www.arpnjournals.com

RAILWAY EC SOFTWARE BASED ON EXPERT SYSTEM AND ITS APPLICATION IN PLANNING REPAIR AND MAINTENANCE SERVICE OF RAILWAY LINES (CASE STUDY: A RANGE OF TEHRAN RAILWAY - WHITE HILL)

Fereydoun Moghadasnejhad[1] and Saeid Mohamadkhah[2]
[1]Department of Civil Engineering, Amirkabir University of Technology, Tehran, Iran
[2]Civil Engineering of Transportation, Science and Research Branch, Islamic Azad University, Tehran, Iran
E-Mail: mohamadkhah.sa@gmail.com

ABSTRACT

The success in repair and maintenance depends on scientific understanding of the geometrical and physical imperfections of rail that in this context in order to maintain proper planning of railway components and fix their disadvantages and design and fabrication of new materials consistent with the natural conditions is necessary and need for it, increasingly is felt. Nowadays new system has been established to improve the operation and maintenance of the rail system that most notably of them is expert system. The system is able to removing defects and fixes basic geometric forms and lines and also increases the safety factor to train and provide favorable conditions for the movement and speed of the trains. In this paper we try to plan Repair and maintenance service of railway lines by using expert system and then with providing Railway EC software in this system, we will try to analyzes the defects of railway system. Therefore, after explaining some concept of Repair and maintenance service and expert system and examine the failures and shortcomings of the rail line we try to pay for calculating the index number. Finally with a case study within a Tehran-Hill Railway white by Software, its failures investigated and strategies provided to repair them.

Keywords: railway lines, software, expert systems, planning, repair and maintenance service.

1. INTRODUCTION

Rail transportation 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 and constant 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 railway s 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

scientific knowledge of geometrical and physical defects of railway, and its components, and how to fix them, in this context, planning in 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 [2].

Today, new systems to improve the repair and maintenance of the rail system have been created, which the most prominent of them is the expert system. 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 [3].

In 1990 a paper published that its 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 [9].

V. D. Majstorović in 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 paper, 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: (i) knowledge engineering for maintenance ES; (ii) basic hypotheses for the development of ES for maintenance; (iii) the level of development and application of ES in the domain of maintenance; and (iv) 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 [10].

In 2005 Yingjie WANG et al 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 [11].

Also in 2006, in a paper that was presented by Habil. Z. Styczynski and M. R. Ganjavi, R. Krebs, it was evaluated the Distance Protection Settings in Electrical Railway Systems with Positive and Negative Feeder. The paper 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 [12] later, the application of expert systems was expanded so that newly researchers use it for seismic signal classification, earthquake prediction [13,14].

In 2013, Rodzyah Mohd et al used expert choice for ranking heritage streets. In this method, the researcher selects pair wise method in the design of the questionnaires. The emails are sent to experts and follow them up for 'face to face' interview. Only two heritage experts contribute due to the requirement on high focus and commitment in providing a qualitative expert's selection. Finally, this research shares the step-by-step strategy in heritage streets' ranking data collection and analysis. The ultimate goal is ensuring achieving high quality of life in the urban outdoor of heritage streets [15]

Paglica et al (2014) provide a paper that was "A Comparison between Consumers and "experts" Choices

by the Sensory Analysis" The analysis is focused on olive oil, given its importance in the present competitive scenario and also for the renewed and growing interest that this product has in nutrition, health and wellbeing. It is in the interests of the different categories of olive oil producers to highlight the value of the specific attributes of their products, through the certification systems, geographical indications or organic farming. We have analysed consumer liking in order to understand what sensory attributes guide the choice, because this can help managers to develop marketing strategies focused on consumers' demands. This study was conducted to identify and define sensory characteristics of five Italian olive oils and to link these differences to consumer and "experts" (the chefs) preferences through the application of preference mapping. This study confirms the hypothesis that experts give more importance to intrinsic attributes than "novices", and also that the chefs are more aware than consumers on the EU certification systems and geographical indications or organic farming [16].

In Iran, expert systems have been studied, which several recent cases have been studied? In 2012, Bazargani et al presented a paper in which the application of expert systems for traffic control in large cities was investigated. In this paper, we try to describe the overall volume information technology applications in transport, and its use in recent years in developed countries is examined for traffic control, so the different systems in intelligent traffic control can be used, which have been studied [17].

Also, an expert system for other issues, including banking [18], automotive engine fault diagnosis [19] was used. In 2011, Ramezani et al in a survey introduced a model in which evaluation and prediction of the readiness of organizations operating equipment, especially military organization are discussed. Model designed according to the needs of the organization and research carried out in the form of a system was introduced. Evaluation the readiness of the system as the hierarchy aggregation, based on the evaluation of equipment systems and sub-systems, according to the weight and importance of each of them in mission [20]. Behyari and colleagues (2012) suggested the use of expert systems in ship maintenance and repair industry [21].

According to the literature cited, noted that, considerable research on the use of expert systems in the transportation industry has not been done. Therefore, in this paper we have tried to examine maintenance planning of railway lines by using an expert system, and then by providing software in this system, rail defects are analyzed. To this end, after expressing the concept of maintenance system and the expert system, and examination of the failures and shortcomings of the rail system, the method of calculating the number of failures index is discussed. Finally, after doing a case study by software, failures of the railways have been studied, and the solutions are provide to repair them.

2. 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 [3]. 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 [3]. 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 paper 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 [9].

V.D. Majstorović in 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 paper, 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: (i) knowledge engineering for maintenance ES; (ii) basic hypotheses for the development of ES for maintenance; (iii) the level of development and application of ES in the domain of maintenance; and (iv) 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 [10].

In 2005 Yingjie WANG *et al* 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 [11].

Also in 2006, in a paper that was presented by Habil. Z. Styczynski and M. R. Ganjavi, R. Krebs, it was evaluated the Distance Protection Settings in Electrical Railway Systems with Positive and Negative Feeder. The paper 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 [12] later, the application of expert systems was expanded so that newly researchers use it for seismic signal classification, earthquake prediction [13, 14].

2.1 Definition and performance of the Expert System[1]

Expert systems or knowledge-based systems[1] (KBS) are rooted in the field of study called artificial intelligence[2] (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 that field. Expert systems must be able to explain the process of its argument and conclusions to the end user [3]. 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 [4]:
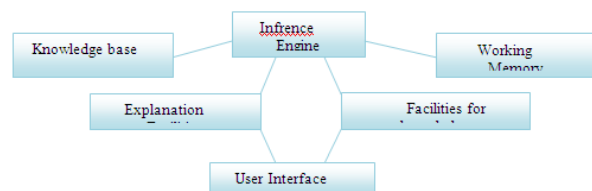
Figure-1. Main components of expert system [4].

In general, the expert system functions, such as recognition of the problem, identify solutions, and the

www.arpnjournals.com

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 [3].

3. RESEARCH METHODOLOGY: 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 rails are 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 decisions are 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, rail head, 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 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 [1].

3.1 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 framework 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. 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 is used, 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.
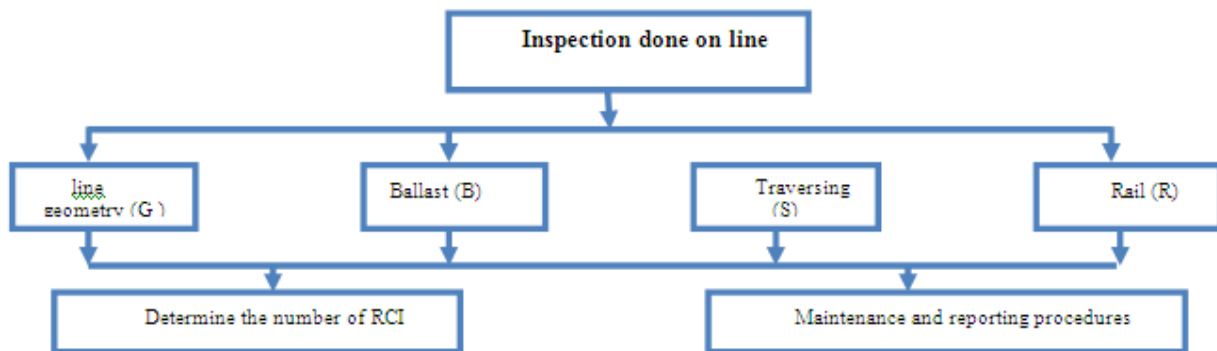

Figure-2. Overview of the expert system in railway [1].

3.2. 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 & maintenance.

www.arpnjournals.com

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 rail jan junction to rail head, the horizontal cracks of rails head, rail jan junction to rail heel, rail heel failure
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 Ballast at the shoulders and railway s, poor drainage side of the railway
Railway geometry		Lack of regular and special geometric properties

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.

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 are provided. It is noted that, for each type of inspection, rules in the expert system are arisen, which according to the type and severity of symptoms and damage, repair methods have been proposed for each of them.
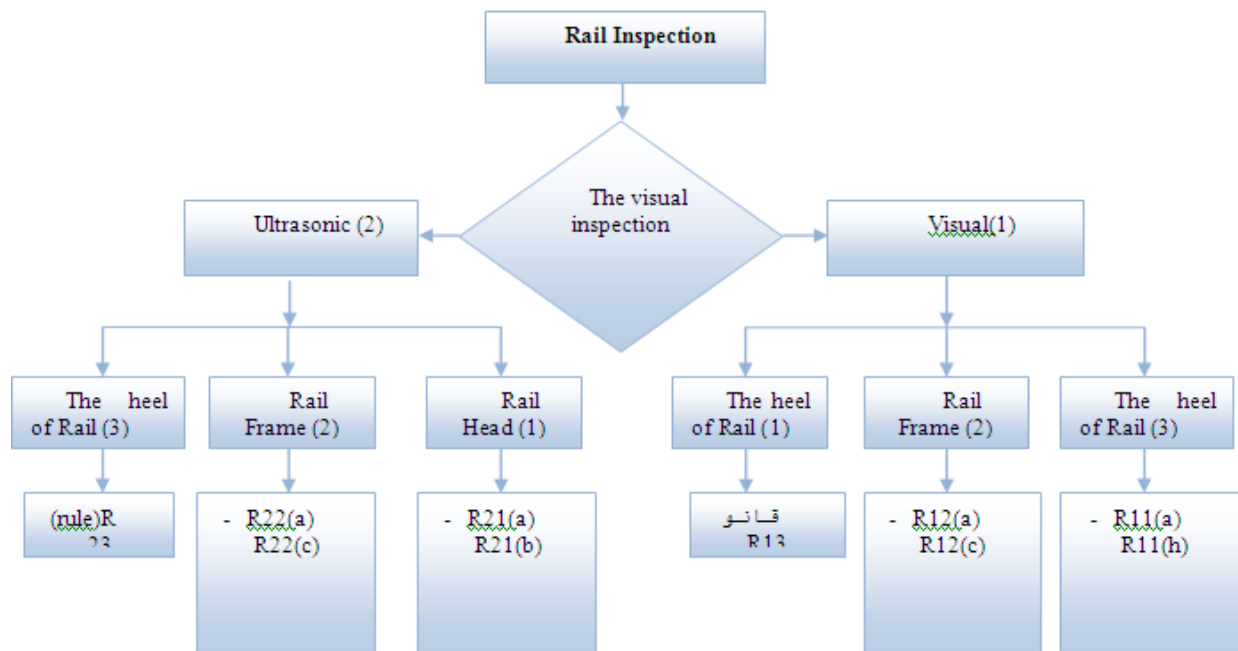
Figure-3. The rail inspection algorithm [1].

www.arpnjournals.com

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 30km / h, 48 h time Elimination of defects	Cutting of failure zone, extension, replacement
R11(b)	Detachment of Rail with a depth of more than 1cm in length more than 5cm, opaque spots in the lateral, horizontal hairline streaks of rust, broadening Head Rail	horizontal crack of rail head HSH	Size cracking less than 200 mm, the average M, 200 mm size fraction, Extreme H	Speed limit of 20 km / h Speed limit of 10 km / h	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 are moderate damage.	Speed limit of 10km / h	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 150mm, Extreme damage and leaving more than 150mm severe	Elimination of defects Extreme intensity, speed of 10km / h, 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	according 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 and	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 10km / h 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 less than 200 mm: average, more than 200 mm: Extreme	Speed of 20km / h and 48 h time proposed Elimination of defects moderate intensity, speed of 10km / h and a = stop the train at high intensity downtime.	Corrective weld in moderate failure, switching rails and Cutting of failure zone in Extreme damage severity.
R12(c)	Horizontal cracks in the body joint	Horizontal crack in heel junction of head & heel FW	For downtime of less than 150 mm: Extreme, more than 150 mm: very Extreme	Speed of 20km / h and subsequent inspections and at intervals of 6 hours downtime in intensity, speed limit of 10km / h and the severity of the failure to stop the train at high intensity downtime	Corrective weld in moderate failure, switching rails and Cutting of failure zone in Extreme 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

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Table-3. Rules defined for an expert system for rail ultrasonic inspection.

The law	Signs	Type of failure	Severity of failure	Repair method
R21(a)	Detection of failures, by the detector 70 ° Longitudinal motion of detector, one of the states: 40-56 mm, 57 to 90 mm, more than 90 mm	Transverse crack of rail head.	Motion of detector 40-56mm, Low intensity, L, 57-90mm moderate intensity, M, more than 90 mm, high intensity H	Low intensity: no action, moderate: Welding correction, speed limit of 30 kilometers per hour, high intensity, Cut the damaged area, and weld joint, replace the rail, the speed limit of 20 km / h
R21(b)	Detection of Failures in the real motion and longitudinal motion of detector: 25-100mm, 101-200mm, more than 200mm	Horizontal cracks of rail head	Motion of detector 25-100 mm, Low intensity, L, 101-200 mm moderate intensity, M, more than 200 mm, high intensity H	Low intensity: Cleaning the surface of the rail movement, moderate: Welding Saby rock, speed limit 20 km / h,, high intensity, Cut the damaged area, and weld joint, replace the rail, the speed limit of 20 km / h
R22(a)	Adjust the detector of 0^0. Recognize the Failure depth of the junction of Jan to rail head and Longitudinal motion detector , one of these cases: 25 to 75 mm, 76 to 200 mm, more than 200	HSW and TSW cracks	Motion of detector 25-75 mm, Low intensity, L, 76-200 mm moderate intensity, M, more than 200 mm, high intensity H	Moderate: Welding correction, speed limit of 20 kilometers per hour, high intensity, Cut the damaged area, and weld joint, replace the rail, the speed limit of 10 km / h
R22(b	recognize the Failure depth in rail heel, and Longitudinal motion detector , one of these cases: 25 to 75 mm, 76 to 200 mm, more than 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 kilometers per hour, high and very high intensity, Cut the damaged area, and weld joint, replace the rail, the speed limit of 10 km / h
R22(c)	recognize the Failure depth in rail heel, and Longitudinal motion detector , one of these cases: 20 to 40 mm, 41 to 75 mm, 76-150, more than 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 more than 150 mm, Extremely Severe E.	Low: no action, moderate, do check with near intervals and the speed limit of 40 kilometers per hour, high : Welding correction with the speed limit of 20 km / h , 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
R23	Using a pair of 70-degree detector, detecting failures in the wings of the heel and lateral movement detector in one of the cases: 10 to 35 mm and more than 35 mm.	Crack or fracture of the rails heel wing FD	Proportional to the motion detector is determined. Motion of detector : M, 10 to 35 mm: M, more than 35, H.	Moderate: Welding modification. High intensity: the use of patches welded or replacement of rails Broken.

3.2.1 Traversing inspection

Inspections carried out on the traverse enter by using the traverse 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 information railway. 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 the proposed methods for proper maintenance in output of system.

www.arpnjournals.com

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 more than 2 defective observed, obvious cracks in the surface or the lower	A defective traversing with permissible speed 20-40km / h	Sequential inspections within a week, the proposed Elimination of defects 28 days
		A defective traversing with permissible speed 60-160km / h	Inspection within 24 hours of the traversing, the proposed Elimination of defects 7 days
		two defective traversing with permissible speed 20-40km / h	Inspection within 24 hours of the traversing, the proposed Elimination of defects 7 days
		two defective traversing with permissible speed 60-160km / h	Emergency and check up to two hours before the train passes, the proposed Elimination of defects 24h
		in more than two defective traversing with speed limit 20km / h	Emergency and check up to two hours before the train passes, the proposed Elimination of defects 24h
		In more than two defective traversing with speed limit 60-160km / h	Very Emergency situation, quickly replacement of traversing
S (b)	View corrosion and crunch, longitudinal cracks in the traversing. Find fracture of the withdrawal of train rails	A defective traversing with permissible speed 20-40km / h	Sequential inspections within a week, the proposed Elimination of defects 28 days
		A defective traversing with permissible speed 60-160km / h	Inspection within 24 hours of the traversing, the proposed Elimination of defects 7 days
		two defective traversing with permissible speed 20-40km / h	Inspection within 24 hours of the traversing, the proposed Elimination of defects 7 days
		two defective traversing with permissible speed 60-160km / h	Emergency and check up to two hours before the train passes, the proposed Elimination of defects 24h
		in more than two defective traversing with speed limit 20km / h	Emergency and check up to two hours before the train passes, the proposed Elimination of defects 24h
		In more than two defective traversing with speed limit 60-160km / h	Very Emergency situation, quickly replacement of traversing

3.2.2 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.
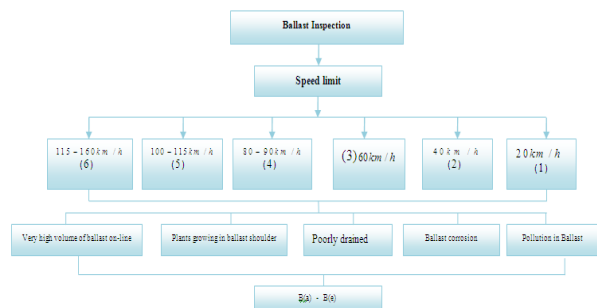
Figure-4. Overview of Expert System of Ballast inspection.

www.arpnjournals.com

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	Routine inspection activities to be done.
		Low pollution and allowable speed of 80	Sequential inspections within a week, the proposed Elimination of defects 28 days
		Pollution intensity and the allowable speed 20	Sequential inspections within a week, the proposed Elimination of defects 28 days
		Pollution intensity and the speed limit from 80	Inspection within 24 hours, the proposed Elimination of defects 7 days
		Infection intensity and the speed limit of 20	Inspection within 24 hours from the time of the proposed Elimination of defects 7 days
		Infection intensity and the speed limit from 80	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 20-60km / h	Sequential inspection within 7 days, schedule maintenance to be performed.
		The high volume of ballast with low intensity and the permissible speed of 80-160km / h	Sequential inspections within a week, the proposed Elimination of defects 28 days
		The high volume of ballast with mean intensity and the permissible speed of 20-60km / h	Sequential inspections within a week, the proposed Elimination of defects 28 days
		The high volume of ballast with mean intensity and the permissible speed of 80-160km / h	Distribution ballast suitable for on-line
		in more than two defective traversing with speed limit 20km / h	Emergency and check up to two hours before the train passes, the proposed Elimination of defects 24h
		in more than two defective traversing permissible speed 40-160km / 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	Within 7 days of Sequential inspections carried out in accordance with the maintenance schedule.
		Poorly drained with moderate Severity permissible speed of 80	Sequential inspections within a week, the proposed Elimination of defects 28 days
		Poor drainage and high Severity allowable speed of 20	Sequential inspections within a week, the proposed Elimination of defects 28 days
		Poor drainage and high Severity allowable speed of 80	Obstacles in the path of the pipes and drains are removed.
B(d)	Find growing plants on line	Line speed of 20-60km / h	Inspection within 24 hours, the proposed Elimination of defects 7 days
		If the line speed is 80-160km / h	The use of chemicals to eliminate unwanted plants, drainage line, riddled mud
B(e)	Find crunch in ballast	Line speed of 20km / h	Inspection within 24 hours, the proposed Elimination of defects 7 days
		Line speed of 40-60km / h	Emergency and check up to two hours before the train passes, the proposed Elimination of defects 24 hours.
		Line speed of 80 - 160 km / h	Replace the screen of ballast

3.2.3 Inspection of Railway geometry

Geometry of railway may be damaged by railway failures and defects which in 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 tables.

www.arpnjournals.com

Table-6. Proposed repair and maintenance method [8].

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 hours from the time of the proposed Elimination of defects 7 days will be considered.
E2	Emergency until two hours before the train passes the review, the proposed Elimination of defects 24 hours.
E1	Emergency situation before crossing train crash wiped out.

Table-7. Deterministic repair and maintenance method of the railway geometry [8].

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
The transverse slope	Lifting jacks for rails to modify the geometry of the line, creating appropriate tamping under the head traverses

Table-8. Expert system rules related to the railway geometric defects [8].

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

3.3. 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 Figure-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 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 the corrected 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 greater than 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 greater than 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 called the 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 is calculated, which will represents the geometry of the railway [2].
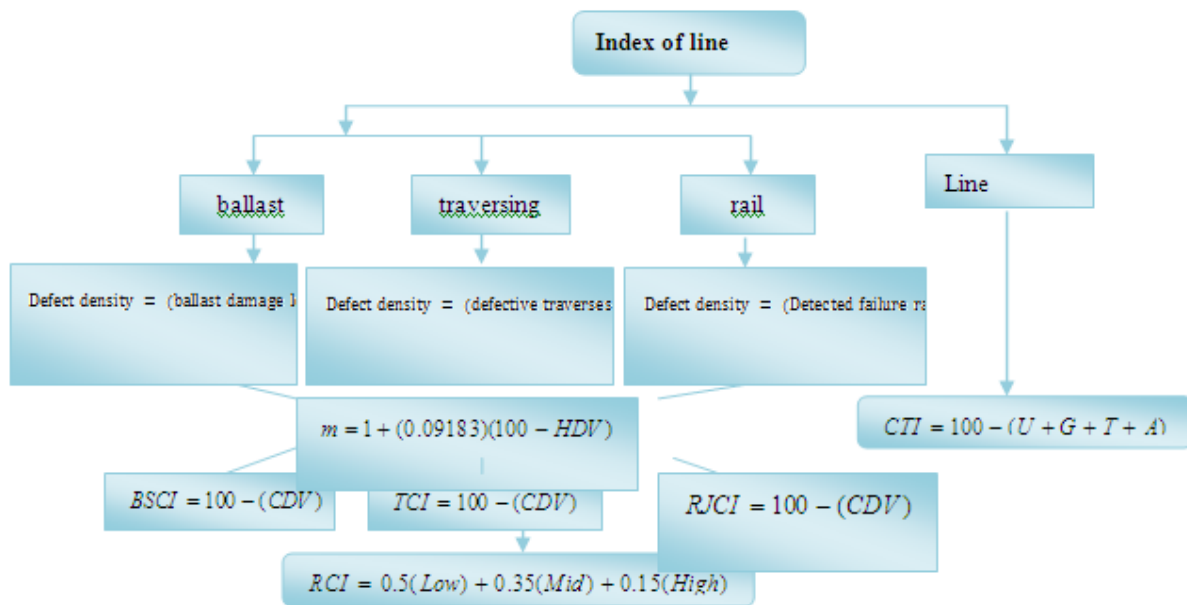

Figure-5. An overview of the railway quality index number.

Overview of numeric data entry related to the quality of the railway and its relationships is according to the pattern of Figure-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

3.3.1 Determination of the critical index number

Referring to the figure 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. The following table displays the relationship defined between the numbers of quality index and quality titles.

www.arpnjournals.com

Table-9. The relationship defined between the quality index numbers and titles of quality [7].

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

4. RAILWAY EC

Railway expert system software according to the rules and expert systems created in the previous sections, and by the Visual Basic programming language is written. In this section, the introduction and description of the general environment and its application are discussed.

4.1 Introduction of software's options

With respect to the components inspected, options have been considered in the application, so the operator can easily enter the resulting data from inspections in the relevant section, the options considered in the software match with options mentioned in the expert system. By selecting the New Project option, a part of the software is shown, in which information on the project, such as the storage path, kilo meter for beginning and end of the path, operator name, date and numbers of the traverses in the route studied are displayed, and by answering options, the project is presented to the system.

Figure-6. General view of software.

Figure-7. Overview of the data entry into the project.

Software general environment has provided the choice of subject under inspection for the user (in a beautiful manner), and you enter the environment by selecting parts of the line, and you can observe relevant information, and then enter the data after inspection.

4.2. Rail inspection

User by selecting the option of inspection of rails, enters into the environment, and where, in addition to viewing and selecting the method of inspection, rail profile selected as the default can be seen, however, this selection is default, and it is due to its popularity in the country's rail lines, and it is changed based on the type of the rail. According to the definition used by the expert system, the rails is divided into the rail head, rail jan and rail heel, and two types of inspections are considered, that by selecting the appropriate option, the user is guided to the environment and the appropriate questions. In the new environment, the operator must also complete the options related to kilo meter and failure in addition to answer questions, so these questions are stored in the system, and in the final report, which will be given to the user after the visit, the area and the type of failure can be recognized.

www.arpnjournals.com

Figure-8. A general view of the rail.

Figure-9. A General view of visual inspection of rail.

Another possibility that is considered for the rail sector and other sectors is that inserting a picture of the failure is possible, if so, a database of registered failures images can be created, and in the next subsequent inspections carried out, they can be used, and it can help the operator to better identify the type and severity of the failure. In the option of visually inspect, and in the inspection of the rails head, 8 types of failures that can be detected with regard to the inspection of the rail head, it is proposed that 3 of these failures have the default images which help the user to better identify the type and severity of failures. How performance of options associated with other components, such as the rail head, because a lot of failures are related to the rail jan appears in the inspections of rail head, and a few failures in Jan by visiting rails Jan are observed, the questions in this area were limited, and the user provides results of the rail jan inspection according to the three questions arisen in this case. Inspection of rail heel is similar to the above cases it is avoided to the explanation unnecessary in this case. In the inspection of rails, and to prevent the possibility of error, and the incorrect diagnosis which often is arisen in the visual inspection, another possibility is intended to inspect

the rail by the user as semi-mechanized, in this case, the user using ultrasonic detectors can detect the position and length of downtime, though small, and by entering relevant data, the user can help the system to determine the type and severity of system failures and find the appropriate method for repair and maintenance. It should be mentioned that, the user is assumed as an expert to use these detectors and how to set it. The use of ultrasonic instructions in Appendix A, can be studied. By selecting the Ultrasonic inspection option, and upon arrival at the rail head, the user faces with two options, which define the choice of ultrasonic irradiation degree on Rails, which for the inspection of the crown, and finding all its imperfections, the two angles in radiation must be used. Inspection software environment in accordance with the previous cases with a kilo meter of failure, and in the case of the relevant image, and sending failure length is possible and all such cases should be answered by the operator, so the system without error can achieve the perfect result in the analysis.

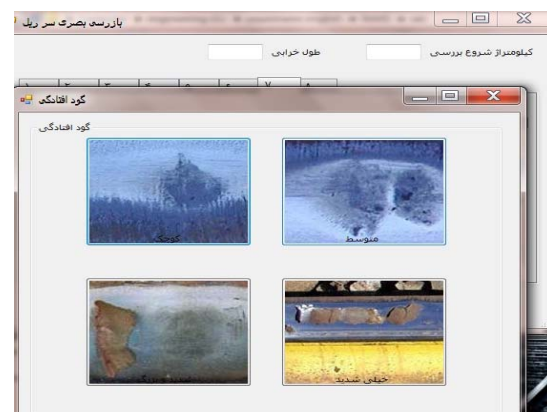**Figure-10.** General view of the failures with a default image.

Figure-11. General view of the Ultrasonic rail inspection.

In the ultrasonic inspection, and in the rail jan section, according to the definitions about that size and the type of the rail, by entering the depth of the failure, the system by analysis done measures the type and severity of failure due to motion of detector and reports to the user.

4.3 Traversing inspection

User in general environment of software and for data entry to inspection of traverses, can refer to the traverse option, and enter its environment. Initially, the user selects the type of the traverse, which in the software, two general types (wood and concrete) is considered. Choosing wooden traverse, a window will open to the user opens in which questions are asked by the operator, such as the past, in this section, the user must enter information related to the failure Kilo Meter and the numbers of defective traverses, in addition to this, the speed of the line is entered into the software to achieve better analysis of the current situation by the user. These conditions are also in the case of concrete traverses, and further explanation, is avoided.

4.4 Ballast Inspection

User, due to defects which seems in ballast, and to enter his data into software in its general environment, with reference to the relevant item can enter into the ballast section, and considering the questions raised by the software, can achieve a good result. By selecting the ballast option, a window will be opened for the user in which the user will be asked questions to determine the type of defect, and by answering any of them, and determining the kilogram meter of failure, and If the process is completed, If the user wants to enter additional information into the software, and then selects the cave and next options, otherwise, choose Exit, therefore, the user completes the relevant inspection.

Figure-12. General view of the Traverse inspection.

Figure-13. General view of the Ballast inspection.

4.5 Inspection of line geometry

In the software for data entry for the line geometric inspection, two options have been considered, they depend on the type of measurement of line geometry, which the user by selection the manually measurement option, can enter the data that achieve by using auxiliary forces from the line, and by choosing the Machine-meter line AK, the user enter into the system the data measured by the machine.

Figure-14. General view of the line geometry inspection.

Given that the speed of line and failure kilo meter is specified by the user, a proper analysis can be expected from software. After the data entry, the user by selecting the exit and return options can enter into general environment of the software, and by selecting the reports option, can achieve a full report of what in kilo meter checked by himself is entered into the software, and can observe analyze and identify the type and intensity of the proposed method of repair and maintenance as output of software.

www.arpnjournals.com

5. CASE STUDY

Case study is a part from Tehran - Tappeh-ye Sefid railway, which were visually inspected, and the results of this inspection is checked by analysis and software Analysis. Inspection path length was selected 500 m in the network, and the network is divided to distances of 20 m, which was used as the default, and decrease coefficients are obtained according to it. Therefore, the inspection path includes 25 areas with 20 meters.

0-20	20-40	40-60	60-80	80-100	....	440-460	460-480	480-500
Section1	Section2	Section3	Section4	Section5	......	Section23	Section24	Section25

Figure-15. View of the inspected parts.

First, data of every part is entered to software designed, and its results and reports, based on the type and severity of failure and deterioration is examined, and some decision is made to measures required. It is noteworthy that, in this path the speed limit 80KM / H is considered. Information collected on the network can be seen in Table 10, it should be clear that, for the line inspected had wooden traverses, and lots of these traverses for various reasons had fractures and cracks, and to avoid wasting time, just a few examples of defective traverses were photographed, and for the rest of them, counting and recording Kilo Meter was sufficient. Then, the inspection of rails and its conditions by using visual assessment is discussed, and then the data recorded in the corresponding section is entered into software. Numbers of sample data entry into the system can be seen in the figures below.

Figure-16. Example of profiles of piece logged.

Figure-17. Example of data entry into the system.

www.arpnjournals.com

Table-10. Summary of inspection and removals done.

Section number	Kilometer	The number of defects found in rail	The number of defects found in Traverses	Section number	Kilometer	The number of defects found in rail	The number of defects found in Traverses
1	0-0+020	2	15	14	0+260-0+280	0	2
2	0+020-0+040	0	14	15	0+280-0+300	0	6
3	0+040-0+060	1	6	16	0+300-0+320	2	7
4	0+060-0+080	3	7	17	0+320-0+340	0	11
5	0+080-0+100	0	6	18	0+340-0+360	0	2
6	0+100-0+120	1	10	19	0+360-0+380	1	7
7	0+120-0+140	0	3	20	0+380-0+400	0	9
8	0+140-0+160	2	2	21	0+400-0+420	0	5
9	0+160-0+180	0	13	22	0+420-0+440	0	3
10	0+180-0+200	0	11	23	0+440-0+460	2	7
11	0+200-0+220	0	2	24	0+460-0+480	2	10
12	0+220-0+240	1	3	25	0+480-0+500	0	11
13	0+240-0+260	0	1				

By completing the inputs of the first part, and after the analysis of line status by the software, the relevant report is described as the following tables. Index number obtained in the first part is 88, which represents an excellent position in the line, and only with regard to the inappropriate conditions of traverses, a proper planning to replace and repair of them can be done. In other parts, so the information is logged, and the report and the corresponding index number as output are provided to the user.

Table-11. First part reporting.

Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive Repair and maintenance	Temporary Repair and maintenance	image
rail	12	8	Failure of rail head TD	Extreme H	Cutting of failure zone, extension, replacement	For state of haven't budget speed limit 30km/h	
Head of rail	16	12	Horizontal crack of rail head HSH	Crack long <200mm	rock abrasion	speed limit 20km/h	
Woody traversing	19	15	Woody traversing	E1	Traversing replacement	Very an emergency must be resolved before Passing the next train	

www.arpnjournals.com

Figure-18. The index number obtained in the first part.

In the following tables, output reports for several other pieces can be observed.

Table-12. Second part reporting.

Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive repair and maintenance	Temporary repair and maintenance	Image
Woody traversing	39	14	Woody traversing	E1	Traversing replacement	Very an emergency must be resolved before Passing the next train	

Due to the lack of rail failure on the second, a number index obtained for rail shows 100, which represents the real condition of this piece is great, but considering the emergency on the traverses, actions required must be done according to the proposed report to fix failure.

Table-13. Third part report.

Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive repair and maintenance	Temporary repair and maintenance	Image
rail	74	6	Small cracks in inside edge of rail	Extreme H	Improved lubrication		
Head of rail	77	6	Small cracks in inside edge of rail	Crack long <200mm	Improved lubrication		
Woody traversing	79	7	Woody traversing	E1	Traversing replacement	Very an emergency must be resolved before Passing the next train	

www.arpnjournals.com

Table-14. Fifth part report.

Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive repair and maintenance	Temporary repair and maintenance	Image
Head of rail	117	12	Small cracks in inside edge of rail	Small and lot cracks with 10-30 degree	Improved lubrication	No action	
Woody traversing	119	10	Woody traversing	E1	Traversing replacement	Very an emergency must be resolved before Passing the next train	

Table-15. Seventh part report.

| Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive repair and maintenance	Temporary repair and maintenance	Image
Head of rail	162	7	concave	Extreme H	H rock abrasion replacement		
Head of rail	151	14	Horizontal crack on rail head HSH	Crack long <200mm	rock abrasion		
Woody traversing	157	2	Woody traversing	E2	Traversing replacement	Very an emergency must be resolved before Passing the next train	

Table-16. Eighth part report.

Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive repair and maintenance	Temporary repair and maintenance	Image
Woody traversing	179	13	Woody traversing	E1	Traversing replacement	Very an emergency must be resolved before Passing the next train	

www.arpnjournals.com

Table-17. Ninth part report.

Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive repair and maintenance	Temporary Repair and maintenance	Image
Woody traversing	199	11	Woody traversing	E1	Traversing replacement	Very an emergency must be resolved before Passing the next train	

Due to the limitations of paper, the complete report can be neglected. However, due to the number of indicators presented for the rails on each part, the population from the selected network of 500 meters can be obtained, and parts that need to have a budget for maintenance can be identified, and they will receive priority. In the following chart, based on the number of components and the index number obtained, comparison of failure between parts can be presented by final indicators.
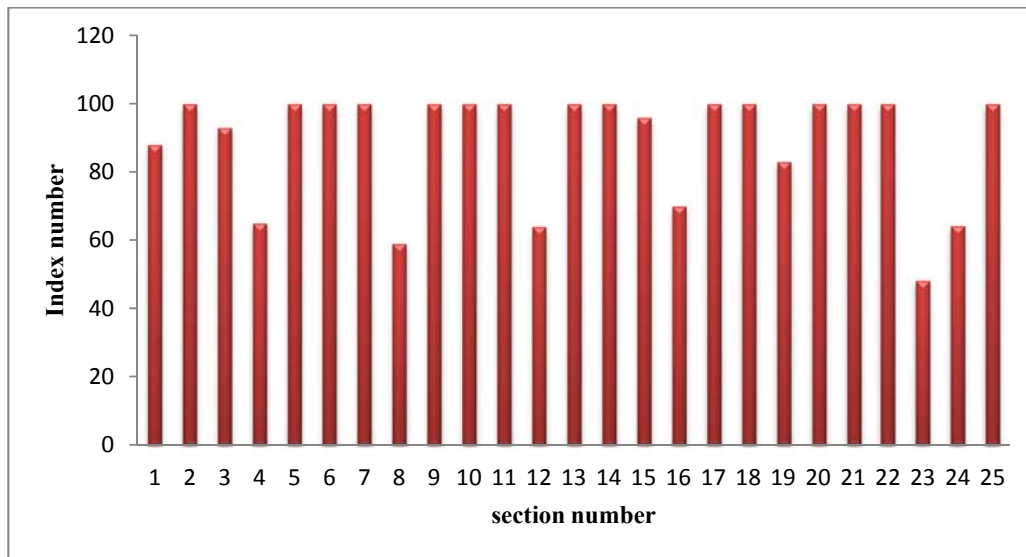
Figure-18. Comparison chart of index numbers found on the network.

Based on the chart and comparisons between components, can be seen, the component No. 23 with the number index 48, compared to other parts has uncomfortable situation, it needs service and maintenance according to what is relevant reports to improve its quality. The profiles of the component No. 23 can be seen in Table-18. In this component, the failure of the horizontal crack of rails head with high intensity is reported, it is recommended that maintenance operations must be done according Saby stone, and in the absence of adequate funding, the speed limit of 20 miles per hour until to fix the failure, must be considered, however, other reported failure is broken rail heel, the intensity of the failure leads to use welded patches or eventually Rail replacement.

www.arpnjournals.com

Table-18. Twenty-third component reporting.

Inspection type	Failure kilometer	Length of failure	Type of failure	Severity of failure	definitive repair and maintenance	Temporary repair and maintenance	Image
Rail	447	12	Horizontal crack of rail head HSH	Separation of the movement part of rails with more that 1cm in depth	Cutting of failure zone, extension, replacement		
Head of rail	453	15	Failure of heel	Extreme H	Using patch welded Replace the broken zone		
Woody traversing	459	7	Woody traversing	E1	Traversing replacement	Very an emergency must be resolved before Passing the next train	

6. CONCLUSIONS

Given that lack of timely detection of failures caused in rails, traverses, ballast and defects caused by the geometry of the line will provide the conditions for the rapid decline and before time considered, providing innovative solutions in the field seems necessary, expert systems, is one of these solutions. The use of computerized expert systems in various projects, particularly rail and railway, can help to improve the railway system in the country. Therefore, in this study, after studying failures and defects in railway system, setting the rules based on expert system, and calculating the number of failures in the system, software to collect a variety of failures in rails, and how to identify its type and severity is provided. Railway ES software presented in this study as a search engine of expert system for planning and determining the type and severity of the failure, and how its maintenance, has inspection and data entry capabilities for each part of the line pavement, this software is able to predict failures of rails in various parts of its environment. A prominent feature of the expert system presented in this paper was the numerical data entry with descriptive information into the system, which by the way, one of the biggest weaknesses of the expert system (simultaneous analysis of numerical and descriptive information) is covered, and new features can be expected from the system.

REFERENCES

[1] Mohammdkhah, Saeid. 2000. presents an expert system for scheduling maintenance of railway lines," Master's thesis, Islamic Azad University, Science and Research Branch, Tehran, Faculty of Civil Engineering.

[2] Behnia AH; Behnia K. 1996. Methods of implementation. Tehran University Press, Fall.

[3] Chaichi P., Shariatmadari N. Mozamai. 2003. The meeting ground of open trench method in Tabriz Metro Tunnel.

[4] Hasanlu Rad, Mahmoud; Salehzadeh H. 2002. Evaluation of the reliability of the tunnel cover. Tunnel Conference.

[5] Rahimi A., Houshmandzadeh M. 2005. New developments in the study of the effects of earthquakes on transport networks.

[6] Eshghi S., Misaghi M., knowing Akbar. 2005. Behaviour of tunnels in the earthquake. Journal of Civil Engineering.

[7] Ameri Mahmoud. 2006. Principles of design and construction of road and rail tunnels in seismic areas. Transportation Research Institute Publications.

[8] INVIS Smokee: Inteligent Video Analysis, Ascom Inc. (www.Phaidra.ascom.com).

[9] Martland Carl. D; McNeil Sue; Dharma Acharya, Rabi Mishalani, James Eshelby. 1990. Applications of expert systems in railroad maintenance: Scheduling rail relays. Transportation Research Part A: General. 24(1): 39-52.

[10] V.D. Majstorović. 1990. Expert systems for diagnosis and maintenance: The state-of-the-art. Computers in Industry. 15(1-2): 43-68.

[11] Habil. Z. Styczynski, M. R. Ganjavi, R. Krebs. 2006. Distance Protection Settings in Electrical Railway Systems with Positive and Negative Feeder" Proceedings of the 2006 IASME/WSEAS International Conference on Energy and Environmental Systems, Chalkida, Greece. pp. 357-361.

[12] Yingjie WANG, Li-min JIA, Xiong KANG. 2005. Railway Operation Intelligent Simulation System. China Academy of Railway Sciences, Beijing, 100081, China.

[13] Laasri El Hassan Ait , Akhouayri, Es-Saïd , Agliz , Dris, Zonta , Daniele , Atmani , Abderrahman. 2015. A fuzzy expert system for automatic seismic signal classification. Expert Systems with applications journal. 42(3): 1013-1027.

[14] Ikram Aqdas; Qamar Usman. 2015. Developing an expert system based on association rules and predicate logic for earthquake prediction. Knowledge-Based Systems. 75: 87-103.

[15] Rodzyah Mohd Yunus, Zalina Samadi, Norezatty Mohd Yusop, Dasimah Omar. 2013. Expert Choice for Ranking Heritage Streets. Procedia - Social and Behavioral Sciences. 101: 465-475.

[16] Pagliuca Margherita Maria; Debora Scarpato. 2014. The Olive Oil Sector: A Comparison between Consumers and "experts" Choices by the Sensory Analysis. Procedia Economics and Finance. 17: 221-230.

[17] Bazargani Mehdi; Afzali mehdi, Gharebaghi Farhad. 20100. Expert Systems Applications in Traffic Control of Cities, Iran.

[18] Mosaveghkhah Masoud; Yazdian Rooholah; Ghalenoei Morteza. 2013. Providing expert system in risk control of banking management. Iran.

[19] Morajjab,Sona; Sadeghi, Ali. 2014. Expert system designed to detect errors on your motor vehicle. Iran.

[20] Ramezani Saeed; Yousefi Mostafa, Taheri Mohsen. 2009. Model designed to evaluate and predict preparedness of equipment. The sixth National conference of Maintenance, Iran.

[21] Behamyari Ehsan; Iranmanesh Mehdi. 2009. Investigating the use of expert systems in ship repair and maintenance industry. Twelfth National Conference of the marine industry, Gilan, Iran.