Response Spectrum Analysis of RC Bridge using Indonesian Earthquake Map 2017: Case Study - Bonak RC Bridge, TTU, NTT, Indonesia

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Keywords: Respons Spectrum, Earthquake Map, RC Bridges.

Abstract: The use of the 2017 Indonesia Earthquake Map has not been massively used by the relevant stakeholders. Even the regulations SNI 2833 : 2016 regarded Indonesia Earthquake Map 2012. Updating maping recently must be followed by newly regulations. However, structural designed must accomodating newly Indonesia Earthquake based on SNI 2833 : 2016. This structural planning made significantly changes of earthquake loads. This reseacrh did newly Earthquake Map to Bonak Bridge with new respons analysis using SAP 2000 as Program analysis. Design to the structure including plate, beam and abutment. This research showed changes of earthquake loads and resulting changed of dimensions and steel reinforcement on structural system.

1 INTRODUCTION

The use of the 2017 Indonesia Earthquake Map (Asrurifak, 2017), has not been massively used by the relevant stakeholders. Even the regulation on the use of Earthquake maps has not been updated, which still uses the old Earthquake map (Umum, 2010). It can be seen in the latest regulation, SNI 2833: 2016 (2016, 2016)], that is appeared in 2016. As is known, Indonesia is located in an area of tectonic and volcanic earthquakes which is meeting of three tectonic plates, there are the Indo-Australian Plate, the Eurasian Plate and the Pacific Plate (Mallisa, 2010). This condition will affecting all of infrastructure designs. The development of research on earthquake conditions is inversely proportional with the newly regulations. Therefore the subject of this research is given describes of influeting newly Indonesian Eartquake Map to the bridge behaviors. It is considerable impacted to the earthquake loads and is possible changes dimensions and steel reinforcement of the structural designs.

2 LITERATURE RIVIEW

A. Indonesian Earthquake Maping

According to the design of structural requirement, Indonesian Government through "Badan Standarisasi Nasional (BSN)" produced regulations of structural design. Started from design, loading, and structural analysis. One of the regulations is implementation of earthquake loads to structural analysis. Therefore, it is necessary to have a common perception and understanding in field of structural planning. Similarity of designers perceptions have seen in Indonesian Earthquake Map. The newly Indonesian Earthquake Map, as in (Asrurifak, 2017) however it is aplicated according to SNI 2833 : 2016, as in (2016, 2016) has not been accomodated of newly regulations.

B. Seismic Analyses

Modelling on bridges seismic analysis was highly produce in a lot of bridges research. A three-dimensionan model of bridges was developed by using SAP 2000 in many parrameters such as changing the superstructure mass, changing the concrete compressive strength, changing the plastic hinge length, and damping results descibes of briges seismic behaviors (Gao, 2018). A type of irregular-continuous bridges and prediction of displacement based seismic design was resulted that pushover curve

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resulted by analysis of capacity of spectrum (Li, Xiang, Wei, Yan, & Xia, 2020). A seismic isolators can effective to stiffness and damping compared to the multi-mode response spectrum analysis (MMRSA). The isolators incuded laminated elastomeric bearings, elasto-plastic devices, and fiction pendulums (Simon & Vigh, 2013). The parameter of respons spectrum which is describe in 2017 Indonesia Earthquake Map it shown in Fig. 1, as in (Asrurifak, 2017)

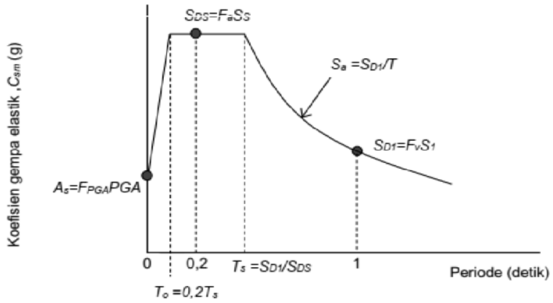


Figure 1: Respons spectrum graph parameter.

3 MODELING OF BRIDGE STRUCTURE

Modelling has used by SAP 2000 Program. A three-dimensional model incuding the shape of bridges, loads, and structure analysis done in this research. For earthquake loads used respons spectrum analysis from newly Indonesia Earthquake Map was appeared in 2017.

C. Materials Spesification

A bridge planned with the spesifications i.e. age of bridge 50 years; length 15 m; trotoar way 2x1 m; concrete compressive strength (fc') 33 MPa; and tensile steel reinforcement 400 MPa.

D. Regulations

The newly indonesian regulations of bridges design was used in this research to established of legal standing. Regulations such as bridges loads regulation SNI 1725 : 2015 [8]; Bridges planned for resisted eartquake behaviors SNI 2833 : 2016.

E. Bridge Modelling

A bridge planned named Bonak Bridge is RC bridge and located in TTU, Indonesia. With long-span model have been seen in Fig. 2 and short-span model have been seen in Fig. 3.

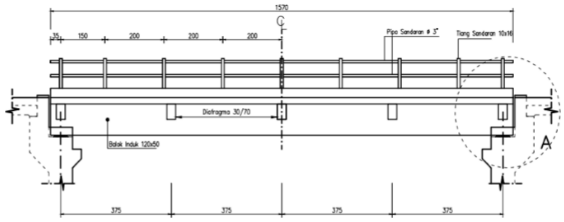


Figure 2: Long-span model.

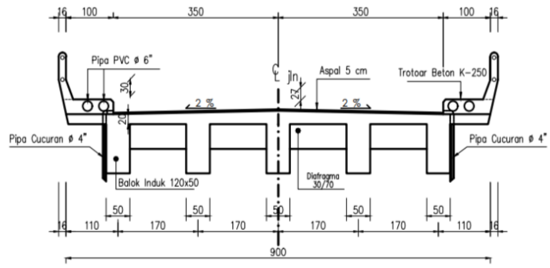


Figure 3: Short-span model.

A SAP 2000 bridge model have been seen in Fig, 4. It has inputs loaded from Dead Load, Live Load, Moving Vehicle Loads and Earthquake Loads.

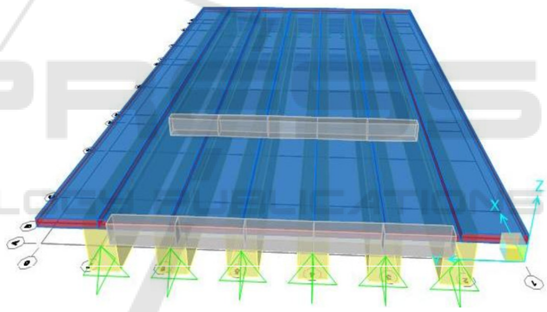
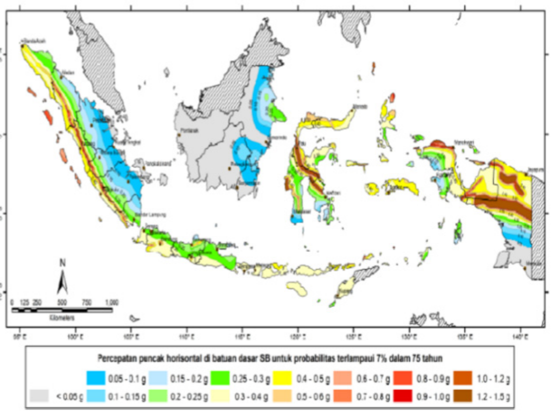


Figure 4: A three-dimensional model.

4 RESULTS AND DISCUSSIONS

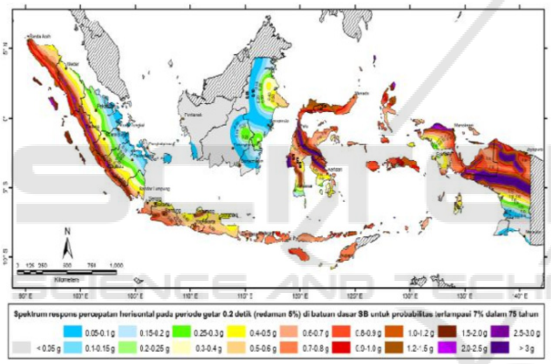
F. Earthquake Loads

- PGA grades with probabilty 7% in 75 years. With range 0.3 – 0.4 g. And the grade in the location of bridge is 0.35 g. PGA map it shown in Fig. 5.



Figue 5: PGA grades of Indonesian Earthquake Map.

- Ss grades (respon spektra 0.2 second) on bed rock condition with probabilty 7% in 75 years with range 0.7 – 0.8 g. And Ss grade in the location of bridge is 0.75 g. Ss map it shown in Fig. 6.



Figue 6: Ss grades of Indonesian Earthquake Map.

- S_1 grades (respon spektra 1 second) on bed rock condition with probabilty 7% in 75 years with range 0.25 – 0.3 g. And S_1 grade in the location of bridge is 0.27 g. S_1 map it shown in Fig. 7.

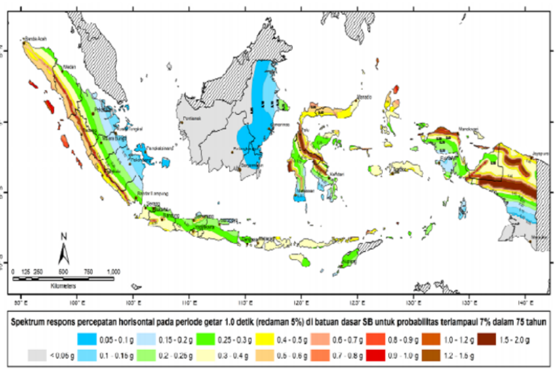


Figure 7: S_1 grades of Indonesian Earthquake Map.

- Based on the earthquake map, the analysis of respons spectrum can obtained the period and the acceleration and it shown on Table 1. And the graph of Respons Spectrum it shown in Fig 8

Table 1: Period and Acceleration of Respons Spectrum.

Number	Respons Spectrum Data	
	Period	***Acceleration***
1	0	0.4025
2	0.1111	0.9
3	0.2222	0.9
4	0.3333	0.9
5	0.4444	0.9
6	0.5558	0.9
7	0.6667	0.828
8	0.7778	0.710
9	0.8889	0.621
10	1.0000	0.552
11	1.1111	0.497
12	1.2222	0.452
13	1.3333	0.414
14	1.4444	0.382
15	1.5556	0.355
16	1.6667	0.331

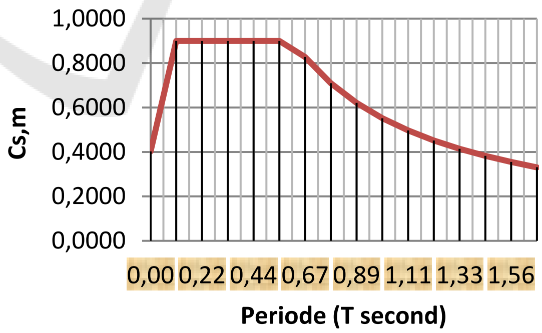


Figure 8: Respons spectrum graph.

G. *Bridge Structure Design*

- Design of trototoar way used steel reinforment at longitudinal bars is 4 D 10; then traversal bars used ϕ 8 – 100. As a part with trotoar way, cantilever slab was design used longitudinal bars D13 – 220; then transversal bars used ϕ10

– 260. The design of trotoar way and cantilever slab shown in Fig. 9

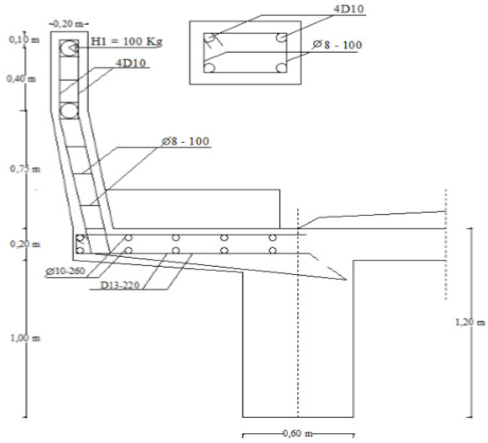


Figure 9: Design of trotoar way and cantilever slab.

- Bridge slab has 200 mm of thickness and was used two level steel reinforment on top level and bottom level. At top level used longitudinal bars D13 – 180 and trasversal bars ϕ10 – 200. And bottom level used longitudinal bars D13 – 220 and trasversal bars ϕ10 – 200. Bridge slab detailed shown in Fig. 10.

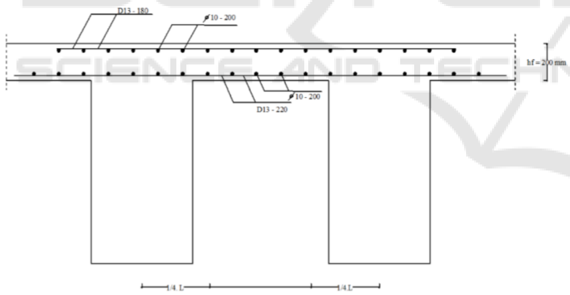


Figure 10: Bridge slab detailing.

- Diafragma beams as a transversal beams of bridge structure have a major functional to avoid deeply deflection of longitudinal beams and to increase the stifness of bridges. A 300 x 500 mm of diafragma beam dimensions was used at top steel bars 2D19 and bottom steel bars 4D19. And traversal steel bars used ϕ13 – 100. The detailed of diafragma beams shown in Fig. 11.

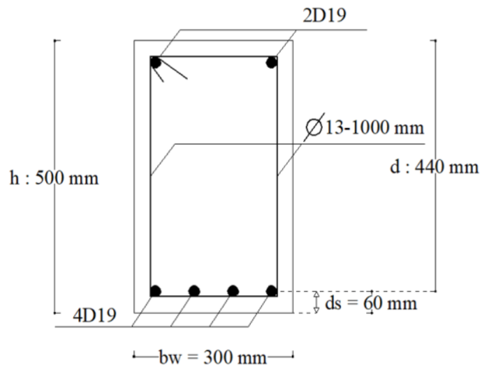


Figure 11: Detailing of diafragma beams.

- Main girders as a longitudinal beams which are resisted to diafragma beams and bridges plate. This main girders with dimensions 600 x 1200 mm was used 15D32 as steel reinforment at longitudinal bars and used ϕ13 – 140 at trasversal steel bars. The detailed of mai girdesrs shown in Fig. 12.

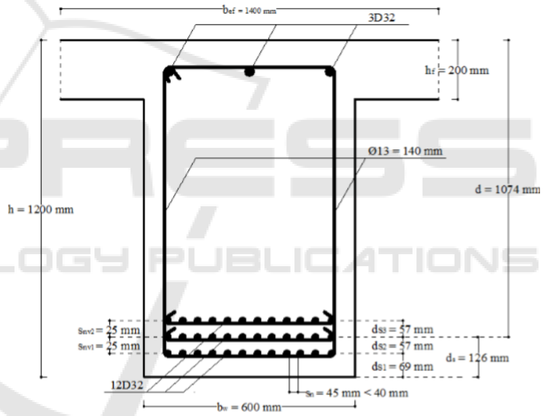


Figure 12: Detailing of main girders.

- Detailing of head abutment and body of abutment are shown in Fig. 13 and Fig. 14.

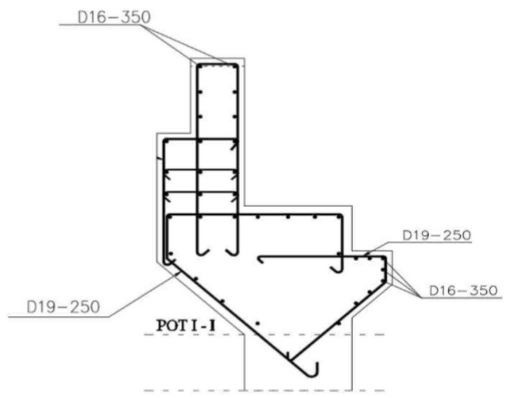


Figure 13: Detailing of head abutment.

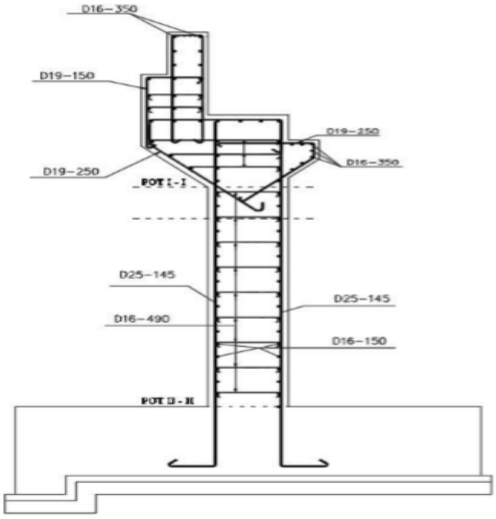


Figure 14: Detailing of body abutment.

5 CONCLUSIONS

The conclusions of this research is describing a three-dimensional bridge model with SAP 2000 program and answered behaviors of structure when use others earthquake loads in Indonesian teritory. The main conclusions from this study are summarized as follows :

- Newly updating of earthquake map can changes earthquake loads
- Changing in earthquake loads can possible changes dimensions and steel reinforment
- Updating earthquake map must followed by the newly regulations

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