

# Analysis of The Factors Causing Accidents at Level Crossings in the Area of PT Kereta Api Indonesia (Persero) Daop 1 Jakarta

Chano Benawan Foenale and Rosalendo Eddy Nugroho

## ABSTRACT

The volume of train trips which every day reaches 1,300 trips causes a high intensity of encounters between trains and other vehicles at level crossings. This raises the potential for accidents involving trains and other vehicles as well as with humans. This study aims to determine the factors that cause accidents, reduce the number of accidents, and improve the safety system at level crossings in the Daop 1 Jakarta area. Qualitative descriptive research method with a population of accidents at level crossings of the PT KAI (Persero) Daop 1 Jakarta in 2016-2019. The number of samples used is 198 accidents with a chronological investigation of accidents. Analysis using Human Factor Classification and Analysis System (HFACS) followed by Fishbone Analysis and 5Whys Analysis. The factors that cause accidents by motorists are unsafe behavior, namely making errors in crossing and violations that are not in accordance with procedures. Factors causing accidents by pedestrians, namely unsafe behavior such as errors and violations committed and pedestrian conditions that do not support crossing. Dis-semination of regulations and laws, procedures for crossing, appeals, and warnings not to carry out dangerous activities at crossings can also be carried out to reduce accidents. Repair of damaged or old facilities with facilities that are in accordance with regulations and making new crossing procedures so that they can be more adhered to are suggestions for improving the safety system.

**Keywords:** Accident, HFACS, Human Factor, Level Crossing.

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**C. B. Foenale\***

Business Management Post Graduate Program, Mercubuana University, Indonesia.

(e-mail: chano.foenale@gmail.com)

**R. E. Nugroho**

Business Management Post Graduate Program, Mercubuana University, Indonesia.

(e-mail: rosalendo.eddy@mercubuana.ac.id)

\*Corresponding Author

## I. INTRODUCTION

Rail-based transportation systems are still an important means of transportation around the world. Every day the train transports goods worth billions of rupiah and millions of passengers from one place to another. Likewise in Indonesia, the train is a means of transportation that has existed in Indonesia since the Dutch colonial era. With a relatively cheaper cost and faster time for short and medium distances, trains are still a good choice for low, middle, and upper economic circles.

Every year the number of users of this means of transportation continues to increase, both as a transportation of people and goods. Until 2019, more than 450 million people have used trains as a means of transportation. More than 45 million tons of goods have also been transported by train both on the island of Java and Sumatra. As one of the transportation alternatives that become the main choice of the community especially in Jabodetabek area. Throughout 2019, PT KAI Daop 1 Jakarta itself has carried 1.2 million passengers with 326 train journeys per day. In addition, PT KCI also recorded that during 2019 the number of KRL passengers amounted to 279 million passengers with an average of more than 900 thousand passengers per day served by 90 Loop KRL totaling 1,057 KRL trips per day.

The very high volume of passengers and train journeys every day reaches 1,300 train journeys both trains and KRL,

coupled with the growth of motor vehicles, causing a high intensity of encounters between trains and other vehicles at the level crossing. This raises the high potential for accidents involving trains and other vehicles as well as with humans.

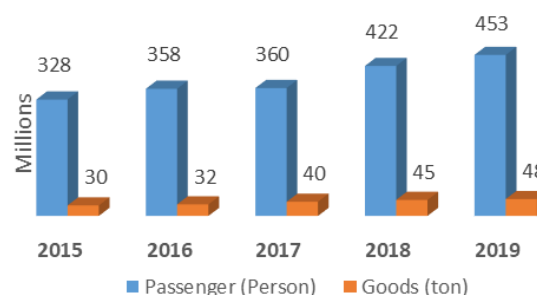


Fig. 1. Graph of Transportation Production of PT KAI (Persero) 2015-2019.

Although it has a special rail line, there is a point where the rail will intersect with the highway or other buildings so that there is a cross of the railway. The intersection between the railway and the road is called a level crossing. In this level crossing, there is a connection between the train and other public vehicles such as cars, motorcycles, or humans so as to potentially interfere with train travel. Based on the data obtained, the number of level crossings from 2016 to

2019 is volatile, which means that although some have been closed, but in the next year there will be new crossings.

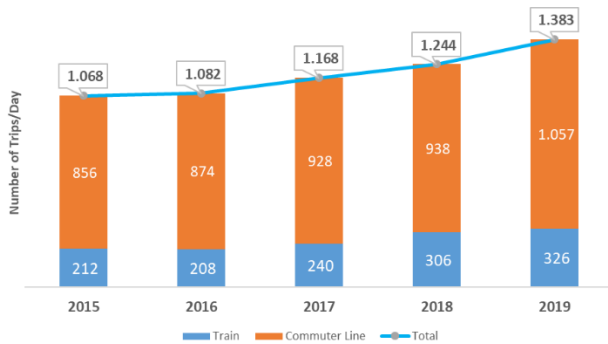


Fig. 2. Graph of Train Travel Per Day in Jabodetabek Area 2015–2019.

In the Area Daop 1 Jakarta recorded there are as many as 461 crossings of a plot with 259 official level crossings and have permission from the Ministry of Transportation while as many as 202 do not have permits or illegal crossings.

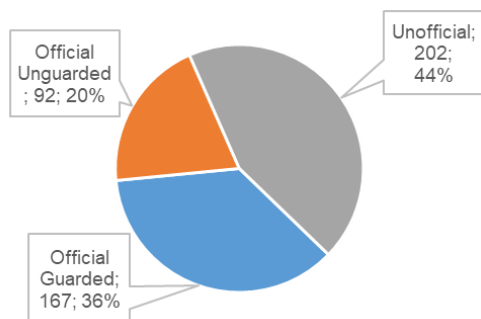


Fig. 3. Number of Level Crossing in Daop 1 Jakarta Area.

PT KAI noted that during 2019 there have been 260 accidents that resulted in 76 deaths at the level crossing. Then the previous year, there had been 395 accidents that left 245 people seriously injured. In total over the past two years there have been 655 accidents. Although the number of accidents decreased, the number of accidents that occurred is still high, so it still poses potential losses that will be experienced by PT KAI.

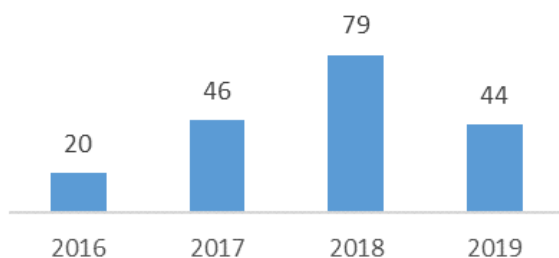


Fig. 4. Accident at Crossing Area Daop 1 2016-2019.

In Daop 1 region itself, from 2016 to 2019 there have been 189 accidents. Based on the data above, it appears that the number of accidents each year is still volatile with a high number. The high number of accidents every year is certainly a potentially detrimental problem for PT KAI (Persero). In addition to fatalities, accidents also cause material losses that are not small for PT KAI (Persero). In some cases, accidents at the crossing caused damage to train

lines and other infrastructure that was very detrimental to PT KAI (Persero). In addition, accidents will cause train travel to be hampered, thus disrupting the operation of the train journey. Seeing the high accident rate, there needs to be more attention to know the causal factors that contribute to the occurrence of accidents at the level crossing.

## II. LITERATURE REVIEW

In the Indonesian Regulation of the Director General of Land Transportation No. SK.770/KA.401/DRJD/2005 concerning Technical Guidelines for Level Crosses Between Roads and Railroads, what is meant by level crossings is the intersection of a plot between a railroad track and a road. It is also mentioned in the Regulation of the Indonesian Minister of Transportation Number PM 94 of 2018 Article 1, level crossings are the intersections of roads and railways.

The Health and Safety Executive (HSE) defines an accident as an unplanned event that results in injury or illness to employees, or damage or loss to property, plant, material or the environment or loss of business opportunities (Nugroho, 2021). Based on the investigation of the National Transportation Accident Committee (KNKT) from 2007 to 2016 presented the factors causing accidents are human factors or human resources, facilities factors, infrastructure factors, environmental factors, and special causal factors in this case the regulation/policy is not right (Saputra, 2018).

Human error can be defined as the failure of a planned action to achieve the desired goal with-out the intervention of some unforeseen event (Reason, 2016). Reason divides human errors into four basic classifications, namely omissions in attention (slips), memory lapses, errors/mistakes, and violations (Guritnaningsih *et al.*, 2018).

In recent years, investigations into the causes of accidents are no longer focused solely on the personal approach that leads to the transfer of the fault to the operator but has shifted to a systematic approach that also analyzes other factors that contribute to the occurrence of accidents or factors that support the occurrence of errors human or human error.

Human Factor Analysis and Classification System (HFACS) is a tool to identify human factors developed by Shappell & Wiegmann. HFACS was formed based on the Swiss cheese model which was previously developed by Reason in 1990 (Latino *et al.*, 2020). The Swiss cheese model shows that accidents can occur due to several interrelated factors or events. The research then uses Fishbone Diagram to is to help identify the root of the problems that arise in a structured way and make it easier for research when researchers identify data collection locations. To solve a problem, 5-Wys Analysis will help find out what the root cause of research is. 5Wyhs Analysis deals with the principle of systematic problem solving (Sutawijaya *et al.*, 2017).

## III. METHODOLOGY

This study aims to find the main causes of accidents that occur at railroad crossings. If the main causal factors can be identified, then a deeper investigation process can be carried out so that recommendations for improvements can then be

found to reduce accidents and achieve the company's desired target. To achieve the objectives of this research, the human error analysis method which has been widely used in the transportation sector is used, namely the analysis of the Human Factor Analysis and Classification System (HFACS).

This research is qualitative research, by conducting a study and investigation of accident reports at level crossings issued by PT KAI (Persero). The results of the study were then analyzed using the HFACS method in order to identify the causes of accidents at level crossings. After finding the factors that cause accidents at level crossings, a more in-depth analysis is carried out using Fishbone Diagrams to find out the root causes of accidents. Furthermore, the dominant causal factors are investigated in more depth using 5whys analysis to find out more deeply why the factors that cause accidents can occur.

#### IV. FINDING AND DISCUSSIONS

##### A. Accident at Daop 1 Jakarta Area Level Crossings

There are 167 guarded crossings or 36% of the total existing crossings. As many as 20% or 92 crossings are not guarded and the most is illegal crossings which are 202 or 44% of all crossings in the Daop 1 Jakarta Area. The crossings in the Daop 1 Jakarta area are mostly illegal crossings. This illegal crossing continues to increase every year along with the development of the environment around the railway line. Data processing was continued by analyzing accident data at the Daop 1 Jakarta area crossing which was recorded from 2016 to 2019, which was 189 incidents. The discussion focuses on events that occur at official level crossings, namely those that are guarded and unguarded. Illegal crossings are not included in the discussion on the grounds that illegal crossings are not official crossings recognized by PT KAI (Persero).

TABLE I: ACCIDENT AT DAOP 1 JAKARTA AREA BY TYPE OF CROSSING 2016-2019

Level Crossing Type	Year				Total	
	2016	2017	2018	2019	Total	%
Guarded	11	20	27	17	75	39,7
Unguarded	9	26	52	27	114	60,3
Total	20	46	79	44	189	100,0

Based on the data in Table I, it can be seen that the number of accidents that occurred at the crossing, both guarded and unguarded. In 2016 there were 20 accidents with 11 incidents at guarded crossings and 9 incidents at unguarded crossings. In the following year, the number of accidents increased with a total of 46 incidents in 2017 with 20 occurring at guarded crossings and 26 at unguarded crossings. The number of accidents again increased in 2018 to 79 accidents. Entering 2019, the number of accidents decreased quite a lot to only 44 incidents with 17 incidents at guarded crossings and 27 at unguarded crossings. The number of accidents from 2016 looks still fluctuating, which means that there is no good handling of accidents at crossings. Based on the data obtained, the number of accidents occurred more at unattended crossings with 60.3% of the total accidents occurring, while accidents occurring at

guarded crossings were only 39.7%, a higher number of accidents at unattended crossings.

Based on research on accident data received and based on observations, variables related to accidents are divided into two variables or subjects. The first variable is motorized vehicles such as motorcycles, cars, trucks, and the like. The second variable is pedestrians or people crossing the crossing on foot. These two variables are considered to be the main factors involved or play a role in the occurrence of accidents both at level crossings that are guarded and unguarded.

TABLE II: ACCIDENT AT DAOP 1 JAKARTA AREA CROSSING BY SUBJECT 2016-2019

Subject	Year				Total	
	2016	2017	2018	2019	Total	%
Motor vehicle	15	24	60	37	136	72,0
Pedestrian	5	22	19	7	53	28,0
Total	20	46	79	44	189	100,0

Based on the data in Table II, it can be seen that the number of accidents that occurred was based on the subject of the cause of the accident, namely motorized vehicles and pedestrians. From 2016 to 2018 the number of accidents by motorized vehicles seems to continue to increase every year, from 2016 as many as 15 incidents continued to increase until 2018 as many as 60 incidents. In 2019 the incidence decreased to 36 events that occurred.

On the subject by pedestrians, the number of accidents in 2016 occurred 5 incidents, then increased to 22 incidents in 2017, but fell again in the following year until 2019 with only 7 incidents. Overall, 72% of accidents at crossings are caused by motorized vehicles, while only 28% by pedestrians.

Based on this data, it can be concluded that motorized vehicles are the most common cause of accidents at crossings. The number of motorized vehicles that continues to increase every year in the Jabodetabek area causes more and more motorized vehicles to cross the crossing so that it can cause accidents, it can be seen that every year the number of accidents by motor vehicles is always more than by pedestrians.

##### B. HFACS Analysis

All accident chronological data that were sampled in the study were examined and researched to be classified using the HFACS framework. The analysis is divided into four parts, namely accidents at Officially Guarded Crossings caused by Motorized Vehicles, Accidents at Officially Guarded Crossings caused by Pedestrians, Accidents at Unguarded Official Crossings caused by Motorized Vehicles, Accidents at Unguarded Official Crossings caused by Motorized Vehicles. Caused by Pedestrians. Each accident report is reviewed by looking for the factors causing the accident and then classifying the cause of the accident using the HFACS criteria framework as a reference. The grouping based on the HFACS was carried out using data obtained from reports of accidents that occurred at level crossings. The data obtained are then analyzed one by one to find out the factors that cause it.

Based on the HFACS classification analysis in Table III, for each causal factor for accidents by motorized vehicles at

level crossings that are guarded it can be seen that of the 51 accidents, 94.7% were caused by Unsafe Acts and 5.3% were caused by Preconditions for Unsafe Acts. It was also found that there were 76 HFACS factors that occurred in the analyzed accident.

Classification for accidents by pedestrians at guarded level crossings there are 24 accidents, 73.6% were caused by Unsafe Acts and 26.6% were caused by Preconditions for Unsafe Acts. It was also found that there were 53 HFACS factors that occurred in the analyzed accident.

The results of the classification of each causal factor for accidents by pedestrians at level crossings that are guarded, it can be seen that of the 85 accidents, 95.8% were caused by Unsafe Acts and 4.2% were caused by Preconditions for Unsafe Acts. It was also found that there were 167 HFACS factors that occurred in the analyzed accident.

From the results of the classification of each causal factor for accidents by pedestrians on unattended level crossings, it can be seen that of the 29 accidents, 74.4% were caused by Unsafe Acts and 25.6% were caused by Preconditions for Unsafe Acts. It was also found that there were 39 HFACS factors that occurred in the analyzed accident.

C. Fishbone Analysis

After the HFACS classification was carried out on the occurrence of accidents at level crossings that were guarded and unguarded, to find out the cause of the accident, Fishbone analysis was carried out. Information for analysis is done by conducting field observations, namely by visiting several level crossings in the research area. In addition, interviews were conducted with crossing guards, local residents and motorcyclists. Documentation studies in the form of accident chronology were also carried out to add information that can be used in Fishbone analysis. In this analysis, the causes of the observed factors are Human, Method, Environment, and Facilities (Latino *et al.*, 2020).

In the fishbone analysis for accidents at guarded level crossings caused by motorized vehicles in Figure 5, several causative factors were found. In terms of humans (Man), one factor is obtained, namely, the vehicle has fallen is hampered. In terms of method, there are four factors, namely breaking through the crossing gates, passing in a hurry, not stopping behind the bars, and not closing the bars. In terms of the environment obtained three factors, namely bad weather, busy traffic, and damaged roads. In terms of facilities, there are four factors, namely invisible signs, inadequate crossing gates, broken/damaged vehicles, and dark crossing conditions.

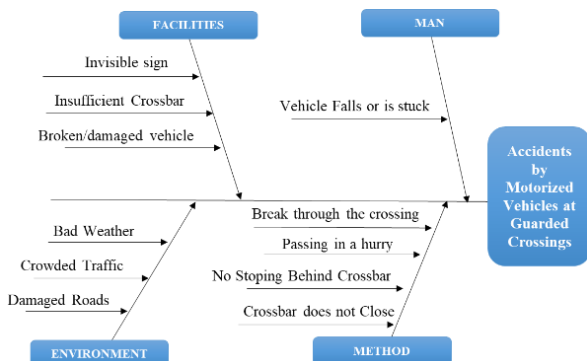


Fig. 5. Fishbone Analysis of Accidents at Guarded Level Crossings Caused by Motorized Vehicles.

The fishbone analysis for accidents at level guarded crossings caused by pedestrians in Figure 6, several causative factors were found. In terms of humans (Man), there are two factors, namely not focusing on crossing, and committing suicide. In terms of method, there are four factors, namely breaking through the crossing gates, passing in a hurry, not stopping behind the bars, and not closing the bars. In terms of the environment obtained three factors, namely bad weather, busy traffic, and damaged roads. In terms of facilities, three factors were obtained, namely invisible signs, inadequate doorstops, and dark crossing conditions.

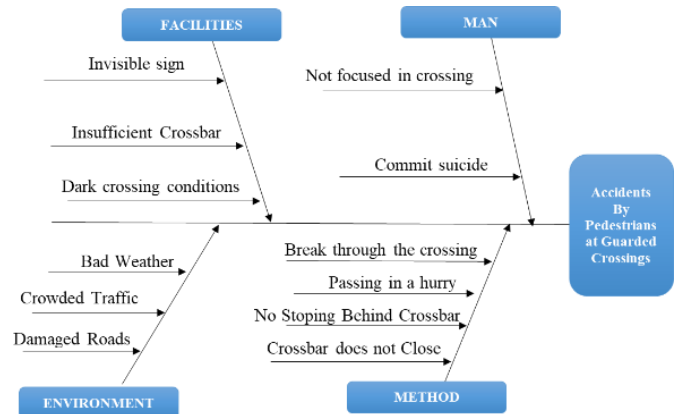


Fig. 6. Fishbone Analysis of Accidents at Guarded Level Crossings Caused by Pedestrians.

In the fishbone analysis in Fig. 7, accidents at unguarded level crossings caused by motorized vehicles, several causative factors were found. In terms of humans (Man), there are two factors, namely the vehicle is falling/obstructed, and not paying close attention to the train coming. In terms of the method, there are two factors, namely passing in a hurry, and not stopping behind the line markings. In terms of the environment obtained three factors, namely bad weather, busy traffic, and damaged roads. In terms of facilities, three factors were obtained, namely invisible signs, broken/damaged vehicles, and dark crossing conditions.

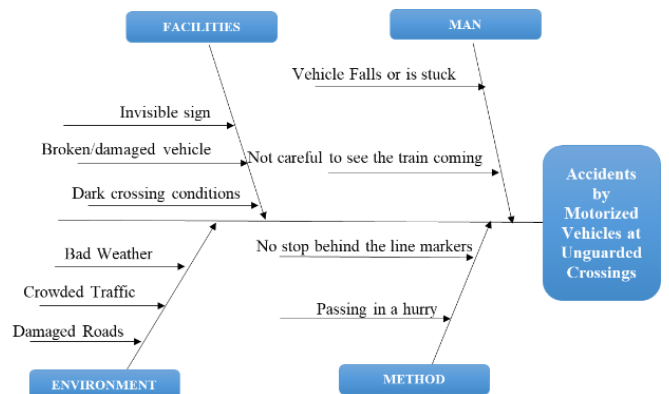


Fig. 7. Fishbone Analysis of Accidents at Unguarded Level Crossings Caused by Motorized Vehicle.

In the fishbone analysis in Fig. 8, Accidents at Unguarded Level Crossings Caused by Pedestrians, several causative factors were found. In terms of humans, there are three factors, namely not paying close attention to the train coming, not focusing on crossing, and committing suicide.

In terms of the method, there are two factors, namely passing in a hurry, and not stopping behind the line markings. In terms of the environment obtained three factors, namely bad weather, busy traffic, and damaged roads. In terms of facilities, there are two factors, namely invisible signs and dark crossing conditions.

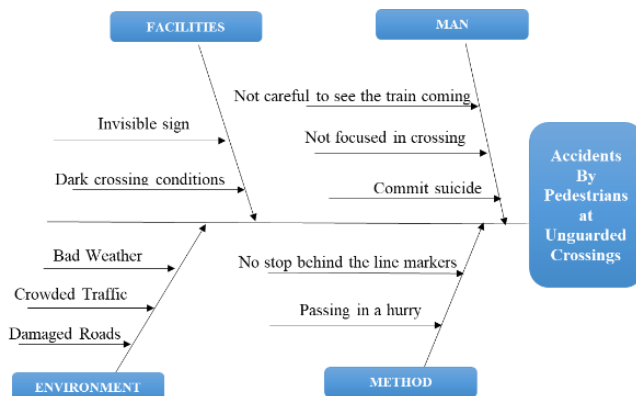


Fig. 8. Fishbone Analysis of Accidents at Unguarded Level Crossings Caused by Pedestrians.

#### D. 5Whys Analysis

Information for the 5 whys analysis is carried out by conducting discussions and interviews with crossing guards, local residents, and motorcyclists, and the company in this case PT KAI (Persero) Daop 1 Jakarta as the provider and manager of level crossings. In this analysis, the causal factors of the factors found in the previous fishbone analysis were obtained.

Based on Fishbone analysis and 5 Whys conducted for four categories of accidents by subject, the results obtained support the HFACS analysis. For the causes of accidents caused by motorized vehicles, both at guarded and unguarded crossings, the same factors were obtained, namely in terms of Humans (Man), the causal factors were the vehicle fell/hampered, and did not pay close attention to the train coming. In terms of the method (method), the causative factors are found, namely crossing the crosswalk, crossing in a hurry, not stopping behind the cross, not closing the crossbar, and not stopping behind the line marking. In terms of facilities, the factors causing the signs are not clearly visible, the doorstop is not adequate, the vehicle is broken/damaged, the condition of the crossing is dark. In terms of the environment (Environment), the causative factors are bad weather, busy traffic, and damaged roads.

For accidents caused by pedestrians, both at level crossings that are guarded and unguarded, the same factors are obtained, namely in terms of Humans (Man) Not Focusing on Passing, Not being careful to see the train coming, and committing suicide, in terms of Method, namely Crossing Crossings, passing in a hurry, do not stop behind bars, Crosses do not close. In terms of facilities, namely signs are not clearly visible, doorstops are inadequate, crossing conditions are dark, and vehicles are broken/damaged. In terms of the environment (Environment), namely bad weather, slippery roads, and damaged roads

## V. CONCLUSION

Based on the results of research and discussion that have been described in the previous chapter, it can be concluded that the results of this study are:

1. The factors that cause accidents at level crossings within the Daop 1 Jakarta area caused by motorists are unsafe behaviour by motorists, namely making mistakes in crossing and violations that are not in accordance with applicable procedures at the crossing, causing accidents. For accidents caused by pedestrians, the causative factor is unsafe behaviour such as errors in crossing and violations committed as well as pedestrian conditions that do not support crossing the crossing.

2. To reduce the number of accidents that occur at level crossings within the Daop 1 Jakarta Area, what can be done is to provide socialization of the applicable laws and regulations related to level crossings. In addition, socialization about the procedures for crossing crossings is also needed so that vehicles or people who want to pass can follow good procedures. Appeals and warnings to motorists and pedestrians not to carry out dangerous activities at crossings can also be made to reduce accidents that occur.

To improve the safety system at level crossings in the Daop 1 Jakarta Area, what can be done is to repair damaged or old facilities with facilities that comply with regulations and can be used effectively. It can also be accompanied by the creation of new crossing procedures so that they can be more obeyed by motorists and pedestrians.

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