Journal of Engineering and Applied Sciences 11 (1): 23-31, 2016
ISSN: 1816-949X

Evaluation of Expert System in Scheduling of Repair and Maintenance of Railway Lines

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Abstract: One of the most important needs of today's world is creating a safe and reliable rail network with a acceptable capacity. In the present age, railway network with advances in technology, changes in the environment and consumer demand has improved and operational activities of the system is up dated. Expansion of the rail network in the region will have certainly a lot cost. Therefore, on time and suitable maintenance of railway lines could keep the national capital and provides a bigger budget for the construction of new line. On the other hand, lack of timely detection of failures created on rails, sleepers, ballast and defects created in the geometry of the line will allow conditions for the rapid decline before the intended time. Thus, on time failure detection, creating the proper planning and regular inspections and timely detection defects rail lines can prevent rail from premature deterioration and erosion. In this study, we have tried to scheduling repair and maintenance of railway lines by using expert system. For this purpose, after expressing some concept of maintenance system of rail and expert system and check system failures and shortcomings of the rail line, we try to discuss the method of calculating the index number of failures. The results show that providing an expert system according to the database that is in its place like an expert entity and responsive at all times and in all circumstances perform appropriate interpretation.

Key words: Scheduling, repair and maintenance, railway lines, expert system, detection

INTRODUCTION

Rail transportation (Rail transport is a means of conveyance of passengers and goods by way of wheeled vehicles running on rails. It is also commonly referred to as train transport. In contrast to road transport where vehicles merely run on a prepared surface, rail vehicles are also directionally guided by the tracks on which they run. Track usually consists of steel rails installed on ties (sleepers) and ballast on which the rolling stock, usually fitted with metal wheels, moves. However, other variations are also possible such as slab track where the rails are fastened to a concrete foundation resting on a prepared subsurface) networks are considered as valuable assets for any country and must be managed in such a way that they must remain for relatively long time at the appropriate levels. Deterioration of infrastructures, increased traffic and budgetary constraints lead to decision-makers and rail organizations have decided to more efficient use of resources available for the maintenance and preservation of this capital. Repair and maintenance management system is a systematic way which provides the possibility to choose the most economical strategy for repair and maintenance through a careful assessment of the current situation and the prediction of the future. This system is the largest railway investment and includes a significant percentage of the cost of operation. Hence, elimination of defect andconstant basic geometric forms basic and designed of rail railway s lead to increase the safety factor for the movement of trains and provides favorable conditions for the movement and speed of the trains. Thus, a rail railway with planning system and the regular maintenance has led to a reduction in accidents on the one hand and on the other hand will move trains regularly. Any development in the proper management of maintenance and repair of railway railways has led to saving indirect resulting from increased capacity and reduce their effects. Due to technical factors and economic resources can be said that the success in the repair and maintenance depends on the

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scientific knowledge of geometrical and physical defects of railway and its components and how to fix them, in this context, planningin order to proper maintain of railway components and fix their flaws and the design and manufacture of new materials, consistent with the natural conditions are necessary and the need for these cases is increased.

In this study, we try to examinerepair and maintenance planning of railway railways using expert system. To this end, after expressing concepts about railway maintenance system and expert systems and reviews failuresand shortcomings of the rail system, the method of calculating the number of failures index is discussed.

The creation of expert systems: Expert systems are part of the artificial intelligence systems which transfer experience and expertise of the experts to the computer and store this knowledge in it and if necessary will use it. An expert system can be well understood as an expert and achieve a good result. With the increasing development of technology and the use of PC, expert systems and artificial intelligence approaches with rapid steps were developed in the 70s and 80's and were used in many mathematical and engineering. Expert systems, during the 70s, were the experimental subjects more than other subjects and researchers focused on data creation methods and reasoning with the computer and did not pay attention to design a real efficient system. In 1980, the transfer of laboratory research of expert systems into commercial systems began and during the 80s, the numbers of these systems increased, so that, in 1985, 50 systems of this type were produced. This has progressed so far that, in 1992, making the system was estimated at 12,500, in fact, it was considered as an impressive record in new technologies. Today, the use of expert systems in cases like help managers to control dust levels, help farmers for pest problem, consult the astronauts in the spacecraft, civil engineers and project managers is expanded.

In 1990, a study published that it's researchers have developed a prototype in conjunction with Burlington Northern railroad (BN) in order to provide more ormal, more consistent and more rational criteria for rail replacement. A productive system was then developed for use in preparing BN's 1990 rail relay program. The system demonstrates the role of expert systems in supporting decision making in railroad maintenance and identified several areas for other applications of expert systems (Martland *et al*., 1990).

Majstorovice (1990) presented a research for diagnosis and maintenance with expert systems. The diagnosis and maintenance of complex mechanical systems represents a very complex interdisciplinary engineering task. This particularly relates to FMS working stations which are the subject of analysis in this study, i.e., expert systems for such purpose. The state of the art and application of expert systems are analysed in the paper from different aspects, namely: knowledge engineering for maintenance ES; basic hypotheses for the development of ES for maintenance; the level of development and application of ES in the domain of maintenance; and the analysis of developed ES for maintenance. At the end, an example of an ES developed for diagnosis and maintenance of working stations in FMS is presented.

Yingjie *et al*. (2005) evaluated railway operation with intelligent simulation system. They mentioned that by using expert system technology method and analyzing the state transfer of railway operation system, an intelligent simulation model for such complex hybrid system is presented. With the help of expert system shell tools G2, this intelligent simulation system is set up in Windows NT environment. It provides an experiment tool for the simulation research of railway operation and transport organization and can be easily applied to other rail transportation systems. This simulation system had successfully applied to simulating Guanzhou-Shenzhen railway operation (Ganjavi *et al*., 2006).

Also in a study that was presented by Ganjavi *et al*. (2006), it was avaluated the distance protection settings in electrical railway systemswith positive and negative feeder. The study discusses some heuristic rules for settings of distance relays in railway systems with positive and negative feeder configurations. The experience is formulated as a set of rules (if condition then effect) and stored in an expert system for fast access (Yingjie *et al*., 2005).

Later, the application of expert systems was expanded so that newly researchers use it for seismic signal classification, earthquake prediction (Akhouayri *et al*., 2015; Ikram and Qamar, 2015).

Definition and performance of the expert system: Expert systems or Knowledge-Based Systems (KBS) (In artificial intelligence an expert system is a computer system that emulates the decision making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, represented primarily as if then, rules rather than through conventional procedural code. The first expert systems were created in the 1970s and then proliferated in the 1980s. Expert systems were among the first truly successful forms of AI software) are rooted in the field of study called artificial intelligence

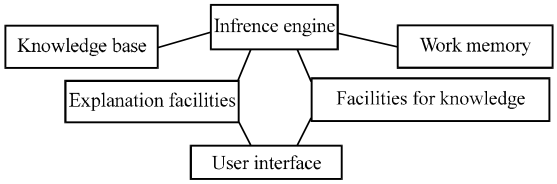

Fig. 1: Main components of expert system

(Artificial Intelligence (AI) is the intelligence exhibited by machines or software. It is an academic field of study which studies the goal of creating intelligence. Major AI researchers and textbooks define this field as “the study and design of intelligent agents”, where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success. John McCarthy, who coined the term in 1955, defines it as “the science and engineering of making intelligent machines”) (AI). This system includes functions that specify how a system can move from one state to the next state and eventually goes into the goal. In this context, to make an intelligent program, a high quality program, so that the specific knowledge is associated with that field, must be designed. Expert system adds a database to the major components identified in other types of computer information systems. The system answers questions and problems specific issues in the field of human reasoning, which it is an expert in thatfield. Expert systems must be able to explain the process of its argument and conclusions to the end user. Using an expert system, scientific and professional information related to the registration of a specialized field can be recorded and it can br distributed to relevant organizations, the quality of the professional works with the confidence of knowing that the system not make mistakes and finally, beginner’s ability gradually can be increased and they are closer to their professional expertise. An expert system according to the following figure consist main components (Fig. 1).

In general, the expert system functions such as recognition of the problem, identify solutions and the choice between them, describing and reasoning solution chosen, interaction with incomplete information or for more information, the possibility of recording and reconstruction all steps in solving a problem can be expressed.

MATERIALS AND METHODS

Evaluation of expert system in railway: In this study, two methods for automated and visual inspection for observation and inspection of the railway system have been studied and its results as the decision tree are designed in the form of an expert system. Visual observation method can detect failures in a railway due to the expression profiles of failure and the necessary steps are taken to resolve them. Of course, it should be noted that failures with visual aspects, usually are considered as heavy rail failures and actions necessary for their maintenance should be performed. Another method of inspection which is a relatively new and technological and also has higher efficiency is an inspection method by using the ultrasonic monitors. The method is as follows, waves by ultrasonic monitors with predetermined angles and specified penetration depth on the railsare radiated and with returning of the waves to a receiver tracking, defect at different depths of rails and carefully is diagnosed and based on the type and size of defects, proper repair and maintenance decisionsare adopted. Finally, according to the data collected and according to describe the objectives, the database is formed with the current situation, an expert system according to data collected that contains the inference engine of the database, is designed. In the subject of railway, inspections are divided to four different levels of rail, traverse, ballast, the geometry of railway and inspections conducted in any of the areas mentioned can contain a subset of the rules, the rules of the principles and foundations of the expert system designed. In the rail sector, there are two types of inspection: visual inspection and ultrasonic inspection. For convenience and efficiency for users more easily, the rail into three parts ovalflaws, railhead, rails Jan, rail heel for each of these regions and their respective views, rules and algorithms are considered in the form of expert system, so after inspections made, the user can detect type and severity of the crash, according to the questions wll be answered first and the best practice of repair and maintenance related to with the failure as the output and the result ofsystem is visible to the user.

Design of rules and knowledge bases: According to the information collected in the past and also explanation of the goals and other issues that were raised in expert systems, a database is formed with the current situation and expert system is designed which includes the engine derived from the database. For this, the frame work of the inspection of the rail system will be discussed. Inspections carried out in each of the rail, traverse, ballast, the geometry of railway may include the subsets of rules, these rules will be the principles and basis of the expert system designed (Fig. 2).

Table 1: Common faults and failures of railways components

A component of railway	Conventional failure
Rail	Rail head horizontal cracks, transverse faults, the vertical cracks of rail head, vertical cracks of rail jan, the vertical cracks of rail Jan, the horizontal cracks of railjan junction to rail head, the horizontal cracks of rails head, railjan junction to rail heel, rail heelfailure
Traverse	
Wood	Cracks or joints bumps and swelling of the skin and decay, moisture in wood, nurak caused by excessive or uneven drying
Concrete	Weathering, damage caused by chemical agents, insolubilization of concrete traverses, longitudinal cracks, traverses damage when exit the train the railway
Ballast	Contaminated ballast, the ballast small, gradual penetration of the ballast surface, traverses abrasion, seepage from the seabed, plant growth, inadequate ballastat the shoulders and railways, poor drainage side of the railway
Railway geometry	Lack of regular and special geometric properties

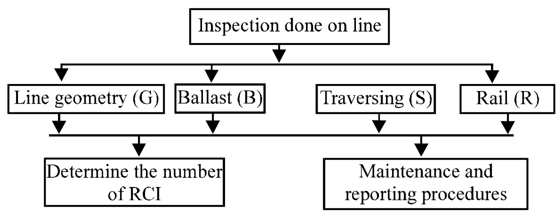

Fig. 2: Overview of the expert system in railway (Saeid, 2009)

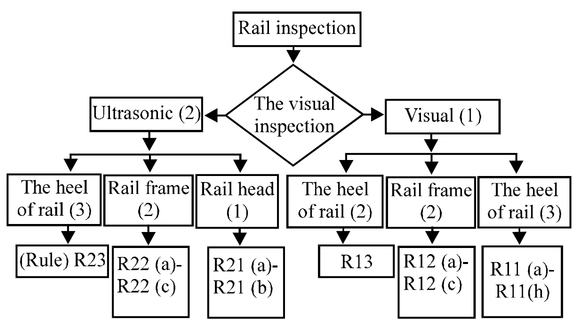

Fig. 3: The rail inspection algorithm (Saeid, 2009)

After inspections made, the user can detect type and severity of the crash according to the questions will be answered first and the best practice of repair and maintenance related to with the failure as the output and the result of system is visible to the user. This method, in similar cases and in other parts of the railway isused and according to the database that is defined in the system, the user will be faced with a series of questions which by answering to them help the inference engine to find the relevant answer from the database.

RESULTS AND DISCUSSION

The inspection carried out on the railway to determine the method of repair and maintenance: The importance of repair and maintenance of railway to know the disadvantages is necessary and inevitable. Examination of issues related to the failure of equipments, both geometrical and physical limitations of the railway understanding the underlying causes will provide an important and critical role in resolving the differences and develop solutions to prevent it and proper repair and maintenance (Table 1).

Signs found in rails can be seen in different parts of rails and can enter as input data into three parts of rail head and rail heel and rail jan of the expert system designed. For each of the above laws, a separate database is considered (Fig. 3).

According to the algorithm and the data collected, it was observed that the visual inspection section of rails in expert system allocate rules to every part of the rail. Rules set out in the following Table 2 are provided. It is noted that for each type of inspection, rules in the expert system arearisen which according to the type and severity of symptoms and damage, repair methods have been proposed for each of them (Table 3).

Traversing inspection: Inspections carried out on the traverse enterby using thetraverse type and speed of the railway in database of expert system. Traverses, in terms of generality are divided into wood and concrete traverses and enter the system based on the type of traverse and speed of informationrailway. Therefore, the S (a) rule for wooden traverse and the S (b) rule for concrete traverse are provided. With regard to the questions that are asked of the user, search engine in the database is looking for answers related to failure, so users can find the type and severity of failure and theproposed methods for proper maintenance in output of system (Table 4).

Ballast inspection: Ballasts play major role in drainage and shaping the geometry of railway and distribution of loads on the rails. Depending on the type of failure detected by the expert system, we can achieve the proposed methods for repair and maintenance. The following context shows an overview of expert system in the inspection of the ballast. The laws of B (a) and B (b) in the following will be introduced (Fig. 4 and Table 5).

Inspection of railway geometry: Geometry of railway may be damaged by railway failures and defects which in

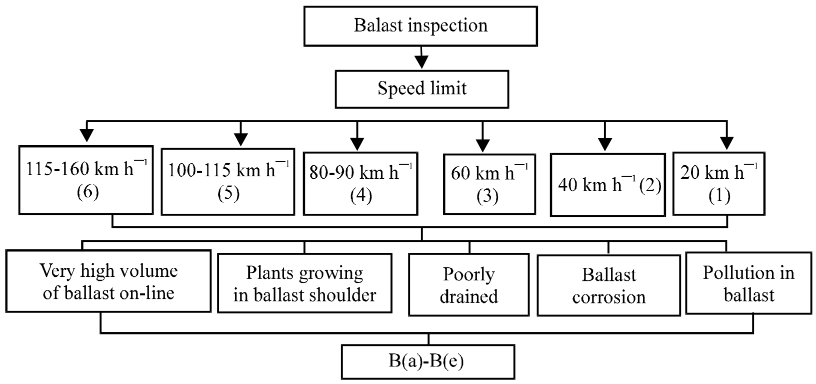

Fig. 4: Overview of expert system of ballast inspection

Table 2: Visual inspection rules of rails

The law	Signs	Type of failure	Severity of failure	Repair method	Certain repair
R11(a)	Smooth and shiny spots on the rail	Crack of transverse rails TD	Extreme H	Limit of 30 km h^{-1}, 48 h time elimination of defects	Cutting of failure zone, extension, replacement
R11(b)	Detachment of rail with a depth of >1 cm in length >5 cm, opaque spots in the lateral horizontal hairline streaks of rust, broadening head rail	Horizontal crack of rail head HSH	Size cracking <200 mm, the average M, 200 mm size fraction, extreme H	Speed limit of 20 km h^{-1} Speed limit of 10 km h^{-1}	Rock abrasion for moderate damage, cutting of rail and welding rail extension and replacement of rails for extremely serious malfunction
R11(c)	Motion blur streaks on the surface of rail, broadening head rail in the area at the, junction of the head and kills rust streaks	Vertical crack of rail head VSH	Cracks in the real depth of 0.5 mm, otherwise, extreme damage severity is moderate damage	Speed limit of 10 km h^{-1}	Replacement, cutting and welding
R11(d)	Existence of gray stains on the moving part of rail, horizontal left side of head rail	Horizontal crack of the body rails Hsu	For small crack than 150 mm, extreme damage and leaving >150 mm severe	Elimination of defects extreme intensity, speed of 10 km h^{-1}, examining repeated failures	Rail replacement in severe damage
R11(e)	Find the black line on the rail and leave the curve connecting the motor to head rail life	Vertical crack of rail body VHU	Small L	--	Corrective weld and replace if broken rails welded rails
R11(f)	Tiny cracks and multiple angles of 10 and 30° relative to the surface of the pavement found	Failure inside rails edge	Aaccording to Figure low, medium, 2, 3 extreme	--	Low: no action mean improvement of rail lubrication, high, switching rails
R11(g)	The bezel around the rail	Bezel	According to type; little, moderate, extreme	--	Like R11(f)
R11(h)	Wave in the surface grooves	Wave	According to type; little, moderate, extreme	--	Moderate: correct the crest rails and remove the ripples and corrective welding, high intensity, switching rails
R12(a)	Find tilted crack in the rail body	Diagonal crack of rails body TSW	Extreme H	Limit of 10 km h^{-1} in the case of highly-stop train	Cutting of failure zone, extension, replacement
R12(b)	Horizontal cracks parallel to Head Rail, near the junction of life	Horizontal cracks in the junction rail John HW	For downtime of <200 mm average, >200 mm: extreme	Speed of 20kmh^{-1} and 48 h time proposed elimination of defects moderate intensity, speed of 10 km h^{-1} and a = stop the train at high intensity downtime	Corrective weld in moderate failure, switching rails and cutting of extreme failurezone in extreme damage severity
R12(c)	Horizontal cracks in the body joint	Horizontal crack in heel junction of head and heel FW	For downtime of <150 mm: extreme, >150 mm: very extreme	Speed of 20 km h^{-1} and subsequent inspections and at intervals of 6 h downtime in intensity,	Corrective weld in moderate failure, switching rails and cutting of failurezone in extreme

Table 2: Continue

The law	Signs	Type of failure	Severity of failure	Repair method	Certain repair
				speed limit of 10km h^{-1} and the severity of the failure to stop the train at high intensity downtime	damage severity
R13	Fracture or opaque stain color on the heels of rail	FD heel fracture	Extreme H	--	Using patch and replace the broken weld

Table 3:Rules defined for an expert system for rail ultrasonic inspection

Signs	Type of failure	Severity of failure	Repair method
Detection of failure by the detector longitudinal motion 70° of detector, one of the states: 40-56, 57-90 mm, >90 mm	Transverse crack of rail head	Motion of detector 40-56 mm, low intensity (L), 57-90 mm Moderate intensity (M) >90 mm, High intensity (H)	Low intensity: no action, moderate: welding correction, speed limit of 30 km h^{-1}, high intensity, cut the damaged area and weld joint, replace the rail, the speed limit of 20 km h^{-1}
Detection of failures in the real, motion and longitudinal motion of detector: 25-100, 101-200 mm >200 mm	Horizontal cracks of rail head	Motion of detector 25-100 mm, Low intensity (L) 101-200 mm Moderate intensity (M) >200 mm, High intensity (H)	Low intensity: cleaning the surface of the rail movement, moderate: welding saby rock, speed limit 20 km h^{-1}, high intensity, cut the damaged area and weld joint, replace the rail, the speed limit of 20 km h^{-1}
Adjust the detector of 0°. Recognize the failure depth of the junction of jan to rail head and longitudinal motion detector,one of these cases: 25-75, 76-200 mm, >200	HSW and TSW cracks	Motion of detector 25-75 mm, Low intensity (L) 76-200 mm Moderate intensity (M) >200 mm, High intensity (H)	Moderate: Welding correction, speed limit of 20 km h^{-1}, high intensity, cut the damaged area and weld joint, replace the rail, the speed limit of 10 km h^{-1}
Recognize the failure depth in rail heel and longitudinal motion detector, one of these cases: 25-75, 76-200 mm >200	Cracks or fractures of rails heel wings FD	Motion of detector 20-40 mm, Low intensity (L), 41-75 mm Moderate intensity (M), 76-150 mm, High intensity (H)	Low: no action, moderate, do check with near intervals and the speed limit of 30 km h^{-1}, high and very high intensity, cut the damaged area and weld joint,replace the rail, the speed limit of 10km h^{-1}
Recognize the failuredepth in rail heel and longitudinal motion detector, one of these cases: 20-40, 41-75, 76-150 mm >150	Cracks, or fractures of rails heel wings FD	Motion of detector 20-40 mm, Low intensity (L), 41-75 mm Moderate intensity (M), 76-150 mm High intensity (H) and motion of detector >150 mm, extremely severe.	Low: no action, moderate, do check with near intervals and the speed limit of 40 km h^{-1} high; welding correction with the speed limit of 20km h^{-1}, extremely severe E: cut the damaged area and weld joint, replace the rail, the speed limit of 10 km weld fusion zone is damaged, replace rails per hour speed limit of 10 km h^{-1}
Using a pair of 70° detector, detecting failures in the wings of the heel and lateral movement detector in one of the cases: 10-35 mm and >35 mm	Crack or fracture of the rails heel wing FD	Proportional to the motion detector is determined. Motion of detector : M, 10-35 mm: M, >35, H	Moderate: welding modification.High intensity:the use of patches welded or replacement of rails broken.

Table 4: Laws of S (a) and S (b) of traverse

Rule	Sign	Traversing conditions	Certain repair method
S(a)	Find bumps, swelling, shrinkage and waste on traversing, traversing number 1 or 2 or >2 defective observed, obvious cracks in the surface or the lower	A defective traversing with permissible speed 20-40 km h^{-1}	Sequential inspections within a week, the proposed elimination of defects 28 days
		A defective traversing with permissible speed 60-160 km h^{-1}	Inspection within 24 h of the traversing, the proposed elimination of defects 7 days
		Two defective traversing with permissible speed 20-40 km h^{-1}	Inspection with in 24 h of the traversing, the proposed elimination of defects 7 days
		Two defective traversing with permissible speed 60-160 km h^{-1}	Emergency and check up to 2 h before the train passes, proposed elimination of defects 24 h
		In more than two defective traversing with speed limit 20 km h^{-1}	Emergency and check up to 2 h before the train passes, the proposed elimination of defects 24h
	traversing with speed limit 60-160 km h^{-1}	In more than two defective traversing	Very emergency situation, quickly replacement
S (b)	View corrosion and crunch,longitudinal cracks in the traversing. Find fracture of the with drawal of train rails	A defective traversing with permissible speed 20-40 km h^{-1}	Sequential inspections with in a week, the proposed elimination of defects 28 days
		A defective traversing with permissible speed 60-160 km h^{-1}	Inspection with in 24 h of the traversing, the proposed elimination of defects 7 days
		Two defective traversing with permissible speed 20-40 km h^{-1}	Inspection within 24 h of the traversing, the proposed elimination of defects 7 days
		Two defective traversing with permissible speed 60-160 km h^{-1}	emergency and check up to 2 h before the train passes, the proposed elimination of defects 24 h
		In more than two defective traversing with speed limit 20 km h^{-1}	Emergency and check up to 2 h before the train passes, the proposed Elimination of defects 24h
		In more than two defective traversing with speed limit 60-160 km h^{-1}	Very emergency situation, quickly replacement of traversing

Table 5: The rules of B (a) to B (e) of Ballast

Rule	Sign	Ballast conditions	Certain repair method
B(a)	Find particles and soil pollution, pollution is very high covered with mud	Low pollution and allowable speed 20 Low pollution and allowable speed of 80 Pollution intensity and the allowable speed 20 Pollution intensity and the speed limit from 80 Infection intensity and the speed limit of 20 Infection intensity and the speed limit from 80	Routine inspection activities to be done. Sequential inspections within a week, the proposed elimination of defects 28 days Sequential inspections within a week, the proposed elimination of defects 28 days Inspection within 24 h, the proposed elimination of defects 7 days Inspection within 24 h from the time of the replace the screen ballast
B(b)	Find plenty of ballast on-line	The high volume of ballast with low intensity and the permissible speed of 20-60 km h^{-1} The high volume of ballast with low intensity and the permissible speed of 80-160 km h^{-1} The high volume of ballast with mean intensity and the permissible speed of 20-60 km h^{-1} The high volume of ballast with mean intensity and the permissible speed of 80-160 km h^{-1} in more than two defective traversing with speed limit 20 km h^{-1} In more than two defective traversing permissible speed 40-160 km h^{-1}	Sequential inspection within 7 days, schedule maintenance to be performed Sequential inspections within a week, the proposed elimination of defects 28 days Sequential inspections within a week, the proposed elimination of defects 28 days Distribution ballast suitable for on-line Emergency and check up to two hours before the train passes, the proposed elimination of defects 24 h Sequential inspection within 7 days, schedule maintenance to be performed
B(c)	Find poorly drained	Poorly drained with moderate severity permissible speed of 20 Poorly drained with moderate severity permissible speed of 80 Poor drainage and high severity allowable speed of 20 Poor drainage and high severity allowable speed of 80	Within 7 days of sequential inspections carried out in accordance with the maintenance schedule Sequential inspections within a week, the proposed elimination of defects 28 days Sequential inspections within a week, the proposed Elimination of defects 28 days Obstacles in the path of the pipes and drains are removed
B(d)	Find growing plants on line	Line speed of 20-60 km h^{-1} If the line speed is 80-160 km h^{-1}	Inspection within 24 h, the proposed elimination of defects 7 days The use of chemicals to eliminate unwanted plants, drainage line, riddled mud
B(e)	Find crunch in ballast	Line speed of 20 km h^{-1} Line speed of 40-60 km h^{-1} Line speed of 80-160 km h^{-1}	Inspection within 24 h, the proposed Elimination of defects 7 days Emergency and check up to 2 hours before the train passes, the proposed elimination of defects 24 h. Replace the screen of ballast

Table 6: Proposed repair and maintenance method

N	Routine inspection work to be done.
P3	Be made within 7 days of inspection as planned maintenance done
P2	An inspection of the week, time of the proposed elimination of defects: 28 days
P1	Inspections to be performed within 24 h from the time of the proposed elimination of defects 7 days will be considered
E2	Emergency until 2 h before the train passes the review, the proposed elimination of defects 24 h
E1	Emergency situation before crossing train crash wiped out

Table 7: Deterministic repair and maintenance method of the railway geometry

Torsion	Ballast tamping and compressing operations and administration of ballast consumption
Difference transverse	Ballast resistance against traversing movement control of joints healthy sleepers
Internal procedures	Rock abrasion surface and internal means to achieve normal
Longitudinal difference	The use of anti-creep clamp the line and install it on the rails, fastenings and condensation control and maintain ballast
Transverse slope	Lifting jacks for rails to modify the geometry of the line, creating appropriate tamping under the head traverses

components of railway are created. Depending on the type of measure which comes from the railway geometry, data is sorted and the raw data enter into an expert system designed. Measurement of railway geometry by two methods: manual and automatic meter of AK is monitored and in considered in the system. Due to the speed of the data and railway, the user can access type and severity of failures and its repair and maintenance methods. Terms of geometric defects are defined in the following Table 6-8.

The proposed index number of rail line: To offer a good indicator for the railway, the reduction coefficients for the various components of railway should be considered for this purpose, relationships and contexts for the reduction coefficients of rails and other components is proposed which are presented in Fig. 5. After removal of failures per unit defined for each failure code, the failures have been collected and the density is obtained in the unit. Then, the amounts of the reduction from reduction curves for the

Table 8: Expert system rules related to the railway geometric defects

Inside edge	Transverse differences	Transverse slope	Logitudinal difference (M) AK 10	Logitudinal difference (M) Manual 8	Surface rails (m) AK 10	Surface rails (m) Manual 6	Low torsion (m) AK 2.7	Low torsion (m) Manual 2	High torsion (m) AK 13.2	High torsion (m) Manual 14	Line speed (km h^{-1}) 20	40	60	80-90	100-115	115-160
<21	<36	<25	<15	<10	<15	<16	<16	<12	<29	<31	N	N	N	N	N	N
21-22	36-40	26-45	15-18	10-11	15-18	17-20	17-18	12-13	29-33	31-35	N	N	N	N	P3	P2
23-26	41-50	46-65	19-24	15-12	19-21	21-24	19-21	14-15	34-38	36-40	N	N	N	P3	P2	P1
27-28	51-55	66-85	25-34	16-22	22-24	25-27	22-23	16	39-43	41-46	N	N	P3	P2	P1	E2
29-30	56-60	86-105	35-45	23-32	25-27	28-30	24-25	17-18	44-49	47-52	P3	P3	P2	P1	E2	E2
31-32	61-66	106-125	46-55	33-35	28-29	31-32	26-27	19-20	50-56	53-59	P2	P2	P1	E2	E2	E2
33-34	67-71	126-145	56-60	36-38	30-31	33-34	28-29	21-22	57-60	60-64	P1	P1	E2	E2	E2	E1
35-37	72-75	146-170	61-63	39-40	32-37	35-40	30-31	23	61-66	65-70	E2	E2	E2	E2	E1	E1
37<	75<	170<	63<	40<	37<	40<	31<	23<	66<	70<	E1	E1	E1	E1	E1	E1

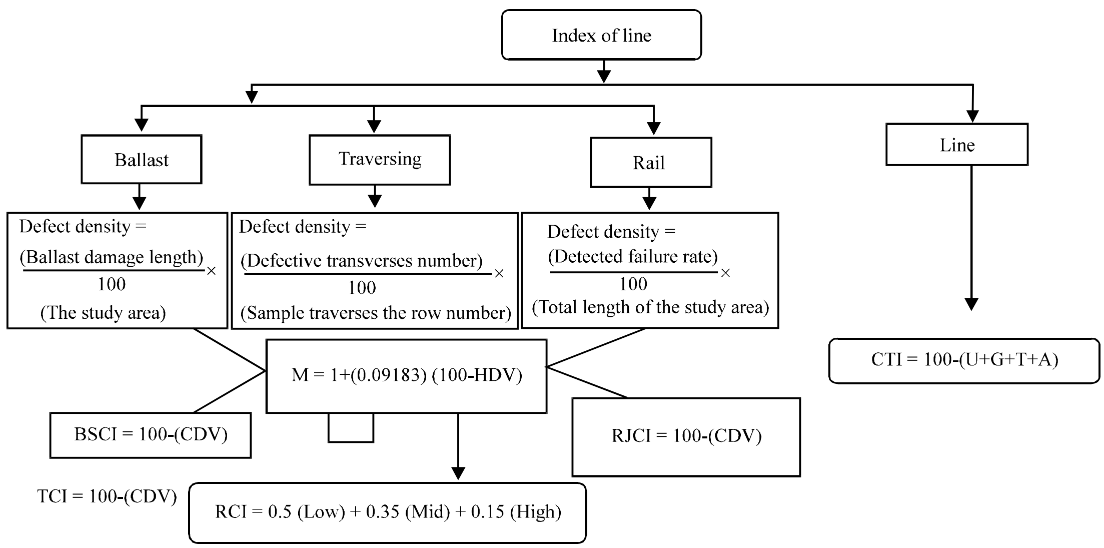

Fig. 5: An overview of the railwayquality index number

reduction in the group of rails, traverses, ballast are determined. Then, the maximum number allowed of reduction values (m) is obtained and choosing of reduction values for the calculation of thecorrected decrease values, finally, the amount of the main decrease which leads to calculate the index for each of the four groups will be calculated. If none or only one of the decrease values was >2, instead of the maximum value, Corrected Decrease Values (CDV), the Total Decrease Value (TDV) which is the sum of the decrease values is used. If more than one decrease value is >2, you must first calculate the value of m (the maximum amount of decrease in the valuations of a unit = HDV). To assess the quality of the railway geometry, the index calledthe CTI is used. In this index, the status of different records of the geometry of the railway is considered and according to the importance of each of the measured parameters, it combines them with certain coefficients and finally, a number iscalculated which will represents the geometry of the railway. Overview of numeric data entry related to the quality of the railway and its relationships is according to the pattern of Fig. 5. The parameters of the following algorithm are:

- U = Number of vertical non-alignment greater than the relevant tolerance
- G = The number of points that the difference in line width in them is greater than the relevant tolerance
- T = Number of twists greater than the tolerance
- A = The number of horizontal non- alignment greater than tolerance

Determination of the critical index number: Referring to Fig. 5 obtained in the course of inspection and determination of the critical index number, a better plan for the maintenance of railway lines can be obtained. Therefore, in most cases, the number 60 is considered as a critical indicator. A number of critical parameter can be changed based on analyzes done and different regions. Table 9 displays the relationship defined between the numbers of quality indexand quality titles.

Table 9: The relationship defined between the quality index numbers and titles of quality

Range of numeric index	Qualitative title	Comment
80-100	Very good	Defects is very low, the performance was not affected, immediate action is required, the need for regular maintenance and preventive
60-80	A good	Moderate damage, the line is sometimes not damaged, routine maintenance and minor repairs are needed.
40-60	Average	Significant damage, injury-line performance, routine maintenance and minor repairs sometimes improving line
20-40	Weak	Severe damage to the small percentage of road damage road performance, major repairs and reconstruction of line sometimes
0-20	Very poor	Extreme damage on a large percentage of the route, stop the track, major repairs and modernization sometimes line

CONCLUSION

One advantage of using expert systems is the ability to use them alongside professional which lead to makedecision based on human expertise and machine precision. The use of computerized expert systems in various projects, particularly rail and railway, can help to improve the railway system in the country. The system is considered as a branch of the broad field of artificial intelligence that has ability to replace an expert in scientific field or special act. In this study, with investigation of the failures and shortcomings of the rail system, the regulation was based on expert system was discussed which can determine repair methods of defects for any part of the rail, then, how to calculate the number of failures indexin this system is presented. The results show that, providing an expert system in this sector, according to the database that is in, it canrespond appropriatelyto surveys done as an expert and at any time and under any circumstances.

REFERENCES

Akhouayri, E.S., D. Agliz, D. Zonta and A. Atmani, 2015. A fuzzy expert system for automatic seismic signal classification. Exp. Syst. Appl., 42: 1013-1027.

Ganjavi, M.R., R. Krebs and H.Z. Styczynski, 2006. Distance protection settings in electrical railway systems with positive and negative feeder. WSEAS. Trans. Power Syst., 1: 357-361.

Ikram, A. and U. Qamar, 2015. Developing an expert system based on association rules and predicate logic for earthquake prediction. Knowl. Based Syst., 75: 87-103.

Majstorovic, V.D., 1990. Expert systems for diagnosis and maintenance: The state-of-the-art. Comput. Ind., 15: 43-68.

Martland, C.D., S. McNeil, D. Acharya, R. Mishalani and J. Eshelby, 1990. Applications of expert systems in railroad maintenance: Scheduling rail relays. Transp. Res. Part A Gen., 24: 39-52.

Saeid, M.K., 2009. Presents an expert system for scheduling maintenance of railway lines. Master thesis, Faculty of Civil Engineering, Islamic Azad University, Science and Research Branch, Tehran.

Yingjie W., L.M. Jia and K. Xiong, 2005. Railway operation intelligent simulation system. China Academy of Railway Sciences, 100081 Beijing, China.