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EVALUATION OF ROUGH SET THEORY FOR DECISION MAKING OF REHABILITATION METHOD FOR CONCRETE PAVEMENT

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Abstract In recent years a great number of advanced theoretical - empirical methods has been developed for design & modeling concrete pavements distress. But there is no reliable theoretical method to be use in evaluation of conerete pavements distresses and making a decision about repairing them. Only empirical methods is used for this reason.
One of the most usual methods in evaluating concrete pavements distresses is to determine the PCI of the Pavement Condition Index. As a result of large number of variables and complicated decision - making algorithm using the information obtained in this method, may have some difficulties. Presenting an analytic -theoretical method mixed with the PCI method may be the bases for the development of a theoretical empirical method in evaluation of concrete pavements distresses & can remove the diffculties.
The present paper describes a method of applying the rough set theory for evaluation of reinforced concrete highway pavements distresses in PCI method to extract the minimal decisian algorithm and selecting the best suitable method of rehabilitation. The significance of the conditional attributes retained in the minimal decisian algorithmis evaluated, and a method of deriving rules from the algorithm for the constraction of expert system is described. The result of this procedure shows the high reliability of this method, using the minimum necessary informations.

Keywords Concrete Pavements, Rough Set, Pavement Distress, Pavement Management.

چکیده در سالهای اخیر روش‌های نظری ـ تجربی طراحی و مدلسازی خرابی‌های روسازی‌های بتنی راهها پیشرفت زیادی نموده است. امّا تاکنون روش نظری قابل قبول و دارای قابلیت اطمینان بالایی برای ارزیابی خرابی‌های روسازی‌های بتنی و تصمیم‌گیری در رابطه با روش ترمیم مناسب آنها ارائه نشده و این کار تنها با استفاده از روش‌های تجربی انجام می‌شود.
یکی از روش‌های تجربی متداول در سنجش خرابی‌های روسازی‌های راه‌های بتنی، روش نشانه وضعیت روسازی (PCI) است، امّا استفاده از نتایج این روش به منظور تعیین راهکارهای مناسب برای‌مرمت و یا بازسازی راه بدلیل تعداد زیاد متغیرها و پیچیده بودن الگوریتم تصمیم‌گیری امری دشوار است. چنانچه یک روش تحلیلی نظری برای رفع پیچیدگی‌های نحوهٔ تصمیم‌گیری روش PCI با آن آمیخته گردد، پایه ایجاد یک روش نظری ـ تجربی برای سنجش خرابی‌های روسازی‌های بتنی گذاشته می‌شود.
در این پژوهش، روش استفاده از تئوری Rough set برای سنجش خرابیهای روسازی‌های بتنی‌راه‌ها بطریقه PCI به منظور تسهیل در تصمیم‌گیری و انتخاب نوع روش ترمیم مناسب، تشریح و ارزیابی می‌گردد و سپس روشی برای بدست آوردن قوانین ساخت سیستم خبره (Expert System) با استفاده از این تئوری ارائه می‌شود و صحت و قابلیت اعتماد نتایج بدست آمده ارزیابی می‌گردد. نتایج حاصل از این ارزیابی، قابلیت اعتماد نسبتاً بالای این روش را، با توجه به نیاز آن به حداقل اطلاعات لازم نشان می‌دهد

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1. INTRODUCTION

Every year a great amount of money is spending for rehabilitation and reconstruction of roads and pavements in most countries. Making an ideal decision for rehabilitation procedures or pavement reconstruction needs to recognize types of failure and severity evaluation of typical distresses (smith et al. 1979).

Two methodes can be used for evaluating of pavement distresses. The first includes evaluating the effect of failure on the intended function for the pavement that its serviceability is under daily traffic. The second is a mechanical evaluation with visual inspection for determining the physical conditions of the pavement and the problems which caused this conditions (Huang, 1993).

The difference between the two methods is because of the correlation of the pavement's behaviour to the constructional procedures. For instance, a crack on the surface of pavement maybe has no effect on the serviceability of the pavement to the traffic, or maybe there is only a few effection. However, when an engineer looks at this crack, in mechanical evaluation maybe he/she thinks that this crack can let the water get inside the base course and increase the deflection of the pavement and cause serious failure. Any change in the behaviour of pavements can cause types of failure and maybe a result of constructional functions (AASHTO Guide, 1993).

One of the methods for evaluating pavement distresses is the pavement condition index (PCI) procedure. This procedure has been recommended by the U. S. Corps of Engineers and is considered as a standard method in many organizations all over the world (Shahin and Walther 1994). PCI is in fact a number between 0 and 100 that shows the pavement condition from poor to excellent. The PCI number is calculated with evaluting several segments of a pavement determining the severity of distress. The information determined in this procedure can provide a complete recognization of the main causes of failure and its relation to the traffic load, the climatic conditions or other effective factors (Pavement Condition Index, 1984).

After evaluating the distresses with PCI method, it is important to make an economical decision about the rehabilitation or repairing the pavement. In most cases it is difficult to select which type of repair is suitable for the pavement. Because the type and the severity of distress may be different in each segment of the road and cannot be repaired with one procedure. On the other hand, a general PCI number cannot provide the sufficient information to make the ideal decision for different parts of a pavement (FWA, 1991). Thus, developement of an adquate algorithm to reduce the number of variables effective in the decision can be very helpful in the decision making with PCI evaluation results.

The present paper describes a method of applying the rough set theory, to determine the severity level of distresses in concrete highway pavements with experimental knowledge. For this purpose, the rough set theory is applied to diagnostic cases, by experts, of the severity levels, or decision attributes, of concrete pavements and removed conditional attributes and classes of each conditional attribute insignificant in the diagnoses to extract minimal decision algorithm which is still capable of making diagnoses equal to those by experts (Attoh and Okine, 2002).

2. ROUGH SET THEORY

Rough set theory is a mathematical tool for dealing with vagueness or uncertainty. This theory was formulated by Zdzislaw Pawlak, a professor and research scientist at Institute of Theoretical and Applied Informatics in Polish Academy of Sciences in 1991 (Pawlak 1991).

Rough set theory is a natural generalization of twin theory (well known in interval mathematics).

In both theories are interested in a set S;

- it can be the set of possible values of some quantity, or
- it can be a set of pixels that form an image.

In many real - life situations, we have only partial infomation about the set S :

- for some points S, we know for sure that s belongs to the set S;
- for some other points S, we know for sure that s does not belong to S;
- for some points s, we do not know whether this point belongs to the (unknown) set S or not.

In this case, the only information that we have

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about the set S is that the set S is in between the set L of all points that difinitely belong to S and the set U of all points that may belong to S (i. e., about which we do not know for sure that they do not belong to S): L is a subset of S, and S is a subset of U. In other words, the available information about the unknown set s can be represented by a pair of sets(L , U) such that L is a subset of U.

When both lower and upper approximation sets L and U are intervals, we get a twin. In knowledge representation, it is natural to consider more general sets defined by properties. Namely, if the only information that we have about the elements S consist of the values of n basic properties $P_1(s)$,... ,$P_n(s)$, then we have to define the approximation. In mathematical terms, we consider the set algebra generated by the sets $S_i = \{s| p_i(s)\}$ (i. e., the smallest class that contains all these sets and that is closed under union, intersection, and complement), and we take pairs (L , U) of elements from this algebra. Such a pair is called a rough set.

Rough set theory has the attention of researchers and theoricians world wide and has been successfully applied in fields ranging from medicine to finance.

3. THE USE OF ROUGH SET THEORY IN SEVERITY EVALUATION FOR CONCRETE PAVEMENT DISTRESSES

For evaluating of pavements distresses, using rough set theory, 27 different cases of information obtained from parts of a reinforced concrete highway pavement, were used in the study. The concrete pavement section belonging to National Road 7, situated in the Andes Range and close to the international frontier between Argentina and Chile. This paper deals with preliminary results obtained after a pavement distress survey conducted during year 2001 for that section (World Bank and PIARC, 2002).

These information was performed by experts in accordance with the diagnostic method prepared by American Army Corps of Engineering in 1984. Removing indistinetive conditional attributes in the diagnostic method, the author put into Table 1 , 12 conditional attributes such as (a) Faulting, (b) Corner Spalling,… . Each conditional attribute is provided with 4 classes which shows high severity, medium severity, low severity & none. The severity levels of all conditional attributes for each segment have been shown with H, M, L which discribe high, medium and low pavement condition lndex (PCI) of the pavement. Table 2 shows the class numbers of conditional attributes and severity levels for 27 segments diagnosed by example. For example, the segment S_1 is classified into the class number 2 of conditional attribute (a) and the class number 1 of the conditional attribute (b), and its severity level is diagnostic as "M". In other words, this table shows the relation between the class numbers of the conditional attributes of each segment and its severily level or decision attribute, and such relations and table are called decision rules and a decision table, respectively.

3. 1. DETERMINATION OF MINIMAL DECISION ALGORITHM

Primarily, it is necessary to check whether the severity levels were compatible with 12 conditional attributes in Table 2 which shows the summary of diagnostic results by experts. The decision rules of all the segments were examined to find non-deterministic rules; i. e., segments which were classified into one and the same class under every conditional attribute but were assigned different severity levels.

None-deterministic rules were not found is Table 2, and hence the severity level proved subordinative to conditional attributes. If non-deterministic rules are found in such a decision table, it means that the number of conditional attributes in the decision table is not sufficient and new conditional attributes have to be added to existing ones. In the process of extracting minimal decision algorithm, it is necessary to make trial and error to rectify non-deterministic rules, if any, and make a decision table free of contradictions.

On the other hand, the segments S_{14}, S_{26} were governed by one and the same rule. In such a case, it suffices to remove one segment and consider only the other. Accordingly, the segment S_{26} which is marked with "#" was removed from Table 2 to obtian a new decision table.

In order to find the conditional attributes insignificant in the diagnoses, a number of conditional attributes should be removed each

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Table 1. Conditional attributes for severity levels of reinforced concrete pavements distresses

conditional attributes	**Classification of individual situations**	**severity levels**
(a) faulting	1. The difference in elevation in two sides of the joint is more than 19mm 2. The difference in elevation in two sides of the joint is more than between 10 mm to 19 mm 3. The difference in elevation in two sides of the joint is more than between 3mm to 10 mm 4. The difference in elevation in two sides of the joint is less than 3mm or no difference	H M L N
(b) corner spalling	1. Spalling depth is more than 51 mm 2. Spalling depth is between 25 mm to 51 mm 3. Spalling depth is less than 25 mm 4. None	H M L N
(c) Joint Seal Damage ofTramsverse Joints	1. Joint sealant is in poor condition over the entire surveyed section with one or more types of damage occuring to a sever degree 2. Joint sealant is in fair condition over the entire surveyed sectian , with one or more types al demage to a moderate degree 3. Joint sealant is in good condition throughout the section with only a minor amount of any of the above damage 4. None	H M L N
(d) Lane/Shoulder Drop – off or Heave	1. The difference in elevation between the traffic lane and the shoulder is more than 102 mm 2. The difference in elvevation is between 51 mm to 102 mm 3. The difference in elvevation is between 25 mm to 51 mm 4. The difference in elvevation is less than 25 mm	H M L N
(e) Popouts1	1. More than 15 percent of pavement area 2. Less than 15 percent of pavement area 3. Very few area 4. None	H M L N
(f) Blow up	1. Blow up causes excessive bounce of the vehicles which creates substantial discomfort 2. Blow up causes a significant bounce of the vehicles which creates some discomfort 3. Blow up has occurred, but only causes some discomfort 4. None	H M L N
(g) Corner Break	1. Crack is spalled at high severity 2. Crack is working and spalled at medium severity 3. Crack is tight (hair line) and is not spalled 4. None	H M L N
(h) Polishing of aggregates	1. Noticeable 2. Very few or no polishing	M N
(I) Edge Punchout	1. High severity 2. Medium severity 3. Low severity (Note to the width and condition of punchout) 4. None	H M L N
(J) Linear Creacking	1. High severityH 2. Medium severityM 3. Low severity (Note to the type of cracking, sealed or unsealed and width and difference in elevation) 4. None	H M L N
(k) Durability (''D'') Cracking	1. In more than 15 percent of slab area, high severity level of joints / creacks exists , so that most pieces can be seperated from the slab. 2. In more than 15 percent of slab area, sever levels of joints/ cracks exist, but piecs is not seperateable. 3. In less than 15 percent of slab area, most of the cracking are sealed and can not seperated. 4. None	H M L N
(L) Slab dividation	1. The number of pices is high 2. The number of pices is medium 3. The number of pices is Low 4. None (According to the severity of cracking and the number of pieces in the cracked slab.)	H M L N

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Table 2. Observation data for diagnosis of pavement distresses severity levels

Segments	Conditional attributes												severity
	a	b	c	d	e	F	g	h	i	j	k	l	
S_1	2	1	4	2	3	2	1	1	3	2	1	4	M
S_2	3	3	3	3	2	1	2	2	4	3	2	1	M
S_3	2	2	2	4	4	4	4	2	3	2	2	4	L
S_4	4	4	1	4	3	3	2	2	3	3	3	4	L
S_5	1	4	3	4	3	2	2	1	1	1	2	3	M
S_6	3	2	2	1	1	1	2	1	2	3	2	3	H
S_7	1	4	4	3	2	4	3	1	2	4	3	4	L
S_8	4	4	4	3	3	4	3	2	4	4	2	3	L
S_9	3	1	3	2	1	2	1	2	1	2	1	3	H
S_{10}	4	3	2	3	2	1	2	1	1	3	3	2	M
S_{11}	3	3	1	2	2	1	1	1	1	2	3	1	H
S_{12}	2	3	4	2	3	2	1	1	2	2	2	2	M
S_{13}	3	2	3	4	4	4	3	1	4	3	2	2	L
S_{14}	4	3	2	2	3	4	3	2	2	1	3	3	M
S_{15}	4	3	1	2	1	1	3	1	2	1	2	2	H
S_{16}	4	4	4	3	2	4	3	2	3	3	2	4	L
S_{17}	3	3	4	2	3	1	3	1	3	3	1	4	M
S_{18}	3	1	3	1	1	2	3	2	1	1	3	2	H
S_{19}	2	1	2	3	2	4	2	1	1	1	2	1	H
S_{20}	1	2	1	3	4	3	3	2	4	3	2	2	M
S_{21}	1	2	1	2	3	4	2	2	3	3	1	4	M
S_{22}	2	2	1	2	3	1	2	2	1	1	1	1	H
S_{23}	3	3	4	2	4	4	3	1	4	4	1	3	L
S_{24}	4	3	3	2	2	2	4	1	2	3	2	3	M
S_{25}	3	1	1	2	2	4	1	1	1	2	3	1	H
S_{26}	4	3	2	2	3	4	3	2	2	1	3	3	M #
S_{27}	2	3	4	3	2	3	3	2	1	4	3	4	M

time, and the decision table should be checked to make sure any contradiction is not occured. For instance, if we remove the conditional attributes (a), (f), (i), (j) and (l), the decision rules of segments S_{21} and S_{22} will be contradictory to each other. This means the severity level of segments S_{21} and S_{22} is subordinative to one of the conditional attributes (a), (f), (i), (j) and (l), so we cannot remove these conditional attributes, simultaneously. We removed each combination from Table 2 minus the segment S_{26}, then checked whether any contradiction occured among the decision rules.

Eight combinations of conditional attributes, case - 1 to 8 have shown in Table 3. All of the combinations consist of the minimum number of conditional attributes, but still are able to diagnose the pavements with no contradiction. For illustrating the procedure for extracting the minimal decision algorithm the method used for case - 1 is presented.

In case-1, the conditional attributes other than those of (a), (c) and (e) of case-1 were removed from Table 2 minus the segment S_{26}, so a new table obtained. In the new table, a pair of segments S_1 and S_{12} and S_9 and S_{18} and so on, has been

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classified by one and the same rule used for each. The segments of each pair were removed except one and the result is given in Table 4.

Table 3. Combinations of conditional attributes

Nos. of cases	Conditional attributes		
1	(a)	(c)	(e)
2	(a)	(f)	(i)
3	(b)	(c)	(f)
4	(b)	(c)	(i)
5	(b)	(c)	(l)
6	(c)	(e)	(f)
7	(d)	(f)	(i)
8	(e)	(f)	(j)

Finally, the classes of the conditional attributes in Table 4 should be checked. All of the class numbers of each conditional attribute were removed one by one and checked for any contradiction. If there is any contradiction it means that the removed class number is significant in the diagnosis of the pavement distresses, otherwise it is insignificant in the diagnosis. For instance, we can obtain a new decision table by removing the class number 2 of the conditional attribute (a) of the segment S_1. In this table, the segment S_1 is assigned number 4 and 3 in the columns of the conditional attributes (c) and (e), and the severity level is diagnosed as "M", while the segment S_8 is assigned to the same numbers in the columns of the same conditional attributes but its severity level is diagnosed as "L". Thus, there is a contradiction between the decision rules of the segments S_1, S_8 which are marked with "#", meaning that the class number 2 of conditional attribute (a) of the segment S_1 is significant in diagnosing the severity level of the segment S_8 and so should not be removed.

As mentioned above, a new decision table was obtained that contains no contradiction and although many of the class numbers have been removed, this table can still make the same diagnoeses as Table 4. In this table, the two segments S_8 and S_{16} and same groups of the segments such as S_6, S_9 and S_{15}, and... have been regarded as one and have the same rule and so the segments of each pair or group were removed except one to obtain a new decision table or Table 5. This table is called the "minimal decision algorithm" that there is no single conditional attribute or class removable without causing contradiction.

Table 4. Dicision table based on conditional attribute in case - 1

segments	Conditional attibutes			Severity level
	(a)	(c)	(e)	
S_1	2	4	3	M
S_2	3	3	2	M
S_3	2	2	4	L
S_4	4	1	3	L
S_5	1	3	3	M
S_6	3	2	1	H
S_7	1	4	2	L
S_8	4	4	3	L
S_9	3	3	1	H
S_{10}	4	2	2	M
S_{11}	3	1	2	H
S_{13}	3	3	4	L
S_{14}	4	2	3	M
S_{15}	4	1	1	H
S_{16}	4	4	2	L
S_{17}	3	4	3	M
S_{19}	2	2	2	H
S_{20}	1	1	4	M
S_{21}	1	1	3	M
S_{22}	2	1	3	H
S_{23}	3	4	4	L
S_{24}	4	3	2	M
S_{27}	2	4	2	M

4. EVALUATING THE MINIMAL DECISION ALGORITHM

The frequencies of appearance in Table 3 of each conditional attribute required by the minimal decision algorithm are shown in the Figure (1). The appearance frequency of the conditional attribute (c) and (f) that is required by 5 case minimal algorithm is five. And, for the conditional

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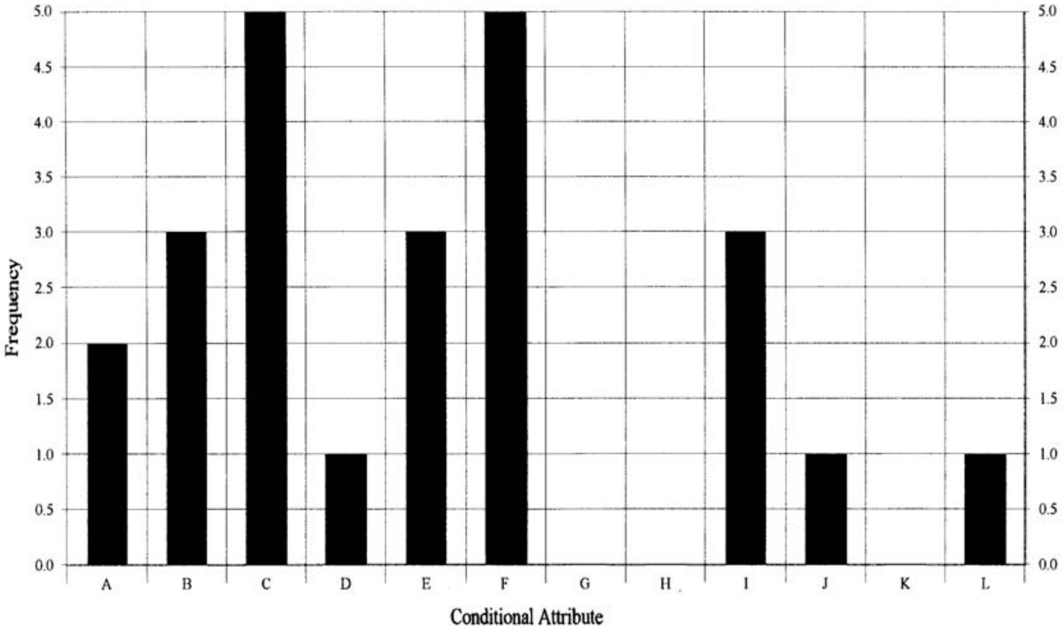

Figure 1. Frequency of conditional attributes

attribute (D) that is only required by case 7th minimal decision algorithm, its appearance frequency is one. By ranking the conditional attributes in the descending order of the appearance frequency, we see that the most significant conditional attributes in evaluating the severity level of the distresses in this highway are: (c) Joint Seal damage of transverse Joints and (f) blow up. We can describe the minimal decision algorithm by rules such as "If conditional part (conditional attribute) THEN conclusive part (severity level of distress or decision attribute).

For example, we can describe the minimal decision algorithm of case - 1 (Table 5) by 18 rules. The decision rules of the segments S_1 and S_2 are representing by the rules 1 and 2, respectively and the rule 18 expresses the decision rule of the segment S_{23}. The decision rule of S_6 in tables indicads that if a pavement is classified into the class number 1 of the conditional attributes(e), the severity level is"H", or:

IF (e) = 1 THEN Severity Level = H

Table 5. Minimal decision algorithm in case-1

Segments	Conditional attibutes			Severity level
	(a)	(c)	(e)	
S_1	2	4	-	M #
S_2	-	3	2	M
S_3	-	2	4	L
S_4	4	1	3	L
S_5	-	3	3	M
S_6	-	-	1	H
S_7	1	-	2	L
S_8	4	4	-	L #
S_{10}	4	2	-	M
S_{11}	-	1	2	H
S_{13}	-	3	4	L
S_{14}	-	2	3	M
S_{17}	3	-	3	M
S_{19}	2	2	2	H
S_{20}	-	1	4	M
S_{21}	1	-	3	M
S_{22}	2	1	-	H
S_{23}	-	4	4	L

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When both of the conditions occure at the same time, so that one of the conditions is that the segment's classification is the class number 2 of the conditional attribute (a) and the second being that the classification of the segment is class number 4 of the conditional attribute (c), the severity level is assigned as"M". The rule below discribes for segment S_1 as:
IF (a) = 2 and (c) = 4 THEN Severity Level = M
In order to determine the severity levels of conclusive part using Expert Systems (ES), we need to check if all the conditions in each rules are satisfied. For instance, for the rule 23, we need to check whether the segment is classified into 4 of (c) and (e) or not. Totally, we need to check 37 conditions in 18 rules of case 1. Besides, the decision tables of the minimal decision algorithm for cases 2 to 8, also have been extracted. Case 5 has the highest number of rules and the total numbers of conditions and case 6 has the less numbers.
Rules for the construction of Expert Systems (ES) should be so described that their number can be minimized for the sake of knowledge renewal and so on. Besides, conditions to be checked also should be so described that their mumber can be minimized to speedy reasoning. Accordingly, the efficient renewal of knowledge and speedy reasoning become possible if an ES is constructed on the basis of the rules derived from the minimal decision algorithm of case 6.

5. COMPARISON OF THE RESULTS OBTAINED FROM ROUGH SET THEORY AND ARTIFICIAL NEURAL NETWORK

To compare the results of the assesment of distress severity level in concrete pavements using two different methods; i.e. rough set theory and artifical neural network, five more segments of the selected road were investigated which their distress characteristics of other 27 segments are tabulated in Table 2.
These distresses are evaluated in the same manner by experts and the results are shown in Table 6. As it can be seen from the table, segments X_1, X_5 and X_2, X_4 and X_3 have the serverity level high (H), medium (M) and low (L), respectively.

Table 6. Observation information regarding assesment of distress severity level for five segments of a concrete pavement

Segments	Conditional attributes												severity
	a	b	c	d	e	f	g	h	i	j	k	l	
***X*₁**	1	3	2	2	1	2	1	1	2	1	3	1	H
***X*₂**	2	4	2	1	1	2	2	1	2	2	1	2	M
***X*₃**	3	4	4	3	2	4	2	2	3	4	3	3	L
***X*₄**	4	2	2	2	1	2	4	2	3	2	2	1	M
***X*₅**	1	2	3	1	2	2	1	1	2	1	2	3	H

To assess the distress severity level of these segments using artificial neural network, observation data in Table 2 were used as training input using Easy NN 8.01 software. This software is one of the most powerful and easy-to-use programs in this field. Many different MLP networks with one through three intermediate layers can be modeled with this software by different number of neurons. It could also use different criteria to finish the operation of net training like reaching a specified value for cycles, specified value for time elapsed, specified error value, etc. Also it has the capability to use and present alphabetical input and output data as well as numerical data. It can also normalize the data between zero and one values automatically, and can present the effect of input and output data. Applying this important ability, the most effective data can be recognized through lots of data variables.
The neural network used here has one hidden layer including 13 neurons which have been determined by trial and error method. The criteria for stop – based training was based on target error less than 0.0003. This is a very low target error and shows that the training of model has high accuracy. Also, the learning rate and momentum value were assumed to be 0.6 and 0.8, respectively.
After the network training procedure and confirming the authenticity of the results, the observation data of Table 6 regarding segments X_1

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, X_2 , X_3, X_4 and X_5 were processed using this method. Consequently, these data were assessed using rough set theory. The results of these investigation are tabulated in Table 7.

As it can be seen in Table 7, the results of rough set theory are compatible with assesment of experts in all 5 cases, where as in artifical neural network method only the results of segments X_1 and X_3 are in accordance with the assessment of experts and rough set theory. Therefore, it can be concluded that the rough set theory has more reliability level in assesment of distress severity level of concrete pavements than the artificial neural network method.

Table 7. Comparison of the results of distress analysis for 5 segments of a concrete pavement for two different methods; i.e. artifical neural network and rough set theory

Seventy level / Segments	Evaluation of experts	Assesment using rough set theory	Assesment using artifial neural network
X_1	H	H	M
X_2	M	M	M
X_3	L	L	L
X_4	M	M	L
X_5	H	H	H

6. CONCLUSIONS

In this paper, the basic information about the decision rules using rough set theory was discussed and the application method of this theory for the decision - making problems was discribed. The method of extracting experiential knowledge of experts from diagnostic results of severity levels of distress in reinforced concrete highway pavements has been disscused and the decision tables of minimal decision algorithm have been determined. Also the results of this method and artificial neural network method have been compared.

The most important results of the present paper are as follows:

1. The decision table determines the most convenient decision for a certain condition. Formulating such decision table may help for any decision making problem.
2. By constructing an Expert System using the rules derived from the minimal decision algorithm, it is possible to renew the knowledge speedy reasoning, efficiently.
3. The minimal decision algorithm is extrated by identification of the significant conditional attributes determined from the diagnostic results of pavements distress by experts, and is used to make the best decision.
4. The rough set theory has more reliability level in assesment of distress severity level of concrete pavements than the artificial neural network method.
5. Rough set theory is used for expressing the set of decision attributes by the set of paired conditional attributes, thus we can use this theory as a method to acquire informations from diagnostic cases which exist in civil engineering problems.

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