Design and Application Evaluation of Pedestrian Crossing Protector

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Abstract: The inter road user conflict of interest bringing on the increase of traffic accident record; in the situation, that pedestrian group usually became the victim, specially the student and the elderly with limitation on crossing the street. An instrument which implementing safety crossing concept, simple manufacture and operation (user friendly), as well as minimum traffic delay occurred, is indispensable. Pedestrian Crossing Protector (PIREN) will be a choice with the function of giving crossing guidance to pedestrian, at a special crossing demand condition. This instrument working concept is using minimum traffic time gap for guiding and managing crossing activity in proper and safe term. The sample crossing activity survey shows that pedestrian and speed characteristics weren't suitable with the manual and need crossing facility. PIREN that was designed for that situation needs 12.11 seconds for taking across nine people, produces delta-flow and delta-degree of saturation as 24.796 pcu/hr and 0.0104 pts.

Key Words: *crossing instrument, pedestrian, traffic smoothness*

1. INTRODUCTION

Entering this third millennium, the increasing number of motor cycle phenomenon happened in Indonesia. As a result, society mobility increase quickly and arise conflict among the road user. Crucial conflict between vehicle and pedestrian, which are two big components of road user, was occurred.

In reality nowadays, the student and the old become resisting factor of traffic fluency, since either psychically or psychologically indigent to response danger quickly and precisely. Especially within rush hour, many people deem their existence to bother traffic smoothness and safety. Furthermore, children that school by the side of national road or other busy highway usually threatened by high-speed heavy vehicles.

The condition occurs because of there is no appropriate management mechanism and facility for pedestrian, which is applicable and user friendly. An instrument with capability to run its function in ferrying or protecting appropriate number of crossing pedestrian at certain moments, without producing significant traffic delay, is needed.

Pedestrian Crossing Protector (PIREN) was designed to answer those problems. PIREN is crossing equipment with two-constrictor fence protecting crossing lane, moved by using alternating current machine and controlled by an operator. The equipment is assigned to operate on certain moments, when there are demand to ferry pedestrian. Cheap and easy equipment with risk of equipment malfunction caused by vandalism is minimized. This research implemented in the objective of evaluation prediction of Pedestrian Crossing Protector (PIREN) performance in the sample location.

2. THEORITICAL BACKGROUND

2.1 Road Capacity Analysis

Road Capacity defined as maximum acceptable traffic flow passing per hour in certain point at particular condition. According to Indonesian Highway Capacity Manual (1997), in determining road capacities, we have to reckon adjustment factors which appropriate with the situation. The adjustment factors are factor adjustment of road wide, dissociation of direction, resistance from other side, and factor adjustment of town size. Basic equation for determine road capacity shall be as follows:

$$C = Co \times FCw \times FCsp \times FCsf \times FCcs \quad (1)$$

Where:

C = Capacities (pcu/ hour)
C_o = Basic Capacities (pcu/hour)
FC_w = Factor adjustment of road wide
FC_{sp} = Factor adjustment of direction dissociation
FC_{sf} = Factor adjustment of side resistance
FC_{cs} = Factor adjustment of town size

2.2 Level of Service

Level of Service (*LOS*) is qualitative measurement expressing perception of driver about quality in ride vehicle. Degree of saturation and speed become Level of Service consideration indicator in IHCM 1997.

2.3 Delay

According to Hobbs (1979), delay caused by desisting is simple defined and measured. On the contrary, delay caused by traffic denseness is difficult measured correctly, because of no universal definition about appropriate travelling speed range measurement for various road types. This delay generated by slow-moving and jammed vehicle at very crowded junction, insufficient road wide, on street parking, etcetera. Above situation, raise reduction of travelling speed below accepted assumed speed. Pignataro (1973) express that delay is time lose when traffic influenced by elements where driver cannot control it.

2.4 Pedestrian Analysis

Because of pedestrian movement complexity, manual measurement is the best way to measure the level of movement of pedestrian. This method can conduct by placing observer with counter at vantage and suitable point. In general, it is incorrect if an observer should measure more than one type of movement in a certain moment. It would be more profitable if multi-

layer observation applied in complex situation (Clarkson, 1982).

Special method to study crossing activity in school environment can be conducted for student group measurement. This method requires determination value of 85th percentile of student group to know the quantity of line in group. Assumption used is one student take location equal to 60 x 60 cm^2. Besides of that, value of 85th percentile of student group is also important in determination of time gap at traffic flow to enable certain group size to cross safely. Sufficient time gap so that certain group with certain size can cross can be calculated by following equation:

$$G = \frac{w}{a} + p + (N-1)S \quad (2)$$

Where:
G = Required Time Gap (s)
w = Wide of road to be crossed (m)
a = Pedestrian Walk Speed (m/ s)
p = Time reaction of pedestrian (s)
N = Quantity of pedestrian line
S = Difference of time between pedestrian line (s)
Value of a, p, and S is different for any location, depend on the condition of that location.

Pedestrian Actual Delay represents something that necessary for analysed in controlling situation. This analysis can be conducted in the manner of measuring traffic flow gap, and determine percentage of time during the gap equal to available G, by formula:

$$D = \frac{T-t}{t} \quad (3)$$

Where:
D = Percentage of time that 85th percentile from pedestrian group that cannot cross safely
T = Total of observation time
t = Total of entire time equal to or greater than G (s)
This determination of gap has to reckon all traffic direction and lane. This control must be enrolled if gap mean emerge less than 1 time every minute.

Driver Total Response Time (Perception, Identification, Emotion, and Volition) increase along with amount of choice and complexity of required decision making. PIEV play an important part in determination of safety stop distance, safety speed in junction, and amber time at crossing traffic lamp (Pignataro, 1973).

PIEV time, in a laboratory condition, range from 0.2 till 1.5 seconds. The American Association State Highway Official (AASHO) recommend value of PIEV equal to 2 till 2.5 seconds in its use for determining safety stop distance for all speed reach and equal to 2 seconds used for sight distance in junction (Pignataro, 1973; NCHRPR 33, 1967).

Pedestrian Walking Speed were between 3 and 4.5 feet per second, and its reaction time revolve in 4 till 5 seconds. Both of the physical factors have to be used in determination of

minimum phase and or crossover operational duration. The observation of pedestrian at streets and intersection indicate that mean crossing speed approximately 4,8 per second and 4,72 feet per second. Difference of crossing time between woman and man indicate that mean crossing speed between woman and man show a value which is statistically significant. At streets location, speed of man 4.93 feet per seconds and woman 4.63 feet per second, while at intersection, man average speed 4.93 and woman 4.53 feet per second (Pignataro, 1973).

Common method which used to identify problems which possible happened at the time of pedestrian crossing the street is through measurement of vehicle-pedestrian conflict (PV), where P means pedestrian that wading street volume at distance 100 - 150 metres area, and V means vehicle volume each hour, 2 direction, at 2 direction undivided road (without median). Land Transport Department of New Zealand (2007), suggest building up of crossing facility if value result of multiplication of amount of pedestrian crossing the road in 60 m long street with amount of vehicle in 1 hour time duration is grater than or equal to 45.000. Exemption in this context is in school environment where come to and leave from school crossing activity observed.

2.5 Survey and Analysis of Pedestrian Crossing Facility Requirement

Several terms of survey for Pedestrian Crossing Facility requirement analysis are Behaviour of student crossing the street survey, spot speed survey, Vehicle Flow Survey, and Behaviour of student accompanying person survey. Fourth type of survey mentioned above held in 30 minutes, and the implementation time could be selected whether coming hour or leaving hour of school (Braise, 2007).

Behaviour of student crossing the street survey and Behaviour of student accompanying person survey data analyzed by Normal Test Statistic.

$$Z_{hit} = \frac{\overline{P} - 0.5}{\sqrt{\frac{\overline{P}(1-\overline{P})}{n}}} \tag{4}$$

$$\overline{P} = \frac{\sum group}{n} \tag{5}$$

Where:

n = sample size

Z_{table} = 1.645 (for degree of confidence 95%)

Comparison of Z_{hit} with Z_{table} value can summarized through following criteria:

- $Z_{hit} \geq Z_{table}$ means that pedestrian Behaviour at that school has already safe with 5% rate of inaccuracy.
- $Z_{hit} < Z_{table}$ means that pedestrian Behaviour at that school has not already safe with 5% rate of inaccuracy yet.

Spot speed survey data analyzed by Z Value Test Statistic.

$$Z_{hit} = \frac{\overline{X} - V_r}{\frac{Sd}{\sqrt{n}}} \quad (6)$$

$$Sd = \sqrt{\frac{\sum (X_i - \overline{X})^2}{n-1}} \quad (7)$$

$$\overline{X} = \frac{\sum X_i}{n} \quad (8)$$

Where:
n = sample size
V_r = design speed
Z_{table} = 1.645 (for degree of confidence 95%)

Comparison of Z_{hit} with Z_{table} value can summarized through following criteria:

- $Z_{hit} \geq Z_{table}$ means that pedestrian Behaviour at that school has already safe with 5% rate of inaccuracy.
- $Z_{hit} < Z_{table}$ means that pedestrian Behaviour at that school has not already safe with 5% rate of inaccuracy yet.

Data of vehicle flow survey interpreted by traffic flow per road capacity ratio and by Level of Service (*LoS*) criteria.

If from four previous surveys, result at least one value that categorized to has not yet been safe criterion, hence pedestrian crossing facilities program is reliable to establish in selected location and need monitoring in its execution (Directorate General of Land Transport of Indonesia Regulation, 2006).

2.6 Survey of Road User Characteristic

Survey of road user characteristic is comprised with Characteristic of Pedestrian Survey, Characteristic of Driver Survey, Characteristic of Cyclist Survey, Characteristic of Motor Cyclist Survey, and Characteristic of Passenger Survey. Survey of Road User Data is analyzed by Normal Test Statistic.

$$Z = \frac{x - 0.5n}{\sqrt{0.25n}} \quad (9)$$

Where:
n = sample size
X = sum of "yes" answer from the criteria
Z_{table} = -1.64

Comparison of Z with Z_{table} value can summarized through following criteria:

- $Z \leq Z_{table}$ means that road user characteristic at that school is against the rule.
- $Z > Z_{table}$ means that road User characteristic at that school has already followed the rule.

3. RESEARCH METHOD AND DATA COLLECTION

This research enrolled in environment of community development partner, which are Madrasah Aliah Negeri of Maguwoharjo and RT.03 Village Community of Tajem, Maguwoharjo, Regency of Sleman, Yogyakarta. Sample location where this research conducted can be figured below.

Figure 1 Satellite photograph of sample location
(captured by Google Earth, 2007)

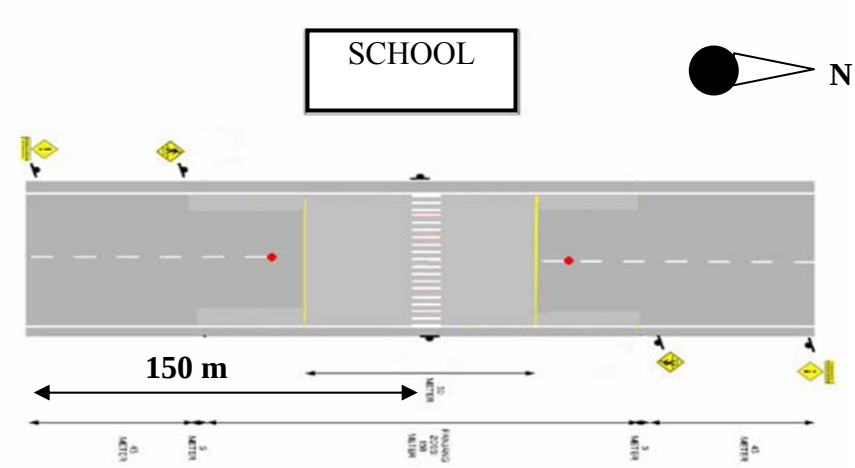

Figure 2 Scheme of PIREN application location

In this research, several research methods are concerned. Library Research is direct research at relevance reference to obtain theoretical data which useful for compiling basic concept in pedestrian safety and analysis. Field research conducted in real location to obtain comparison between practice and theory so that defined objectives can be achieved. Laboratory Research is covering activity of design, equipment production, error investigation, and calibrates equipment by suitable tools and procedures. Laboratory Research makes the best use of acceptable computerised system in the form of design and simulation of the instrument. Surveys that is implicated as data collection process, has characteristic as pedestrian and traffic.

3.1 Pedestrian characteristic when crossing the street

Population of this survey is all students of the school, who do crossing activity everyday. This

definition formulated by assumption that population unit characteristic (student) do not change nor has insignificant change of characteristic so that was not changed population characteristic.

Sample of this survey is the part of population owning characteristic which is equal to population. It is reliable that sample size of this survey is 10% from amount of student in that school in minimal. Method of sample selection is Simple Random Sampling, with intake time adapted to study time of concerned school. Officer will of record student characteristic of that school, started from the beginning of crossing activity till the end of that series.

There are four criteria to assess student character in crossing the street, that is:

- Standard procedure of crossing (Await a moment, Behold right, Behold left, Behold right again)
- Way of crossing (walk or run)
- Used facility (with zebra cross or pedestrian overpass or without facility)
- Crossing pedestrian status (self-supporting or not self-supporting)

3.2 Traffic Characteristic

Surveys related with Traffic Characteristic consist of traffic speed survey, traffic volume survey, and behaviour of student accompanying person survey. Population in this survey is:

- All vehicle, which pass over the street in front of the school (*through traffic*)
- Student Accompanying person vehicle whether private vehicle or school bus or public transport.

This definition formulated by assumption that population unit characteristic (student) do not change nor has insignificant change of characteristic so that do not change population characteristic. Sample is the part of population with same characteristic to population itself. Sample size is determined for 30 vehicles unit in minimal. Method of sample selection is Simple Random Sampling. Sample selected randomly from passed vehicle at the road in front of the school, as follow:

- Surveyed vehicle speed is measured using km/ hour
- Number of surveyed vehicle recorded per period of time (vehicle/ 5 minutes)

4. DISCUSSION

4.1 Design and specification of PIREN

Pedestrian Crossing Protector is designed, with specification of performance adapted by existing traffic condition and crossing activity in Main Road of Tajem Maguwoharjo Yogyakarta.

Specification of designed PIREN is:

- Stretching Time = maximum 5 second
- Folding Time = maximum 5 second
- Crossing time = ± 7.11 second
  (up to 9 people, 3 crossing line)
- Total of operational time = ± 12.11 second

PIREN appearance can be shown as figure below.

Figure 3 Appearance of Pedestrian Crossing Protector Instrument

To calculate Non Passing or Minimum Safe Stop Distance in condition those vehicles have to reduce its speed related with activity of PIREN, used following formula:

$$\text{Safe Stop Distance} = r \times Vt + \frac{V^2}{2g(f \pm i)} \quad (9)$$

Where:

i = road gradient (%)
V = initial velocity (m / s)
g = acceleration of gravity (9.81 m / s^2)
f = friction coefficient (0.4)
r = time reaction of (1 s)

Because of zero lengthwise direction of road inclination (flat surface), and vehicle initial velocity is 25 m/ s, hence safe stop distance needed is 135.625 m. Therefore, traffic sign is placed 150 m before application location of PIREN, as a warning sign of pedestrian crossing activity existence.

4.2 Characteristic of Pedestrian

Observation is conducted for five minutes during 06.30-07.00 WIT periods, August 28, 2008 in sample location. Result of Study presented in the following table.

Table 1 Characteristic of pedestrian survey data

Pedestrian		Yes	No	Sum (x)	Sample (n)	Z	Result
1	When crossing the street, student stop, behold right and left, and listen	16	14	16	30	0.36548	Follow the rule
2	Crossing through in front of school bus	0	30	0	30	-5.4772	Against the rule
3	Accompanying person hold student	0	30	0	30	-5.4772	Against the rule
4	Using zebra cross	8	22	8	30	-2.5560	Against the rule
5	Walk in the road-side	18	12	18	30	1.09544	Follow the rule
Total		42	108				

4.3 Characteristic of Driver

Observation is conducted for five minutes during 06.30-07.00 WIT periods, August 28, 2008 in sample location. Result of Study presented in the following table.

Table 2. Characteristic of driver survey data

Driver		Yes	No	Sum (x)	Sample (n)	Z	Result
1	Park not so close to intersection	0	10	0	10	-3.16228	Against the rule
2	Not doing double parking	0	10	0	10	-3.16278	Against the rule
3	Park in restricted area	3	7	3	10	-1.26491	Follow the rule
4	Speed limit violation	3	7	3	10	-1.26491	Follow the rule
5	Give priority for pedestrian	0	10	0	10	-3.16228	Against the rule
6	Use safety belt	5	5	5	10	0	Follow the rule
7	Not breaking the stop line	0	10	0	10	-3.16228	Against the rule
8	Give turning sign	7	3	7	10	1.2649	Follow the rule
Total		18	62				

4.4 Characteristic of Cyclist

Observation is conducted for five minutes during 06.30-07.00 WIT periods, August 28, 2008 in sample location. Result of Study presented in the following table.

Table 3 Characteristic of cyclist survey data

Cyclist		Yes	No	Sum (x)	Sample (n)	Z	Result
1	Use helmet	0	23	0	23	-4.79583	Against the rule
2	Not riding in side walk	14	9	14	23	1.0425721	Follow the rule
3	Safe riding style	4	19	4	23	-3.12771	Against the rule
Total		18	51				

4.5 Characteristic of Motor Cyclist

Observation is conducted for five minutes during 06.30-07.00 WIT periods, August 28, 2008 in sample location. Result of Study presented in the following table.

Table 4. Characteristic of Motor Cyclist Survey Data

Motor Cyclist		Yes	No	Sum (x)	Sample (n)	Z	Result
1	Use helmet	10	6	10	16	1	Follow the rule
2	Use special jacket, spectacle, shoes, gloves	0	16	0	16	-4	Against the rule
3	Safe riding style	3	13	3	16	-2.5	Against the rule
Total		13	35				

4.6 Characteristic of Passenger

Observation is conducted for five minutes during 06.30-07.00 WIT periods, August 28, 2008 in sample location. Result of Study presented in the following table.

Table 5. Characteristic of Passenger Survey Data

Passenger		Yes	No	Sum (x)	Sample (n)	Z	Result
1	Student entering the car/ sit on the motor cycle from sidewalk side	7	4	7	11	0.904	Follow the rule
2	Using Safety Belt	2	9	2	11	-2.11	Against the rule
3	Not snatching away & scattering from/ to school bus	0	11	0	11	-3.32	Against the rule
Total		9	24				

Road User Characteristic Survey result can be concise in this figure.

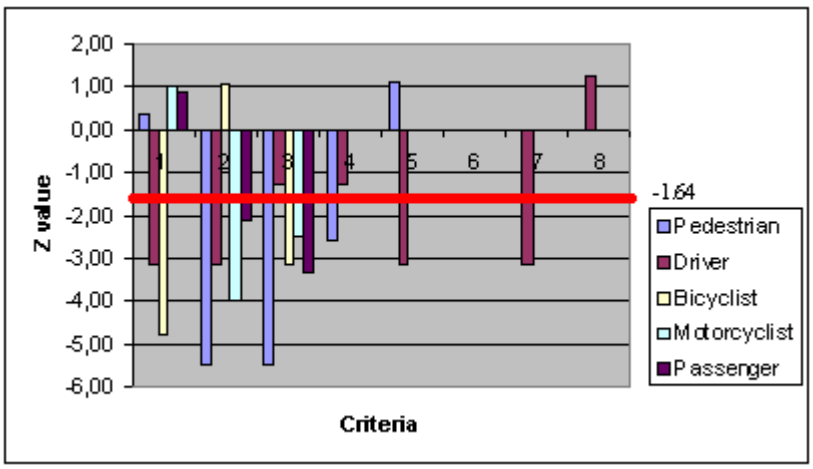

Figure 4 Road user characteristic survey summaries

4.7 Pedestrian Crossing Facility Requirement

4.7.1 Behaviour of Student Crossing the Street Survey

Survey Data

n = 18

∑ group = 10

Through Normal Test Statistic, result:

$\overline{P}$ = 0.56

Z_{hit} = 1

Z_{table} = 1.645

Z_{table} > Z_{hit}

Hence, pedestrian behaviour in sample location has not already safe with 5% rate of inaccuracy yet.

4.7.2 Spot Speed Survey

Survey Data

$\sum (X_i - \overline{X})^2$ = 3.33218216

$\overline{X}$ = 12.4034737

n = 10

Vr = 6.94 m/ s

Sd = 0.60847552

Z_{hit} = 28.3708476

Because of $Z_{hit} > Z_{table}$, so road in front of sample location has already safe with 5% rate of inaccuracy. On site space mean speed is 12.38 m/s, whether on side time mean speed is 12.40 m/s.

4.7.3 Traffic Flow Survey

Traffic Volume for each type of vehicle should be multiplied by pcu factor, which is:

Motor Cycle = 0.33 pcu
Passenger Car = 1pcu
Heavy Vehicle = 1.3
Unmotorized Vehicle = 0.8

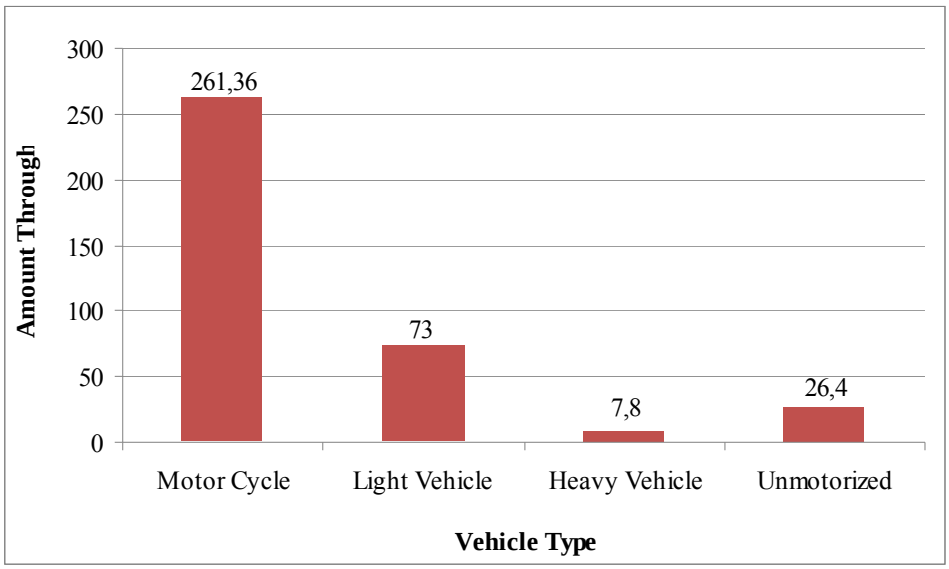

Figure 5 Traffic flow survey summary

Main Road of Tajem Maguwoharjo Characteristic is described as follow:

Road Class = secondary collector
Road Width = 6 m (WCA + WCB)
Shoulder Width = 1 m (WSAO = WSBO)
Town Size = 1.0 – 30 million residences
Area Type = residential
Segment Length = 1.16 km
Road Type = two-lane two-direction undivided (2/2)
Analyzing Period = 2008, morning peak hour

Capacity of Main Road of Tajem Maguwoharjo according to IHCM 1997 is:

CO = 2900 pcu/hour
FCW = 0.87
FCSP = 1
FCSF = 0.94
FCCS = 1

So that,

C = 2371.62 pcu/hour

Degree of Saturation of Main Road of Tajem Maguwoharjo according to IHCM 1997 is:

$$DS = \frac{V}{C} \quad (10)$$

V = 737.12 pcu/hour
DS = 0.310808646

According to IHCM 1997, acceptable DS boundary is DS < 0.75. Hence, Main Road of Tajem Maguwoharjo still categorized as non saturated road. If DS > 0.75, so special treatment for repairing Level of Service is required.

4.7.4 Behaviour of Student Accompanying Person Survey

Survei Data

n = 18

$\overline{P}$ = 0.67

Z_{hit} = 1.73

Z_{hit} > Z_{table}

Therefore, Student Accompanying person Behavior has already safe with 5% rate of inaccuracy.

There are two from four survey result that categorized to has not yet been safe criterion, hence pedestrian crossing facilities program is reliable to establish in selected location and need monitoring in its execution.

4.8 Pedestrian Study

Crossing Activity Condition at sample location shows that:

- Pedestrian Volume = 180 people/ hour
- Traffic Volume = 737,12 pcu / hour
- PV Value = 132.682

Refers to Land Transport Department of New Zealand Standard of Crossing Facility Requirement (PV ≥ 45.000), hence that location need crossing facility. Group Pedestrian Study is enrolled by this following form.

Table 6 Pedestrian study and designed number of row analysis

Date		:28-08-08		Crossed Road Width	:5.4 m
Total Study Time		:15 minutes		Side To Side Distance	:6 m
Location		:Tajem			
Group Size	Number of Row	Number of Group		Cumulative	Calculation
		Torus	Sum		
26-30	6				Designed Number of Row Find is found, from 85th percentile calculation of group size by multiplied Total Group with 15%.
21-25	5				
16-20	4	I	1	1	
11-15	3	II	2	3	
6-10	2	IIIIIIII I	9		
≤ 5	1	III	3		-> 85th = (2.25)
Total Groups =			15		N = 3

By means of above study, Designed Number of Row can be obtained, which is 3 rows pedestrian group (85^{th} percentile calculation of group size by multiplied Total Group with 15%).

Crossing Time Gap Analysis is enrolled by this following sequence.
Value of G (s) = 9.62
Duration of Study (s) = 900
Crossing Time Gap is calculated by this formula:

$$G = \frac{w}{a} + p + (N-1)S \tag{11}$$

Where:
G = Crossing Time Gap Required (s)
W = Crossed Road Width (m)
a = Pedestrian walking speed (m/s)
p = Pedestrian reaction time (s)
N = Pedestrian Group Number of Row
S = Difference Time between Row (s)

Table 7 Pedestrian study and crossing time gap analysis

No.		1	2	3	4	5	Total
Gap ≥ G	t (s)	13.08	13.44	12.85	14.07	13.31	66.75

Data Survey in sample location is:
W = 6 (m)
a = 1.0675 (m/s)
p = 2 (s)
N = 3
S = 1 (s)
Hence,
G = 9.62 (s)
So Crossing Time Gap Required in sample location is 9.62 seconds.
Delay Caused by Pedestrian Crossing Activity is considered by:

$$D = \frac{T-t}{t} \tag{12}$$

Where:
D = Time duration percentage where 85^{th} percentile from pedestrian group could not crossing safely
T = Total of Study Time
t = Total of all time that greater than or equal to G (s)

Data Survey in sample location is:
T = 900 s
t = 66.75 s
Hence,

D = 12.48 %
So Delay Caused by Pedestrian Crossing Activity in sample location is 12.48%.
This calculation is done by assumption that 180 cm crossing lane can be passed by 3 pedestrian in parallel arrangement.

4.9 Traffic Condition Analysis

4.9.1 Free Flow Speed analysis by IHCM 1997

$$FV = (FVo + FVW) \times FFVS \times FFVCS \quad (13)$$

Free Flow Speed of Main Road of Tajem Maguwoharjo is:
FVo = 42 (km/ hour)
FVW = -3
FFVSF = 0.98
FFVCS = 1
Hence, Light Vehicle Free Flow Speed (FV) is 38.22 (km/ hour).

4.9.2 Road Capacity & Degree of Road Saturation analysis by IHCM 1997
Capacity of Main Road of Tajem Maguwoharjo which was calculated using equation (1) is:
C = 2371.6 (pcu/ hour)
Survey and previous calculation result that:

$$DS = \frac{Q}{C} \quad (14)$$

Q existing = 737.12 (pcu/ hour)
DS existing = 0.3108

4.9.3 Speed and Travelled Time analysis by IHCM 1997

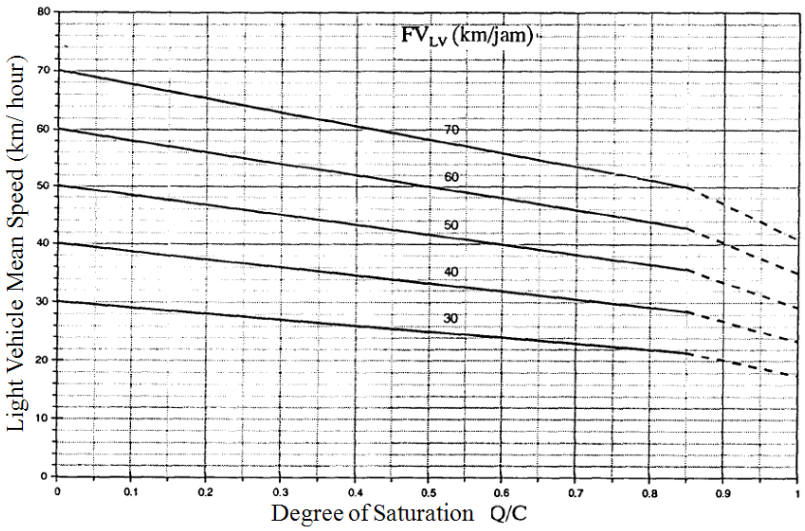

Figure 6 Speed as a function of DS for 2/2 UD Road
(Figure D-2:1, IHCM 1997)

Data Survey:
Road Segmen Length = 1.16 km

According to Figure D-2:1, IHCM 1997 above, than:

V existing	= 34	km/ hour
Travelled Time existing	= 0.0341	hour
	= 122.82	s

4.9.4 Traffic Condition Analysis by PIREN application use IHCM 1997

Capacity of PIREN which have been designed is to ferry minimum 9 students for once operation (12.11 seconds). Related to previous Pedestrian Study, there are average 90 students who cross in front of partner location at come to school hour. Approximately 10 time gap is available in 30 minute at come to school hour, where 85th percentile from pedestrian group can cross the road during the time that greater than mean gap. Therefore, PIREN should ferry 10 pedestrian groups (± 9 students) in minimal during half an hour duration.

By operate 10 times, consequently PIREN will create delay equal to 121.1 second in 30 minute. By traffic analysis related with IHCM 1997, this delay will influence traffic condition as:

$$S_p = S_t + D_l = S_t \times \frac{Q_p}{Q_t} \tag{15}$$

Where:

S_p = Travelled time with PIREN application
S_t = Travelled time without PIREN application
D_l = Delay caused by PIREN activity
Q_p = Traffic volume with PIREN application
Q_t = Traffic volume without PIREN application

So that:

S_p	= 3721.1	s
	= 1 hour 2.01 minutes	
Q with PIREN	= 761.92	pcu/hour
ΔQ with and without PIREN	= 24,796	pcu/hour
DS with PIREN	= 0.3213	

5. CONCLUSION

In general, existence of Pedestrian Crossing Protector Instrument would be an alternative solution to effort creation of crossover activity efficiency and security in the future. Some result and conclusion that can be obtained from this research are:

- Pedestrian Crossing Protector Instrument represents one of the solutions to bring up crossing efficiency and effectiveness at busy hours.
- Pedestrian Crossing Protector Instrument can assist in eliminating difficulty of pedestrian to cross the street without causing unacceptable Level of Service condition (LOS < 0.75).
- Result of condition study of traffic at partner location according to Directorate General of Land Transport of Indonesia Regulation No. SK 3236/AJ 403/DRJD/2006 is:
  Characteristic of Pedestrian not yet safe;

Characteristic of Speed of Vehicle not yet safe;
Characteristic of Traffic Volume has safe;
Characteristic of Student Accompanying person has safe.

- Specification of performance of PIREN designed for application in partner location is:
  Time stretch : maximum 5 second.
  Time fold : maximum 5 second.
  Crossing time : ± 7.11 second (for 9 people)
  Totalize operational time : ± 12.11 second.
- Magnitude of pedestrian crossing - vehicle crashed and number of fatalities mechanism of the protector were not yet recorded and observed.

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