Experimental Analysis of Scouring Around the Round Nose Bridge Pier Using Different Bed Material Conditions

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Abstract-Unexpected weather events, manufacturing defects, shoddy workmanship and poor building maintenance are all common causes of bridge collapse. However, scour damage to bridge pilings is far and away the most common cause of serious damage. Sediment is removed from bridge piers by running water's hydraulic force, a process called scouring. Scour around the piers of a bridge must be taken into account when determining its safety. It's been studied in a number of different ways. Through the use of three different discharge rates (0.32-0.37-0.032m3/s), the round nose bridge was successfully integrated into the sandbed, which was measured at 0.57mm in diameter by this research team's team of engineers and engineers. A uniform distribution of particles in the bed resulted in a geometric standard deviation (g) of grain sizes between 1.22 and 1.30. sg of gravel particle size distribution is less than 1.4, and the round nose bridge pier was incorporated into a gravel bed with gravel sizes from 4.1 mm to 14.25 mm Flexible vegetation should be used at distances of 0, 4, and 6 D from the round Nose Bridge Pier, where D is the diameter of the round nose of the Pier. Vegetation upstream served as a water filter. Each test required three hours to complete. At each of the diagonals (upstream, downstream, left, right, and upstream and downstream) a point gauge was lowered into the water to measure the depth of local scour. In an experiment, scouring around the round nose bridges pier employing flexible vegetation was reduced by up to 50% at 0D, 38.11 percent at 4D, and 30.15 percent at 6D distances. Stubborn vegetation reduces scouring by 33.44 percent, 30.92 percent, and 27.38 percent at zero, four and six dimensional distances. A lower scouring rate was observed for flexible vegetation than for rigid vegetation in the vicinity of round nose bridge pilings. A distance between the pier and the vegetation was increased in order to reduce scouring caused by flexible and rigid vegetation.

Keywords- Wide Crested Trapezoidal Weir, Scour Depth; Flexible Vegetation; Rigid Vegetation

1 Introduction

Scouring is the process by which the hydraulic force of flowing water removes sediment from bridge piers and abutments. Horseshoe vortices are formed around bridge supports and piers due to redirected water flows. Cleaning can be accomplished in three ways: by local scouring, contraction scouring, or by aggravations or degrading substances. Scouring around obstructions in a stream is called "local scouring" in this context. When a bridge collapses due to local scour, the most common cause is a collapsed foundation. Horse shows have vortex systems, for example, which are secondary flows [1]. Local scouring relies heavily on three vortex systems: the one in the wake, the one in the trailing wake, and the one in the bow wave. The bed material rises to the floor in a wake vortex system. The pier's shape and water depth influence the system's strength. When the piers are submerged, the trailing vortex system does not exist in practise. The fragmentation of the piers' upstream flow creates a horseshoe vortex system. Because of the horseshoe vortex, the upstream side of the bridge pier is particularly vulnerable to bed scouring. Different types of waves, such as horseshoe vortex and bow wave, appear on the water's surface [2].

Octagonal, square, circular and oval pilings were all used to estimate the scour depth around the pilings in order to determine the scour depth. Compared to the square piling, the scour depth of the piling was found to be between 10% and

20% greater. If something were to happen, the circular and oval faces of the piling would be in the path of most traffic as compared to the square piling (Ghani & Mohammadpour, 2016) [3].

2 Experimental Procedures

"It was done one sand and gravel at a time to fill in the main channel. Testing was carried out on a sand or gravel bed 8 metres by 15 centimetres deep and the same length. This component is used to carry out all scour studies. With regard to the flume's centerline and at a distance of 4 metres from the sand bed, a bridge pier was constructed in the test section. Three discharge rates (0.023 m3/sec, 0.027 m3/sec, and 0.032) were used in each experiment to measure Froude Numbers [4]. Measurement of flow discharge after the tailgate was accomplished by placing a trapezoidal weir at the channel's end (Reca et al. 2006). The flow depth, h, is maintained at 15 cm for each set of trials.

2.1 Laboratory Channel.

The Hydraulic Laboratory, Civil Engineering Department, University of Engineering & Technology Taxila, and the Pakistani Institute of Science and Technology conducted all of the trials in the laboratory channel. The following are the main components of the laboratory flume.

1.Pipe leading to the inlet 2. The primary means of communication. 3. Setting basin as a foundation 4. Excessive waste Pipe Weir's number five

Figure 1: Laboratory Channel

2.2 Material.

The channel's middle was marked with a 6-cm-diameter round nose bridge pier for testing purposes. For the tested pier sizes, B/D ratios greater than 10 are required for the flume width and pier nose diameter (i.e. D=6cm). As an alternative to real plants, the flexible model array was constructed from conventional broom heads and was used to study hard-vegetated channels. For the flexible vegetation, stacked broom heads with a diameter of 0.04 mm each were used and were inserted into the sand bed with Hole sizes of 3 millimetres are perforated evenly across the surface [5].

a)  b) 

Figure 2 : Round Nose Bridge Pier a) With rigid Vegetation b) With Flexible Vegetation

3 Research Methodology

The experiment was conducted on a sediment bed of 10 metres long. With this final one-third of sediment bed zone covered, we were confident that all velocity profiles had been established (Vaghefi, Akbari, & Fiouz, 2016). Perpendicular to the centerline, the pier was set up and ranged accordingly. When it came to B and D, there was a 16:1 ratio. According to Ballio, Teruzzi, and Radice, the contraction effects on scour depth are present at W/D 3. (2009). B/D 5 was found to have a reduced contraction effect by Lança, Fael, Maia, Pêgo, and Cardoso (2013). As a result, the contraction effect had no impact on the findings of this study.

Experiments were conducted on a round nose bridge pier with three different flow discharges, i.e., 22,27,32 l/s.. Weirs at the end of the canal after the tailgate were used to measure discharge flow rates (Reca et al. 2006). For each set of trials, the flow depth, h, is maintained at 15 cm. It was determined that B/h>5, D/h0.7 was met in order to reduce the impact of water depth and eliminate secondary flows (Melville and Hadfield 1999). All experiments were carried out at Froude Numbers 0.189, 0.22, and 0.26 at 0.023m3/s, 0.027m3/s, and 0.032m3/s. The flow discharge was measured by a trapezoidal weir at the end of the canal after the tailgate (Reca et al. 2006). 42 experiments in the laboratory channel used sand and gravel as the bed material. Tests were conducted on the round nose bridge pier with and without various types of artificial vegetation (Artificial Flexible and Rigid). a three-hour equilibria was maintained in all experiments (Karimi et al. 2017). Melville and Chiew (1999) defined the equilibrium period for scour depth as the time during which the scour depth does not fluctuate by more than 5% of the pier diameter at any given point in time. At the end of each test, the flume was gently drained, and the depth of the scour hole was recorded.

4 Results

A pier's scour depth is directly related to its flow velocity. It is also true that an increase in flow velocity increases the scour depth due of its erosive activity, until it hits the critical velocity, which causes a drop in the pier scour depth. As vegetation is erected and distances between pier and vegetation diminish, the maximum scour depth (ds/D) falls, indicating that round-nose piers with sand beds are most susceptible to scour

4.1 Graphs

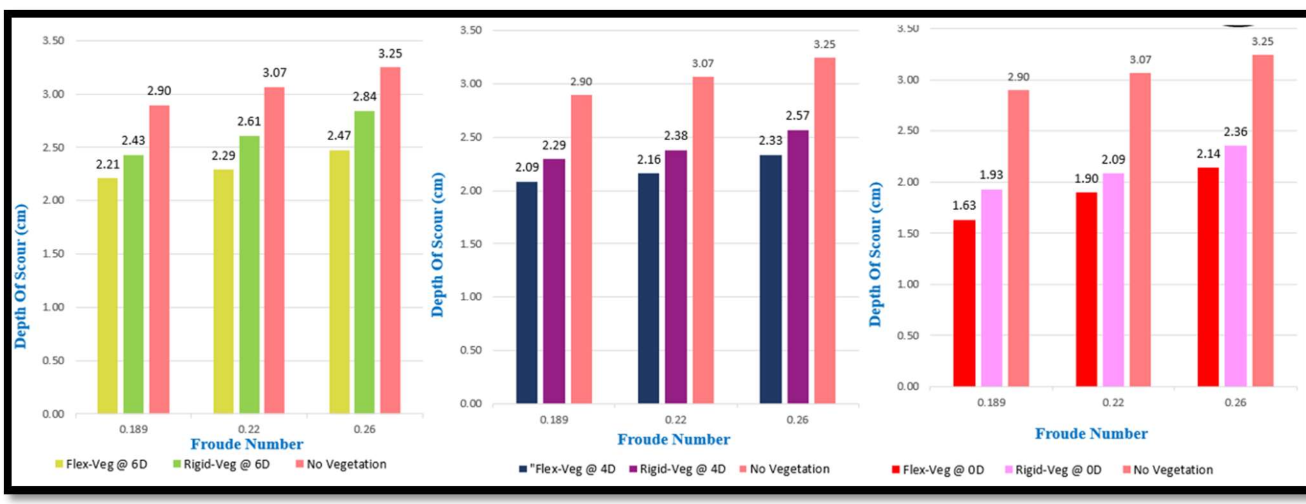


Figure 3: Relationship between scour depth (ds) and Froude Number for sand bed material.

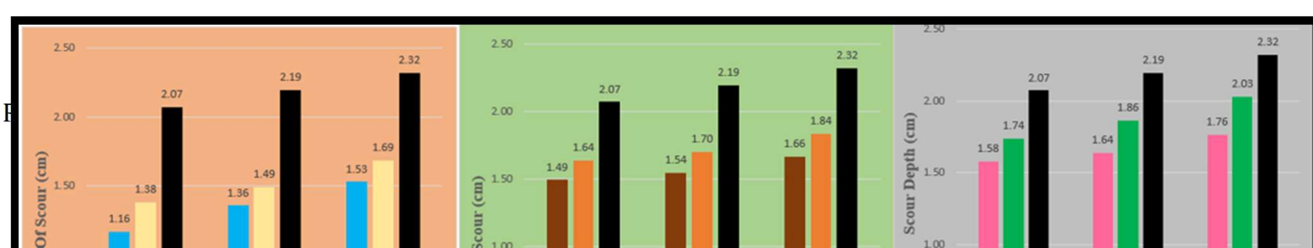


Figure 4: Relationship between scour depth (ds) and Froude Number for gravel bed material.

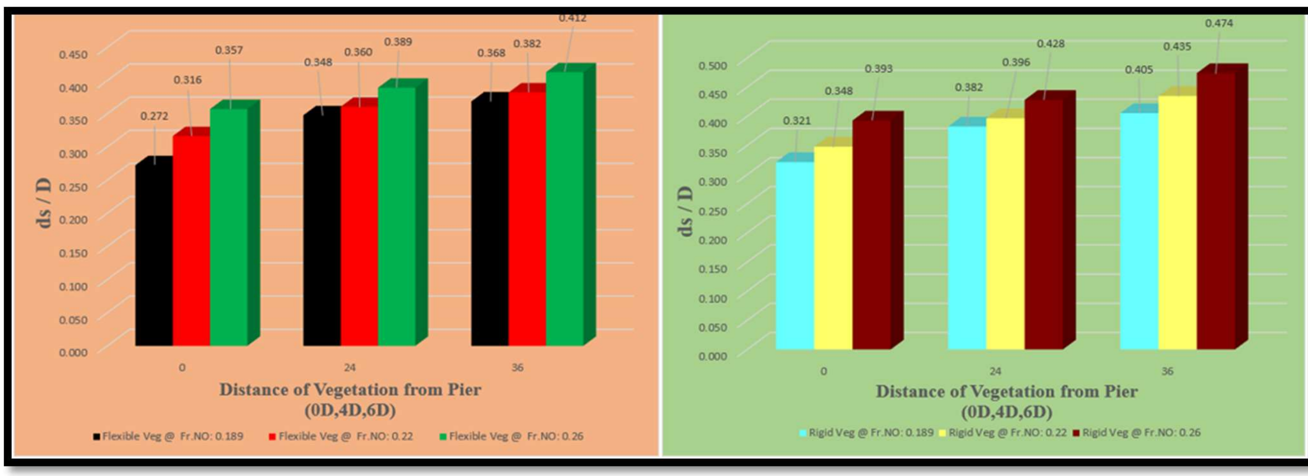


Figure 5: The ds/D versus Distance b/w vegetation and the pier having sand bed installed at upstream side.

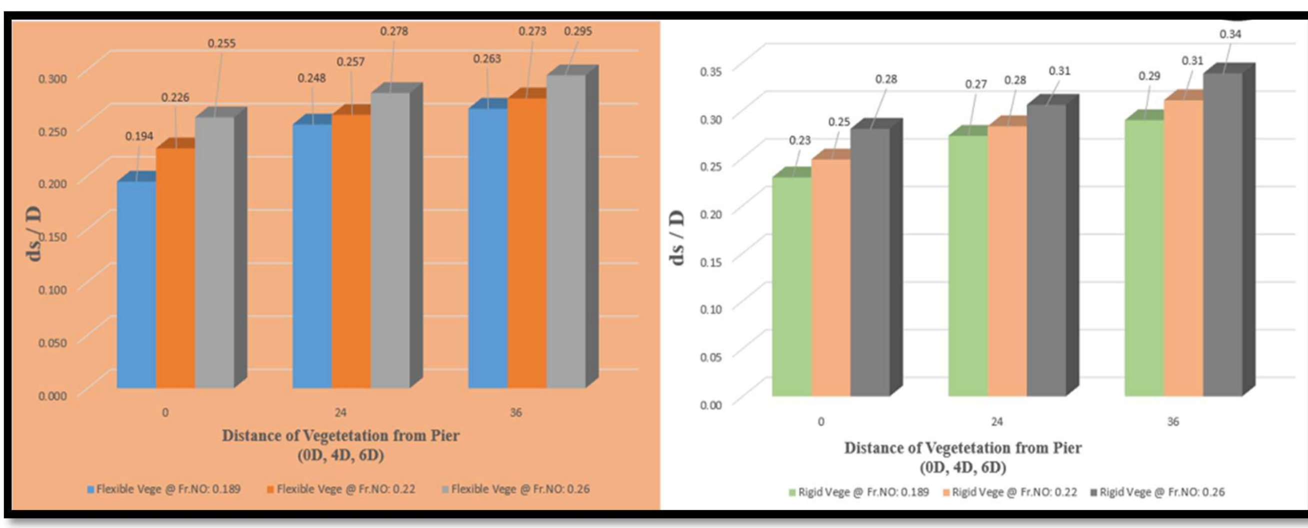


Figure 6: The ds/D versus Distance b/w vegetation and the pier having gravel bed installed at upstream side.

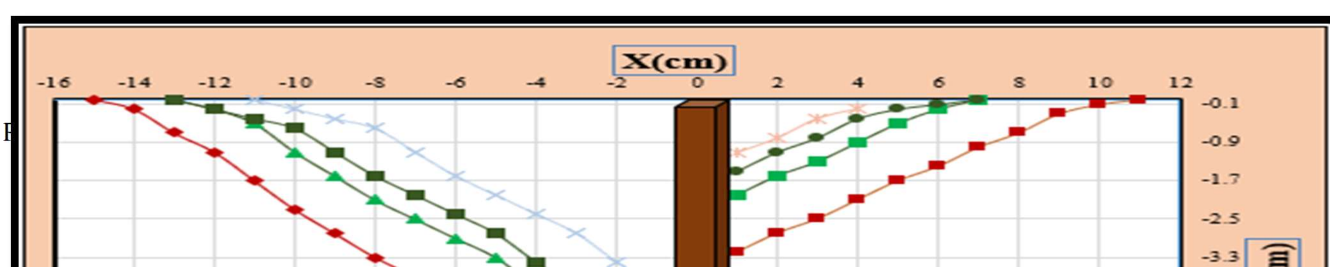


Figure 7: With and Without Flexible Vegetation, the lateral scouring profile of the Round Nose Bridge Pier.

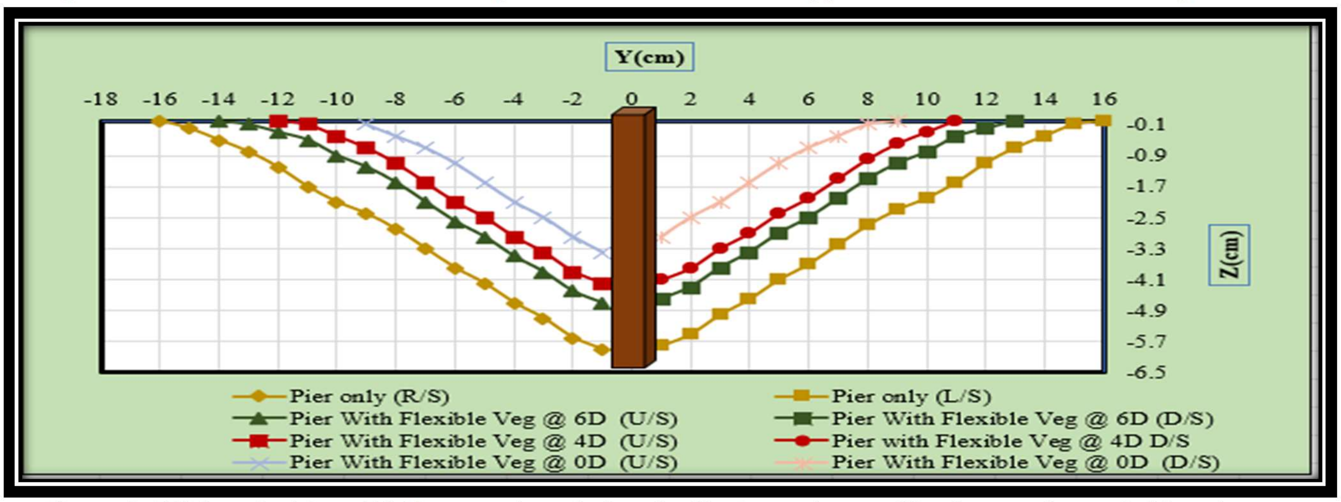
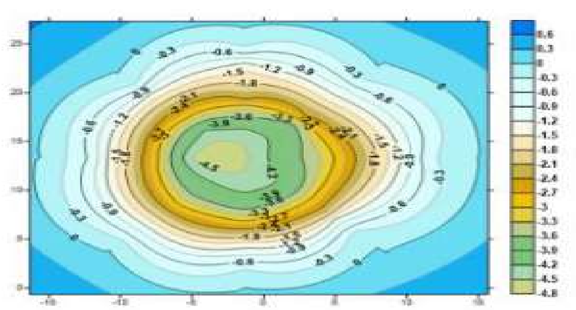


Figure 8: With and without Rigid vegetation, the longitudinal scouring profile of a round-nose bridge pier.

4.2 Use of Software

To produce a contour map and 3D geometry for all tests, Golden SURFER Software surveyed the bed topography around the pier. Not only do scour depth contour maps reveal information about the scour process, its dimensions, and its topography, but they can also be used to devise countermeasures for scouring protection under various flow circumstances.

a) 

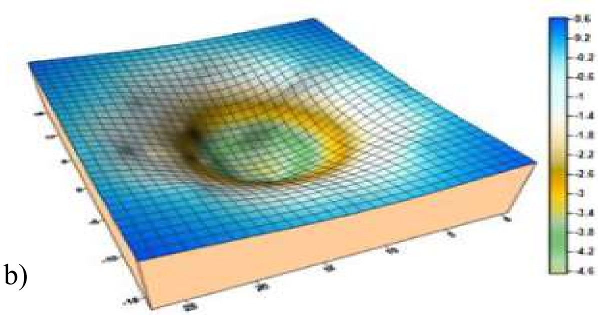
b) 

Figure 9: Scour Hole around Pier without vegetation a) Contour map & b) 3D Geometry.

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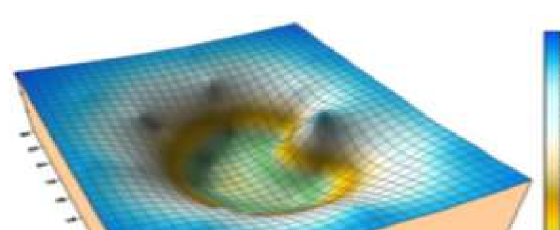

a)

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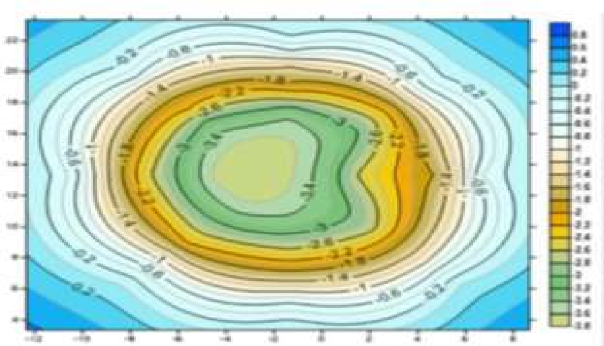
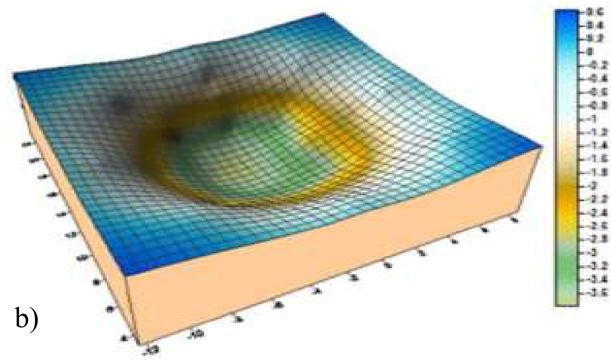
Figure 10: Scour Hole around Pier with flexible vegetation at 0D a) contour map and b) 3D geometry.

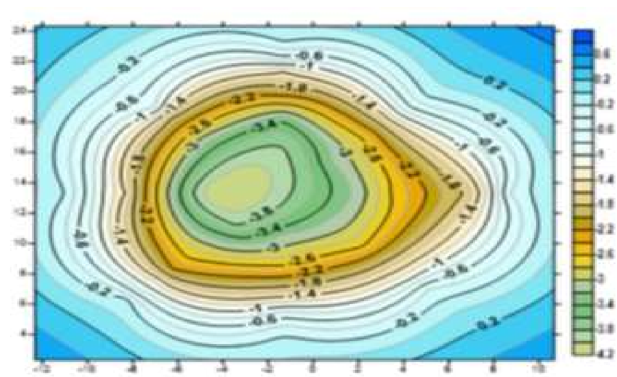


a)



b)

Figure 11: Scour Hole around Pier with flexible vegetation at 4D a) contour map and b) 3D geometry.



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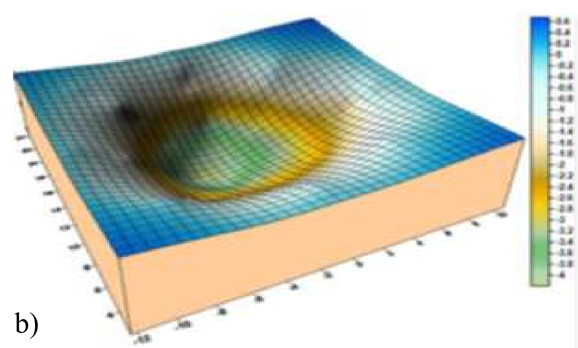

b)

Figure 12: Scour Hole around Pier with flexible vegetation at 6D a) contour map and b) 3D geometry.

5 Conclusion

According to this study, the following findings can be drawn:

1. The scouring depth increases with increasing Froude Number in clear water.

2. When the distance between the pier and vegetation was as close as possible, the scouring around the pier decreased the most.
3. When there is a minimum distance between a floating pier and flexible vegetation, scouring around the pier is reduced by 43.79.0 percent. Vegetation that is more adaptable at distances of four and six dimensions reduces scouring by 38.11% and 34.15%, respectively. Sourcing is reduced by 33.44%, 31.92%, and 27.38% at 0, 4, and 6 degrees.
4. When the distance between the pier and the flexible vegetation is at its smallest or 0D, scouring around the pier decreases by up to 52%. Flexible vegetation also reduces scouring by 44.21 percent and 38.35 percent when used at 4D and 6D distances. When scouring is compared to rigidity in vegetation, flexibility in vegetation reduces it by the most, by 37.44%, 34.92%, and 32.38% for various ds/D ratios (0D, 4D, and 6D).
5. Scours and corrective measures are clearly depicted in maps generated under a variety of flow, sediment, and vegetation conditions.

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6 References

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