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Modeling the Train Accidents at Railroad Crossings in East Java

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ABSTRACT: *The growing train movement and people activities around the railroad will increase the frequency of traffic in railroad crossing. This potentially results in the increase in traffic accidents. The prediction of the number of such accidents is influenced by some factors dealing with variables on sensory psychological behaviors and the perception of the drivers passing the crossings. Observations were made at 33 points railroad crossing with not guardrail in East Surabaya DAOP VIII. The responsive variables are determined by the explaining variables namely the number of train accidents in railroad crossing. The explaining variables are those determining the value of responsive variables, consisting of three factors namely train engineering features, road engineering features and environment. The last Poisson regression model possesses four determining variables significant with the number of accidents that is the train speed, the distance of signs and the railroad crossing, flashing lamps and the average daily traffic. The train speed seems to be a primary factor contributing to the high level of accidents. The results of sensivity analysis show that if the train speed increases of 50%, the number of accidents will increase 40%. Facilities that should be quickly provided are among others: provision and installation of flashing lamps and Early Warning System (EWS).*

Key word: *railroad crossing, train engineering features, road engineering features, environment factor, Poisson regression*

I. INTRODUCTION

The System of railway affairs in East Java has been established since the Dutch collonialism era. The lines of train in East Java consist of North Line (Surabaya Pasar Turi – Semarang – Jakarta), Central Line (Surabaya Gubeng – Yogyakarta – Jakarta), South Ring Line (Surabaya Gubeng - Malang – Blitar – Kertosono – Surabaya) and East Line (Surabaya Gubeng – Jember – Banyuwangi). This province also possesses a transportation system of commuter trains with a route of Surabaya – Sidoarjo – Porong, Surabaya – Lamongan – Babat, Surabaya – Mojokerto, and Malang – Kepanjen. The train movement in each operation area (herein called DAOP), each DAOP VII Madiun, Daop VIII Surabaya and DAOP IX Jember is high enough, which result in a complicated problem and one of its negative effects in the increasing number of train movement in east Java is accidents. In East Java, there are 1441 railroad crossings consisting of 1103 crossings without guards, 338 with guards and also gate and 96 illegal crossings (PT.Kereta Api Indonesia, 2010), and the potency to open or to add new railroad crossings is very great, especially the opening of illegal crossings due to the growth of hinterland in either the right or left side railroad because of the growing land use in each railroad areas. The growing train movement and people activities around the railroad will increase the frequency of traffic in railroad crossing. This potentially results in the increase in traffic accidents.

Train accidents in railroad crossing often happen in line with the time development. The prediction of the number of such accidents is influenced by some factors dealing with variables on sensory psychological behaviors and the perception of the drivers passing the crossings (Raslear, 1996); categories of warning equiptments, volume of road traffics, volume of train traffic, visibility of the condition in the crossings (Gitelman and Hakkert 1996); types of warning equiptments, crossing geometric, railroad geometric, volume of rtaffic (Saccomanno, Liping Fu and Moreno 2001); the number of the passing train, active equiptment, road safety, rescuing operation, warning sign of flickering lamps, (Mok and Savage 2003); width of crossing geometric, traffic control equipment, flickering lamp time, speed in heaping land, size of crossing, warning signs, stop sign, number of railroad, number of tract, diameter of road separator, audit of safety, AADT, warnign equiptment, control management, barrier control, status of class of road, types of area aroung the crossing (business, residence, agriculture, etc)(Kang Lee and Ren Hu 2007); number of train identification, levels of service, types of vehicles involved, number of damage of vehicles, number of the people injure or die (Collister and Flaum 2007); factors of engineering in the crossings, of human beings, of environment (Zaharah Ishak 2007); traffic separator, behavior or drivers' responses factors to the equipments in railroad crossings (Ko, Washbum, Courage dan Dowell 2007); volume of traffic and trains per hour, speed of vehicles approaching the crossings, percentage of heavy vehicles, levels of service (LOS), speed of the train approacing the crossings (Zaharah Ishak,Yue and Somenahalli 2010); features of trains, roads, railroad crossings and of traffic (RenHu,ShangLi and KangLee 2011). The above variables really influence the prediction of accidents in railroad crossings, therefore some of the variables that influence one another may be simulated intro a model of prediction of accidents in railroad crossings.

Various models of prediction of train accidents in railroad crossing have been developed. Federal Railroad Adminstration (FRA) of America has studied accidents in railroad crossings by accomodating variables among others multiplication of the average daily traffic factor in roads and traffic of the trains that passed, the number of the passing trains per day, the speed of the trains, the number of tracts, the number of lanes in roads and types of road hardening prove to influence the number of accidents in railroad crossings. Empirical results show that the Poisson regresion is appropriate for estimaing the possibility of accidents; and the negative binominal regression is good for predicting accident risks and effects (Kang Lee dan Ren Hu 2007). The model was developed using a Petri Nets approach by taking into account components of basic concepts of safety, infrastructure engineering techniques, levels of surrounding enviroment and all factors in human beings (Zaharah Ishak,Yue dan Somenahalli 2010). The zero Possion regression model has also been developed to delienate the relationship between the number of zero death or injury, and additional data and explaining variables were collected in 592 locations of Railroad Grade Crossing (RGC) in Taiwan (RenHu,ShangLi dan KangLee 2011).

Up to now, no research has been made to make a model of prediction of train accidents in railroad crossing with no gate by accomodating and combining and developing all explaining variables that have once been studied by previous researchers with different analyses. The resulted model would be built to predict train accidents in legal railroad crossings without gate when a train is moving in a single track which generally happens in developing countries with the minimal level of the society on the safety of trains – this makes them easy to open ilegal railroad crossings. The results of this present study was expected to be useful for making any action programs to reduce the number of train accidents.

II. THEORIES AND METHOD

The variables of this present research consist of explaining and responsive variables. The responsive variables are determined by the explaining variables namely the number of train accidents in railroad crossing. The explaining variables are those determining the value of responsive variables, consisting of three factors namely train engineering features, road engineering features and environment. The train engineering features factor contains variables of the width of crosing, number of tract, speed of train, volume of passing train, free vision of the engineer of locomotive, guardril in the crossing , the existence of flashing lamp and siren. The road engineering features factors consist of agricultural areas, business, residence, industrial and road lights. In the modelling of the number of accidents, a Poisson regresion analysis calculated using a statistical software GenStat Discovery Edition 3 is employed. The stages of the data analyses are as follows:

1. Testing the distribution in the response variable (Y) using the Kolmogorov-Smirnov test of the data on the number of accidents. In this test, the data of the number of accidents are expected to follow the that of Poisson.
2. Establishing the model of the Poisson regression with a general model of $\mu = \exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k)$, making the following steps:
   a. Modelling the Poisson regression analysis in each explaining variables (independent variables). Estimating parameters for each combination of the Poisson regession model, with a general model $\mu(x_i, \beta) = \exp(\beta_0 + \beta 1X1i + \ldots + \beta kXki)$, dengan i = 1, 2, 3, 4, 5.
   b. Testing the parameters in each combination using Chi-Square, in GenStat Software this value are transformed to F dan t statistics.
   c. Testing the model for each combinations simultanesously with deviance criteria.
   d. Determining the best model with the smalles deviance from each combination of variables.
   e. Making an interpretation of the best model.

III. RESEARCH RESULTS

The data distribution following the Poisson distribuition shows specific characteristics among others it is discrite and limited in time or certain areas. The accident posisbility is very small, meaning the any vehicles passing railroad crossings have a very small possibility to get accidents. The average number of accidents is 1, 45, meaning that in the last three years the number of accidents is about 1 -2 times in one point. From the results of the Kolmogorov Smirnov test, the obtained value of the *Kolmogorov-Smirnov Z* is 1.341 with *asymp.Sig. (2-tailed)* or *p-value* of 0,055. It may be concluded that the data on the number of train accidents followed the Poisson distribution. The modelling showing the relationship among the numbers of train accidents in railroad crossings would be made by using the Poisson regression analysis. The analysis consists of three stages, first making a model for each explaining variables, second, modelling a combination of variables that prove to have a significant influence from the results in the first stage, and three, selecting the determining variables in the second stage which are really significant as a whole.

In a model with single determining factor, an analysis for significant 15 explaining variables from the results of a descriptive analysis on the number of accidents is made. In the analysis, an emphasis is given on the results of the regression coefficient test. If the result is significant (probability value < 0,05), this variable will be included in the establishment of the simultaneous model. The analysis of each variable is presented in Table 1 :

Tabel 1. A Poisson Regression Analysis of the Influence of the Train Speed

Variable	estimate	s.e.	t(*)	p-value.	Test results
Train speed	0.0311	0.0115	2.69	0.007	Significant
Train Volume	0.0558	0.0255	2.19	0.029	Significant
Signs	0.223	0.436	0.51	0.609	Not Significant
Distance of signs	-0.0248	0.0126	-1.96	0.049	Significant
Free view	-0.00118	0.000592	-2.00	0.046	Significant

Guardrail	0.182	0.298	0.61	0.541	Not Significant
Flashing Lamp	-0.598	0.29	-2.06	0.039	Significant
Road width	0.362	0.182	2.00	0.046	Significant
Number of lane	0.171	0.472	0.36	0.718	Not Significant
the average daily traffic	0.001436	0.000577	2.49	0.013	Significant
Road flatness	0.223	0.436	0.51	0.609	Not Significant
Types of construction	0.633	0.306	2.07	0.039	Significant
Road marks	0.27	0.295	0.92	0.360	Not Significant
Environment	0.598	0.29	2.06	0.039	Significant
Lighting	0.266	0.333	0.80	0.425	Not Significant

From the result of modelling with a single determining factor of 15 explaining variables, there are 9 (nine) variables with significant influence, mean while the rest (6 variables) do not give any significant influence. Then a simultaneous model involving 9 the (nine) significant variables are analysed. The results of the Poisson regression analysis enclosing the 9 determining factors filtered in the first phase are shown in Table 2.

Table 2. An Analysis of the Poisson Regression of the 9 Chosen Variables

Variable	estimate	s.e.	t(*)	p-value	Test results
Constant	-0.79200	0.52400	-1.510	0.145	-
Train speed	0.01117	0.00647	1.730	0.098	Not Significant
Train Volume	0.00969	0.00882	1.100	0.283	Not Significant
Distance of signs	-0.01170	0.00532	-2.200	0.038	Significant
Free view	-0.00042	0.00023	-1.850	0.078	Not Significant
Flashing lamps	-0.14700	0.13300	-1.110	0.280	Not Significant
Width of road	0.11570	0.08140	1.420	0.168	Not Significant
the average daily traffic	0.00065	0.00037	1.760	0.092	Not Significant
Types of construction	0.04500	0.14300	0.310	0.757	Not Significant
Environment	0.03600	0.13900	0.260	0.800	Not Significant

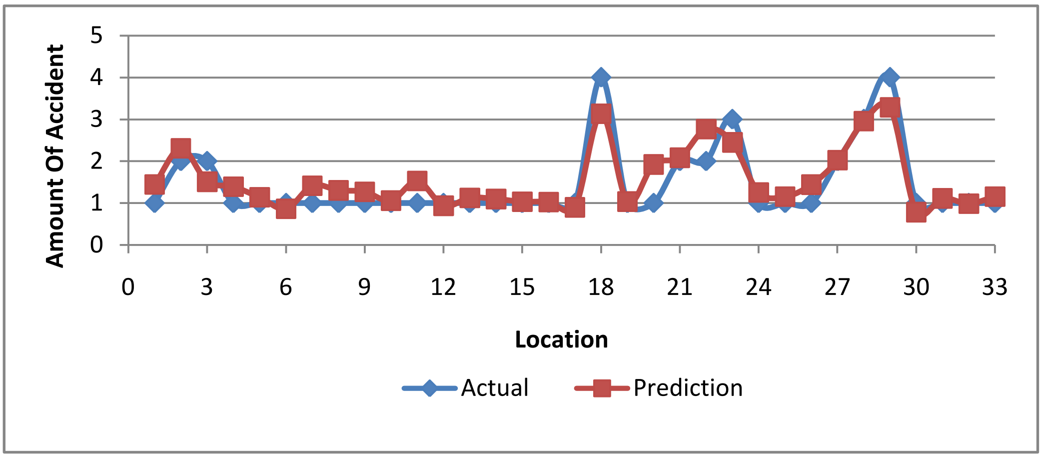
The last stage is intended to establish a regression model significant to the level of accidents simultaneously or partially. The selection of such a model is made by excluding variables one by one that partially does not influence the level of the accidents. From the results of the selection, there are four variables with significance of 0.05 namely: the train speed (X3), the distance of signs and the railroad crossing (X7), flashing lamps (X10) and the average daily traffic (X14), that significantly influence the level of accidents.

Table 3. A Final Model of the Results of the Poisson Regression Analysis

Variable	estimate	s.e.	t(*)	t pr.	Test results
Constant	-0.5910	0.3670	-1.610	0.118	-
Train speed	0.0130	0.0044	2.960	0.006	Significant
Distance of signs	-0.0125	0.0047	-2.640	0.013	Significant
Flashing lamp	-0.2575	0.0953	-2.700	0.012	Significant
the average daily traffic	0.0011	0.0002	5.680	0.001	Significant

The results of the analysis of the four chosen variables show the p-values of less than 0.005. therefore, the best model has been obtained. The following is the results of the analysis using the Poisson regression equation:
Y = exp(- 0,591 + 0,01302 Train speed – 0,01253 Distance Of Signs – 0,2575 Flashing lamp + 0,001122 Average daily traffic)

The validation of the model will measure the level of appropriatennes of the model with the results of real observation. The results of such validation may be considered through the results of analysis of deviation between the estimated value and the real value, the correlation value and the deviation test between the results of prediction and real values. From the results of validation and the prediction value and the number of real accidents, it seems that they seem not too different. The following is presented the results of the deviation analysis from the last model and the picture of accidents prediction and the number of real accidents in each point.



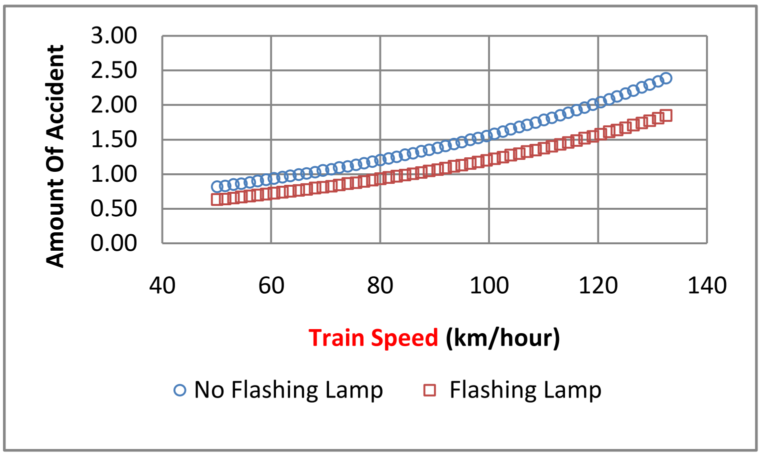
Picture 1. Values of Prediction of the Number of Accidents Based on the Poisson Regression Model

Picture 1 shows that the results of the prediction of the number of accidents reach the actual value. If the prediction value of the number of accident is rounded, there are 27 points (81.8%) posessing the same value between the prediction and the actual ones and 6 other points show differences. The different points are among others the sample points no. 11, 18, 20, 22, 23 and 29. The validation of other models was made by calculating the results of the deviation test of the number of accidents between the prediction and actual values. The test was made using the paired- t-test. As in the Table 5.34, the average difference between the prediction and actual values are -0.0303 with the p-value of 0.662 (higher than 0.05). It can be concluded that there is no significant difference between the prediction value (from the Poisson regression model) and the actual value..

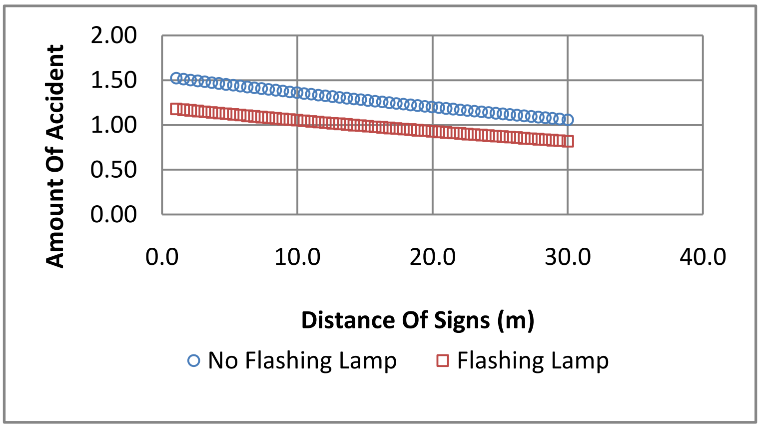
The last Poisson regression model possesses four determining variables significant with the number of accidents. On the basis of the obtained model, decreasing the number of accidents can be reached with the following ways:

- Reducing the train speed when passing railroad crossings.
- Putting in signs in a greater distance before the point of crossing
- Maintaining and keeping flashsing lamps to make them function well
- Giving special attention at morning and afternoon peak hour daily traffic with guard in the railroad crossing with not guardrail.

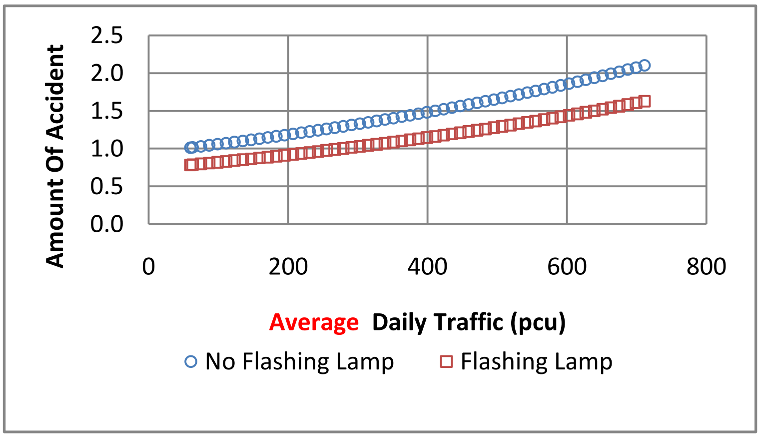
In this part, an analysis of the level of sensitivity of a determining variable is made with the assumption that the condition of other variables are unchanged. The analysis of sensitivity will be graphically shown by splitting the data into two conditions: availability and unavailability of flashing lamps. The trains speed is around 65 – 90 kms/h, the distance between the sign and the crossing is about 3 – 40 meters, meanwhile the value of the average daily traffic is from 33.8 – 919.6 smp. The level of accidents is too low if in the crossing flashing lamp is available, the train moves in low speed, yje distance between the sign and the crossing is far enough from the crossing point and the daily traffic is not intense.



Picture 2. Amount Accident Prediction at few of Velocity



Picture 3. Amount Accident Prediction at few distance of Sign.



Picture 4. Amount Accident Prediction at few of the average daily traffic

From the results of the sensitivity analysis on the basis of the changes in the train speed and in the number of accidents, it is known that if the increase in the train speed reaches 50%, the number of accidents is predicted to increase around 40%. If the increase is 100%, the number of accidents is predicted to be about 90%. And in the results of the analysis of sensivity of the changes in the distance of the signs and the crossing and in the number of accidents, it is shown that the decrease in the distance of the sign and the crossing point to 50% is predicted to be able to increase the number of accidents up to 20%. If the distance is reduced up to 75%, the number of accidents is predicted to increase about 35%. From the results of the analysis of sensitivity to the changes of the average daily traffic up to 100%, it is predicted to increase the number of accidents of about 8%. If the value of the average daily traffic increases up to 200%, the number of accidents is predicted to increase of 17%.

IV. DISCUSSION

From the results of modelling with the Poisson regression analysis, there are four independent variables found to be significant in the model. The variables are the train speed, flashing lamps, the distance between the signs and the crossing, and the average number of daily traffic. The application of the model of the Poisson regression has a high validation, which is in line with a research Chi-Lee and Ren-Hu (2007) made that the Poisson regression is good for predicting the possibility of accidents; and the negative binomial regression is good for predicting the risks and effects of accidents.

Average daily vehicles passing railroad crossing has a correlation with the number of traffic accidents. The higher the average vehicle crossing the railroad in a year, the higher the number of accidents in raildroad crossings. This also applies to the train speed and the possibility of accidents. Although human factors play a big role in accidents, but this shows that the train, roads and environment features give a big contribution to accidents in railroad crossings.

In the last model, it can be explained that the train features factor is important since from the four determining variables in the number of accidents, three of which are train features such as train speed, flashing lamps, and the distance between the signs and the railroad crossings. Road feature factors are representend by the average daily number of traffics. While the environment factors condsisting of crossing areas (agriculture, housing and industry) are included into the last model. In the process of modelling, from the results of analysis in the first pat, it is evaluated that in the single determining model, the following variables give significant influence on the number of accidents in railroad crossing, namely:

- Train speed
- Train Volume

- The distance between the signs and the railroad crossings
- Free view
- flashing Lamp
- Width of road
- the average daily traffic
- Types of construction
- Environment

But in the advanced model combining all single determining variables, there are merely four variables that prove to have significant influence on the number of accidents. There are five variables considered as variables with strong potentials as the causes of accidents namely:

- Train volume
- Free view
- Width of road
- The average daily traffic
- Types of construction
- Environment

A train feature important to hamper accidents is flashing lamp. This tool contained in the siren, both of which function together. In the whole data, the number of railroad crossings with flashing lamps is 14 points (42,4%) while the rest, 19 points (57.6%) without flashing lamps. The importance of the control equiptment is in line with a research Coleman (1997) made. The control equipment of trafic provides passive-static warning, guidance and in some cases, obligatory action for drivers. Trafic control equipments are assets that give warning that the train is approaching. They are activated by a train in the circuit of tract/rail detection. This active control equiptments are prodived with the same signs of crossings to give a passive control.

The railroad crossings provided with flashing lamps are 14 points, 13 of which (92.9%) became places for accidents once in three years, meanwhile in one other point, 3 times accidents happened. Different from points of observation without flashing lamps amounting 19 points, there are 2 points (10.5%) with a high level of accidents namely 4 incidents during 3 years. This automatic instalation will help reduce the number of accidents. The research results support the research made by Mok and Savage (2003). From the analysis, it can be concluded that the instalation in the Guardrail or flashing lamps contributed about the fifth of reducing the number of accidents. The development from a campaign "safey operation" intended to inform the public about proper attitudes in railroad crossings has long been made. In the 1970s and early 1980s, an instalation of "ditch lamp" in the locomotive has been known.

At present there is a wireless technology of early warning tool in railroad crossings. Due to the development of transportation technology and provision of supporting facilities and infrastructures, a system of transportation arrangement will be needed to improve pleasure and safety of the users of transportation facilities, especially in railroad crossings which are not provided with guardrails. The tool of early warning in railroad crossings has made use of a wireless system, so no cable is needed. This tool may turn on after the sensor works when the traiin will pass the point in one km before it and it will transmit a sign to the warning tool to turn on. This system also uses electric power from solar cells so that it will not depend on the electric supply from the state electricity enterprise. Therefore it may be used in most railroad crossings located in a tract with no electric network.

The train speed seems to be a primary factor contributing to the high level of accidents. The results of sensivity analysis show that if the train speed increases of 50%, the number of accidents will increase 40%. The level of sensitivity of this train speed is far superior than the distance between the signs and the crossings namely 20% and the average daily traffic which is merely of 6%. This result is in line with that of Coofster and Pflaum (2007) stating that the explaining variables significantly influencing the possibility of accidents are the train speed, the number of trains passing the crossings each day, the percentage of heavy vehicles (trucks), the number of vehicle traffic (number of lanes), signs on the roads, flashing lamps, railcrossing angle, the surface of road and railroad crossings, trade, housing and industrial areas. The problem of train speed in Indonesia is dilemmatic. Reducing the train speed will result in the addition of movement time, whereas without reducing the speed, the train often comes late in its destination. It seems in contradiction with the development of railway affairs in other countries, where the train speed has always been added. In Indonesia, it it PT KAI that operates the trains. While the facilities and infrastructure are handled by the government.. Reducing train speed should be made due to bad condition of the track, and this condition happens because fund allocation from the government to maintain the track is very small compared with what actually needs. As a result, from year to year, the condition of the track will be worse. As an operator, reducing the speed is an appropriate choice since if an accident happens, it is the operator (PT KAI) that will be responsible for it. Up to now, the maintenance of the tracks are still held by PT KAI as an operator.

The results of modelling using the Poisson regression will be used to predict the point at which a railroad crossing should be paid attention. A "blackspot" status for a railroad crossing with high level of accidents will be able to help reduce accidents. A blackspot is a crossing with high risk of collision. It is suggested that one of the way is to allocate fund for all fields of problems. A random incident of collision is very various in space and time. A high risk in a certain crossing in a year does not always show high risk in the next year. A risk of collision needed to express any risk may be anticipated in a certain period. This estimation may be obtained using a model to rpedict a frequency of collission and therefore it is accurate and reliable. The identification of a blackspot merely based on the number of collission will not give any complete picture of the risk in each crossing. The risk of collission consists of two components: frequency and consequence (level o severity). Ignoring such a consequency may result in less intervention in any railroad crossing with the severe level of collission and riska -based model is needed to identify any spots where collissions often happen.

The results of prediction of the number of accidents in each spot may be used to attribute certain characteristics ot the spot. Another indicator to choose the best criteria is comparing the number of expected accidents and that of observed accodents (Rakhmat *et al.,* 2012). The results of the comparison may be in the form of

a. Location which is predictied to be dangerous is actually harmful (*correct positive)*
b. Location which is predictied not to be dangerous is actually not harmful (*correct negative)*
c. Location which is predictied to be dangerous is actually not harmful (*false positive)*
d. Location which is predicted not to be dangerous is actually harmful (*false negative)*

In this case, if the observed number of accidents is higher than the expected one, it can be categorised into *correct positive (CP).* If the observed number of accidents is lower than the expected one, it is categorized as *false positive (FP).* In Table 5.40, it is shown that the criteria excessive number of accidents using the prediction model resilts a number of segment classified as the biggest *correct positive (CP) as* compared with the other three criteria, namely 7 segments (from 10 mist dangerous segments) and 14 segments (from twenty most dangerous segments).

Table 4. A Comparison of Actual and Predicted Values from the Poisson Model

Spot	Actual	Predicted	Information	Spot	Actual	Predicted	Information
1	1	1.45	False Positive	18	4	3.13	Correct Positive
2	2	2.31	False Positive	19	1	1.04	False Positive
3	2	1.51	Correct Positive	20	1	1.92	False Positive
4	1	1.39	False Positive	21	2	2.08	False Positive
5	1	1.14	False Positive	22	2	2.77	False Positive
6	1	0.86	Correct Positive	23	3	2.45	Correct Positive
7	1	1.41	False Positive	24	1	1.25	False Positive
8	1	1.30	False Positive	25	1	1.16	False Positive
9	1	1.27	False Positive	26	1	1.44	False Positive
10	1	1.06	False Positive	27	2	2.03	False Positive
11	1	1.53	False Positive	28	3	2.96	Correct Positive
12	1	0.94	Correct Positive	29	4	3.29	Correct Positive
13	1	1.12	False Positive	30	1	0.78	Correct Positive
14	1	1.10	False Positive	31	1	1.11	False Positive
15	1	1.03	False Positive	32	1	0.99	Correct Positive
16	1	1.02	False Positive	33	1	1.15	False Positive
17	1	0.90	Correct Positive				

In Table 5.40, it is shown that there are 10 spots which are really dangerous namely spot 3 (Bojonegoro regency ; 140+135, SRJ-BWO), spot 6 (Lamongan regency; 162+681, BBT-GEB), spot 12 (Lamongan regency; 179+735, SLR-LMG), spot 17 (Gresik regency; 199+790, LMG-DD), spot 18 (Surabaya city; 222+603, KDA-TES), spot 23 (Sidoarjo regency; 26+121, SPJ-BH), spot 28 (Pasuruan regency; 43+629,, PR-BG), spot 29 (Pasuruan regency, 44+610, PR-BG), spot 30 (Malang regency; 29+128, SN-LW) and spot 32 (Blitar regency; 76+158, NB-SBP).

In this research fangerous segments are determined by comparing three criterias with the data of train accidents from 2010-2012 and applying the resulted model to get the expectation of average number of accidents on the referred population. The criteria to determine the dangerous segments that will be used are among others:

a. The excess of the number of accidents using the model of traffic prediction is made by determining the difference of number of accidents from the prediction model and the results of the observation.
b. The level of accident is mad by comparing the real number of accidents and the daily crossing of a segment,
c. The frequency of accidents is made by ordering the data on traffic accidents from the highes to the lowest.
d. The results of identification of all examined spots using the criteria of the excess number of accidents create a rating of dangerous segments based on the difference between the observede number of accidents and the expexted results of the prediction model. The result of discussion on the basis of the final model of the Poisson regression analysis will results in some implications intended to reduce the level of accdients.

To avoid any collision between the train and general transportation in railroad crossings is made by applying a technology to improve the reliability of the signals, either those in any crossing with/without guard. The available and proper technology for the purpose is installing the AWS (Automatics early Warning System). Since there are thousands of railroad crossings with no automatic gate, it is proper to apply the AOCL (Automatic Open Crossing, Locally monitored) since it is cost effective. Besides the application of the technologies, other efforts which should be simultaneously applied are as follows:

a. Completing traffic signs on the roads that will cross the railroad crossings.
b. Controlling any railroad crossing by closing or combining two or more crossing into one.
c. Reducing railroad crossing using flyover or underpass

An alarm system in railroad crossing is used by providing flashing lamps and sirens. In each railroad crossing with or without gate, signs and alam/sirens should be provided, since the most effective sense is ears (earing), and ears can respond information without being able to be caught by sense of sight, especially in any crossing surrounded by high buildings. Psychologically, if alarm (siren) is heard, there is tendency for one sense to be more alert than others. For example, for the sense of sight (eyes) although they have seen any written warning, but there is a tendency that the influence of impatience is still higher. Alarm or siren should be placed in each crossing especially those with no gate. It is better any censor or switch alarm/indicator lamp are put 500 mt from the crossing, so that drivers may quickly know the position of the train to take any step to avoid accidents.

V. CONCLUSION

From the discussion above, some conclusions can be made. The train accidents happening in railroad crossings without guardrails in the operational area of DAOP VIII Surabaya for the last 3 (three) years, from 2010 to 2012, are 149 incidents with the following characteristics: hit by persons, by motor cycle (R2) and by personal vehicles or truck (R4) with the death of 30 persons, injuries, 107 persons and no victims of 12 persons. From the results of modelling the Poisson regresion, there are four determining factors of accidents namely train speed, the distance of the signs and the railroad crossing, flashing lamps and the average daily traffic. The train speed possesses the highest sensitivity to the number of accidents.

From the results of modelling to the number of accidents, some reccomendations are offered. Installing flashing lamps in each railroad crossing with not guardrail proves to contribute to the decrease in the number of accidents. So it is recommended that in each railroad crossing without guardrail be put in flashing lamps. It should optimize the participation of the people living around railroad crossings to maintain the warning signs or other safety facilities in railroad crossing with no gate. Any activity of socialization to people living around the crossings should be made in roder to improve their participation in keeping the security and safety in the crossings.

Technical guidance to the people should also be given to improve the participation of the people living around railroad crossings with not guardrail. The operator should make a stronger coordinating with the concerned institutions to improve safety and security in the railroad crossing with no guardrails because of limited budget from the operator to providing the safety facilities. Facilities that should be quickly provided are among others: provision and installation of flashing lamps and Early Warning System (EWS), signs in certain distances (not too near or too far), signs of speed limit and of signal 35 for each railroad crossing with no gate and inspection and control are made in cooperation with concerned institutions to close any illegal railroad with no gate.

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