The effect of sea water corrosion on tensile strength of combination welded joint of stainless steel 304-201

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Abstract. Construction installations built with stainless steel are the main choice of the list of materials that can be used for construction near the sea. With the recent discovery of tungsten inert gas (TIG) technology, construction with stainless steel can be realized. In some cases stainless steel welding joints are made by connecting with stainless steel of different types without regard to the strength generated especially if experiencing corrosion in this case corrosion due to sea water. In this study the tensile strength of stainless steel combination joints of type 304-201 was tested and compared with similar joints of types 304-304 and 201-201. The effect of seawater corrosion on the tensile strength of stainless steel joints was also examined. This research found that the highest tensile strength is 304-304 joints followed by 304-201 combination connections and the lowest is 201-201 joints. The effect of seawater corrosion is known to reduce the tensile strength of all types of joints.

1. Introduction
Strong and corrosion resistant construction is needed for structures near the sea both for ships and construction building near the sea. Stainless steel is the best choice today because it is easily realized by discovering the tungsten inert gas (TIG) welding technique.

TIG welding does not require the consumption of electrodes as in the arc welding process [1]. TIG welding is widely used in stainless steel [2]. Las TIG produces higher tensile strength for stainless steel compared to using metal inert gas (MIG) [3]. However, with the availability of various types of stainless steel on the market, many in the field do not care anymore due to welding connection when using stainless steel of a different type, moreover the stainless steel welded joint will experience sea water corrosion due to its location near the sea or beach.

This research aims to determine the tensile strength of welded stainless steel combination joints 304-201 to be compared with similar welded joints of stainless steel 304-304 and 304-201 both before and after experiencing seawater corrosion.

2. Experimental
The composition of stainless steel 304 can be observed in Table 1 while the composition of stainless steel 201 can be observed in Table 2
Table 1. Composition of stainless steel 304

| Element | Value       |
|---------|-------------|
| C       | 0.08        |
| Mn      | 2           |
| Si      | 1           |
| Cr      | 18-20       |
| Ni      | 8-10.5      |
| P       | 0.0045      |
| S       | 0.03        |
| Fe      | Balance     |

Table 2. Composition of stainless steel 201

| Element | Value       |
|---------|-------------|
| C       | ≤0.15       |
| Mn      | 10.7        |
| Ni      | 0.53        |
| Cr      | 14.7        |
| Cu      | 1.21        |
| V       | 0.108       |
| Al      | 0.36        |
| S       | ≤0.03       |
| Si      | ≤0.75       |
| P       | ≤0.06       |
| Fe      | Balance     |

Stainless steel plates with a thickness of 1 mm of type 304 and 201 are cut with a width of 10 mm and a length of 100 mm. The plate is then joined at the width by TIG welding so that the length of the test specimen becomes 20 mm. Thus there are 3 variations of welded joint namely 304-304 welded joint, 201-201 welded joint and 304-201 welded joint.

Figure 1. Welded joint variations

The specimens were then sprayed with sea water regularly every day for 1 full month (30 days) and carried out tensile testing. The results of the next test are compared with the results of tensile testing of specimens that do not experience seawater corrosion.

3. Result and discussion

The graph in Fig. 1. shows the results of tensile testing of welded joints from similar material, namely 304-304 joints. Tensile strength reaches 447,167 N/mm². This value is the highest value of all types of connection variations in this study. This is due to the transition zone or HAZ in the form of denrite structure [1] and also due to the presence of carbide precipitation [4]. This is followed by a combination of 304-201 joints where the tensile strength is found around 422,004 N/mm² (Fig. 2).
The lowest tensile strength value was found in the 201-201 welded joint which only reached 380,293 N/ mm².

**Figure 2.** Graph of Tensile Strength of welded joints 304-304 before and after the process of sea water corrosion for 30 days

**Figure 3.** Graph of Tensile Strength of weld joints 304-201 before and after the process of sea water corrosion for 30 days

**Figure 4.** Graph of tensile strength of 201-201 welding joints before and after the process of sea water corrosion for 30 days
Overall seawater corrosion decreases tensile strength for all types of welded joints as presented in the graphs in Fig. 2, 3 and 4. However, it is worth watching out for since the greatest decrease in strength is found in 201-201 welding joints where tensile strength decreases from 380,293 N/mm$^2$ to 357,327 N/mm$^2$ which means there is a decrease of 6% for corrosion of sea water for 30 days, while the connection 304-304 decrease in tensile strength is quite low at only 2.9% followed by a 304-201 welded joint which ranges from 3.4%. The plastic properties of welded joint from this research will be studied for future work. The suitable method for observation of plastic properties will be investigate by using indentation approach [5,6].

4. Conclusion

It can be concluded that the weld joints of stainless steel 304-304 have better tensile strength than the combination of 304-201 welding joints and also 201-201 weld joints. For this reason, it is necessary to avoid welded joint made of stainless steel 304 to 201. Tensile strength for all stainless steel welding joints is decreased due to seawater corrosion.

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