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Concrete Damage Risk Rating Examination to Existing Buildings Henny Wiyanto, Reagen Yocom, and Glen Thenaka Abstract Building assessment is a measure that has to be taken by building management to the existing building or operational building because it is very critical to the safety and comfort of the building's users. One of the commonly used building assessment methods is visual assessment. Visual assessment is a non-destructive concrete assessment that is done to identify and define different concrete conditions, which can be seen during its' lifetime. Concrete damage assessment is done to estimate the risk rating of concrete damage against the existing building structures. The risk assessment process is done in three steps: risk identification, risk analysis, and risk evaluation. There are three risk ratings: low, medium, and high. Risk rating examination of the existing building is determined based on the concrete damage type and condition rating value on the building structure element, concrete damage frequency on the building, and critical weight of the building structure element. Risk rating examination results of concrete damage are used to determine priorities building structure element repair. Keywords Concrete damage Risk rating Visual assessment An existing building 1 Introduction Concrete damage on reinforced concrete structures cannot be avoided. This is caused by a lot of factors, one of which is poor construction implementation and low material quality. As time goes on, existing building usage also predominantly affects H. Wiyanto (&) R. Yocom G. Thenaka Department of Civil Engineering, Faculty of Engineering, UniversitasTarumanagara, Jakarta 11440, Indonesia e-mail: hennyw@ft.untar.ac.id © The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2022 523 H. A. Lie et al. (eds.), Proceedings of the Second International Conference of Construction, Infrastructure, and Materials, Lecture Notes in Civil Engineering 216, https://doi.org/10.1007/978-981-16-7949-0_47 the building's condition. Improper building usage will cause physical damage to the building itself. Building usage is the act of using a building according to its' intended function [1, 2]. Oftentimes, building management or owners neglect the building's condition and do not perform proper building assessments because of cost factors. Even though building condition assessment can lower the risk of further building damage, which severely endangers the building's users, that is very risky towards the safety and comfort of building users. Building condition assessment is done with assessment towards concrete damage condition, which is done to estimate the risk of structural and non-structural damage in order to perform building reparation. According to ISO 31000:2009 [3], the risk assessment process is done with three steps: risk identification, risk analysis, and risk evaluation. The search for references about building condition rating has been performed from multiple sources, which are [4–21]. Based on that problem, the risk assessment needs to be done towards con- crete damage to the existing building structure. 2 Method Concrete damage risk rating examination to the existing building is performed in the following steps. 2.1 Risk Identification Concrete damage risk identification is a step to identify the amount and location of concrete damage on a building structure that can lower a building's functionality. Concrete damage location is divided into four structure elements: shear wall, col- umn, beam, and slab. Concrete damage identification is made using visual assessment. 2.2 Risk Analysis Concrete damage risk analysis is a step done to assess risk towards the concrete damage types that have already been identified according to the damage amount and location. Damage location affects the structure element critical weight. The amount of concrete damage describes the damage frequency of a damage type on the building. Concrete damage risk assessment is done with the following steps: Determining Concrete Damage Type and Condition Rating Based on concrete damage type and condition rating search results for building from multiple Table 1 Concrete damage type and condition rating [20] No. Damage type Condition rating 1 Craze crack 2.54 2 Mapping crack 3.00 3 Random cracks 3.36 4 Delamination 3.25 5 Pop-outs (small) 2.75 6 Pop-outs (medium) 2.93 7 Pop-outs (large) 3.36 8 Scaling (light) 2.53 9 Scaling (medium) 2.88 10 Scaling (severe) 3.13 11 Scaling (very severe) 3.47 12 Spall (small) 2.86 13 Spall (large) 3.40 references, namely [4–18, 22–24], concrete damage type and condition rating are determined for existing buildings in Indonesia by Wiyanto et al. in [19, 20] as in Table 1. Criteria and measures for each concrete damage condition rating are as shown in Table 2. Determining Concrete Damage Frequency Concrete damage frequency is determined based on the amount of damage done to the building. Damage fre- quency is determined using three criteria based on Table 3. Determining Concrete Damage Risk Rating The concrete damage risk rating is determined based on concrete damage condition rating and concrete damage fre- quency using Eq. 1. Table 2 Criteria and measure for each concrete damage condition rating [19, 20] Condition rating Description Criteria Measure 1 Very good No damage No repairs are needed, but still needs maintenance 2 Good Light damage Needs reparation in the field of routine maintenance 3 Medium Medium damage Immediately needs further assessment or testing and or reparation 4 Bad Heavy damage Needs structure strengthening or weight reduction 5 Very bad Very heavy/ critical damage It cannot be maintained or demolished Table 3 Damage concrete frequency Rating Frequency 1 Rare (R) 2 Moderate (M) 3 Common (C) P RRse ¼ CI fcd ð1Þ ncd RRse is the concrete damage risk level of each structure element, CI is the concrete damage condition rating, fcd is the concrete damage frequency, and ncd is the amount of damage done. Determining Building Damage Risk Rating Building damage risk rating is determined based on concrete damage risk rating and damage location. Concrete damage location is divided into four structure elements, each with its own critical weight. Based on structure element critical weight search results for buildings from multiple references, namely [9–13, 21], structure element critical weight for existing buildings is determined by Wiyanto et al. in [19, 20], such as in Table 4. Building damage risk rating is determined using Eq. 2. P SR ¼ RPRse wse wse ð2Þ SR is the building's damage risk rating, and wse is the structure element critical weight, as shown in Table 4. Based on the building's damage risk rating value, concrete damage risk rating can be described by referring to Table 5. 2.3 Risk Evaluation Concrete damage risk evaluation is a step used to determine priority towards risk on a building so that further measures can be taken according to the risk rating. This is done in order to maintain and repair a building to increase safety and comfort for the building's users. Table 4 Structure element critical weight [19, 20] Structure element Critical weight Shear wall (SW) 1 Column (C) 1 Beam (B) 0.7 Slab (S) 0.5 Table 5 Concrete damage risk rating Rating Risk Criteria 1 Low S < 5 2 Medium 5 S < 10 3 High 10 S 15 3 Results and Discussion Assessment is applied to an existing high-rise building. Concrete damage risk rating assessment is done based on visual assessment on a 13-year-old 13-story parking building. Assessment is initiated with damage type examination, which is done on each building structure element, and condition rating of each damage. The results of concrete damage examination and condition rating assessment can be seen in Table 6. Table 6 Parking building concrete damage type and condition rating No. Damage type Element Condition rating 1 Craze crack C 2.54 2 Mapping crack S 3.00 3 Scaling (very severe) B 3.47 4 Spall (small) B 2.86 5 Spall (small) SW 2.86 6 Random Cracks S 3.36 7 Scaling (light) S 2.53 8 Scaling (severe) S 3.13 9 Scaling (light) S 2.53 10 Random cracks C 3.36 11 Spall (large) C 3.40 12 Pop-outs (medium) B 2.93 13 Scaling (medium) B 2.88 14 Spall (small) C 2.86 15 Spall (small) S 2.86 16 Spall (small) B 2.86 17 Spall (small) B 2.86 18 Scaling (very severe) B 3.47 19 Scaling (light) C 2.53 20 Spall (small) C 2.86 21 Spall (small) B 2.86 22 Scaling (severe) B 3.13 23 Random cracks S 3.36 24 Spall (small) B 2.86 25 Spall (small) B 2.86 26 Delamination C 3.25 27 Scaling (very severe) C 3.47 28 Random cracks B 3.36 Table 7 Parking building concrete damage frequency No. Damage type Frequency Rating 1 Craze crack R 1 2 Mapping crack R 1 3 Scaling (very severe) R 1 4 Spall (small) C 3 5 Random cracks R 1 6 Scaling (severe) R 1 7 Scaling (light) R 1 8 Spall (large) R 1 9 Pop-outs (medium) R 1 10 Scaling (medium) R 1 11 Delamination R 1 Based on the damage types that are identified in the visual assessment, concrete damage frequency on that building is determined. Damage frequency from each damage can be seen in Table 7. Concrete damage risk rating of each structural element is determined based on concrete condition rating assessment results and the concrete damage frequency on the building. The risk rating assessment of each structural element can be seen in Table 8. The parking building's structural damage risk rating is determined based on the concrete damage risk rating of each structure element, with the structure element's critical weight. Parking building structure damage risk rating assessment can be seen in Table 9. Building damage risk rating is determined referring to Table 5. A risk rating of 5.95 shows that the parking building's concrete damage risk rating is 2, which is the medium rating. Medium risk means that further examination and reparation mea- sures need to be done on the building. From the risk rating, it can be shown that the shear wall and beam elements are the highest priority for examination and repa- ration measures. Table 8 Parking building concrete damage risk rating No. Damage type Condition rating Frequency rating Risk rating Shear wall 1 Spall (small) 2.86 3 8.58 RRsw 8.58 Column 1 Craze crack 2.54 1 2.54 2 Random cracks 3.36 1 3.36 3 Spall (large) 3.40 1 3.40 4 Spall (small) 2.86 3 8.58 5 Scaling (light) 2.53 1 2.53 6 Spall (small) 2.86 3 8.58 7 Delamination 3.25 1 3.25 8 Scaling (very severe) 3.47 1 RRcl 3.47 4.46 Beam 1 Scaling (very severe) 3.47 1 3.47 2 Spall (small) 2.86 3 8.58 3 Pop-outs (medium) 2.93 1 2.93 4 Scaling (medium) 2.88 1 2.88 5 Spall (small) 2.86 3 8.58 6 Spall (small) 2.86 3 8.58 7 Scaling (very severe) 3.47 1 3.47 8 Spall (small) 2.86 3 8.58 9 Scaling (severe) 3.13 1 3.13 10 Spall (small) 2.86 3 8.58 11 Spall (small) 2.86 3 8.58 12 Random cracks 3.36 1 RRbm 3.36 5.89 Slab 1 Mapping crack 3.00 1 3.00 2 Random cracks 3.36 1 3.36 3 Scaling (light) 2.53 1 2.53 4 Scaling (severe) 3.13 1 3.13 5 Scaling (light) 2.53 1 2.53 6 Spall (small) 2.86 3 8.58 7 Random cracks 3.36 1 RRsl 3.36 3.78 Table 9 Parking building damage risk rating No. Structure element Risk rating Critical weight RRse wse 1 Shear Wall 8.58 1 8.58 2 Column 4.46 1 4.46 3 Beam 5.89 0.7 4.12 4 Slab P3.78 0.5 1.89 3.2 19.05 SR 5.95 4 Conclusion The building damage risk rating resulted from damage type assessment based on visual to existing buildings can be used to describe risk criteria. The risk rating value can describe concrete damage risk towards building structure, so it can be used to determine priorities for the measures that will be done to the building. These measures can be in the form of building maintenance, destructive testing, and building reparation. This risk rating assessment method can be applied to existing buildings in order to determine building structure element reparation priority. References

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