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**Abstract** :
MARDI developed the RiceFert formulation to assist in fertilizer recommendation rate for optimal paddy growth. The formulation followed an adjustable soil test–target yield equation (ST-TY) into dedicated software. The output from the RiceFert software includes a total rate of N, P2O5, and K2O fertilizer (kg/ha) and split application or straight fertilizer rate (kg/ha). Additionally, the output from RiceFert was integrated to GIS to produce maps according to the specific fertilizer recommendation rates. With interpolation techniques, thematic maps added more information, such as total area coverage according to individual classification classes. This paper discusses the overall process of fertilizer recommendation rate for paddy fields, starting with the RiceFert formulation, followed by map production using interpolation techniques according to the fertilizer recommendation output. The RiceFert strategy is expected to benefit local authorities because it offers vital information to farmers for optimal rice growth and output.

Full article

Journal ID : **TRKU-12-02-2023-11540** Total View : **0**

**Title** : ANALYSIS OF FLUID TYPES AND MINERAL FUNCTION CLUSTERS IN THE GEOTHERMAL MANIFESTATION AREA OF GEOTHERMAL SPRINGS, TOLOK I VILLAGE, TOMPASO DISTRICT, MINAHASA REGENCY

**Abstract** :
Geothermal manifes-tations of hot springs are formed due to the flow of hot fluid that comes from rock fractures that are below the surface. The nature of various rocks and the heat produced from below the surface makes the characteristics of each geothermal system different. One of them has an impact on each chemical content of the fluid that appears on the surface varies. The purpose of this research was to find out more about the condition of existing hot springs as the object of study in determining the type of fluid and functional groups manifestation geothermal hot

springs of Tolok I village, Tompaso, Minahasa Regency. For determining the type of fluid laboratory tests were carried out and the results of these laboratory tests were conducted by Liquid Chemistry Plotting on the ternary plot diagram. To analyze fluid functional groups, water samples were tested using FTIR spectroscopy. The measurement of physical parameters was also carried out to support this research. The results showed that the type of fluid in the study area was chloride type with a percentage of 51% and the functional groups obtained were functional groups of amides, ketenes and carbonates.

Full article

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# Condition Rating Examination Based on Visual Assessment of Concrete Damage Caused By Poor Implementation

Henny Wiyanto[1], Chaidir Anwar Makarim[2], Onnyxiforus Gondokusumo[3]

Civil Engineering Doctoral Program, Universitas Tarumanagara - Jakarta, Indonesia[1,2,3]

**ABSTRACT**— Concrete damage condition rating based on visual assessment is qualitative and subjective and depends on the investigator's experience, knowledge, and skills, which results in varied assessments from each investigator. To resolve this problem, a condition rating scale of visual-based concrete damage assessment has been developed in order to show a measured condition and rate the concrete damage conditions of buildings. The scale can describe buildings that are in very good to very bad condition; a very bad rating means that the building cannot be used. This assessment also calculates the building structure element's critical rating. The condition rating scale is determined based on the concrete's damage condition and the concrete's compressive strength requirements. Concrete damage-condition rating values are determined based on expert appraiser feedback that was obtained through a questionnaire, which was processed using the fuzzy logic approach. The condition rating scale usage of visual-based concrete damage assessment will show the building's structural element damage condition rating and the building damage condition rating as a whole, as well as the actions that need to be taken. Assessment results can also show a priority scale to determine the next actions to be taken by the decision-maker.

**KEYWORDS:** Condition Rating, Visual Assessment, Concrete Structure, Poor Implementation.

## 1. INTRODUCTION

The condition of a building's structure can be identified by performing a control inspection. A building's functionality depends heavily on control inspection. Lack of control will cause damage to the building at a faster rate and impact repair costs. The first step of control inspection is a visual assessment of the building's structure [1]. According to ACI 201.1R-08 [2] visual assessment is often used as the first step in the evaluation of a building's structure for continuous use or change, strength or deformation analysis, or to determine the need for maintenance and rehabilitation. SEI/ASCE 11-99 [3] declared that the condition of existing building materials is rated with a visual assessment method, a non-destructive examination evaluation, and a destructive examination, including field procedures and laboratory. [4], [5], declared that a visual assessment does not have a reference yet, so the assessment is done subjectively. [6], declared that a condition rating is a numeric indicator that can be used on building structures and is used to assign a ranking. An assessment is meant to evaluate an existing building structure's condition to ensure the adequate safety of its existing weight. There is no code that determines the condition rating's characteristics and category. A condition that is assessed with a visual assessment tends to be qualitative and is usually declared in vague linguistic terms such as ―bad,‖ ―good,‖ or ―very good.‖ A condition that is declared in linguistic terms varies from person to person. Because of that, qualitative information that is obtained from a visual assessment is subjective and depends on the experience, knowledge, and skill of the investigator. A number of condition rating assessment scales have been developed all around the world to deal with this qualitative element. This scale usually provides a condition that can be measured in terms of damage and adequate repair needs. To perform a reliability assessment, a reference value is needed as a condition comparison scale. Because of that, the acceptable value of the building structure's reliability needs to be determined first [7]. The problem is how to find the highest acceptable structure reliability level. This value can be determined from a target reliability level that is planned [8]. According to ISO 2394:2015 [9] reliability is the ability for a structure or a structural element to fulfill a specific requirement in carrying a planned workload according to the condition that is determined at a certain point. A structure has the correct reliability level if it fulfills the requirements and reaches a specific target level against the serviceability limit state, ultimate limit state, and structural integrity. According to SEI/ASCE 11-99 [3] assessment consists of data collection and analysis, evaluation, and a systematic recommendation about the part of the building that is affected by the suggested function. [10], said that a reliability assessment of an existing building structure can be done through two steps: first, a visual assessment and then a more detailed assessment through an assortment of examinations before concluding with a reliability assessment. Up until the examination, there are already a number of standards and manuals that can be examined and assessed for reference. But until now, there has been no standard reference or technical guidance for structural reliability. The consequence is a descriptive assessment without a quantitative reference that is clearly measured. This lack of clarity makes it difficult for the decision-maker to take responsibility for a building assessment's result. Therefore, a reference for visual assessment needs to be developed in the form of a condition rating assessment scale.

## 2. Concrete Damage Condition Rating Scale

A rating assessment scale for the concrete's condition is needed as a reference in performing a visual assessment. A condition rating scale is formed from multiple research studies. [11] in 1998, performed a condition rating assessment on bridge concrete damage to determine repair priorities. They used six damage levels based on rating values. [12], performed a damage assessment of structural components with five criteria levels. [13], performed a bridge condition assessment using four ratings, from very good to very bad, with a condition index rating. [14], [4], [5], [15], [16], performed a building concrete damage assessment using six ratings, from lowest (a condition that doesn't need repairs) to highest (a condition that needs treatment right away). [17], performed a rating assessment of a building's concrete damage risk with four categories from lowest (very bad) to highest (very good) with a value spectrum. [18], performed a bridge concrete condition assessment using four condition ratings with a bridge soundness score (BSS) value interval.

## 3. Concrete Damage Examination Based on Visual Assessment

Concrete damage on buildings can be interpreted as the existence of a concrete condition change related to concrete performance. This damage can be in the form of physical changes in the concrete that can be seen with the naked eye and concrete quality degradation that can be detected by performing an examination on the concrete body. These changes are caused by multiple factors, such as natural disasters, environmental conditions, inadequate construction, inappropriate building usage such as too much weight, a building function change, and inadequate or no maintenance. Building damage leads to high risk for the building's users. To identify the concrete damage on the building, an assessment of the concrete's condition is needed. Visual assessment is a good first step in identifying concrete damage. Visual assessment is a concrete surface assessment that identifies and defines multiple concrete conditions that can be seen by the naked eye. Visual assessment provides important information about the structure's function and endurance [2]. Damage that is usually detected includes cracking, leaching/staining, spalling, delamination, and efflorescence. Damage can develop further over time. The visual form is used to perform an assessment of damage based on a visual assessment [4], [5]. Visual assessment can be used in an investigation strategy to optimize the workload needed. Surface-cracking patterns, peeling, cracking, and other elements can function as important visual forms for the first damage assessment [14]. ACI 201.1R-08 [2] stated that the types of physical concrete damage are cracking, distress, and feature and texture phenomena relative to its development. SEI/ASCE 11-99 [3] stated that multiple concrete damage types are based on concrete physical conditions and iron reinforcement. [4], [5], stated that concrete damage types are based on concrete physical conditions, including corrosion, alkali aggregate reactions, freeze-thaw attacks, sulfate attacks, acid attacks, and fatigue.

## 4. Concrete Condition Rating Assessment Method

The condition rating scale determination is based on concrete damage conditions and concrete compressive strength requirements, which are described from very good to very bad. Very good means that the building fulfills the planned concrete compressive strength requirements, while very bad means that the quality of the concrete is very low and that the building cannot be used anymore or must be demolished (Table 1). Concrete damage condition rating scale determination refers to ACI 228.23-13 [19], SEI/ASCE 11-99 [3], PBI [20], and SNI 2847:2013 [21], with consideration to a number of references, such as [12], [14], [4], [5], [15], [16], as well as feedback from expert appraisers.

**Table 1** Concrete condition rating scale

| Condition Rating | Description | Criteria | Measure |
|---|---|---|---|
| 1 | Very good | No damage | No repairs 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 | Cannot be maintained or demolished |

Each structural element has different critical risks according to the building structure element's function. Therefore, in this concrete damage condition rating assessment method, the critical weight for each structural element is determined, as seen in Table 2. The critical weight is determined based on opinions from feedback appraisers by considering references such as [14], [4], [5], [15], [16], [18], [17].

**Table 2** Structure element critical weight

| Structure Element | Critical Weight |
|---|---|
| Shear wall (sw) | 1 |
| Column (K) | 1 |
| Beam (B) | 0,7 |
| Plate (P) | 0,5 |

The damage type that can be classified as a result of poor performance can be seen in Table 3. This concrete damage type identification refers to ACI 201.1R-08 [2], ACI 228.2R-13 [19], SEI/ASCE 11-99 [3], as well as feedback from building construction expert appraisers.

**Table 3** Concrete damage types caused by poor performance

| No. | Damage Type | Damage Criteria |
|---|---|---|
| 1 | Cracks are perfect or imperfect separations from concrete into two or more parts that result from a fracture. | |

| | | |
|---|---|---|
| | Craze Crack | Random cracking that occurs in a soft manner or results in gaps on plaster surface, cement paste, mortar, or concrete. |
| | Crazing | A continuation from a craze crack that happens on the surface. |
| | D-Cracks | Cracks on concrete that are parallel to joints and angles. |
| | Hairline Crack | Thin cracks on concrete surface. |
| | Maping Crack | Cracks that occur because of shrinkage caused by a dried concrete surface that is held by thicker concrete or concrete with no shrinkage. |
| | Random Cracks | Uncontrolled cracks that occur because of the cracks appear in multiple directions from a control joint. |
| | Transverse Crack | Cracks that happen transversally because of flexibility. |
| 2 | Delamination | Concrete separation occurs in a horizontal and parallel manner, usually on the concrete's surface. Very often found on bridge decks and floor plates in parking buildings. |
| 3 | Honeycomb | Void in the concrete caused by a lack of vibration during fresh concrete pouring, low and inadequate slump, or reinforcement tightness. |
| 4 | Pop-outs are separations of a small part of concrete due to internal pressure that causes thinning. Depression/concrete damage usually takes the form of a cone. | |
| | Pop-outs (small) | Up to 10mm (0.4‖) pop-out size |
| | Pop-outs (medium) | Between 10mm and 50mm (0.4‖ and 2‖) pop-out size |
| | Pop-outs (large) | Larger than 50mm (2‖) pop-out size |
| 5 | Scaling is matrix cement peeling near the surface. Scaling is part of the disintegration process. | |
| | Scaling (light) | Scaling occurs only on the mortar surface and doesn't cause rough aggregate visibility. |
| | Scaling (medium) | Scaling occurs on the mortar surface with 5mm to 10mm depth (0.2‖–0.4‖) and exposes rough aggregate. |
| | Scaling (severe) | Scaling occurs on the mortar surface with 5mm to 10mm depth (0.2‖–0.4‖), and rough aggregate is eroded with 10mm to 20mm depth (0.4‖–0.8‖) |
| | Scaling (very severe) | Scaling occurs on rough aggregate with deeper depth than 20mm (0.8‖) |
| 6 | Spalling is the fallout of concrete fragments, usually in the form of concrete shards. | |
| | Spall (small) | Circle or oval-shaped or elongated in other cases, with no more depth than 20mm (0.8‖) and 150mm (6‖). |
| | Spall (large) | Circle or oval-shaped or elongated in other cases, with more depth than 20mm (0.8‖) and 150mm (6‖). |
| 7 | Distortion | Dimension or shape change caused by design factor or poor implementation, excess weight, quake, expansion. |

**Table 3** Concrete damage types caused by poor performance (con.)

| No. | Damage Type | Damage Criteria |
|---|---|---|

| | | |
|---|---|---|
| 8 | Stratification | Segregation from too much water or vibration on the concrete, which horizontally forms a layer with soft material on top, causing the rough material to gravitate to the bottom. |

The concrete damage condition rating value is determined based on feedback from expert appraisers through a questionnaire, which is processed with the fuzzy logic approach. Data processing refers to [14], [4], [5], [15], [22], [23], [24], [25]. The condition rating assessment is determined using the scale from Table 1 and the structural element critical rating using Table 2. Data processing is done with the following steps:

- Validation is performed by removing invalid data and negligible respondent opinion. Data is removed if:

$$R_i < (R_{i+1} \text{ and } R_{i-1}), \text{ then } R_i = 0{,}5\,(R_{i+1} + R_{i-1}) \tag{1}$$

where *Ri* is the number of respondents at condition rating *i* (1, 2, 3, 4, 5).
Negligible respondent opinion is removed if:

$$R_i < 0{,}1\sum_{i=1}^{n} R_i \text{ , then } R_i = 0 \tag{2}$$

where n is the highest condition rating (5).
- Data normalization uses the following formula:

$$\mu_i = \frac{R_i}{R_{i,\max}} \tag{3}$$

where $\mu_i$ is membership function at condition rating i.
- Concrete damage type condition rating is determined with the centroid method, which is as follows:

$$CI = \frac{\sum_{i=1}^{n} \mu_i i}{\sum_{i=1}^{n} \mu_i} \tag{4}$$

where *CI* is damage type condition rating, and *i* is condition rating.
- Building concrete damage condition rating is determined by performing the weighted average method by considering the structure element's critical weight.

$$SCI = \frac{\sum_{se=1}^{e} w_{se} CI_{se}}{\sum_{se=1}^{e} w_{se}} \tag{5}$$

where SCI is structural condition rating, *Wse* is structure element type critical weight, *CIse* is structure element condition rating, and e is structure element type. Concrete damage condition rating description and criteria, as well as the treatment performed towards the assessed building, is determined using Table 1.

This concrete damage condition rating assessment validation is done by applying the concrete damage data that resulted from the investigation and existing building assessment by expert appraisers.

## 5. Results and Discussion

A questionnaire was made to determine the condition rating value for each concrete damage type. The resulting data is processed with the fuzzy logic approach to result in a condition rating value for each type of concrete damage resulting from poor implementation. Data validation can be seen in Table 4.

**Table 4.** Data validation

| No. | Damage Type | Data Validation I | | | | | Data Validation II | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | Craze Crack | 1 | 6 | 7 | 1 | 1 | 0 | 6 | 7 | 0 | 0 |
| 2 | Crazing | 0 | 5 | 8 | 3 | 0 | 0 | 5 | 8 | 3 | 0 |
| 3 | D-Cracks | 0 | 1 | 12 | 3 | 0 | 0 | 0 | 12 | 3 | 0 |
| 4 | Hairline Crack | 1 | 10 | 5 | 0 | 0 | 0 | 10 | 5 | 0 | 0 |
| 5 | Maping Crack | 0 | 2 | 11 | 2 | 1 | 0 | 2 | 11 | 2 | 0 |
| 6 | Random Cracks | 0 | 1 | 9 | 5 | 1 | 0 | 0 | 9 | 5 | 0 |
| 7 | Transverse Crack | 0 | 1 | 10 | 4 | 1 | 0 | 0 | 10 | 4 | 0 |
| 8 | Delamination | 0 | 0 | 12 | 4 | 0 | 0 | 0 | 12 | 4 | 0 |
| 9 | Honeycomb | 0 | 1 | 8 | 6 | 1 | 0 | 0 | 8 | 6 | 0 |
| 10 | Pop-outs (small) | 0 | 7 | 6 | 3 | 0 | 0 | 7 | 6 | 3 | 0 |
| 11 | Pop-outs (medium) | 0 | 3 | 10 | 2 | 1 | 0 | 3 | 10 | 2 | 0 |
| 12 | Pop-outs (large) | 0 | 1 | 9 | 5 | 1 | 0 | 0 | 9 | 5 | 0 |
| 13 | Scaling (light) | 1 | 7 | 8 | 0 | 0 | 0 | 7 | 8 | 0 | 0 |
| 14 | Scaling (medium) | 0 | 2 | 14 | 0 | 0 | 0 | 2 | 14 | 0 | 0 |
| 15 | Scaling (severe) | 0 | 2 | 10 | 4 | 0 | 0 | 2 | 10 | 4 | 0 |
| 16 | Scaling (very severe) | 0 | 0 | 8 | 7 | 1 | 0 | 0 | 8 | 7 | 0 |
| 17 | Spall (small) | 0 | 2 | 12 | 1 | 1 | 0 | 2 | 12 | 0 | 0 |
| 18 | Spall (large) | 0 | 0 | 9 | 6 | 1 | 0 | 0 | 9 | 6 | 0 |
| 19 | Distortion | 0 | 0 | 3 | 11 | 2 | 0 | 0 | 3 | 11 | 2 |
| 20 | Stratification | 0 | 0 | 2 | 10 | 4 | 0 | 0 | 2 | 10 | 4 |

The concrete damage condition rating is determined based on membership function for each damage type NS can be seen in Table 5.

**Table 5.** Concrete damage condition rating

| No. | Damage Type | Membership Function ($\mu_i$) | | | | | $\sum_{i=1}^{n} \mu_i i$ | $\sum_{i=1}^{n} \mu_i$ | *CI* |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | |
| 1 | Craze Crack | 0 | 0.86 | 1 | 0 | 0 | 4.71 | 1.86 | 2.54 |
| 2 | Crazing | 0 | 0.63 | 1 | 0.38 | 0 | 5.75 | 2.00 | 2.88 |
| 3 | D-Cracks | 0 | 0 | 1 | 0.25 | 0 | 4.00 | 1.25 | 3.20 |
| 4 | Hairline Crack | 0 | 1 | 0.5 | 0 | 0 | 3.50 | 1.50 | 2.33 |
| 5 | Maping Crack | 0 | 0.18 | 1 | 0.18 | 0 | 4.09 | 1.36 | 3.00 |
| 6 | Random Cracks | 0 | 0 | 1 | 0.56 | 0 | 5.22 | 1.56 | 3.36 |
| 7 | Transverse Crack | 0 | 0 | 1 | 0.4 | 0 | 4.60 | 1.40 | 3.29 |
| 8 | Delamination | 0 | 0 | 1 | 0.33 | 0 | 4.33 | 1.33 | 3.25 |
| 9 | Honeycomb | 0 | 0 | 1 | 0.75 | 0 | 6.00 | 1.75 | 3.43 |
| 10 | Pop-outs (small) | 0 | 1 | 0.86 | 0.43 | 0 | 6.29 | 2.29 | 2.75 |
| 11 | Pop-outs (medium) | 0 | 0.3 | 1 | 0.2 | 0 | 4.40 | 1.50 | 2.93 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 12 | Pop-outs (large) | 0 | 0 | 1 | 0.56 | 0 | 5.22 | 1.56 | 3.36 |
| 13 | Scaling (light) | 0 | 0.88 | 1 | 0 | 0 | 4.75 | 1.88 | 2.53 |

**Table 5.** Concrete damage condition rating (con.)

| No. | Damage Type | Membership Function ($\mu_i$) | | | | | $\sum_{i=1}^{n}\mu_i i$ | $\sum_{i=1}^{n}\mu_i$ | *CI* |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | | | |
| 14 | Scaling (medium) | 0 | 0.14 | 1 | 0 | 0 | 3.29 | 1.14 | 2.88 |
| 15 | Scaling (severe) | 0 | 0.2 | 1 | 0.4 | 0 | 5.00 | 1.60 | 3.13 |
| 16 | Scaling (very severe) | 0 | 0 | 1 | 0.88 | 0 | 6.50 | 1.88 | 3.47 |
| 17 | Spall (small) | 0 | 0.17 | 1 | 0 | 0 | 3.33 | 1.17 | 2.86 |
| 18 | Spall (large) | 0 | 0 | 1 | 0.67 | 0 | 5.67 | 1.67 | 3.40 |
| 19 | Distortion | 0 | 0 | 0.27 | 1 | 0.18 | 5.73 | 1.45 | 3.94 |
| 20 | Stratification | 0 | 0 | 0.2 | 1 | 0.4 | 6.60 | 1.60 | 4.13 |

The assessment is applied to a 16-year-old 45-floor apartment building. Based on the visual examination results, the concrete damage data on each building's structural elements are obtained. The building's condition is assessed by rating the concrete damage condition according to the CI value that is obtained from Table 5, by calculating the structural element critical weight according to Table 2, and by determining the building condition according to Table 1. The visual investigation and assessment results can be seen in Table 6.

**Table 6.** Building concrete damage condition rating assessment

| Elemen Number | Damage Type | $CI_{se}$ | Element | | $w_{se}CI_{se}$ |
|---|---|---|---|---|---|
| | | | *se* | $w_{se}$ | |
| 1 | Honeycomb | 3.43 | B | 0.7 | 2.401 |
| 2 | Craze Crack | 2.54 | P | 0.5 | 1.270 |
| 3 | Spall (small) | 2.86 | P | 0.5 | 1.430 |
| 4 | Scaling (light) | 2.53 | P | 0.5 | 1.265 |
| 5 | Scaling (light) | 2.53 | P | 0.5 | 1.265 |
| 6 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 7 | Delamination | 3.25 | P | 0.5 | 1.625 |
| 8 | Delamination | 3.25 | P | 0.5 | 1.625 |
| 9 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 10 | Craze Crack | 2.54 | P | 0.5 | 1.270 |
| 11 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 12 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 13 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 14 | Craze Crack | 2.54 | P | 0.5 | 1.270 |
| 15 | Craze Crack | 2.54 | P | 0.5 | 1.270 |
| 16 | Craze Crack | 2.54 | B | 0.7 | 1.778 |
| 17 | Craze Crack | 2.54 | P | 0.5 | 1.270 |
| 18 | Delamination | 3.25 | P | 0.5 | 1.625 |
| 19 | Delamination | 3.25 | P | 0.5 | 1.625 |
| 20 | Delamination | 3.25 | P | 0.5 | 1.625 |
| 21 | Craze Crack | 2.54 | B | 0.7 | 1.778 |
| 22 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 23 | Delamination | 3.25 | P | 0.5 | 1.625 |
| 24 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 25 | Crazing | 2.88 | P | 0.5 | 1.440 |

**Table 6.** Building concrete damage condition rating assessment

| Elemen Number | Damage Type | $CI_{se}$ | Element | | $w_{se}CI_{se}$ |
|---|---|---|---|---|---|
| | | | $se$ | $w_{se}$ | |
| 26 | Craze Crack | 2.54 | B | 0.7 | 1.778 |
| 27 | Crazing | 2.88 | P | 0.5 | 1.440 |
| 28 | Scaling (light) | 2.53 | P | 0.5 | 1.265 |
| | | | Σ | 14.8 | 42.02 |
| | | | **SCI** | 2.84 | |

The concrete damage condition rating assessment results in Table 6 show that the building concrete damage condition rating is medium, with damage caused by poor implementation. The medium condition rating means that further investigation and repairs on some of the building's structural elements need to be implemented immediately. Validation towards assessment results is done by expert appraisers.

## 6. Conclusion

A building's condition rating based on visual assessment is usually achieved using a descriptive assessment that is qualitative and subjective and depends on the knowledge, experience, and skills of the investigator. A code that determines the concrete's damage condition rating does not yet exist. To resolve that, a condition rating scale to perform a rating assessment of the concrete damage condition is developed. This scale normally provides a measurable condition to determine a damage rating. The scale being developed here can accurately show a building's condition from best to worst, where worst is a building that cannot be used anymore. A condition rating from a visual assessment for each type of concrete damage is determined based on assessment from expert appraisers. To accommodate qualitative and subjective assessments, data processing is done with the fuzzy logic approach. Condition rating values that result from each type of concrete damage describe damage criteria. That condition rating can describe the building's structural element damage condition and building damage condition rating, as well as determine the action needed. Therefore, this condition rating value can be used to determine a priority scale for implementation between structure elements or between buildings. This concrete damage condition rating assessment based on visual assessment can be the base to implement further examination in the form of a non-destructive or a destructive examination of the assessed building structure.

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