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Critical Index Determination Method on Visual Assessment of Concrete Damage for Buildings

Critical Index Determination Method on Visual Assessment of Concrete Damage for Buildings

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Abstract. Visual Assessment is an initial assessment of the concrete condition of a building (non-destructive test). There are multiple types of concrete damage, so it is necessary to identify the type of damage that could be assessed visually. To find out the critical level of each type of concrete damage, a Critical Index method is needed. Based on the analysis sets, the range of Critical Index is 0 to 4. The value of 0 indicates a very good Critical Index of concrete, whereas the value of 4 shows a very bad Critical Index of concrete. The value of 0 can be interpreted as the concrete is not damaged and 4 means that the concrete is not acceptable. Determination of Critical Index method can be used to determine the Critical Index of any type of damage to the concrete in a building and to determine the level of damage according to each type of damage.
Keywords: Critical Indeks, Concrete Damage, Visual Assessment.

1. Introduction

Concrete is one of the main components forming a building structure consisting of shearwall, columns, beams, and slab. As time and natural condition go by, a building can suffer damage on parts of the building structure. To be able to find out the concrete conditions in reinforced concrete construction, buildings are evaluated using the Visual Assessment method. Visual Assessment is a non-destructive assessment method of the concrete condition of a building, so this method can be first step to assess the condition of damage to concrete structures. Based on these needs, it is necessary to identify the type of damage to the concrete structure visually and set Critical Index for each type of damage. The method of determining the Critical Index on the damage to concrete structure of this building is expected to be a reference for conducting this assessment.

2. Method

Determination of the Critical Index is carried out with the following steps:

2.1. Identification of damage type

Identification of types of concrete damage visually taken from various literature. The literature consists of national and international regulations and the results of previous similar studies published at the international level [1-5], [7].

2.2. Determination of Critical Index

Determination of the Critical Index will be carried out on all types of concrete damage that have been identified. Determination will be done with the following steps:

2.2.1. Data Collection

Data collection was carried out by assessing each type of concrete damage through a questionnaire. Assessments are obtained based on expert opinion consisting structure consultants, lecturer, research scientist, and an experienced contractor in the field of reinforced concrete construction. The range of Critical Index is 0 to 4. The value of 0 indicates a very good Critical Index of concrete, whereas the value of 4 shows a very bad Critical Index of concrete. The value of 0 can be interpreted that the concrete is not damaged and 4 means that the concrete is not acceptable. Identification of Critical Index of Concrete Damage can be seen as in Table 1.

Tabel 1. Identification of Critical Index of Concrete Damage

Critical Index	Criteria	Identification of Damage
0	Very Good	No action is needed
1	Good	Acceptable, No need to repair
2	Moderate	Not acceptable, Repair needed
3	Poor	Not acceptable, Needs immediate repair
4	Very Poor	Cannot be maintained

2.2.2. Data Processing

Data processing intends to determine the Critical Index for each type of concrete damage that determined using the Relative Important Index method. To find out the comparison of one type of damage with other types of damage will be used the Analytical Hierarchy Processing method [6].

3. Results and Discussion

This study was applied to buildings with reinforced concrete construction. Visual Assessment is an assessment using the eye senses to determine the type of damage that occurs in a concrete structure. Damage that occurs in the concrete structure is identified and the Critical Index for each type of concrete damage determined by following formula:

$$CI_{Tn} = \sum_{t=0}^{4} \left(\frac{t.Ct}{N}\right)$$

Explanation:
CI_{Tn} : Critical Index Damage
C_t : Number of responses at Critical Index Level
t : Critical Index Level
N : Total of respondence

Damage is grouped according to structural elements, namely shearwall, column, beam, and slab. Each structural element has a different critical weight namely cw_{sh}, cw_c, cw_b, and cw_s.
It is probable that in some parts of the structure occur more than one type of damage. If there is more than one type of damage in the same location, it is necessary to know the level of damage between the type of damage one with the other types of damage. So the level of damage in that location can be determined. This can be seen as in Table 2 dan Table 3.

Table 2. Comparison Matrix of Concrete Damage

Damage Type (T)	**T_1**	**T_2**	**T_n**
T_1	CI_{T11}	CI_{T12}	CI_{T1n}
T_2	CI_{T21}	CI_{T22}	CI_{T2n}
T_n	CI_{Tn1}	CI_{Tn2}	CI_{Tnn}
Total	**CIT_{T1}**	**CIT_{T2}**	**CIT_{Tn}**

Table 2 portrays the comparison between one type of damage and the others, so it can be determined that Critical Index Total Damage is determined by the following formula:

$$CI_{Tnn} = \frac{CI_{Tn}}{CI_{Tn}}$$

$$CIT_{Tn} = \sum_{T=1}^{n} CI_{Tnn}$$

Explanation:
CI_{Tnn} : Critical Index Damage n against other Damage
CIT_{Tn} : Critical Index Total Damage

Table 3. Normalization of Comparison Matrix of Concrete Damage

Type (T)	**T_1**	**T_2**	**T_n**	**Average**
T_1	A_{T11}	A_{T12}	A_{T1n}	**A_{T1}**
T_2	A_{T21}	A_{T22}	A_{T2n}	**A_{T2}**
T_n	A_{Tn1}	A_{Tn2}	A_{Tnn}	**A_{Tn}**

Based on the table above, the level of damage between types of damage with one other damage is determined by the following formula:

$$A_{Tnn} = \frac{CI_{Tnn}}{CIT_{Tn}}$$

$$A_{Tn} = \frac{\sum_{T=1}^{n} A_{Tnn}}{n}$$

Explanation:
A_{Tnn} : Weight Critical Index Damage

A_{Tn} : Average Weight Critical Index Damage

4. Conclusion

Based on the analysis, it could be concluded that the method of determining the Critical Index could be used to determine the Critical Index of all types of damage of the concrete in a building and to know the level of damage for each type of damage. So when more than one type of damage happens in one location, the level of damage can be determined.

5. References

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Determination of Critical Index Determination of the Critical Index will be carried out on all types of concrete damage that have been identified. Determination will be done with the following steps: Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI. Published under licence by IOP Publishing Ltd 1 2.2.1. Data Collection Data collection was carried out by assessing each type of concrete damage through a questionnaire. Assessments are obtained based on expert opinion consisting structure consultants, lecturer, research scientist, and an experienced contractor in the field of reinforced concrete construction. The range of Critical Index is 0 to 4. The value of 0 indicates a very good Critical Index of concrete, whereas the value of 4 shows a very bad Critical Index of concrete. The value of 0 can be interpreted that the concrete is not damaged and 4 means that the concrete is not acceptable. Identification of Critical Index of Concrete Damage can be seen as in Table 1. Tabel 1. Identification of Critical Index of Concrete Damage Critical Index Criteria Identification of Damage 0 No action is needed Very Good 1 Good 2 Moderate 3 Poor 4 Very Poor Acceptable, No need to repair Not acceptable, Repair needed Not acceptable, Needs immediate repair Cannot be maintained 2.2.2. Data Processing Data processing intends to determine the Critical Index for each type of concrete damage that determined using the Relative Important Index method. To find out the comparison of one type of damage with other types of damage will be used the Analytical Hierarchy Processing method [6]. 3. Results and Discussion This study was applied to buildings with reinforced concrete construction. Visual Assessment is an assessment using the eye senses to determine the type of damage that occurs in a concrete structure. Damage that occurs in the concrete structure is identified and the Critical Index for each type of concrete damage determined by following formula: CITn = ? (t.Ct 4 t=0 N) Explanation: CITn : Critical Index Damage Ct : Number of responses at Critical Index Level t : Critical Index Level N : Total of respondence Damage is grouped according to structural elements, namely shearwall, column, beam, and slab. Each structural element has a different critical weight namely cwsh, cwc, cwb, and cws. It is probable that in some parts of the structure occur more than one type of damage. If there is more than one type of damage in the same location, it is necessary to know the level of damage between the type of damage one with the other types of damage. So the level of damage in that location can be determined. This can be seen as in Table 2 dan Table 3. Table 2. Comparison Matrix of Concrete Damage Damage Type (T) T1 T2 Tn T1 CIT11 T2 CIT21 Tn CITn1 CIT12 CIT1n CIT22 CIT2n CITn2 CITnn Total CITT1 CITT2 CITTn Table 2 portrays the comparison between one type of damage and the others, so it can be determined that Critical Index Total Damage is determined by the following formula: CI Tn CITnn = CI Tn CITTn = ? CI Tnn n T =1 Explanation: CITnn : Critical Index Damage n against other Damage CITTn : Critical Index Total Damage Table 3. Normalization of Comparison Matrix of Concrete Damage Type (T) T1 T2 Tn Average T1 T2 Tn AT11 AT12 AT21 AT22 ATn1 ATn2 AT1n AT1 AT2n AT2 ATnn ATn Based on the table above, the level of damage between types of damage with one other damage is determined by the following formula: ATnn = CI Tnn CITTn n ATn = T =1 ? ATnn n Explanation: ATnn : Weight Critical Index Damage ATn : Average Weight Critical Index Damage 4. Conclusion Based on the analysis, it could be concluded that the method of determining the Critical Index could be used to determine the Critical Index of all types of damage of the concrete in a building and to know the level of damage for each type of damage. So when more than one type of damage happens in one location, the level of damage can be determined. 5. References [1] American Concrete Institute (ACI) Committee 201. (2008). "Guide for conducting a visual inspection of concrete in service". ACI 201.1R-08, Farmington Hills, MI. [2] American Society of Civil Engineers (ASCE). (2000). "Guideline for Structural Condition Assessment of Existing Buildings". SEI/ASCE 11-99, Reston, Virginia 20191- 4400. [3] Jain, K.K. and Bhattacherjee, B. (2012). "Application of Fuzzy Concepts to the Visual Assessment of Deteriorating Reinforced Concrete Structures". Journal of Construction Engineering and Management ASCE. March. 138:399-408. [4] Mitra, G., Jain, K.K., and Bhattacherjee, B. (2010). 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