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Selection Model of Building Demolition Method Based on Expert System

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***Abstract*—Demolition needs special attention because the planning process is complex and has a high risk. In decision making, practitioners face various conditions that influence the choice of demolition methods. This study aims to develop an optimal model for building demolition methods based on the building characteristics. Identification of criteria was conducted in in-depth literature review and interviews with practitioners who have carried out demolition in Indonesia. The five criteria used in this study were structural characteristics, field conditions, costs, previous experience and time. Furthermore, Multiclass and Multi-label Classification were used to make the optimum demolition method decisions. For model validation, 27 story buildings in Indonesia were used as case studies. The simulation results show that the proposed model can make decisions on the selection of demolition methods with an accuracy of 89.3%. In addition to being able to provide an optimum decision on demolition methods, this model can also provide an estimate of the possible impacts of the selected demolition method.**

***Keywords*—demolition, building, impact demolition, expert system, multiclass and multilabel classification**

I. Introduction

Demolition or deconstruction needs special attention. Because, if the results of this stage are reused or recycle, they can reduce pollution, save energy and reduce environmental pollution and preserve natural resources [1]. Demolition needs to be conducted for the structures that experience conditions such as, affected by disasters, changes in the function of buildings, reconstruction of cities [2], rapid economic development [3], serviced age issues permitted [4] and property damage [5]. Demolition is often misunderstood when it is considered as breaking down structures and lifting debris to the landfill. This assumption is wrong since the planning process for completing demolition projects is far and complex. Thus, the demolition practitioner must be an expert in estimating risks and considering strict regulations to avoid environmental and social damage.

The characteristics that change demolition criteria from one demolition project to another drive the selection of demolition methods to be very risky and time consuming for practitioners [6]. The right choice of demolition method is very important because demolition will have a serious impact and safety, recycle of materials and components and costs [7]. Over the past few years, many studies have developed models for demolition construction [6]. This leads to the need for a mechanism that allows practitioners to make quick decisions aided by a system.

Expert system is investigated to be used as a decision-making approach in the demolition construction industry. The expert system is developed to imitate the human decision-making ability as expert in this field that can provide more understood suggestions and explanations. The Expert System approach includes using the Supervised Machine Learning Classification. Classification is a technique for predicting in which category the data should be located. Classification can determine the class of a target variable (dependent variable) based on one or more variables that affect predictions (independent variables). In particular, there are Multi-class and Multi-label Classification which function to group Input/variable elements into one of three classes/groups or more.

Therefore, this study proposes the use of a Multi-class model and Multi-label Classification from the Expert System to obtain a model decision making for the selection of demolition methods. It is expected that this model can be used by practitioners to overcome problems from previous methods. This study aims to obtain criteria that influence practitioners' decisions in selecting demolition methods and obtain appropriate demolition methods with the proposed models and their impacts. Therefore, it is expected that the results of the research obtained will be more realistic in accordance with the conditions experienced by practitioners and can significantly influence the decision-making process that will be carried out.

II. LITERATURE REVIEW

The characteristics that change demolition criteria from one demolition project to another drive the selection of demolition methods to be very risky and time consuming for practitioners. Previous studies tried to obtain criteria that influence the choice of optimal building demolition methods. Criteria that affect the structural characteristics are the shape and size of structures, unstable structures, extent of demolition, scale of construction, previous building use, health and safety [2, 4, 6, 8-13]. Whereas in terms of field conditions, there is a level of disturbance permitted, the presence of hazardous materials, environmental risks and the location of the structure [2, 4, 8, 9, 11-14]. In addition, there are costs that must be safe and financially feasible [6, 9, 10, 13-15] and prior experience is needed as seen from the limits given by the client, structural engineer needs resources, transportation considerations [4, 6, 9, 11-14]. Meanwhile, in term of time, demolition in general must be conducted as quickly as possible [6, 8, 9, 10, 13, 15], and the value of the materials to be recycled will be higher and better [6, 9, 10, 14, 15]

The choice of demolition method is very important because it will have a serious impact and safety, recycle of materials and components and costs. Previous studies also tried to find out what methods can be conducted in building demolition. Demolition using hands can be conducted using diamond disc cutter, hand hammer and diamond wire saw [16]. Demolition can be done by using a machine that can be controlled remotely, a machine with a high range, a tower with application of high-reach cranes, mechanical, hydraulic and using drilling and sawing [4, 17-19]. Furthermore, demolition can be done by using chemical substance, explosives, bursting and hot cutting [2, 4, 18-20]. In addition, demolition can be done by using high pressure water drainage [18].

Furthermore, there were few studies that tried to find the effects of demolition or deconstruction. The environmental impacts from demolition include accumulation of debris, air pollution, soil pollution, water pollution and energy use and fuel consumption [5, 21-25]. Meanwhile, the economic impacts of demolition include energy and material costs, equipment and labor rates, reduction of hazardous materials, value of material that can be saved and tax exemption [5, 21, 22]. In addition, the social impacts of demolition consist of public health, workplace security, noise and job creation and community involvement [5, 21, 22, 26]

Over the past few years, many studies have developed models for demolition construction [5, 6, 27]. In addition, the recent approach related to demolition shows that time planning methods and influential resource scheduling are carried out just like previous experiences. The main disadvantage is that the planning method applied can only count to a certain level of detail with a limited number of activities [13]. Therefore, a very high computational effort is needed to enable practitioners to make quick decisions.

III. METHODOLOGY

In this study, interviews and questionnaire surveys were conducted to obtain information from demolition practitioners.

A. *Criteria that Influence Practitioner's Decisions in the Selection of the Demolition Method*

In the demolition process, the decision that must be decided by practitioners is to determine the right and optimal demolition method. The influencing criteria have been obtained from previous research, while interviews were conducted with the experts who are experts in demolition in Indonesia to obtain relevant and irrelevant criteria. Data analysis uses a relevance index with a relevance rating between 1 and 5, where 1 represents irrelevant and 5 is very relevant.

B. *Data Collection*

The data collection process was carried out by distributing questionnaires to practitioners who had carried out demolition in Indonesia. The purpose of this questionnaire is to obtain information about conditions that are in accordance with the input and output needed in the development of the model. Afterwards, the collected data is divided into two categories, the first data is used as a training model and the second data is used as model validation.

C. *Model Validation*

Model validation was conducted by applying the model to demolition construction projects, especially buildings, then calculating the model's accuracy or model feasibility and discussing the results of the model. This validation can be conducted using the match-not-match method. The data used in validation is testing data that is different from the data used as training in modeling. Therefore, the validity of the resulting model can be truly measurable.

IV. RESULTS & ANALYSIS CONCLUSION

A. *Characteristics of Respondents*

Respondents were those who had demolished buildings in Indonesia.

B. *Criteria for the Final Model*

There were 20 criteria including the impact therein which had an influence on practitioners' decisions in choosing the demolition method. Afterwards, the questionnaire was distributed, and the results were analyzed using a validity test and reliability test. The results of the questionnaire are shown in Table I. Cronbach Alpha coefficients for building characteristics and impacts are 0.84 and 0.69 which are above 0.6 and therefore, samples have good reliability

TABLE I. LIST OF CRITERIA CONSIDERED FOR THE SELECTION OF THE DEMOLITION METHOD BY PRACTITIONERS

No	Criteria That Affect the Selection of the Demolition Method	R Count	R Table	Conclusion
1	shape and size of the structure	0.651	0.311	Valid
2	structural stability	0.608	0.311	Valid
3	extent of demolition	0.467	0.311	Valid
4	scale of construction	0.672	0.311	Valid
5	health and safety	0.342	0.311	Valid
6	the level of interference allowed	0.613	0.311	Valid
7	presence of hazardous materials	0.754	0.311	Valid
8	environmental considerations	0.577	0.311	Valid
9	location and/or accessibility	0.625	0.311	Valid
10	cost considerations	0.628	0.311	Valid
11	restrictions given by the client	0.720	0.311	Valid
12	Structural Engineer requirement	0.715	0.311	Valid
13	resources (equipment and factories)	0.362	0.311	Valid
14	time consideration	0.361	0.311	Valid
15	air pollution	0.715	0.311	Valid
16	energy use and fuel consumption	0.638	0.311	Valid
17	energy and material costs	0.569	0.311	Valid
18	location and/or accessibility	0.679	0.311	Valid
19	workplace safety	0.510	0.311	Valid
20	noise	0.449	0.311	Valid

C. *Estimation of the Demolition Method Selection Model*

In developing the model, the input model used is the 14 building characteristics and 6 impacts obtained from the previous stage as shown in Fig. 1. Meanwhile, the modeling was processed using Multi-class and Multi-label Classification. The structure of the model developed is shown in Fig. 2. Multi-class and Multi-label Classification to PYTHON software consists of 14 building characteristics and 6 impacts inputs with each input is categorized.

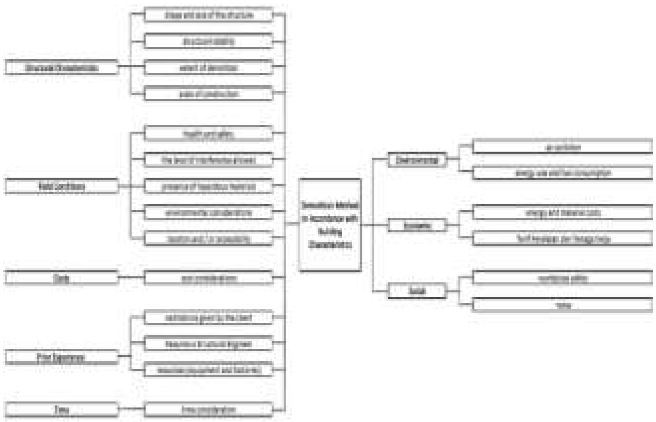

Fig. 1. Estimation of the Demolition Method Selection Model

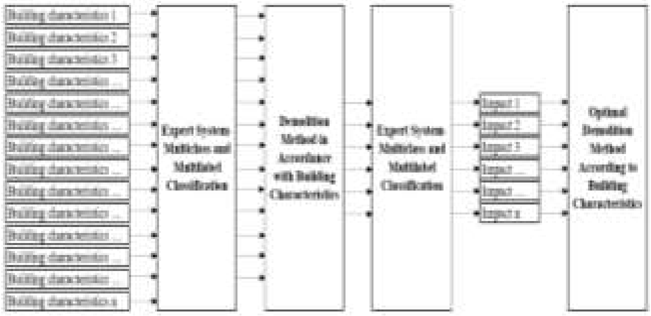

Fig 2. Estimation of the Demolition Method Selection Model Using Multi-class and Multi-label Classification

D. *Model Implementation*

By applying the model to the actual data, validation and accuracy of the model was known to obtain the right and optimal demolition method. The actual data was the result of the demolition process carried out by Practitioners in Indonesia; in this case, the result indicated the method used at that time. The results of the implementation of the 9 actual data models are shown in Table II and Table III below. he results of model in determining the demolition method have an accuracy of 89.3%. The results of model in determining the demolition impact have an accuracy of 98.3%.

TABLE II. RESULTS OF MODEL IMPLEMENTATION FOR DEMOLITION METHOD

No.	Actual Condition	Model's output	Training Accuracy	Model Accuracy
24	M2, M7, M9	M2, M7, M9	100%	86%
17	M2, M9	M2, M9	100%	90%
12	M1, M2, M7, M9, M13	M1, M2, M7, M9, M13	100%	81%
10	M1, M2, M9, M10	M1, M2, M9, M10	100%	95%
13	M2, M4, M6, M9, M12	M2, M4, M6, M9, M12	100%	95%
4	M1, M2, M7, M8, M9	M1, M2, M7, M8, M9	100%	95%
19	M1, M2, M9, M10	M1, M2, M9, M10	100%	86%
3	M1, M2	M1, M2	100%	86%
1	M2	M2	100%	90%
	Mean		100%	89.3%

TABLE III. RESULTS OF MODEL IMPLEMENTATION FOR DEMOLITION IMPACT

No.	Actual Condition	Model's output	Training Accuracy	Model Accuracy
79	i1 (4)	i1 (4)	95%	95%
12	i2 (5)	i2 (5)	100%	100%
54	i3 (4)	i3 (4)	93%	95%
58	i4 (4)	i4 (4)	100%	100%
87	i5 (5)	i5 (5)	100%	100%
5	i6 (5)	i6 (5)	95%	100%
	Mean		97.2%	98.3%

E. *Study Case*

The model application in the X building demolition project case study was used to predict the optimal demolition method selection using the multi-class and multi-label classification stage and model validation. Inputs were retrieved from two data sources, namely primary data through questionnaires and secondary data (historical) in the form of data from the Project. The results of testing the data on the actual data are presented in Table IV and Table V.

TABLE IV. MODEL TEST RESULTS FOR ACTUAL DATA

No.	Actual Condition	Model's output	Testing Accuracy	Model Accuracy
18	M1, M2, M9	M2, M9	93%	95%

TABLE V. MODEL TEST RESULTS FOR ACTUAL DATA

No.	Actual Condition	Model's output	Testing Accuracy	Model Accuracy
84	i1 (4)	i1 (4)	95%	95%
82	i2 (4)	i2 (4)	100%	100%
50	i3 (4)	i3 (4)	93%	95%
14	i4 (4)	i4 (4)	100%	100%
3	i5 (5)	i5 (5)	100%	100%
48	i6 (5)	i6 (5)	95%	100%

The simulation results generate a method that can be used to do demolition. M1 is a demolition method using a diamond disc cutter, M2 uses a hand hammer and M9 uses mechanical (non-hydraulic). The error rate of multi-class and multi-label classification predictions in the choice of the demolition method is 5% -10% and the accuracy of the prediction model is 90% -95%. The simulation results on the impact show that air pollution produced (i1) is moderate (4), energy use and fuel consumption (i2) are efficient (4), energy and material costs (i3) are not large (4), equipment and labor tariffs (i4) are not large (4), workplace security (i5) is very safe (5) and noise (i6) is not disturbed (5). The error rate of multi-class and multi-label classification predictions in the choice of the demolition impact is 0%-5% and the accuracy of the prediction model is 95% -100%.

V. CONCLUSION

Based on data analysis, it was found that the main criteria affecting practitioners in choosing demolition methods were structural characteristics, field conditions, costs, prior experience and the speed at which demolition was carried out. While the main impacts arising from demolition were environmental impacts, economic impacts and social impacts. The demolition method selection model proposed in this study pays attention to five main criteria with fourteen input characteristics of buildings to be demolished. Inputs are structure shape and size, structural stability, extent of demolition and scale of construction, safety, level of disturbance permitted, presence of hazardous materials, environmental considerations, location and/or accessibility, costs, client specifications, structural engineer approval, availability of resources, and time considerations. The environmental impacts include air pollution and energy and fuel use; the economic impacts include equipment and labor and energy and material costs, and social impacts include workplace security and noise. The model has an accuracy value of 90-95% in determining the decision to choose the demolition method and an accuracy of 95% -100% in determining the impact that might arise due to demolition.

REFERENCES

[1] Yeheyis, M., Hewage, K., Alam, M. S., Eskicioglu, C., & Sadiq, R. (2013). An overview of construction and demolition waste management in Canada: A lifecycle analysis approach to sustainability. Clean Technologies and Environmental Policy, 15(1), 81–91.

[2] Pranav, P., Pitroda, J., & Bhavsar, J. J. (2015). Demolition : Methods and Comparision, (August).

[3] Quarmby, T. R. (2011). Safe, healthy and sustainable demolition. Loughborough University.

[4] Rathi, S. O., & Khandve, P. V. (2014). Demolition of Buildings – An Overview. Ijaerd, 1(6), 1–8. Diambil dari http://www.ijaerd.com/papers/finished_papers/ijaerd 14-0268.pdf

[5] Anuranjita, A., Berghorn, G. H., Bates, D., & Syal, M. G. M. (2018). Life Cycle Assessment Framework for Demolition and Deconstruction of Buildings. Proceeding of Construction Research Congress 2018, (1), 148–157.

[6] Abdullah, A., & Anumba, C. J. (2002). Decision model for the selection of demolition techniques. Advances in Building Technology, 2, 1671–1679.

[7] Anumba, C. J., Abdullah, A., & Ruikar, K. (2008). An integrated system for demolition techniques selection. Architectural Engineering and Design Management, 4(2), 130–148.

[8] Kasai, Y., Rosseau, E. and Lindsell, P. (1998). Outline of Various Delllolitioll Methods and their Evaluatioll. In RlLEM International Symposium on Demolition and Reuse of Concrete and Masonry: demolition methods and practice. London: Chaprnan and Hall.

[9] Fesseha, T. (1999). Criteria for Selection of Demolition Techniques. Loughborough University, UK.

[10] Hurley, J. W., McGrath, C., Fletcher, S. L., & Bowes, H. M. (2001). Deconstrllctioll and Reuse of Construction Material. Building Research Establishment, 1–17.

[11] Islami, M. W. (2014). Analisa Metode dan Biaya Pembongkaran Bangunan Pasar Turi Tahap- III Surabaya. ITS Surabaya.

[12] Ganjbakhsh, H., Abdullah, A. Bin, Sadi, M. K., & Yadollahi, M. (2015). Effective Training Factors for Competency of Demolition Operatives in Malaysia. International Journal of Economics and Financial Issues, 5, 238–241.

[13] Hübner, F., Volk, R., Kühlen, A., & Schultmann, F. (2017). Review of project planning methods for deconstruction projects of buildings. Built Environment Project and Asset Management, 7(2), 212–226.

[14] Coelho, A. and J. de B. (2009). Economic analysis of conventional versus selective demolition – A case study. Elsevier, 3–11

[15] Wafiq, L., & Adi, T. J. W. (2016). MODEL ALAT BANTU PENGAMBILAN KEPUTUSAN METODE, (2014), 1–8.

[16] Abdullah, A., Anumba, C., & Durmisevic, E. (2003). Decision tools for demolition techniques selection. 11Th Rinker International Conference on Deconstruction and Material Reuse, (Mcdm), 55–72.

[17] Tatten, J. J. (2000). Demolition and Dismantling. The Journal of The National Federation of Demolition Contractors.

[18] Abdullah, A. (2003). Intelligent Selection of Demolition Techniques. Loughborough University.

[19] Anumba, C., Abdullah, A., & Fesseha, T. (2003). Selection of demolition techniques: A case study of the Warren Farm Bridge. Structural Survey, 21(1), 36–48.

[20] Barsottelli, M., & Avci, O. (2013). Fundamentals of Highway Bridge Demolition. Structures Congress 2013, 680–688.

[21] Zahir, S., Syal, M., Lamore, R., & Berghorn, G. (2016). Approaches and Associated Costs for the Removal of Abandoned Buildings. In ASCE Construction Research Congress (hal. 229–239). Zamagni.

[22] Ajufoh, M. O., & Ogwuche, H. (2016). Appraising the Effects of Building Construction Activities on the Immediate Environment. In The Academic Conference of Mediterranean Research and Publications International on Sustainable Development, 4. Bauchi, Nigeria.

[23] Achillas, C., Moussiopoulos, N., Karagiannidis, A., Banias, G., & Perkoulidis, G. (2013). The use of multi-criteria decision analysis to tackle waste management problems: A literature review. Waste Management and Research.

[24] Denhart, H. (2010). Deconstructing disaster: Economic and environmental impacts of deconstruction in post-Katrina New Orleans. Resources, Conservation and Recycling.

[25] Sharrard, A. L., Matthews, H. S., & Roth, M. (2007). Environmental Implications of Construction Site Energy Use and Electricity Generation. Journal of Construction Engineering and Management.

[26] (ASMI), A. S. M. I. (1997). Demolition Energy Analysis of Office Building Structural System.

[27] Chen, Z., Abdullah, A. B., J.Anumba, C., & Li, H. (2014). Case of idiopathic red iris tumor. Rinsho ganka. Japanese journal of clinical ophthalmology, 16, 1019–1022.