Study on Indexes of Recycled Aggregate

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Abstract: Recycled aggregate database was founded according to experimental results excluded from references. An Artificial Neutral Network was then established to analyze influences of indexes of recycled aggregate on compressive strength of recycled concrete. Key indexes including water absorption ratio and crushing value were finally proposed.

Key words: recycled aggregate database; Artificial Neutral Network; indexes
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Recycling of concrete has become an attractive issue in recent years due to pressing environmental requirements[1-3]. Reuse of concrete, therefore, has attracted more and more attention. After crushing, grading etc, recycled coarse aggregate (RCA) and recycled fine aggregate (RFA) can be produced. The successful application of RCA has been reported both in China and abroad in practice. The application of RFA is rarely reported in practice due to its extremely high water absorption ratio. Although the reuse of RCA is common, it is generally confined to lower grade application occasion. Which can be attributed to weaknesses of RCA, the relatively higher water absorption as compared to natural aggregate (NA) and micro-cracks resulting from demolishing and crushing in the production of RCA. A series of factors influence compressive strength of recycled aggregate concrete (RAC), such as water to cement ratio, water absorption ratio and crushing value of RCA. This investigation was aimed to establish an ANN model for prediction of compressive strength of RAC.

1 Database of RAC

Many factors have a link with the compressive strength of RAC. Among them, mix proportions of RAC as well as RCA quality are of first consideration. Water to cement ratio (w/c) plays an important role governing the strength development of RAC. Net w/c means remained water after absorption of RCA divided by mass of cement. And RCA differs from NA for its inferior quality and higher water absorption. Three parameters including net water-cement ratio, crushing value and water absorption ratio were regarded as input value whereas 28 d compressive strength was taken as output value. All data were extracted from published references.

2 Modeling of ANN

Various methods have been proposed to predict compressive strength of RAC for many years. Traditional prediction was based on regression equation usually composed of one to three parameters. The prediction doesn't accord with the actual value sometimes due to both fixed form of the equation and the variation of RCA and RAC. If new data is quite different from original, errors may occur.

Artificial neural network (ANN) doesn't need a specific equation form. Instead of that, it requires enough data for inputs and outputs. BP neural network is generally recognized as a stable network with a relatively higher precise for prediction[4]. A BP model was put forward including three input neurons (w/c ratio, crushing value and water absorption) and one output neuron (compressive strength). The number of hidden layers and the number of hidden units equals 1 and 8, respectively.

2.1 Compressive strength predicted by ANN and by regression

Tab.1 summarizes the predicted compressive strength both by ANN and by regression. After 415 ep-

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ochs. Training of the BP network was successfully completed and the acceptable error of 1×10^{-5} can be achieved.

For comparison of strength prediction, a regression formula can be obtained as shown in equation (1) and the correlative coefficient R=0.92.

$$F = 36.1734 + 10.434(C/W) - 0.3030Q_a - 2.8831W_a \quad (1)$$

Where F represents the compressive strength of RAC after 28 d curing, C/W means the net cement-water ratio, Q_a(%) stands for the crushing value of RA and W_a(%) means the water absorption ratio of RA. This equation indicates that the compressive strength of RAC is primarily governed by net cement-water ratio. Reduction of w/c contributes to strength improvement considerably. Both lower water absorption and lower crushing value benefit to compressive strength of RAC. 1% increase of water absorpton denotes approximately 3 MPa reduction of compressive strength. When compared with prediction results by ANN, We can see clearly that the prediction accuracy by network is much higher than that of regression equation. For the complexity of compressive strength of RAC, ANN technology is therefore more suitable for strength prediction.

Tab. 1　Prediction of compressive strength of RAC

Actual Strength	By ANN		By Regression	
	Strength	Error	Strength	Error
MPa	MPa	%	MPa	%
39.4	41.5	5.3	41.51	5.4
36.7	35.9	2.2	40.77	11.0
49.4	47.0	4.8	45.53	7.8

2.2　Recommended Indexes of RA

According to equation (1), the water absorption ratio can be expressed as equation (2):

$$W_a = 12.547 + 3.619(C/W) - 0.105Q_a - 0.347 \times F \quad (2)$$

Suppose that F ranges from 30 ~ 60MPa (medium strength concrete) and W/C is within the range of 0.3 ~ 0.5 for successful placing of concrete. The maximum acceptable value of water absorption, 14%, can then be obtained. Because crushing value doesn't exert an obvious influence on compressive strength of RAC, the requirements are the same as specified for the natural aggregate.

3　Conclusions

BP network can predict compressive strength of RAC with a relatively higher accuracy as compared to traditional regression method. Net water-cement ratio affects compressive strength of RAC significantly. In addition, both water absorption behavior of RA and its crushing value influence compressive strength of RAC. To manufacture medium strength concrete, the upper limit of water absorption ratio of RA is 14%.

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再生骨料指标体系研究

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摘　要：根据文献试验数据建立了再生骨料数据库。建立了包括三个输入神经元（净水灰比、压碎值和吸水率）和1个输出神经元（抗压强度）的BP网络。提出了压碎值、吸水率等关键指标的规范建议值。

关键词：再生骨料数据库；人工神经网络；指标

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