The study of mitigation potential hazard of scouring to the substructure of Cipamingkis Bridge

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Abstract. Development of infrastructure planning especially bridges must consider the potential factors of disasters such as earthquakes and scouring. Some bridges in Indonesia have been damaged before they reach the age of the bridge. In general, existing bridges in Indonesia experienced many failures caused by scouring on the abutments and pillars of the bridge. This study aims to identify the types of damage to the substructure of the bridge due to the occurrence of scouring. Cipamingkis bridge at the location of West Java province road becomes the object of the case in this study. Cipamingkis bridge was built in 1986. The bridge is cracked and collapsed due to the collapse of the bridge foundation hit by the flood based on research that has been done by Institute of Water Resources Engineering in 2017 river condition until now still experiencing a decrease of a river bed. Besides due to the tendency of decreasing the bottom of the river, the problems that occur are also the activity of excavation C and scouring due to the bend of the river. The reinforcement system is determined by the value of the condition (rating factor). Some of the things that are recommended from some analysis and evaluation results are to build a new single span bridge with a length of 60 meters, retrofitting existing pillars, and making of abutment safety building using gabion. The pillar reinforcement and bridge replacement system is designed with a safety factor (SF) greater than 2 so that bridges are safe and capable of carrying service load.

1. Introduction
Based on the Bridge Management System database (BMS), Indonesia has 34,327.14 km (89%) of national roads, with a light damage condition of 4242.68 km (11%). The total length of the bridge located on the national road is 316.2 km with the following categories:

- Very good 157 km (49.7%)
- Good 58.9 km (18.6%)
- Light damage 44.2 km (14%)
- Heavily damaged 25.4 km (8%)
- Critical 13.2 km (4.2%)
- Collapsed 17.5 km (5.5%)
Figure 1. Condition of the bridge in Indonesia.

Based on figure 1, in Indonesia, more than 50% of bridge conditions are in a state of minor damage until the conditions collapse. Damage to the bridge can be caused by age factor of the bridge, overload, environment (corrosion), disaster (earthquake, volcano, flood, landslide), and scouring the river [12]. The bridge located at the river location has the potential to damage the lower buildings due to river scouring. One of them is Cipamingkis bridge which is located in Jonggol provincial road area of Bogor regency of West Java and located at coordinates of LS 06º28’45,41” and LU 107º04’29,23”. Cipamingkis bridge was built in 1987 [7, 8]. Figure 2 shows a sketch of the initial condition of the Cipamingkis bridge before it collapsed.

Figure 2. Sketch the initial condition of Cipamingkis bridge before it collapsed.

Based on Bina Marga in 2017 [1], before the collapse of the Cipamingkis bridge consists of 3 (three) spans with a length of 30 meters each, bringing the total length of the bridge 90 meters. The upper structure type of Cipamingkis bridge is the type of prestressing girder. The width of the bridge 10 (ten) meters with lane road 2 (two) directions. In 2017, Cipamingkis bridge structure is broken due to the collapse of the pile foundation caused by the scouring of river flow around the foundation. The Cipamingkis river flows quite swiftly and erodes one of the foundations of the central bridge, causing a shift in the pole or other support [7, 8]. The fracture scheme of the Cipamingkis bridge is shown in figure 3.
Based on the results of the investigation that has been done by Institute of Water Resources, the main cause of Cipamingkis bridge damage is the decline of soil in the foot of the cliff due to degradation of river basin, river cliff sculpting as a result of flow in the outer bend, and decreasing stability of the cliff and bridge structure due to the decrease of river bed and river bank scour. Also, river basin materials dominated by sand and stone into C quarry mining by communities around the river, this can add to the acceleration of basic decline along this river segment [13, 14].

With this, it is necessary to assess the condition of the bridge. In general, bridge damage according to the source of the cause can be classified into 2 (two), namely the damage triggered by material degradation due to internal and external factors and element damage caused by external influences [3]. Damage to the material due to internal factors can occur from the beginning of construction work that is not according to plan; maintenance period is not handled properly, and so on. This damage if left unchecked will cause more damage, even can lead to structural failure [5, 6]. Material damage due to external factors, among others, the exfoliation of concrete blankets due to corrosion, cracks due to excess load, and others while the types of damage that can be classified as elemental damage include the bending of the trunk elements, the sloping of the pillars, the decline of the foundation, the deflections that occur in the girder beyond the deflection, etc. [9].

This study aims to determine the condition of Cipamingkis bridge after the collapse of the pile foundation due to scour. Special examination on pillar elements is done by first determining the foundation damage due to scouring, followed by performing pillar capability analysis including the foundation in carrying a combination of loads that may occur on the bridge. Special inspection of the bridge refers to Pd. T-21-2005-B (Bridge Inventory Inspection Manual) which is a refinement of the Bridge Inspection Manual, Bridge Management System (BMS), 1992 [4]. The bridge load calculation refers to SNI 1725: 2016 concerning the loading of the Bridge.

Investigation under the bridge is a river-related check on the safety of the bridge structure. The components that need to be examined consist of an examination of defects, damage, and condition of the foundation of under bridge structure at water flow area, height measurement, length of foundation element, and base scouring dimension (opening height, width, and scour depth) [10].

2. Methodology

The method used in this research is first to check the condition of existing bridge Cipamingkis after collapsed. Activities carried out include the examination of river cliffs around the bridge, the bridge safety building in the form of building the base of the river, the pillar of the bridge, and the upper structure. Results obtained from the inspection of the condition of the bridge is NK (Rating Factor). The NK value consists of values 0 to 5 with the following description: NK = 0, no damage, generally on newly built bridges, NK = 1, bridges in a slightly damaged state where repairs are done with routine maintenance, NK = 2, bridges in a state of moderate damage, NK = 3, bridges in moderate damage, NK = 4, bridges in critical condition, and NK = 5, bridges in a state of collapse and bridges must be constructed. After the NK value is determined, the next step is to conduct bridge loading analysis concerning the loading standard of SNI 1725: 2016 [2]. Based on the results of analysis and evaluation
will get the value of the remaining capacity of the bridge Cipamingkis which further recommended whether the bridge should be strengthened or made a new bridge. Some retrofit technology alternatives applied to Cipamingkis bridge are discussed in the results of this study.

3. Discussion

On 14 April 2017, there was a decrease on one of the bridge pillars (Cariu direction) due to the failure of the pillar foundation, the decrease caused by the grinding of granular sand material that occurred under the foundation [11]. The magnitude of the decline in the direction of Cariu is 1.5 m, so it is not possible for all types of vehicles to pass. Due to the breakdown of Jonggol-Cariu line causing the breakdown of Jonggol-Cianjur traffic where alternative paths must rotate far enough. The result of examination of Cipamingkis bridge condition after the collapse, shown in table 1.

| No. | Type of Damage Element | Cause | NK | Picture of Bridge Damage |
|-----|------------------------|-------|----|--------------------------|
| 1.  | The main water flow is disrupted | There is a ruin of a damaged security building at the bottom of the bridge | 4 | |
| 2.  | Scour occurred on the river cliff in the direction of Cariu | River water flow | | |
| 3.  | Damage of the bridge safety building in the form of building the base of the river | River water flow | | |
Based on table 1, the condition value for the pillar is NK = 4, meaning that the condition of the pillar descends in a critical condition and required reinforcement, while for the upper structure with NK 5 it is necessary to change the upper structure. The Dinas Bina Marga Propinsi Jabar has done strengthening of the structure under the form of pillars. As for the upper structure of the building is made into two spans with each length of 60 meters and 30 meters as shown in figure 4.

Figure 4. Cipamingkis Bridge after reinforced

From figure 4, the Cipamingkis bridge pillar has been reinforced, and the upper structure is constructed using a 60-meter steel frame type bridge. Detailed retrofitting of the existing pillars on the bridge is shown in figure 5.
The design of steel frame structure spans 60 meters refers to the Guideline no. 07 / BM / 2005 on Standard Steel Construction Upperstructure on Class A and B Bridges [15]. The loading of the bridge refers to SNI 1725: 2016 [2]. The result of structural analysis using software program for steel frame type is shown in figure 6.
Based on the results of the analysis, it is found that the value of bridge capacity Cipamingkis after reinforced greater than the load working with the safety factor (SF> 2). However, the value of the SF safety factor is not directly related to the age of the bridge. If Safety Factor (SF) is increased by 50% to 3 does not mean the age of the bridge increases 50% longer. However, with these safety factors, the bridge will be safe against collapse and workloads.

To anticipate the occurrence of damage due to river scouring Cipamingkis bridge also carried out improvement and retrofitting efforts at the bottom of the river which includes the manufacture of gabion by abutment as shown in figure 7.

The gabion construction as illustrated in figure 7 is intended to prevent the occurrence of river flow scouring to the base of the bridge. Gabion can reduce the pressure of the active soil due to water that can flow through the sidelines of the rock.

4. Conclusion
Cipamingkis bridge that has been aged 30 years have broken due to the decline of the pillar as a result of the scour on the substructure. Based on the visual investigation, the damage is estimated due to the broken link between the floor of the companion wall with the building foundation in the form of bore
This phenomenon occurs because local scours cause the structure is not strong to withstand the forces on the condition of the occurrence of floods. Pillar bridge with critical condition value (NK = 4) must be reinforced. The condition of the upper structure with NK = 5 causes the structure to be rebuilt. The substitution of the upper structure is done by changing two spans into one span with a length of 60 meters. Based on the analysis result, pillar reinforcement system and upper structure change have a safety factor (SF) greater than 2 to enable bridges in a safe condition and able to bear the service load.

Acknowledgments
The author would like to thank Mr. Ir. Deded P. Sjamsudin, M.Eng.Sc. As the Head of Institute Road of Engineering and Mr. Joko Pumomo which has provided support for this research activity. Furthermore, the authors also wish to thank Mr. Wawan Witarnawan, Mr. Abinhot Sihotang, and Mr. Samun Haris as a resource person who has given the science is very helpful to the author.

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