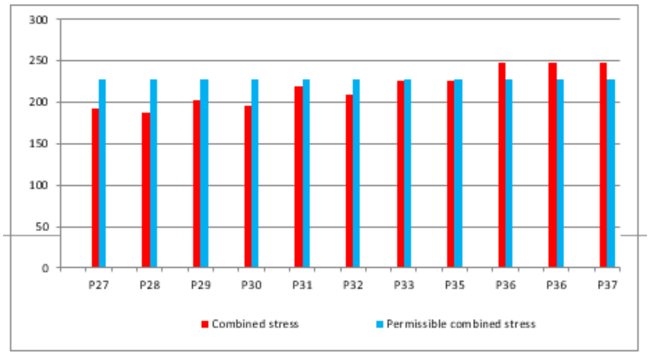

Figure 1.3: Stress-strength comparison for plate girders with square web cut-outs

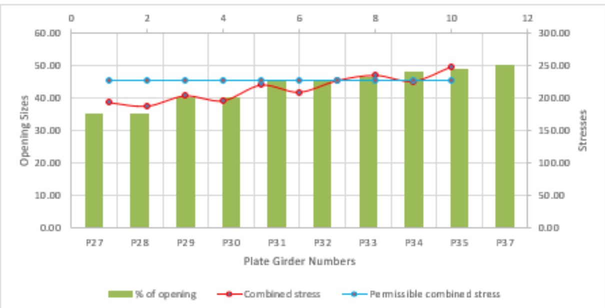

Figure 1.4: Stress-strength comparison for plate girders with square web cut-outs

In the above graph, for plate girders P27 to P37, there is a huge difference between the values of combined stresses and permissible stresses. However, for plate girders P33 and P35, there is hardly any gap between the two values, indicating that the cross-section is utilized to its optimum capacity. The size of web cut out at which cross-section is utilized to its optimum is 46% of the web depth.

Now a second set of plate girders with different set of parameters was checked for varying sizes of square cut-outs was checked for stresses and deflection.

And then a third set was checked for square web cut-outs to affirm the results.

Next, the plate girders were studied for circular cut-outs in the webs. The same set of ten plate girders which was studied for hexagonal cut-outs was studied, was studied for circular web cut outs.

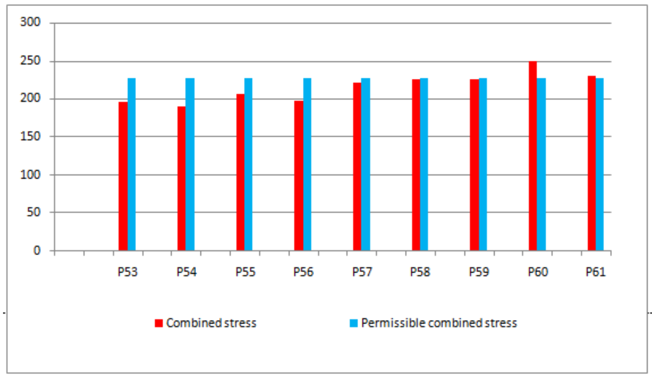

Figure 1.5: Stress-strength comparison for plate girders with circular web cut-outs

Figure 1.6: Stress-strength comparison for plate girders with circular web cut-outs.

In the above graph, for plate girders P53 to P61, there is a huge difference between the values of combined stresses and permissible stresses. However, for plate girders P58 and P59, there is hardly any gap between the two values, indicating that the cross-section is utilized to its optimum capacity. The size of web cut out at which cross-section is utilized to its optimum is 56% of the web depth.

Next, a second set of six plate girders with different span, loads and element sizes with circular web cut outs of varying sizes was studied.

CONCLUSION

In the present study, plate girders with varying spans, loads and element sizes and varying web cut out shapes and sizes was studied. It was observed that hexagonal web cut outs gave optimum cross-section at 54% of web depth, square web cut outs gave optimum cross- sections at 46%, whereas circular cut outs were optimum at 56% of the web depths.

Considering that circular shape gives the most economical area and also keeping in mind the ease of fabrication of circular openings and since there are no corners in a circular shape, thus avoiding concentration of local stresses, it is concluded that circular cut outs in webs of plate girders are most economical.

Steel been a costly commodity in construction industry and if a particular geometry is leading us to saving of such an important resource we are contributing to national cause.

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