VIBRATION ANALYSIS OF A PROPOSED EXPERIMENTAL PROTOTYPE RAILWAY LEVEL CROSSING SYSTEM

SAHIN YILDIRIM, CAGLAR SEVIM, SUKRU SU, MENDERES KALKAT

1,3Erciyes University, Engineering Faculty, Mechatronic Engineering Department, Kayseri, Turkey
2Nigde University, Engineering Faculty, Mechanical Engineering Department Nigde, Turkey
E-mail: sahiny@erciyes.edu.tr

Abstract- As well known, commercial transports with railways are very important for secure travelling and conditions. In recent years, in spite of advanced high technology, there is still aircrafts, cars, and buses crashes in the world for travelling. Because of these reasons, it is preferable and inevitable to prefer railway travelling for passengers. Nowadays, rail-way crossing system are very important parts of railway systems for car, bus and van drivers. Uncontrolled railway crossing (URC); it becomes very big problems and dangerous for car drivers; because of railway conditions and fast passing. An investigation on intelligent railway and crossing design and analysis with intelligent sensor and control technology are outlined in this paper. Firstly, the proposed prototype were designed with all mechatronic elements such as instruments and conditions. Secondly; the proposed prototype of electro-mechanics system was set up as designed conditions. However, the train system’s vibration was analyzed with different working speed conditions and rail-way profiles. On the other hand the closing and opening speeds times were changed with different speeds of railway systems.

Index Terms - Rail-Way Level Crossing, Train System, Vibration Analysis.

I. INTRODUCTION

Moving objects crossing in front of the train may cause grade-crossing crashes. For instance, detection of obstacles (people, vehicles) crossing in front of the train will be an important potential solution. Some researcher’s results that have been investigated by other researchers. Some Railway Level Crossing (RLC) accidents is one of the major contributing factors of railway related fatality problems in many countries. It's Turkey, safety issues at RLC are very serious relative to those of developing countries. However, RLC accidents have continuously become a problem in railway industries in especially when it involved fatalities. RLC is considered as a unique intersection. The systems are complex and dealing with at least two mode of transport. Therefore collision between motor vehicles and trains is likely to happen at RLC and cause catastrophic consequences [1], [2].

Safety and the operational problems at RLC can be further classified into highway and railway. The highway component comprises drivers, pedestrians, vehicles and roadway segments, whereas the train component is classified into train and track at crossing locations. The functions and characteristics of the two components and their corresponding elements represent the risk at RLC locations. Various studies have been conducted in many countries, based on a range of issues associated with safety level at RLC. Accident at RLC may be caused by a single factor or by the combination of many other factors. There is a growing realization of the need to consider contributory factors involved in accidents at RLC. Caird [3] has recommended that emphasis need to be focused on the multiple contributors to accident at RLC rather than looking at a single factor only. As in basic safety engineering studies; there are at least three basic contributing factors need to be considered. There are engineering infrastructure, level crossing surrounding environment and human factors. To address these issues, Caird discussed the angle and visibility aspects at RLC while other researchers studied factors associated with RLC due to familiarity, misjudgment and distraction. Additionally, the works of Caird [3], and Harwood [4] also argued the technical contributing factors related to the configuration and design of RLCs.

Various accident prediction equations and risk indexes were developed in order to cater for the problems at RLC. Study conducted by Saccomanno [5] revealed two basic perspectives of model developed in the United States during 1950 to 1970. Detroit Formula (1971). The US DOT model was generally recognized as the industry standard. The analysis methods used range from Multiple Linear Regressions to techniques including special statistical distributions such as the Poisson and Negative Binomial distribution [6]. However, past data is vital for analysis purposes. The lack of data in some countries is a drawback of traditional approaches and leads to leave the problem of RLC untreated [7].

II. THE PROPOSED EXPERIMENTAL ANALYSIS

Railway safety is a crucial and important aspect of rail operation the world over. Malfunctions resulting in accidents usually get wide media coverage even when the railway is not at fault and give to rail transport, among the uninformed public, an undeserved image of inefficiency often fueling calls for immediate reforms. This paper is aimed at helping the railway administrations concerned to strengthen their safety culture and develop the

monitoring tools required by modern safety management. Rail/road intersections are very unique, special, potentially dangerous and yet unavoidable in the World. Here two different entities with entirely different responsibilities, domains, performances come together and converge for a single cause of providing a facility to the road user. During the normal operation also, there is every possibility of accidents occurring even with very little negligence in procedure and the result is of very high risk. The potential for accidents is made higher as the railways control only half the problem. The other half, meanwhile, cannot really be said to be controlled by one entity, as even though traffic rules and road design standards supposedly exist, the movements of road users are not organized and monitored by one specific entity as rigidly as rail movements.

For the purposes of finding obstacles systems laser sensors, radar, etc., similar equipment is widely used, these sensors because of restrictions on does not provide sufficient functional knowledge of hardware. As the external environment, particularly with a grade of this sensor is scanned, the thin barriers if such situations will emerge [3]. In addition to this, what is the detected barriers and to provide detailed information about the classification, it is impossible to make

There is a continuing need to improve safety at Railway Level Crossings particularly those that do not have gates and lights regulating traffic flow. A number of Intelligent Transport System interventions have been proposed to improve drivers’ awareness and reduce errors in detecting and responding appropriately at level crossings. However, as with other technologies, successful implementation and ultimately effectiveness rests with the acceptance of the technology by the end user.

The parameter considered will be categorized according to various factors. There are engineering infrastructure, level crossing surrounding environment and human factors as in Fig. 1. Schematic representation and dimensions of the proposed prototype train system is described in details in Fig.2.

In this section, design methodology development in assessing the level of risk at RLC locations is shown in Fig. 3. The purpose of the design is to give good background on real time systems. There are three phases involved in this modeling process. Firstly, model creation phase requires an understanding on the RLC operation, current practice and tools available for analysis.

The case study of this research will cover active types of RLC in Turkey. Therefore, the understanding of the overall concept of active types of RLC operations is needed. The basis of understanding of RLC operation obtained from the Turkish Standard. All instruments of the prototype system is drawn and outlined according to category as illustrated in Fig. 4. There are few studies using SPN and its extension dealing with safety study at RLC. By referring to the research gap, an improvement will be made in terms of the parameter consideration and categorization. The engineering infrastructure, level crossing surrounding environment and human factors will be the factors considered. The prototype of the rail way and intelligent crossing system is shown in Fig. 5.

The system was tested with different working speeds for analyzing vibration conditions of railway. However, the purpose of this analyze is to predict opening and closing time of bars of railway crossing system.

The proposed railway crossing system was tested with different operating speeds and points for performance and vibration analysis. For each test, four acceleration sensors having identical technical characteristics were used to analyze the system. These sensors were firstly placed on the right side of the system taking the level crossing as the reference, and vibration data were obtained for three different speeds (low, average high). Then the acceleration sensors were placed on the left side of the system and, again, vibration data were obtained for three different speeds (see Fig. 6). From the figure, the placed sensors were indicated for position of railway. In both test groups, the acceleration sensors were placed on exactly opposing positions, just next to the level crossing, on the bend start, on the straight line and on the bend end. The results of these approaches were outlined in the Figs. 7-10 for the case of right side of the system. The results indicates results of 4 sensors measurements. As can be seen from figure there is accelerations between 15 and 20 seconds.

On the right system, unlike in the left, the distance on the point where the rails unite where the second accelerometer was placed is slightly more. Therefore, higher vibration peak point values were obtained compared with the left system (see Fig. 11). A switch line exists just next to where the third accelerometer is located in the right system. The results of these approaches were outlined in the Figs. 12-14 for the case of left side of the system. The results indicates results of 4 sensors measurements. As can also be seen from figure there is accelerations between 15 and 20 seconds This resulted in higher, compared with the left system, peak values in all speeds. Besides, in all tests, the peak point values obtained from all vibration sensors increased in parallel with the increase of vibration frequency as velocity increased.

A complete tour time of the train for low, average and high speeds is 32.5, 18 and 13 seconds, respectively. The opening and closing times of the level crossing varies accordingly.
Vibration Analysis Of A Proposed Experimental Prototype Railway Level Crossing System

Fig. 1. The effects of railway crossing system. [8]

Fig. 2. Real time dimensions of Machine system

Fig. 3. Designed proposed railway level crossing system.

Fig. 4. Schematic representation experimental approach analysis of proposed railway level crossing system

Fig. 5. Proposed experimental railway and crossing set-up prototype with instruments

Fig. 6. View measuring position of vibration sensors on the right side of the system

Figure 7. Dynamics model of prototype train system

Fig. 8. Acceleration variation prototype of train system with 0.35 m/sec speed for right side
Vibration Analysis Of A Proposed Experimental Prototype Railway Level Crossing System

CONCLUSIONS AND DISCUSSION

In the world, in spite of advanced technology, railway level crossings (RLC) accidents and fatalities are still continuing and become the great concern in railway industries and passengers in especially when it involved fatalities. This paper has described an experimental prototype research framework in developing RLC safety systems specifically for Turkey's as a case study. The proposed research design in developing a risk index is outlined. The parameter considered will be justified during the model development stages. Since RLC safety systems is complex, the used of intelligent control approach in reliability safety engineering studies will be applied in order to have better understanding on the behavior of the systems. The components such as engineering infrastructure, level crossing surrounding environment and human factors considered in the prototype model can help in selecting a sound alternative for selected location for further improvements.

On the other hand, it is not easy and cheap to make real time experimental set-up for such systems, because of very high project budget. The main motivation and purpose of this experimental work is to identify low-risk, low-cost, accidents and fatalities railway level crossings solutions.

In principle, there are a number of possible strategies for reducing crashes at railway level crossings. These include: Improving the conspicuity of the train, in order to increase the probability that the driver of the road vehicle will detect the train. Providing active control at the crossing, eliminating the need for a driver to make a decision. Providing some form of direct communication between the train and the road vehicle which would warn the driver of the approaching train. Improving crossing signing, markings and other forms of passive warning. Education, training or enforcement programs aimed at road vehicle drivers. Improving sight distance or reducing the speed of trains and/or road vehicles. Closing the crossing.

The future stage of this investigation will use a railway traffic simulation approach with behavioral models developed for evaluating the short-listed systems. The tools developed in this study will
provide rail authorities and researchers with the means to evaluate railway level crossings protection systems to improve safety at level crossings.

ACKNOWLEDGMENT

Authors would like to express their deepest appreciation to Erciyes University, which provided us the opportunity to support FCD-2014-5163 coded this project. Authors would also like to thank Railway Company in Turkey providing them broad information, and documents about conditions and infrastructure of rail-way system in Turkey.

REFERENCES