LINK SLAB CAPACITY IN BRIDGES SUPPORTED BY LEAD RUBBER BEARING AND ELASTOMER

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Abstract
Debris accumulation in bridge slab gaps which use expansion joints can restrain deck expansion, causing undesirable forces on floor deck and damage to the structure. In order to avoid the worst possibility that can occur, an alternative using link slab is utilized. The use of link slab at high level seismic force location, requires the Seismic Isolation System on bridge to reduce the seismic force. The application of Seismic Isolation System can be conducted by Lead Rubber Bearing (LRB) type of seismic isolator. This study compares the use of Lead Rubber Bearing (LRB) and elastomer on bridge link slabs against the dimension of the link slab. In this study structural modeling used 2 models: bridges supported by elastomer and bridges supported by LRB with software-made. The link slab analysis approach used were analytical methods or classical methods. Based on results of the analysis, the width of the crack that occured on bridge supported by LRB is 0.218 mm while on the bridge supported by elastomer is 0.269 mm. The use of Lead Rubber Bearing (LRB) type of support will give more advantages to the design of the link slab since it results in smaller crack design criteria.

Keywords : *elastomer, lead rubber bearing, link slab, seismic isolation system*

INTRODUCTION

Most bridges in Indonesia are simple multiple-span, which use a simple support system (Lestari, 2018). A simple support system will cause a gap between the floor deck and the abutment or the inter-floor decks that can be connected by expansion joint (Iman, Sugihardjo, & Sidharta, 2012). The use of expansion joints will result in various problems. Over time, there will be fatigue and decreased strength at the expansion joint, which will then result in the crack forming a small slit that allows rainwater to go through the slit. Therefore, it can lead to corrosion of the girder and its support, which if left unchecked, the damage to expansion joint will cause inconvenience for the bridge user in driving and the high cost of bridge maintenance (Bagus Ansori, 2012). In addition to allowing rainwater to go through the slit debris accumulation that occurs in the gaps can restrain deck expansion, causing undesirable forces on floor deck and damage to the structure (Caner, 1997).

In order to avoid the worst possibility that can occur, an alternative using link slab is utilized. The study of the use of link slab was first introduced by (Caner & Zia, 1998). The further study against link slab design on the composite bridge by taking into account the weakest area on the interface between link slab and floor deck was carried out by (Qian, 2009). (Qian, 2009) recommend adding a shear connector on transition zone to improve the performance of composite multiple simple span bridge. (Irawan, 2012) conducted a study on composite bridge which uses link slab in various ranges with results a recommendation of debonding zone length, optimum link slab thickness and reinforcement to fulfil the required cracking moments, with the link slab material used was Engineered Cementitious Composite.

The study that has been carried out does not take into account the impact of the use of bearing types, while Indonesia is included in a region that is very prone to earthquakes (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2010) and the use of Seismic Isolation System on the bridge is required to reduce the earthquake force that occurs (Alvin Giovanni, 2018). According to (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2010), many bridge constructions in Indonesia implemented Seismic Isolation System. Seismic Isolation System, in general, are isolator bearings such as Hugh Damping Rubber Bearing, Lead Rubber Bearing, or Pendulum Bearing.

This study conducted a capacity of link slab in bridges supported by Lead Rubber Bearing (LRB) and elastomer on cracking effect.

METHODS

The link slab analysis approach adopts studies conducted by (Caner & Zia, 1998), (Qian, 2009), and (Sugihardjo, Piscesa, & Irawan, 2012). Loading analysis in bridges supported by Lead Rubber Bearing (LRB) and elastomer refers to (SNI, 2016a) and (SNI, 2016b). Reinforcement calculation based on (SNI, 2013). Flow chart the research method is illustrated in Figure 1.

Structural Modeling

Structural modeling in two models, bridge supported by Lead Rubber Bearing and bridge supported by elastomer which are performed using software. The bridge structure is a two spans steel box girder with a length 60 m of each spans. The link slab is in the middle gap while the ends of the bridge are expansion joint.

The Lead Rubber Bearing specifications use have a Characteristic Strength of 197 kN and Stiffness of 1.33 kN/mm. the elastomer specification used have dimensions of Ø850x33 mm with vertical load of 850 tons and maximum horizontal load of 39.7 mm.

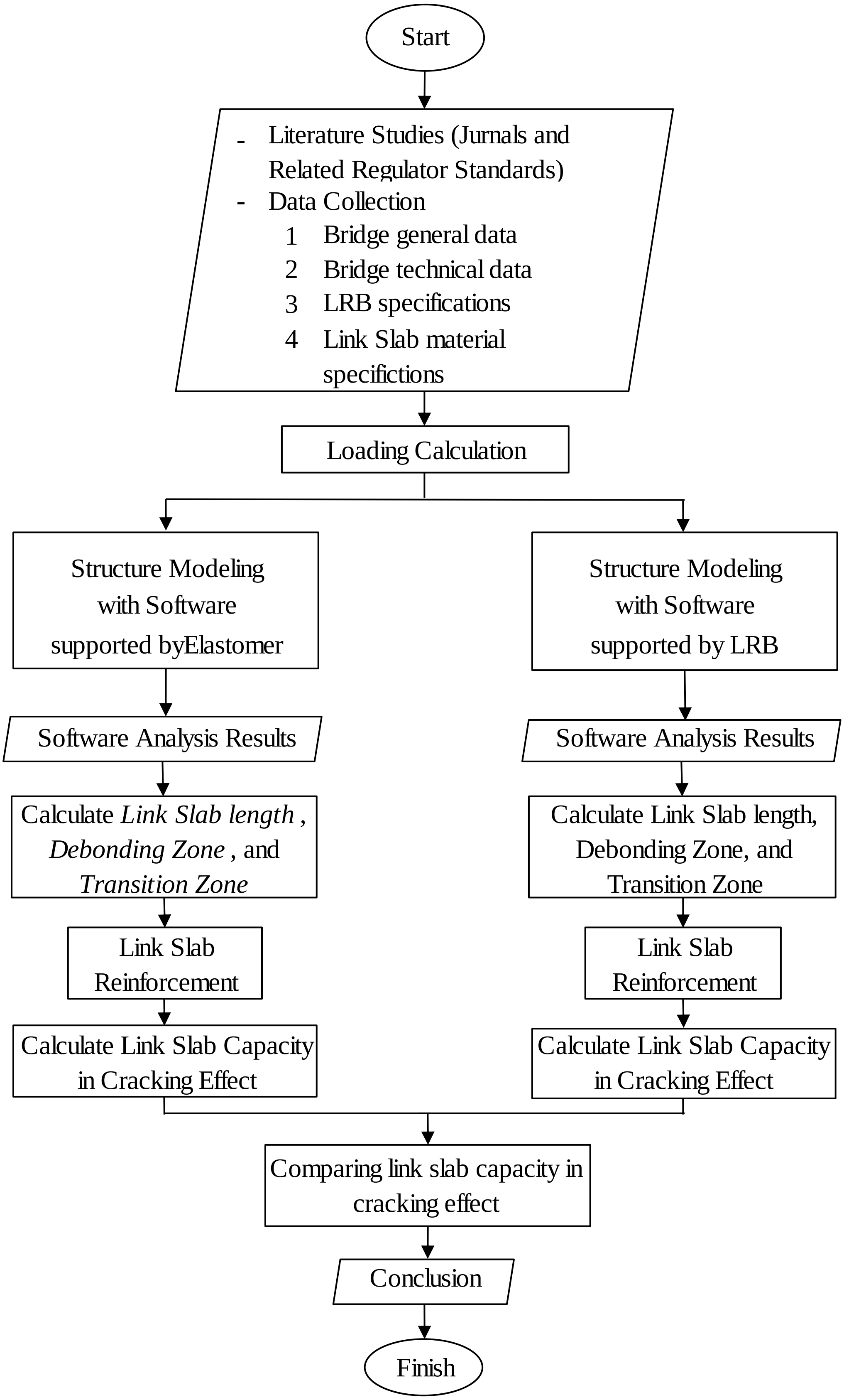

Figure 1. Flow Chart

Classic Methods of Link Slab Analysis

The link slab will be examined using the classical method or analytic method introduced by (Caner & Zia, 1998). The link slab is designed in such a way that it is able to bear the moment due to rotation that occur on the beam which rests on two placement due to live load by calculating the shock factor and super dead load.

Due to shock factor and super dead load, the end rotation of the beams is calculated by Eq.[1].

$$\theta = \frac{PL_{sp}^2}{16E_cI_{sp}} + \frac{qL_{sp}^3}{24E_cI_{sp}} \qquad [1]$$

The bending moment capacity provided by the cross section of the link slab must be strong enough to hold the existing rotation. Based on the energy method, the bending moment on the uncracked link slab is calculated by Eq.[2]

$$M_a = \frac{2E_cI_{ls,g}}{L_{dz}}\theta \qquad [2]$$

The reinforcement ratio and depth of compressed concrete zones that are not cracked can be calculated by Eq.[3].

$$\sigma_s = \frac{\frac{2E_cI_{ls'g}}{L_{dz}}}{A_s\left[d - \frac{1}{3}kd\right]} \le 0.40\sigma_y \qquad [3]$$

Link Slab Capacity in Cracking Effect

The width of the crack that occurs on the link slab based on (224R-01, 2001) is calculated by Eq. (4) with the required crack width in Table 1.

$$w = 0,076 \times \beta \times f_s \times \sqrt[3]{d_cA} \times 10^{-3} \qquad [4]$$

Table 1. Guide to reasonable crack widths, reinforced concrete under service loads

Exposure condition	Crack width	
	in.	mm
Dry air or protective membrane	0.016	0.41
Humidity, moist air, soil	0.012	0.30
Deicing chemicals	0.007	0.18
Seawater and seawater spray, wetting and drying	0.006	0.15
Water-retaining structure	0.004	0.10

RESULTS AND DISCUSSION

The analysis results of the link slab in a 60 m spans bridge obtained a length of debonding zone is 7.2 m with a ratio of 12%. The length of the transition zone is 2.5% of the span, which is 1.5 m. The total length of the link slab is 10.2 m.

The link slab capacity against to rotate due to living load in the cracking effect is presented in Table 2.

Table 2. Crack width against end rotation due to live load

	Rotation	Crack width
	(rad)	(mm)
LRB	0,00523	0,112
Elastomer	0,00501	0,107

The maximum rotation obtained is 0.00523 rad, higher than the rotation obtained by (Sugihardjo et al., 2012) is 0.00374 rad. It can occur since the span length in this study, 60 m, which is twice as the span length in the study by (Sugihardjo et al., 2012) is 30 m.

The link slab capacity against to bending moment due to seismic force in the cracking effect is presented in Table 3.

Table 3. Crack width against bending moment due to seismic force

	Bending moment	Crack width
	(kNm)	(mm)
LRB	2392,549	0,218
Elastomer	2949,453	0,269

The crack width that occurs still fulfil the required crack width which is 0.300 mm; this confirms in the graph in Figure 2.

Figure 2. Comparison of crack width that occurs with required crack

Due to live load, the width crack that occurs on link slab in bridge supported by Lead Rubber Bearing (LRB) is 0.112 mm, higher than the width crack that occurs on link slab in bridge supported by elastomer which is 0.107 mm. The difference that occurs is not too significant, that is 0.005 mm. It can occur due to the characteristic of the Lead Rubber Bearing (LRB) is more flexible in the horizontal direction, so that it has more significant displacement that conduced end rotation and width crack that occur to be higher.

Due to seismic force, the width cracks that the width crack that occurs on link slab in bridge supported by

Lead Rubber Bearing (LRB) is 0.218 mm, smaller than the width crack that occurs on link slab in bridge supported by elastomer which is 0.269 mm. The difference that occurs is 0.051 mm. It is happened due to the characteristic of the Lead Rubber Bearing (LRB) that can reduce seismic force that occurs on the bridge structure, to produced smaller seismic force design, which has been proven by (Alvin Giovanni, 2018).

CONCLUSION

The conclusion based on research and analysis results that have been carried out that the type of bearing gives a difference in crack width that occurs, so there is a difference between the two. The crack width difference due to living load and seismic force on the link slab in bridges supported by Lead Rubber Bearing (LRB) and elastomer is 0.005 mm and 0.051 mm. It is necessary to do further study of the width crack that occurs whether it gives an effect on the performance of the link slab in bridge.

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