Experimental Study Improving The Friction in The Surface of Cold Form Steel Connections Using Adhesive

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Abstract. The purpose of this study is to test the strength of light steel joints using screws and the addition of adhesives to the surface of the joint. The addition of adhesive is done to increase the frictional force on the surface of the joint. The study was carried out experimentally by giving axial tensile strength to the specimens. The specimen is a mild steel connection made from a lip channel profile that is connected back to back with 2 screws and has 2 variables, namely adhesive and without adhesive. Each variable has 3 samples. The experimental results show that the addition of adhesives to the joint system is proven to increase friction. This shows that the joints that use adhesives have a greater strength of 17.20% than the joints without adhesives. The mechanism of collapse of the joint using adhesive starts from the collapse in the friction plane, then the screw undergoes tilting and subsequently experiences a collapse in the fused plane. From the results of this study it was concluded that the use of adhesives can be used as an alternative to increase the frictional force on the surface of the mild steel joints.

1. Introduction
The surface of the cold formed steel connection is relatively slippery and has a relatively small frictional force, so that the cold formed steel connection relies more on the bearing mechanism [1, 2]. Therefore, the cold formed steel connection which generally consist of a number of screws (SDS) and have a relatively small connection strength, which is caused by the thickness of a cold formed steel plate which is relatively thin and gives little resistance to the contact area [3,4]. Some alternatives to increase the strength of cold formed steel connection can be done among others by enlarging the contact area of the bearing as done in Setiyarto's research [5], or by adding adhesive to increase the frictional force on the connection surface as will be discussed in this paper.

Recent research on the use of adhesives as additives or substitutes for cold formed steel connection has been carried out. The results of it shows that the adhesives have the potential to increase the strength of cold formed steel connection steel [6,7,8,9,10]. It is because the adhesive has a fairly high shear strength [11] and the thickness of the adhesive layer also affects the tensile and shear strength generated in the connection plane [12].

This research presents an alternative way to increase the cold formed steel connection by increasing the friction force in the area of the cold formed steel connection that uses screws. The basic idea is the addition
of adhesives on the surface of the joint as shown in Figure 1. The research method was carried out experimentally by giving a tensile load to the specimen in the form of a cold formed steel connection consisting of a screw connection without an adhesive and a screw connection with an adhesive. The results showed that the use of adhesives has the potential to increase joint strength by up to 17.2%.

2. Method
This study used specimens made of two cold formed steel rods with lip channel sections that are connected back to back using two screws. The type of screw used is the SDS (Self Drilling Screw) with a diameter of 4.8 mm. The number of screws installed is 2 pieces with vertical formation. Cold formed steel uses a lip channel profile measuring 200 mm x 75 mm x 35 mm with a plate thickness of 0.75 mm. Tensile coupon tests are performed first and produce $F_u = 624.12$ Mpa and $F_y = 570$ Mpa. Adhesive uses Epoxy Resin. Based on the tensile coupon test, the adhesive has a tensile strength of 7,619 kN. The specimens are intended to be seen more clearly in the Table 1.

| No | Specimen Number | Code |
|----|-----------------|------|
| 1  | Connection non adhesive | 3 | C.2S-NA-1, C.2S-NA-2, C.2S-NA-3 |
| 2  | Connection with adhesive | 3 | C.2S-WA-1, C.2S-WA-2, C.2S-WA-3 |

To model the specimen can be seen Figure 1.
3. Results and Discussion
The specimen in Figure 1 is given an axial tensile force using a Universal Testing Machine to the point of failure. The test results can be seen in Table 2 and the shape of the collapse such as tilting and the whole bearings can be seen in Figure 2 and Figure 3. During the test, the relationship between load and displacement is recorded and the results can be seen in Figure 4.

The test results show that connections that use adhesives have a higher strength than connections that do not use adhesives, as produced in the research of Komara et al. [6]. Table 2 shows that connections using only screws (C.2S-NA) have an average tensile strength of 8001 N, while connections using a combination of screws and adhesive (C.2S-WA) have an average tensile strength of 9663 N. The addition of adhesives to the surface of the connection has increased the frictional force so that the strength of the connection has increased by 17.2%.

Table 2 Connection Tensile Test Results

| No | Specimens   | Pmax (N) | Average (N) | Collapse                      |
|----|-------------|----------|-------------|-------------------------------|
| 1  | C.2S-NA-1   | 7810     |             | Tilting, Hole Bearing, Pull Over |
| 2  | C.2S-NA-2   | 7300     | 8001        | Tilting, Hole Bearing, Pull Over |
| 3  | C.2S-NA-3   | 8892     |             | Tilting, Hole Bearing, Pull Over |
| 4  | C.2S-WA-1   | 9358     |             | Friction, Tilting, Hole Bearing, Pull Over |
| 5  | C.2S-WA-2   | 10022    | 9663        | Friction, Tilting, Hole Bearing, Pull Over |
| 6  | C.2S-WA-3   | 9609     |             | Friction, Tilting, Hole Bearing, Pull Over |

Figure 2. Form of Specimen Collapse With Adhesive

The failure mechanism that occurs in connections that use adhesives is different from connections without adhesives. The collapse of the cold formed steel connections using adhesives begins with the collapse of the friction first on the cold formed steel surfaces that are attached to each other. In contrast to the connection that only relies on the bearing mechanism of the screw, the collapse of the tilting and hole bearings such as Figure 3 occurs faster. As discussed in the research of Komara et al. [5] that the friction resistance produced by the adhesive is able to prevent tilting from occurring earlier causing the cold formed steel connection to become more ductile and stronger. In this study also can be seen from the load-
displacement relationship in Figure 4 which shows that the friction strength of the adhesive provides a high enough initial strength before the bearing mechanism of the screw stack occurs at the connection.

Figure 3. Non Adhesive Specimen Collapse Form
4. Conclusion
Cold formed steel connection systems that use screws and the addition of adhesive to the surface of the connection will produce greater tensile strength compared to the connection system without using adhesive. In the specimen for this study, the additional strength that occurred was 17.2%. The failure mechanism experienced by cold formed steel connection without adhesives tends to experience the same collapse mechanism, starting from tilting, hole bearing and pull over the plates are no longer in tight position. Whereas cold formed steel connections that use adhesives tend to be more ductile, it is because before tilting occurs, the frictional force of the joint surface first contributes to the strength first.

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