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Behavior Of Connection Of Plates To Steel Pipe

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Abstract— Pipes are common profiles in steel structures. These sections can be found in trusses, either chord or web members. Steel pipes can be connected by a single gusset plate, based on strength that can be calculated using available design rules in different guidelines. A new connection can be offered using two parallel plates which leads to higher strength. This connection subjected to normal load is examined in this paper. A finite element analysis is used to explore the effects of some factors on the strength of this connection.

Index Terms— Steel pipe, Web-member, Two-plates.

1 Background

Steel pipes are widely used for their structural effectiveness. The varied range of steel pipe geometry makes them a preferred choice. Steel pipes offer good behavior to all types of straining actions. The connection to steel pipes is important in steel design. The current paper is performed to study a new connection to a steel pipe using two parallel plates under normal load.

Many papers were published on web-member connections using one gusset plate. Different guidelines provide design rules to estimate the strength of this type of connection. The design rules depend on the cross-section of the members whether they are polygonal or rounded sections. Another factor is the shape of the joint, such as the K, Y, X, or T joint as provided in the guidelines. The last factor is the direction of the plate, whether perpendicular to the member or parallel. In this paper, the T-section with two plates with gap and parallel to the member is discussed as shown in Figure 1.

Regarding the previous publications, Bae et al. in 2009 examined parallel two-plates connected to a rectangular shape and they found that the joint with two-plates had higher strength, especially with a large gap between the two plates. Failure modes were found different if compared to the connection with one plate only. Swoo in 2019 examined the same configuration using high grade of steel. The length of the member and their support articulation affected the strength of the connection. Also, the strength of the connection should be reduced as long as the steel yield gets higher.

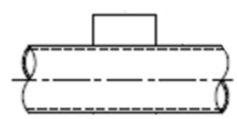

Figure 1 Plate parallel to steel pipe connection

2 Verification

Finite element analysis was used for the study in this paper and verified against the results of experiments published by Lee et al. in 2019 as shown in Figure 2.

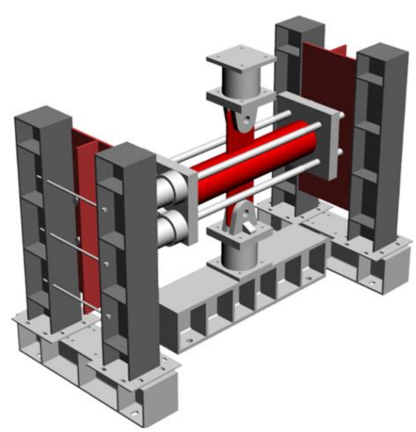

Figure 2 Experiments by Lee et al. in 2019

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2.1 Elements type

The current study was performed using common software used in many publications. Solid elements with 8 nodes were used for building all elements in the model.

2.2 Material properties

The stress-strain relationship was modeled linearly up to yield stress of 350 N/mm2 with a slope equal to 210,000 N/mm2, then a constant value of stress was considered till a strain value of 0.2.

2.3 Loads and supports

As shown in Figure 3, the steel pipe was considered a simple beam with pin support at one end and sliding support at the other point. The load was applied on the plate for the models with one plate only, and on a distributor plate for the models with two parallel plates with a gap.

2.4 Mesh

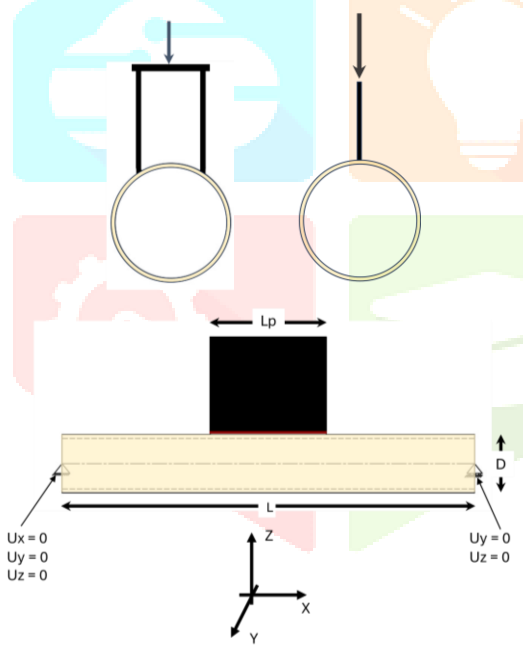

Figure 3 One and two gusset plates to steel pipes under normal force

Figure 4 provides a view of the finite element mesh created for the gusset plate and the steel pipe. The mesh distribution was dense at the region of the connection and coarse outside the region under concern.

2.5 Outcomes

Figure 5 shows a comparison between the published experiment by Lee et all in 2019 and the finite element model created in this paper. Good comparison was found with trusted results of the finite element. The current finite element is reliable.

3 Study and Results

The factor that was taken in the current study is the diameter-to-thickness ratio. The range was between 30 to 100 as shown in Table 1.

Figure 4 Mesh of finite element

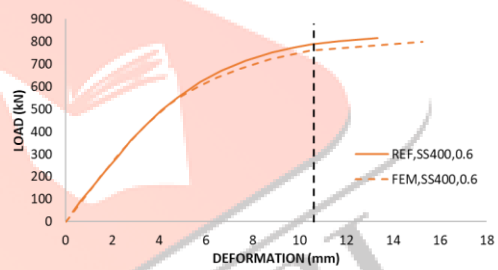

Figure 5 Load-deformation curves for comparison

Different models were performed, some with one plate parallel to the member, others with two-plates with a gap and parallel to the member, and the third group with one plate perpendicular to the member.

The deformed shapes of different models are presented in Figure 6. The comparison between two parallel plates and one perpendicular plate shows notable differences in behavior, strength, and failure modes. Double two-plate connection gives higher strength than SBP. It was noticed that by increasing the gap between the parallel plates, a higher strength of connection was found.

Table 1: Dimension of models

D (mm)	t_0 (mm)	D/t_0
200	6	30
	5	40
	4	50
	3	60
	2.5	80
	2	100
300	10	30
	8	40
	6	50
	5	60
	4	80
	3	100
400	12.5	30
	10	40
	8	50
	6	60
	5	80
	4	100

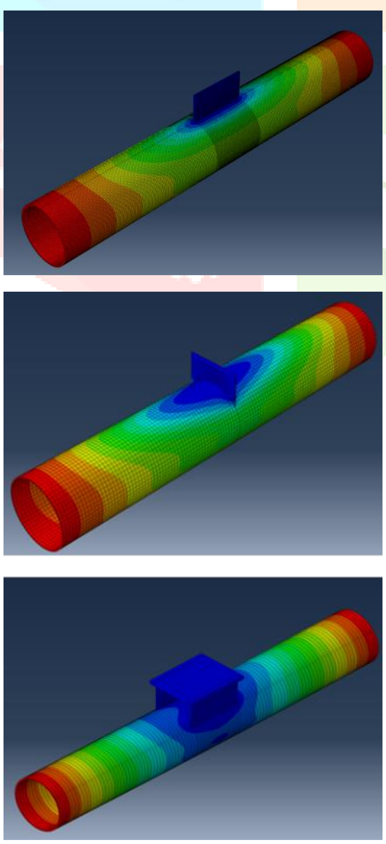

Figure 6 Deformed shapes of different FE models

A comparison was conducted between the results of the finite element models of one parallel plate connection versus the design guidelines of the same connection based on EuroNorm. The guideline gave higher connection strength than finite element models. The design rules were found to be conservative by 20% up to 35%. This is acceptable for the design process. A higher percentage, reaching 70%, was found for the small diameter of 200 mm as shown in Figure 7.

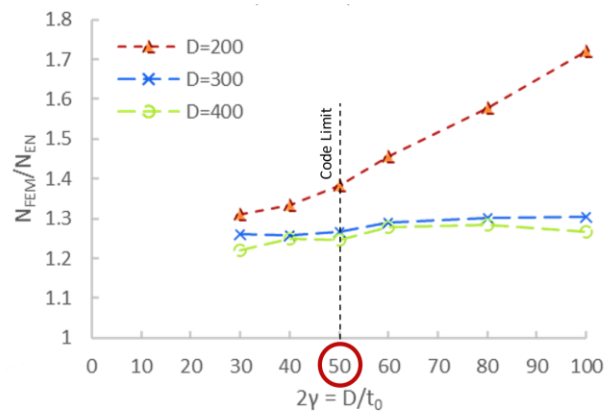

Figure 7 Comparison with EuroNorm guidelines of one parallel plate connection

Another comparison was conducted between the results of the finite element models of two parallel plate connections and connections with one perpendicular plate. This comparison proved that the two-plate connection had a higher strength of 1.5 times that of the one perpendicular plate. Figure 8 presents the comparison between both connections.

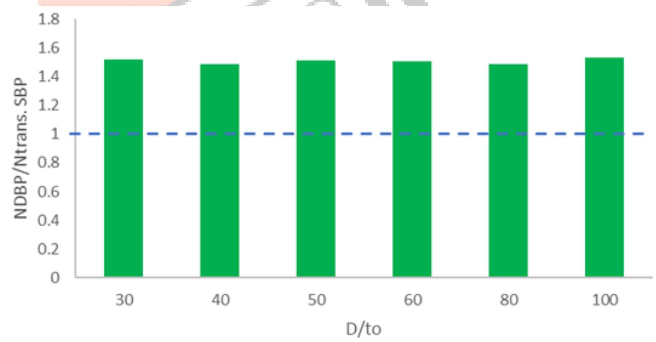

Figure. 10 Comparison between two parallel plates and one perpendicular plate

4 Conclusions

1. Guidelines are on the conservative side.
2. A two-plate connection parallel to a member gives higher strength than a one-plate connection whether the plate is parallel or perpendicular.
3. The wider the spacing between the plates, the more strength can be found.
4. A two-plate connection parallel to a member gives higher strength than one perpendicular plate connection by 150%.

5 DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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