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# Calcium Sulfate Dihydrate (gypsum) Quality Test Using *Radiography Non Destructive Test* (RNDT)

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## Abstract

Calcium Sulfate Dyhidrate/gypsum is a material commonly found in nature which is used at industrial site for making a wall, roof, etc. One of the problems found in material industry is crack deffect, white crack defects is very difficult be identified it visibility. *Radiography Non-Destructive Test* (RNDT) is non destructive test supported by digital radiographic producing digital image. This work aims to determine the gypsum properties to find out crack defect using RNDT. Radiographic image depends on exposure factors (kV, mA, s, and SID). Digital image can be proceed using Octave-GUI to determine the crack defect area, image processing using Prewitt detection. Radiographic digital result of 3 gypsum boards (a, b and c) and 2 gypsum profil samples (d and e) were found the crack on each samples. RNDT was perfomed using X-ray voltage at 60 kV on a, b, c, d, and e samples. Each samples crack area value are 158.13 $mm^2$; 127.43 $mm^2$; 196.81 $mm^2$; 73.97 $mm^2$; dan 18.80 $mm^2$. Others RNDT was using X-ray voltage at 70 kV on samples a, b, c, d, and e. Each samples crack area value are 220.62 $mm^2$; 1,711.57 $mm^2$; 209.33 $mm^2$; 76.50 $mm^2$; dan 11.18 $mm^2$. In conlusion, the crack area values obtained can be used as RNDT.

**Keywords:** X-ray, Gypsum, RNDT, Image Processing.

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## 1. Introduction

Calcium sulfate dihydrate is a compound obtained from hydration process of calcium sulfate hemihydrate which is usually found on gypsum [1]. Main weaknesses of gypsum board are its ease of absorbing water and weak mechanical strength [2]. Gypsum board industry there is usually reject of 4-8% from the production capacity. The reject is in form of broken edge, cracks, inhomogeneous color, but doesn't reduce product quality, on average 120-240 sheets/day can still be used for cheap house [3]. Non-destructive test (NDT) is part of material testing methods, which differs from destructive testing, it doesn't break the material tested [4]. The goal of NDT is to detect defect using certain procedure on certain object by an operator.

RNDT (Radiography Non-Destructive Test) is an NDT method which usually used to detect internal defect in material. This is based on X-ray or γ-ray capability to pass through material and converted into visible light, resulting in photographic image by transmitted radiation. Ability of material to absorb X-ray or γ-ray differs for different material thickness, transmitted ray shows variation in intensity which appears in receiving film. This may be used to examine material qualities [5].

Defect (discontinuity) in image from RNDT may be visualized using digital filter and smoothing each noise in the radiographical image [6]. Prewitt edge detection filter is a filtering method that uses spatial convolution or operation that similar to it.

$$Rx = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} Ry = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

**Figure** 1: Prewitt Convolution Kernel (3x3).

Prewitt Operator uses partial differential operator to perform convolution on the image, and further using first derivative of extrusion amplitude or second order derivative of zero point amplitude to detect edges. This classical operator has been frequently used for edge detection [7].

Digital radiographic image in "*.JPEG" format is processed using software *Octave-GUI*. Gypsum image grayscale is increased to obtain a image with strong contrast, then gypsum image is convolved with edge detection operator. Further value of crack area is calculated using equation:

$$A = \alpha N_{pix} \tag{1}$$

where $A$, α, and $N_{pix}$ are sequantially size area ($mm^2$), unit length *pixel* ($mm^2$/pixel), and number of *pixel* (pixel). Unit length pixel α multiplied by 1 or $\sqrt{2}$ and this value is added into the previous value, because it depends on the next pixel's location [8].

## 2. Methods

### 2.1. Image acquisition

Gypsum which would be exposed, was cut to certain size area depending on exposition table. X-ray generator of type SF-100BY was used along with digital radiography. Digital radiography equipment had been developed in Physics laboratory, Physics Department, UNNES. Image film capture was changed with light-tight tube. Light tight tube was used to convert X-ray to visible light. Then, image on intensifying screen was captured and

recorded using Digital Single Lens Reflex (DSLR) which was connected to a computer hence picture may be observed in computer monitor as can be seen in Figure 2[9]. Gypsum was exposed using X-ray generator with exposition factor of mA, s, and distance respectively 16 mA; 0.2 s; and 100 cm. kVp value is set to be 60 kV dan 70 kV.

## 2.2. Image processing

X-ray exposition result was in form of digital image which further processed using software *Octave GUI*, a program developed to analyze crack. Digital image grayscale was processed to obtain expected image. Then, edge detection filter was applied to transform the image so that its edge become clearer and count the number pixels resulting from the process to determine value of crack size area.

## 2.3. Validity test

Prewitt detection filter needs to have its validity tested using artificial crack. Prewitt detection filter would measure size area of the artificial filter and compares the value. *Relative difference* is a relative value that indicates difference between two measurements as appears in equation (2)

$$RD = \frac{\left|A_{real} - A_{Prewitt}\right|}{A_{real}} \tag{2}$$

Where $A_{real}$ is size area of the crack which the value was known beforehand and $A_{prewitt}$ is size area as measured by Prewitt edge detection filter.

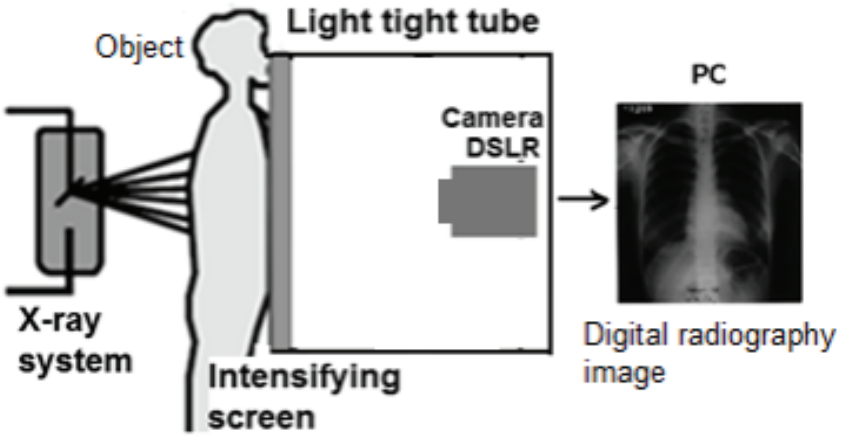


**Figure** 2: Diagram of digital radiography system [9].

## 3. Result and Discussion

Result from the experiment is in form of digital radiographic image with "*.JPG" format. Digital radiographic image had pixel size of 5,472 x 3,648 *pixel*. Exposition area in the setup was 5,404.59 $cm^2$, then using equation 1 the value of α is known to be 0.0271 $mm^2$/pixel. 5 samples of gypsum analyzed consists of 3 gypsum board (a, b, and c) and 2 gypsum profil (d and e). Digital image was enhanced by multiplying the grayscale value so that there would be more contrast between crack and non-crack area. Contrast in the image was used to ease differentiation between crack and non-crack. Original and processed images are shown in Figure 3.

In Figure 3 red rectangles show crack on gypsum, this show clear cracking on all samples. Grayscale value at crack area is 0-70. Digital image which had been processed then processed further using edge detection filter. This is so that crack in the image would be clearer. Edge detection filter would clear up the edge by convolving image with Prewitt operator resulting in binary, with cracks located at 1's and non-crack area is 0. Convolved image then had its value at each pixel summed over to obtain $N_{pix}$. $N_{pix}$then subtituted into equation 1 if it is known α is 0.0271 $mm^2$/pixel it would produce Table 1

TABLE 1: Measurement of gypsum crack area.

| Sample | X-ray Voltage (kV) | | | |
|---|---|---|---|---|
| | 60 | | 70 | |
| | $N_{pix}$(Pixel) | A($mm^2$) | $N_{pix}$(Pixel) | A($mm^2$) |
| A | 4130 | 158.13 | 5762 | 220.62 |
| B | 3328 | 127.43 | 44701 | 1,711.57 |
| C | 5140 | 196.81 | 5467 | 209.33 |
| D | 1932 | 73.97 | 1998 | 76.5 |
| E | 491 | 18.8 | 292 | 11.18 |

Gypsum board (a, b, dan c) had size area of 8,100 $mm^2$and has thickness of 9 mm. Table 1 shows that the gypsum have very small crack size area compared to the board size, this indicates that gypsum was in good condition. There was indeed cracks on each gypsum samples, however the crack size was so small and negligible in use. Gypsum profil (d dan e) is difficult to measure because of its inhomogeneity and its nonuniform thickness. Gypsum profil has relatively smaller crack size compared to gypsum board because its solid structure.

Crack size area at each X-ray voltage differs, this is because X-ray energy emitted by X-ray generator also differs. The higher X-ray voltage the higher the energy of X-ray will

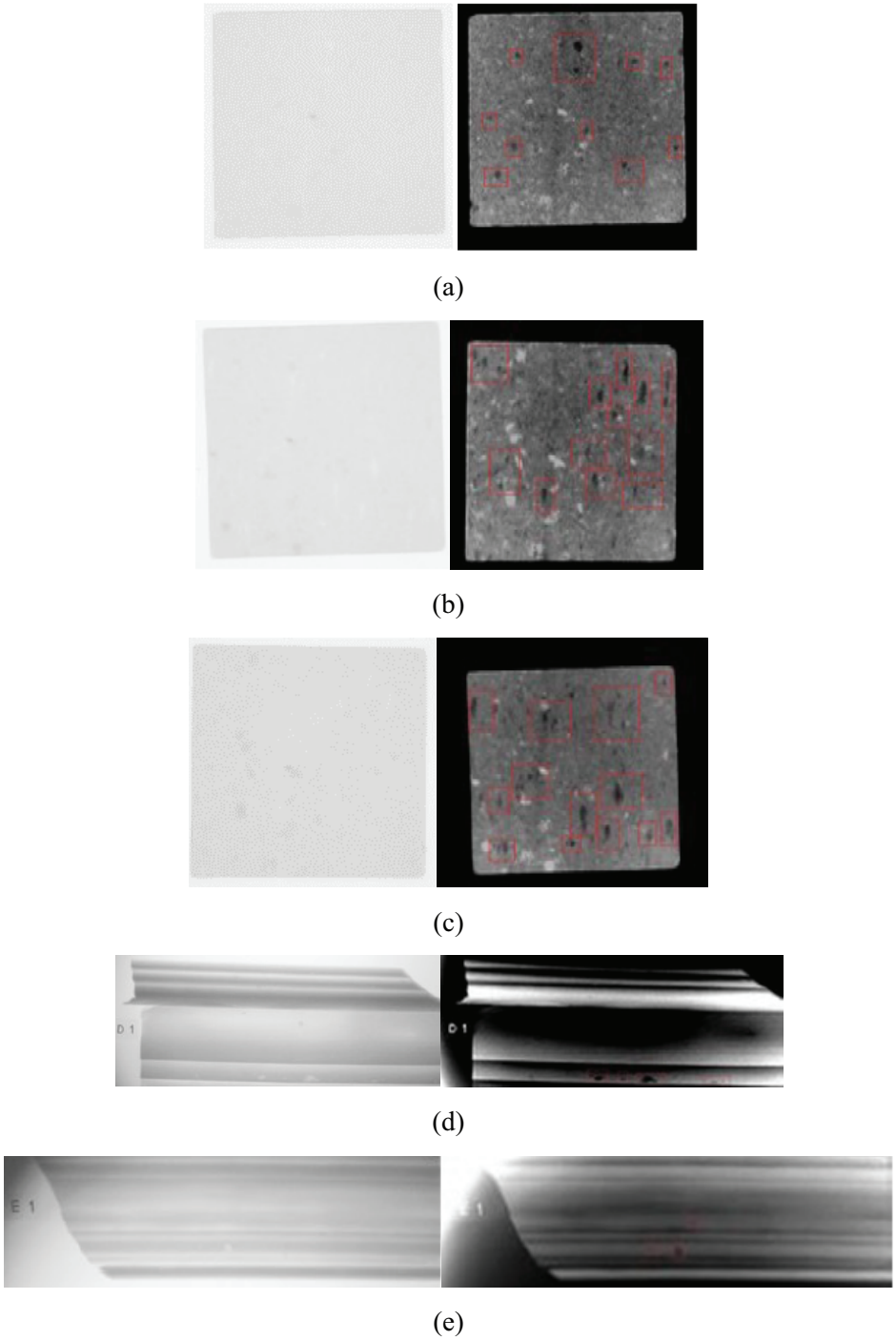

**Figure** 3: Original Image (left) and Processed Image (right).

be, this also applies at constant Ma, s, and exposition distance. High X-ray energy will cause most of the X-ray to pass through the material without undergoing attenuation. It needs to be noted that attenuation coefficient of each material differs.

Prewitt edge detection filter also needs to undergo accuracy testing.Artifical crack was made to test how accurate Prewitt edge detection filter in determining a crack, This is to guarantees the reliability of data in Table 1.

Table 2: Result of artificial crack size area measurement.

| | No. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| $A_{real}$(mm$^2$) | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
| $A_{prewitt}$(mm$^2$) | 4.84 | 9.25 | 11.97 | 17.66 | 22.14 | 25.77 | 30.93 |
| RD (%) | 3.15% | 7.49% | 20.20% | 11.72% | 11.46% | 14.11% | 11.63% |

Table 2 shows that RD values are inbetween 3.15% - 20.20% (Average 11.39%). This value show relatively insignificant differences, hence it is fairly reasonable to use Prewitt edge detection filter and data in Table 1 are reasonably reliable.

## 4. Closing

### 4.1. Conclusion

Cracks can be determined using RNDT with low voltage X-ray. Prewitt edge detection filter is able to detect edges with fairly good accuracy, hence cracks on gypsums can be detected.

### 4.2. Proposition

Other types of edge detection filter has high accuracy so can be used to detect edges more accurately.

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