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## Loss Estimation by Employing the Crack Width Distribution Characteristics of RC Structural Members

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## Introduction

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Generally, repair cost estimation of building structures after an earthquake is derived from the members' damage state (DS1, 2, 3...) with the unit cost and the damaged area.

If DS is defined by the maximum damage (IDR, crack width ...), the "same DS level" might not indicate the "same amount of damage (crack width and length)".

For the RC structural damage & loss estimation which can describe "amount of damage (crack width and length)", this research proposed the "crack width distribution characteristics" using the deep-learning based damage detection.





34.3

M/QD

N/BD $\sigma_{R}$ 

Curing Method

curing Period

 $\sigma_{R}$  (N/mm)<sup>2</sup>

0.67

35.5

Shielded

3 months

0 (no axial force)



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Exposure (web wall surface)

8 months

38.7

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## Noise reduction ON/OFF before Annotation

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## Deep-learning Model

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## Learning model construction



Damage detection

## Hyperparameters of the learning model

CNN	ResNet18 & DeepLabv3+
Layer	108 layers
Number of Classes	3 (background, crack, and spalling)
Optimization	Adam
Initial learning rate	0.0005
Mini batch size	10
Input Image Size	300 x 300

## Deeplabv3+ with Stochastic Dropout





## Damage Area Detection

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## Detected Crack & Spalling Area

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*li*: the crack length corresponding to the crack width class *i*.



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## Crack length estimation for RC shear wall

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## Crack length based on geometric shape model

$$l_{max} = \frac{H}{\cos \theta_{cr}} \left( \frac{H \sin \theta_{cr} + L \cos \theta_{cr}}{S_{cr}} - 2q \right) + \frac{q(q+1)S_{cr}}{\sin \theta_{cr} \cos \theta_{cr}}$$

$$q = \frac{H\sin\theta_{cr}}{S_{cr}} \ (q = 0 \ if \ q < 1)$$

## Probabilistic crack length distribution



 $l_i$ : the crack length corresponding to the crack width with *i* class.



## Example of detailed repair cost estimation using crack width distribution characteristics

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Crack Width	Repair method	Repair cost (JPY/m)
~0.2mm	Sealing	910
0.2~1.0mm	Epoxy resin Injection	6600
1.0mm~	U-cut + Flexibility epoxy resin filling	3400





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- To obtain the crack width distribution characteristics, new image processing techniques of thinning and contour extraction as noise reduction ON/OFF system are applied to the preprocess of annotation for deep-learning.
- WM specimen (shield-cured, little drying shrinkage) showed a slightly larger log standard deviation in the crack width distribution characteristics. WD2 specimen (cured for 3 months with drying shrinkage) and WD1 specimen (cured for 8 months with drying shrinkage) showed smaller log standard deviation.
- Considering the combined amount of crack width and crack length, the selection of the appropriate repair method for a given crack width changed with the percentage of crack length with a given crack width in the total crack volume, and the overall repair cost also changed.