Feasible Treatment Selection for Routine Maintenance of Flexible Pavement Sing Fuzzy Logic Expert System

Rajnish Kumar, Sanjeev Kumar Suman, and Ankita Singh

Abstract Pavement maintenance management system motivates to provide a scientific tool for maintenance and rehabilitation of roads pavement at desired serviceability levels. In view of the fund's constraints and the need for judicious spending of available resources, the maintenance planning and budgeting are required to be done based on scientific methods. Unfortunately, the current maintenance practices are ad-hoc and subjective in nature. Pavement condition responsive maintenance is very useful for judicious disbursement of maintenance funds. The objective of this paper is to select a feasible treatment for routine maintenance based on pavement condition parameters of flexible pavement using Fuzzy Logic Expert System (FLES). Six different national highways have been selected to provide the maintenance based on the PCI, traffic volume, pavement age, precipitation, temperature and budget. FLES offers a convenient tool to better represent the uncertainty involved in pavement condition rating and assessment. The pavement maintenance treatment needs are generally determined based on the results of visual inspection, which in most of the cases does not give an adequate representation of pavement condition. Treatment selection FLES model has considered anticipated distresses-based condition index, anticipated traffic, and prevailing climate, age of the pavement and budget for treatments. Model predicts treatment types based upon their expected life. The triangular membership function for all the parameter is considered and analyzed with sufficient number of fuzzy rules as suggested by the maintenance engineers. The predicted result was compared with the twenty-five maintenance engineer's responses, which shows homological results. Hence, this approach may provide an appropriate and economically viable maintenance treatment.

R. Kumar (✉) · S. K. Suman · A. Singh
National Institute of Technology Patna, Patna 800005, India
e-mail: rajnish.ce17@nitp.ac.in

S. K. Suman
e-mail: sksuman@nitp.ac.in

A. Singh
e-mail: ankitas.pg19.ce@nitp.ac.in

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1 Introduction

The systematic planning of maintenance strategies is an integral part of the pavement management system's decision-making process. The premature failure of pavement section before its design life due to unavoidable uncertainties (occurrence of traffic, variation in drainage conditions, rainfall, weather conditions, and non-uniform construction) is an issue that needs to be addressed strategically. The decisive process can be data-centric, an expert system, or both. A timely updated PMS database is not readily available in developing countries like India. The maintenance of India's extensive road network largely depends on expert opinion. Deciding the most appropriate maintenance strategy for a large number of pavement sections is complex. The only efficient way for effective pavement management is to employ a computerized system [1].

The pavement maintenance management system is carried out considering the pavement rating system or PCI which reflects the structural and functional properties. The maintenance issues are always a major concern for the maintenance engineer over a period of time [2]. There are several researchers who have done a considerable amount of work in the field of pavement maintenance. The overall condition index is developed considering the expert opinion, traffic information and pavement distress to prioritized the pavement section. The prioritization model is developed based on the budget constraints for maintenance [3]. Saaty's scale is used to provide the weightage or relative importance among the assigned variables or alternatives subjectively. The Analytical Hierarchy Process (AHP) is one of the prioritization model which is adapted to provide the pavement maintenance based on the relative importance [4]. The pavement maintenance strategy is also prioritised at the network level using the AHP [5]. The AHP has shown the strength in the selection of alternative but it is very complex and time cosuming technique when the number of alternatives are more than eight [6]. Multi-attribute utility theory (MAUT) is also used in the prioritisation of pavement in terms of utility function. MAUT is advantageous in the selection of most suitable preferences among the availabe alternatives [7]. However, MAUT is unable to produce individual utility function [7].

The fund allocation for maintenance strategy is determined on the basis of increment in the vehicle operation cost (VOC). The VOC increases with the time due to increment in the traffic loading [3]. A deterioration model is developed considering cracking, raveling, potholes and roughness. A comparison is made between developed deterioration model and HDM-4 deterioration [8]. In HDM-4 software, the higher value of NPV/CAP ratio represents the requirement of a higher maintenance strategy [9]. The remaining service life is also considered as an indicator for the maintenance work of a pavement [10]. However, HDM-4 sotware is an expensive software which is not affordable for everyone. Fuzzy logic is a powerful inference system between linguistic and numerical data. It establishes the relationship between symbolic and numerical spaces [11]. Now, a day fuzzy logic expert system (FLES) receives the attention of the researcher due to incorporation of human expert knowledge with its nuances. Fuzzy logic reveals the result in an interpretable way for a researcher. Fuzzy logic is a powerful inference system between linguistic and numerical data. It establishes the relationship between symbolic and numerical spaces. Now, a days FIS got the attention of the researcher due to incorporation of human expert knowledge with its nuances [12, 13].

The FLES has been adopted by the researchers to reveal the pavement condition. For the development of pavement rating system, FLES is used [14–16]. However, pavement roughness is determined using the fuzzy set theory [15]. Furthermore, it is used to determine the future condition of pavement distresses and finally determine the pavement performance [16, 17]. The maintenance and rehabilitation is evaluated using fuzzy logic [18]. Fuzzy logic systems (FLS) have the advantage of being able to integrate experts' basic information into decision-making processes through the use of implication laws capable of representing imprecise knowledge and qualitative data. Fuzzy structures are useful for modelling expert logic because they effectively manage linguistic rules and are fault-tolerant to subtle adjustments in input or device parameters. Based on the previous study of FLES, it is concluded that the pavement treatment process is determined using the the various pavement deteriorating parameters.

The objective of this paper is to develop a multiobjective optimisation technique for the pavement treatment selection process using the various deteriorating parameters.

2 Methodology

FLES has been proposed for the evaluation of optimal pavement treatment using the various pavement affecting parameters. There is always an issue regarding the selection of treatment process for a pavement managers from various set of solution available. The pavement deteriorating parameters are selected based on the literatures and from the expert advise. In the formulation of FLES, each solution reflected an optimal pavement treatment based on various objectives. In this study, there are six different parameters selected as the input of the FLES model whereas the pavement treatment process is used as the output. The input parameters of the model are PCI, traffic condition, precipitation, temperature, pavement age and budget allotted. If–then rules are used in the FLES model to establish a relationship between input parameters and output parametrs. The fuzzy rules are developed using the expert knowledge but it may changes from expert to expert. The expert opinion is the best suited option in the formulation of fuzzy rules. In this study, a group of twenty five pavement pavement maintenance engineers having working experience more than ten years are selected to define the fuzzy rules.

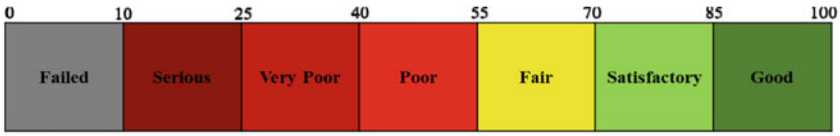


Fig. 1 Pavement condition index (PCI) rating [10]

2.1 Pavement Condition Index (PCI)

PCI is widely accepted for highways, airfields and parking lots to determine the pavement surface condition. The PCI is a numerical index, ranging from 0 (for a failed pavement) to 100 (for a pavement in perfect condition) which provides pavement's structural integrity and surface operation condition [9]. The PCI value is calculated based on the distress type, severity and quantity of pavement. The distresses in pavement are grouped into four categories such as surface defects, cracks, deformation and disintegration [10]. The degree of pavement deterioration is a function of distress types, distress severity and amount or density of distress. Deduct value was introduced as a type of weighing factor to indicate the effect of these factors [19] (Fig. 1).

2.2 Traffic Volume

The pavement distresses are mainly caused by pavement condition and traffic moving through it, so the maintenance mainly depends upon these two factors. As per IRC:37 (2018), the traffic volume is the number of commercial vehicles that passes through particular road segment, this traffic volume is measured in the form of cumulative vehicle per day (CVPD). The average annual growth rate of commercial vehicle is considered as 5% while designing the highways [20]. Different CVPD is obtained for different pavement section, hence, it is required to characterised the traffic volume in terms of CVPD (as shown in Table 1).

Table 1 Traffic volume factors [20]

Traffic	Commercial vehicle per day (CVPD)
Low	0–2000
Medium	2000–5000
High	5000–7000

Table 2 Categories of rainfall departure from normal [22]

Category	Rainfall amount (in cm)
Low rainfall	0–100
Medium rainfall	100–250
High rainfall	250–350

2.3 Precipitation

Precipitation in terms of rain, fog, snow, results in the change of moisture level of pavement and consequently due to this rise moisture level, distresses are formed in the pavement. Dawson [21] explore the various ways in which the moisture affects the pavement. The precipitation in the form of rainfall is generally drain out from the pavement through the gullies, drains and pipes that are constructed along with the road drainage whereas the surface runoff might enter inside the pavement through the distresses (cracks and potholes). Local water table also plays important role in formation of pavement distresses, due to near subgrade water table, the bonding between the subgrade and pavement layers degrades the bonding between aggregates, this results in the formation of potholes. During the flood and heavy rain, pavement subgrades might be completely submerged in water which also result in the negative impact in pavement.

India Meteorological Department (IMD) define rainy day with precipitation of 2.5 mm or more whereas extremely heavy rainy day is explained with rainfall greater than 650 mm [22]. During the entire monsoon period, from June to September, India received approximately 86% (102.08 cm) of its annual rainfall. The rainfall in India is categorised as High, Medium and Low (shown in Table 2).

2.4 Temperature

In the hot climate regions, due to elevated environmental temperature, the pavement surface gets heated up (up to 50 °C) which results in disintegration of bond between bitumen and fine aggregate, this tendency is known as ravelling whereas in the cold region, freezing low temperature of pavement renders the brittle property of surface which is prone to generate cracks. The stress–strain response of pavement is hugely depending on pavement temperature. The stress–strain response helps in spreading the wheel load over the surface and limiting this stress–strain response may results in load related deterioration [23]. Due the elevated pavement temperature, the resistance to permanent deformation is reduced for the pavement material. During this situation, thermal stress in asphalt layers is developed which results in thermal cracking [24]. According to IMD, most of the region of Indian states having 0–5 °C temperature in the winter season whereas 39–42 °C temperature is recorded in the summer season. The utility scores are developed using IMD report of temperature variation.

Table 3 Different categories of pavement age [20]

Pavement age	Age in years
Category 1	0–4
Category 2	4–8
Category 3	8–12
Category 4	12–15

Table 4 Categorisation of budget allotted for pavement treatment

Budget	Fund allotted (in lakh)
Low	0–15
Medium	15–30
High	30–75
Very High	>75

2.5 Pavement Age

The target National Highways in this study are having design period of 20 years as well as corridors, having design period of 30 years are also considered. More detailed design period of different categories of road are prescribed in IRC:37 (2018). A long-life pavement is designed for more than 50 years which is also termed as perpetual pavements. The pavement age is categorised in to four different categories and they are tabulated in Table 3.

2.6 Budget

The treatment is provided in the flexible pavement to maintain the pavement condition using the fund allotted by the Government. The budget is categorized in to four different group as low, medium, high and very high (as shown in Table 4). The fund allotted for maintenance for each one kilometer below 15 lakhs is termed as low budget whereas the fund allotted greater than 75 lakhs is termed as very high budget. The budget is utilized to improve road condition and extend its life.

2.7 Pavement Treatment Process

The treatment process is categorized in to four different group such as preventive treatment, maintenance/renewal, strengthening/rehabilitation and reconstruction (as discussed in IRC:82- (2015). The preventive treatment is mainly provided in the flexible pavement to fill the crack. The treatment process is adopted based on the types of distresses and their severity level. The periodic renewals treatment process

Table 5 Different types of flexible pavement treatment process [25]

Treatment process	Membership range (in terms of expected life in years)
Crack fill (CF)	0–2
Fog seal (FS)	1–3
Slurry seal (SS)	2–5
Chip seal (CS)	3–7
Micro-surfacing (MS)	5–8
Ultra-thin friction course (UTFC)	7–10
Thin hot mix bituminous overlay (THO)	8–12
Hot in place recycling (HIR)/cold in place recycling (CIR) + thin HMB overlay (THO)	10–13
Ultra-thin white topping (UTWO)	12–15
Reconstruction (R)	13–15

is a provision to provide a surfacing layer over the pavement after certain interval of time. The renewal treatment rectifies the camber, super elevation which get flattened due to repeated traffic. The suggested periodic renewal treatment is provided to eliminate the pavement roughness based on the experience and pavement condition. The pavement is strengthened using the hot mix bitumen mixture overlay and ultra-thin white topping. Once the pavement is completely deteriorated, the pavement is reconstructed or replaced [25].

The different types of treatment process are selected from the various literatures and various maintenance engineers advise. The range of MF for treatment process are suggested by the experts. The selection of treatment process for an older pavement are varied with expert to expert. Total twenty-five experts have been participated and their opinion have been considered. The treatment process with respect to the age of pavement is changes with expert to expert. Hence, the average range of already constructed pavement age is mentioned in Table 5 corresponding to various treatment process.

3 Data Collection

Six different national highways (NH) of Bihar, India are selected for this study. Pavement distress data, traffic volume, pavement age, precipitation, temperature, and the budget available for maintenance are all gathered in order to offer the optimal treatment to the pavement. The pavement distresses and severity level have been acquired from the field during the visual examination. All data required for this study is gathered from six distinct NHs situated in Bihar, India. NH-30 connects Bakhtiyarpur to Patna, NH-19 connects Patna to Chhapra, NH-28 connects Patna to Dhobi, NH-102 connects Chhapra to Muzaffarpur, and NH-57 is in Dabhanga

(a) NH-102 (b) NH-19 (c) NH-83 (d) NH-30

Fig. 2 Pavement condition of four national highways of India

(Bihar), India. The pavement condition of four NH is shown in Fig. 2. The pavement condition index (PCI) is computed utilising distress data in accordance with ASTM D6433-11 guidelines [26]. The traffic volume, pavement age and budget available for all six NH are collected from the national highway authority of India (NHAI) whereas temperature and precipitation has been tabulated from the Indian Meteorological Department (IMD) rainfall statistical report 2019 [22].

4 Model Formulation

FLES model is developed using the Fuzzy Inference System Program (FISPro). The FISPro software is developed using C + + language having a graphical Java interface for automatic learning. This software helps in developing FIS from the numerical data. The FISPro software has different learning methods not like machine learning or deep learning which have a black box system. FISPro is easy to operate and produce the entire fuzzy rules [27]. The basic working structure of FIS is explained in Fig. 3. The FIS is widely accepted for the classification problems. The learning approach consists of fuzzy partitioning, fuzzy rule induction and fuzzy defuzzification. The semantics is maintained while implementing the FISPro software. For a multi-objectives optimization model, an index is developed to maintain the semantic interpretability [28].

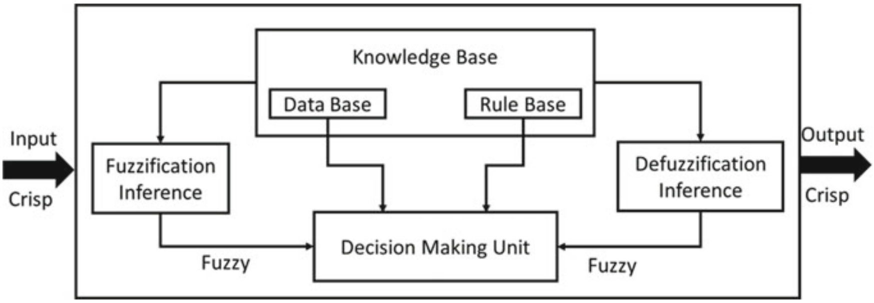


Fig. 3 The basic structure of FIS

4.1 Generation of Membership Functions

A fuzzy set is deliberated as a smooth boundary which generalizes the membership functional notation from black to white binary category. This binary category provides partial membership on the basis of classical set theory. In the fuzzy set, the membership is categorized between 0 to 1 [29], where 0 represents the non-membership function and 1 is represented for complete membership function. In mathematical terms, a fuzzy set is described by a mapping of the interval [0,1] from its discourse universe. MF is graphically represented and also define the membership degree through the mapping from variable space. The generated membership function in this model is shown in Fig. 4.

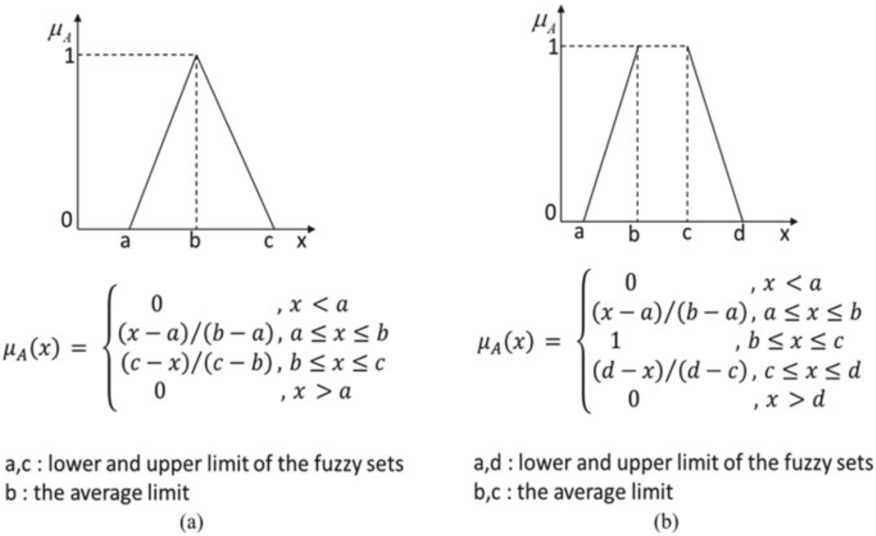


Fig. 4 Shape of membership function **a** triangular member function **b** trapezoidal member function

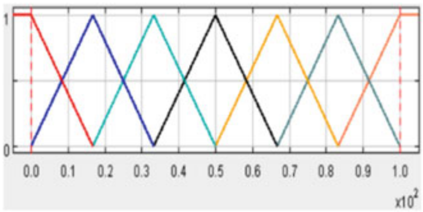
In this paper, the membership functions are mainly developed in triangular and trapezoidal shapes. The mathematical expression for MF is also explained in Fig. 4. The input parameters such as PCI, traffic, precipitation, temperature, pavement age and budget are defined in the FISPro software. The low and high cluster is drawn as semi trapezoidal shape whereas medium cluster have been expressed through triangular shape. Each input parameter is categorized and their ranges are explained in the Sect. 2.

4.2 Membership Function

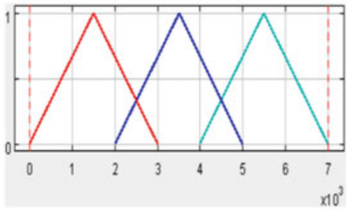
The defined ranges of input variables are entered in the FISPro software to generate the membership function (MF). Each parameter has their different range of variation and according to them MF is developed by the FISPro. The lower and higher range of input parameter are generated in semi-trapezoidal shape whereas mid-range value is represented by triangular shape in developing the MF for all input parameter. The remaining input parameter such as traffic, precipitation, temperature, age and budget has been represented by triangular membership function, since, the input parameter value has been defined in a range bound by the maintenance engineers. The graphical representation of MF generated using FISPro is shown in Fig. 5. The MF for the pavement treatment process is also generated and shown in Fig. 6. All ten-treatment process has been defined with respect to the age of pavement and their corresponding age has been represented by Table 5. The MF for treatment process has been generated by FISPro and their graphical representation is shown in Fig. 6. The MF for each pavement treatment process is represented as triangular shape by FISPro software, since they lie in a range bound. The variation in their ranges of each input and output parameter is expressed by x-axis whereas the y-axis represents the MF in the range of [0,1]. The zero is explained as the no relation whereas the maximum relation is shown through 1.

4.3 Formulation of Fuzzy Rule

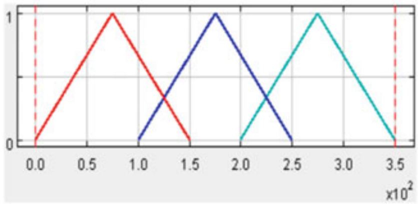
The fuzzy rule is generated using simple and logical IF–THEN rules [30]. Fuzzy rule formulation is a major challenge for a high dimensional problem. The selection of every possible rule is not as easy as it looks. The fuzzy rules are designed based on expert knowledge or from the numerical data that restricts a number of possible situations [14]. For a more precise rule, one may have a higher number of fuzzy rules with more information. The successive refinement and sequential set of fuzzy rules will provide a precise rule. The complete fuzzy rule for any model is equal to $\prod_{i=1}^{n} m_i$ [14] where m represents the number of MF for i input and numbers of input are indicated by n. The *i*th pair rule is as follow:



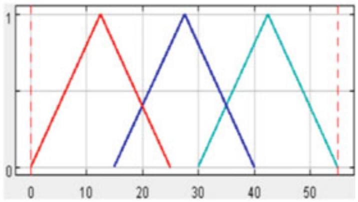
(a) Membership Function for PCI



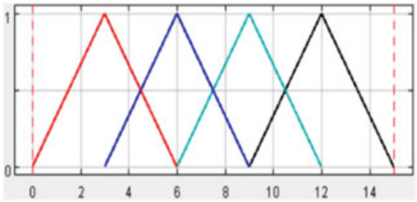
(b) Membership Function for traffic



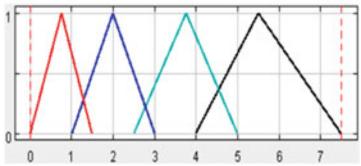
(c) Membership Function for precipitation



(d) Membership Function for temperature



(e) Membership Function for Age



(f) Membership Function for budget

Fig. 5 Membership function for input parameter

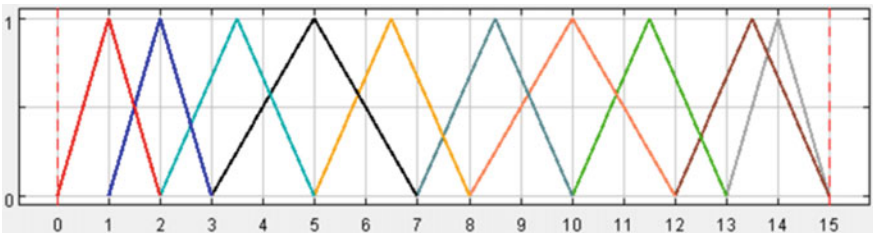


Fig. 6 Membership function for the output variable (treatments)

$$If\, x_1 is A_1^i AND x_2 is A_2^i \ldots\ldots AND x_p is A_p^i THEN y_1 is C_1^i$$

The rule formulation in this paper is complex due to the consideration of six input variables with different ranges of variation and one output variables. FISPro software is used to overcome this issue. Fuzzy system is generated with the numerical

Rule	Active	IF PCI	AND TRAFFIC	AND PRECI...	AND TEMP...	AND BUDGET	AND AGE	THEN TREA...
1688	✔	EXCELLENT	L	H	M	M	A-6-12	CRACK FILL
1689	✔	EXCELLENT	L	H	M	H	A-0-6	FOG SEAL
1690	✔	EXCELLENT	L	H	M	H	A-3-9	FOG SEAL
1691	✔	EXCELLENT	L	H	M	H	A-6-12	FOG SEAL
1692	✔	EXCELLENT	L	H	M	H	A-9-15	FOG SEAL
1693	✔	EXCELLENT	L	H	H	L	A-0-6	CRACK FILL
1694	✔	EXCELLENT	L	H	H	L	A-3-9	CRACK FILL
1695	✔	EXCELLENT	L	H	H	L	A-6-12	CRACK FILL
1696	✔	EXCELLENT	L	H	H	M	A-0-6	CRACK FILL
1697	✔	EXCELLENT	L	H	H	M	A-3-9	CRACK FILL
1698	✔	EXCELLENT	L	H	H	M	A-6-12	CRACK FILL
1699	✔	EXCELLENT	L	H	H	H	A-0-6	FOG SEAL
1700	✔	EXCELLENT	L	H	H	H	A-3-9	FOG SEAL
1701	✔	EXCELLENT	L	H	H	H	A-6-12	FOG SEAL
1702	✔	EXCELLENT	L	H	H	H	A-9-15	FOG SEAL
1703	✔	EXCELLENT	M	L	L	L	A-0-6	CRACK FILL
1704	✔	EXCELLENT	M	L	L	L	A-3-9	CRACK FILL
1705	✔	EXCELLENT	M	L	L	L	A-6-12	CRACK FILL
1706	✔	EXCELLENT	M	L	L	M	A-0-6	CRACK FILL
1707	✔	EXCELLENT	M	L	L	M	A-3-9	CRACK FILL
1708	✔	EXCELLENT	M	L	L	M	A-6-12	CRACK FILL
1709	✔	EXCELLENT	M	L	L	H	A-0-6	FOG SEAL
1710	✔	EXCELLENT	M	L	L	H	A-3-9	FOG SEAL
1711	✔	EXCELLENT	M	L	L	H	A-6-12	FOG SEAL
1712	✔	EXCELLENT	M	L	L	H	A-9-15	FOG SEAL
1713	✔	EXCELLENT	M	L	M	L	A-0-6	CRACK FILL
1714	✔	EXCELLENT	M	L	M	L	A-3-9	CRACK FILL
1715	✔	EXCELLENT	M	L	M	L	A-6-12	CRACK FILL
1716	✔	EXCELLENT	M	L	M	M	A-0-6	CRACK FILL
1717	✔	EXCELLENT	M	L	M	M	A-3-9	CRACK FILL
1718	✔	EXCELLENT	M	L	M	M	A-6-12	CRACK FILL
1719	✔	EXCELLENT	M	L	M	H	A-0-6	FOG SEAL

Fig. 7 A part of designed rule base for the fuzzy-based treatment selection system

data using FISPro [27]. Wang and Mendel's method is used to generate the fuzzy rule considering the predefined MF for used input and output variables [31]. It starts generating the rule for each training dataset. The defined fuzzy rule with expert knowledge is shown in Fig. 7. The FISPro software have generated more than three thousand rules on considering the input parameter and output parameter with their variation in the ranges. The expert advises have been proven very helpful in identifying the most appropriate rule in the selection of the pavement treatment process using the flexible pavement deteriorating parameters. Total 1882 set of legitimate rules are identified for the selection of various treatment process.

4.4 Defuzzification

The defuzzification is always necessary for the gradual conjunctive rules. The findings are obtained using maxima and centroid defuzzification. The continuous function is revealed only by the centroid defuzzification [32]. This function is not linear and generally monotonic in nature. But, when two rules are triggered at the same level then defuzzified values shift towards the wider one. The fuzzy linguistic output is converted into a crisp output using the defuzzification process considering the centroid defuzzication. The fuzzy rule is analyzed through rule viewer as shown in Fig. 8. The effects of individual MF of each input for the output are observed through the rule viewer.

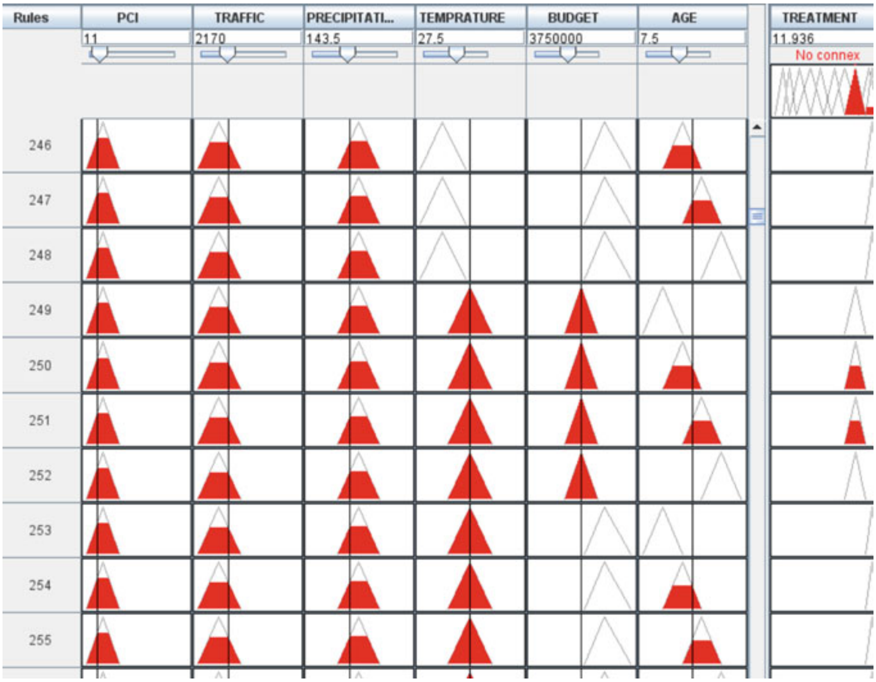


Fig. 8 Fuzzy rule viewer window for the inference system using FISPro software

5 Results and Discussion

The developed FLES model is able to optimise a flexible pavement treatment process using the various input parameter such as PCI, traffic, age, precipitation, temperature and budget. Each input parameter has been categorised as mentioned in section II and their range of variation is also defined. The MF for each parameter is developed as their range of variation mentioned in section II. The fuzzy rules are developed by FISPro based on the input parameter and output parameter.

5.1 Validation of FLES Model

The developed fuzzy model has been used to perform a case study over six national highways. The data has been collected from NH-30, NH-19, NH-28, NH-83, NH-57 and NH-102 at the locations such as Fatuha, Hazipur, Gopalganj, Gaya, Darbhanga and chhapra situated in Bihar. Using generated rules and membership functions, the FLES is analyzed of its efficiency. For each chosen section at six different national highways, data corresponding to various parameters is recorded as mentioned in Table 6. The inference results are obtained from the FLES model and compared with

Table 6 Selection of treatment process using the expert advise

Highway	PCI	Traffic (CVPD)	Age (Years)	Precipitation (cms)	Temperature (^{0}C)	Budget (in Lakh)	Inference result	Treatment FLES	Treatment expert advise
NH-30	90	2321	10	271	41	12.00	3.58	SS/CS	CF
NH-19	63	3080	9	227	16.5	25.50	9.32	UTFC/THO	UTFC
NH-28	23	756	12	245	47.8	58.50	14	UTW/R	R
NH-83	45	6649	5	266	12.65	65.25	13.7	UTW/R	UTW
NH-57	36	1060	12	230	43	47.56	10.9	THO/HIR/CIR	HIR/CIR
NH-102	53	3549	7	98	36.85	30.75	9.54	UTFC/THO	UTFC

the expert's choices. The FLES model has suggested us two treatment choices for a given set of conditions due to overlapping discourse for treatments membership defined by expected life. The maintenance engineer or the expert has suggested the treatment process depending upon the budget available for undertaking maintenance works. The decision can also be based on pavement conditions accompanied by the pavements' age. Due to limited fund allocation, the budget followed by pavement conditions is given more priority than other parameters.

For the data sets in Table 6, NH 30, the inference results have provided two choices—slurry Seal and chip seal. However, used FLES for the first dataset has shown some inconsistency with the expert's decision that suggests the use of crack fill for the given set of varying conditions. For the second section (NH 19), the inference results have been represented the use of an Ultra-thin friction course or Thin HMB overlay which describe the agreement with expert's treatment choice of the ultra-thin friction course. In case there is availability of higher budget and if the condition and age demands, Thin HMB overlay can also be feasible. The expert's opinion for the section chosen corresponding to NH 28 was the reconstruction, and the inference also suggests the use of Ultra-thin white topping or reconstructing the pavement section. NH 83, NH 57, and NH 102 have represented the compatibility with the expert's choices. Out of 6 sections, the five-pavement section have shown the consistency which defends the developed FLES approach's applicability.

6 Conclusions

The inferred results have shown the homogeneity with the expert's judgment while making choices for the treatment, considering the parameters used while developing FLES. Maintenance engineers have mostly stressed over the existing condition, budget, anticipated traffic, and age for the rule designing followed by other factors' influence. However, the developed FLES has provided two suggestive choices which lead to obscure choices. The available budget and resources are followed by pavement condition and then pavement age is used as the supportive parameter by the concerned experts or engineers in the selection of appropriate choices. The study has mainly focused to make treatment selection more efficient and effortless. Simultaneously, appropriate and feasible choices can be made as introduced FLES helped make the selection process closer to human reasoning.

Further study can look into each parameter's sensitivity concerning the choices made. Other structural and functional factors can also be incorporated. A hierarchical system can be developed that considers both pavement condition assessment and treatment selection.

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