A Simple Method on Measuring Road Pavement Damage For Access Road to Residential Estates

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Abstract

The ability of a road pavement structure in carrying out its function reduces in line with the increase traffic loading especially of overloaded heavy vehicle is one of the serious problems for maintain road pavement if the situation went uncontrolled. In Malaysia for instance, at present there is no official restriction on which roads that these heavy vehicles can use although road pavement are designed to sustain vehicle loading according to their respective categories. Heavy vehicles are not wanted in residential areas and these lead to resident association illegally put up barriers at the entry and exit points of the access road in the residential estate. The severity of the problem post by heavy vehicle to the residential access roads, classified as JKR U2 roads is never scientifically measured and this trigger the urgency for this study.

Key Words*: Road pavement damage, Access roads, Residential estates*

1. Introduction

Road has played an important role in the trade and transportation system throughout the world, and it became rapid increase in the pavement infrastructure development in Malaysia. Gazette under Federal Roads Ordinance is usually roads linking the state capitals, airports, railway stations and ports. Currently, Malaysia has more than 80,300 km roads and the road is divided into three main categories namely toll expressway (1,700 km), federal roads (17,500 km) and state roads (61,100 km) and the life spans are between 10 to 15 years (Zakaria and Hassan, 2005). Local authority road (city mall, municipal or local council) or kampong (district office) road is depending upon jurisdiction and normally maintained by the responsibility local authority (Haron, 2004).

Due to high traffic volumes and associated congestion on many of the classified roads in urban areas drivers often seek to use local roads as alternative routes. These alternative routes are used not only by cars but also by heavy vehicles. Heavy vehicles generate higher noise levels, higher vibration levels and more fumes, and their larger size results in greater visual intrusion. Heavy vehicles also can cause severe damage to the road pavement since axle loadings of heavy vehicles are considerably greater than that of cars. Therefore the effects of increased levels of heavy vehicle traffic on local roads may include:

- Deterioration of environmental amenity of a residential area;

- Deterioration of safety of pedestrians, cyclists and local traffic of a residential area;

- Damage to the road pavement as a result of the increased loading.

An effective road maintenance program demands strategic allocating of the limited resources (funding) to those roads that provide most benefits in return. The main goal is to determine maintenance strategies that minimize the long-term costs of preserving the road network in a desired condition. In order to achieve this goal, road agencies need sound management practices and procedures in place to increase their chances of making the right decisions about the road infrastructure. The strategy is simple, have the right treatment for the right road at the right time. However, accomplishing this is a much more complex process. It essentially starts by obtaining adequate information about the road network through the collection of the road condition data that fully describe both surface and structural level of road deterioration. The collected data should be objective as much as possible, reliable, repeatable and used in the decision making process Othman (2006).

For the road network owners, the pavement represents an important component of their assets. The pavement is affected by loads, due to traffic and climate, which will affect the pavement condition and slowly deteriorate the pavement. Without proper maintenance, the pavement network would deteriorate to the stage where major expenditure is needed to restore its condition to the original level and the residual value of the

pavement or network would be very low. Timely and proper pavement maintenance reduces this depreciation to the benefit of both the road owners and road users. In the process of optimal selection and timing of the maintenance measures, the road owners are supported by information and data from pavement management systems (PMS) on appropriate pavement performance indicators, measured by monitoring devices and stored in databases (Ramos et al., 2004). This data together with pavement performance models gives to the road owner information concerning the pavement behaviour in the long term, which helps the maintenance programming.

2. Type and Factors of Damages

According to Highway Research Board, 1970 cited by Pavement Interactive, 2010, pavement distress is "any indication of poor or unfavourable pavement performance or signs of impending failure; any unsatisfactory performance of a pavement short of failure". The causes of pavement failures are divided into two categories, which are an internal and external failure. Internal failures of pavement are usually because of the lack adequate pavement mixtures, weaknesses of component materials and poor construction. Meanwhile, external failures are due to overloading, diesel spillage, flooding, sink holes and other unforeseen cause such as earthquake, volcanoes and others. The failures of flexible pavement are divided into four categories, which are surface deformation, surface defects, cracking and patching and potholes (Rani, 2007).

Most comment from the road users is a about loaded heavy vehicles that caused pavement damage. They want to increase the axle load limit to avoid delivery delays and meet higher storage chargers. Table 1 below shows the comparison weight limit of the truck among various countries.

Table 1 Comparison Weight Limit of Truck among Various Countries

Countries	Type	Weight limit (maximum)
Malaysia	Two-axle-fixed truck Three-axle-fixed truck Four-axle-fixed truck	16 tons 21 tons 25 tons
Singapore	Two-axle-fixed truck Three- axle-fixed truck Four-axle-fixed truck Articulated truck	16 tons 24 tons - 24 tons
Thailand	Two-axle-fixed truck Three-axle-fixed truck Five-axle-fixed truck	12 tons 21 tons 39 tons

(Source: MRTV3, 2010)

The ability of a road pavement structure in carrying out its function reduces in line with the increase traffic loading especially of overloaded heavy vehicle is one of the serious problems for maintain road pavement if the situation went uncontrolled. In Malaysia for instance, at present there is no official restriction on which roads that these heavy vehicles can use although road pavement are designed to sustain vehicle loading according to their respective categories. For sure however, heavy vehicles are not wanted in residential areas and these lead to resident association to put up barriers at the entry and exit points (access roads) of the residential estate which are illegal according to the local government rule. The severity of the problem post by heavy vehicle to the residential access roads, classified as JKR U2 roads in Malaysia is never scientifically measured and this trigger for a study for development of a prediction model on road pavement damage at residential estate access road due to heavy vehicles.

3. Study Objectives

One of the objectives of this study is explore various methods in measuring road pavement damage due to heavy vehicle and the second objective is to come up with a simple model for road pavement damage for access road (JKR U2) to residential areas.

This study focuses on several U2 roads main areas in Ampang, Selangor and Kuantan, Pahang.

4. Study Approach

The study combined and used information from the critical review of extant literature with observations made at identified stations and analysed to achieve the research aims. Observations of the surface pavements were made at 1 KM around the identified stations. The location, Taman Kosas in Selangor was chosen because it was the earliest U2-road in Malaysia and Selangor has the highest residential locations compared to in the other states. Data obtained from the sites were analysed using SPSS to determine the percentage and frequency of the main types of damages, the seriousness of the damages and the traffic volume of heavy vehicle factor affecting pavement performance. Furthermore, reports by others were also reviewed and analysed together with the information obtained in this study to develop engineering recommendations.

Observation Method, while being relatively infrequent in social science surveys, is common place in transport and, more particularly, traffic surveys. Two basic types of Observation Method are the direct and the indirect Observation Method. Examples of direct Observation Method include:

(a) Transport inventory surveys (e.g. using techniques such as video recording (Fahey and Chuck, 1992).
(c) System performance surveys (such as travel time surveys, intersection delay surveys (Richardson and Graham, 1982), and public transport performance surveys (Attanucci et al., 1981).
(d) To obtain direct information on route choice characteristics (Wright, 1980), or to observe the speed and acceleration characteristics of vehicles in traffic systems (Akcelik, 1983).
(e) Vehicle classification surveys, in which vehicle types are identified by various means such as manual visual recognition, profiles from inductance loops, and pattern recognition from single tube axle counters (Bayley, 1983). In addition to identifying vehicle types, a greater emphasis is being placed on obtaining the weights of heavy vehicles by means of a wide variety of weighing-in-motion (WIM) devices.

Traffic Data were collected from the selected area by manual observation method. Data were organized in statistical tables, charts, and figures and prepared in order to represent data in an easy and illustrative manner.

These data were analysed and used in the predicted regression models. Several regression prediction models were formed and the best models were chosen.

The main causes for traffic and the top driver behaviour that should be avoided by drivers were determined. The main focus in this study is to resolve this serious problem that is threatening the U2 Roads, and causing major economic and social concerns in this country. It is recommended to widen the study area and to do a comprehensive study for most areas.

SPSS (Statistical Package for Social Sciences) software was used in forming the Regression Models in this study. SPSS is considered one of the most frequently used program for researchers in many fields such as engineering, science, art, education. The method of least squares that leads to the best fitting line of a postulated form to a set of data is used to form Regression Models between the dependent variable Yi, and independent

Variables Xi. In this study, the dependent variable Yi includes road damage. On the other hand, the independent variable Xi includes the number of trucks which caused road damage.

Stepwise calibration procedure was used to form the Multiple Linear Regression Model. The selections of explanatory variables follow the following four guidelines to decide which explanatory (independent) variables to include in the linear regression model. The selected independent variable has to follow the following four rules:

1. Must be linearly related to the dependent variable.
2. Must be highly correlated with the dependent variable.
3. Must not be highly correlated between themselves.
4. Must lend themselves to relatively easy projection

The selected regression model has to have maximum 3 to 4 variables in order to have an easy projection and application, and in order to have a lower cost. Also, the selected regression model should have strong coefficient of determination R^2 value (Montgomery 2010).

5. Results and Analysis

A relationship between the dependent and the independent variables of the form it was calibrated by the method of least squares. This relationship is known as a multiple linear regression model as shown below.

$$Yi = ß0 + ß1X1 + ß2X2 + \ldots + ß\,n\,X\,n$$

Data set are presented in Tables 2 and 3.

Table 2 Total U2 Roads damage because of Drivers' Behaviour for the U2 Roads in the Study Area

N	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
1	24	5	4	2	2	3	3	1	7	22	25	10	4
2	27	2	4	3	2	3	5	2	9	20	25	12	5
3	27	5	4	7	2	2	3	1	9	25	28	11	9
4	29	5	4	2	3	2	5	2	6	21	26	8	5
5	30	5	4	2	2	3	1	2	7	20	21	10	4
6	33	5	4	7	3	4	2	2	5	20	22	9	10
7	33	5	4	3	2	2	2	2	5	22	24	7	5
8	33	2	4	2	3	2	8	2	5	22	30	7	5
9	33	5	4	2	2	4	7	1	5	19	26	9	4
10	34	5	4	4	2	2	4	1	6	23	27	8	6
11	35	2	4	3	3	2	3	2	5	20	23	7	6
12	35	5	4	2	3	2	4	1	7	21	25	9	5
13	36	5	4	2	2	1	3	1	9	20	23	10	4
14	36	5	4	4	2	3	9	2	5	26	35	8	6
15	36	5	4	3	2	3	6	1	9	26	32	12	5
16	36	5	4	4	2	2	8	1	5	21	29	7	6
17	36	5	4	4	2	3	2	1	9	22	24	12	6

18	37	2	4	3	2	2	3	1	5	26	29	7	5
19	37	2	4	3	2	2	1	2	5	23	24	7	5
20	38	2	4	2	2	2	6	1	9	20	26	11	4
21	39	2	4	4	3	1	1	1	7	25	26	8	7
22	39	5	4	4	2	3	6	2	8	21	27	11	6
23	40	5	4	2	3	2	7	1	6	21	28	8	5
24	40	2	4	4	3	3	3	2	5	24	27	8	7
25	40	5	4	2	3	2	5	2	9	20	25	11	5
26	40	5	4	4	3	4	3	1	8	24	27	12	7
27	41	5	4	2	3	2	9	2	6	20	29	8	5
28	42	2	4	2	2	1	4	1	7	25	29	8	4
29	42	2	4	2	2	4	6	2	6	22	28	10	4
30	43	5	4	4	2	4	2	2	9	22	24	13	6
31	45	5	4	3	2	2	6	2	5	25	31	7	5
32	45	5	4	2	2	2	2	1	9	20	22	11	4

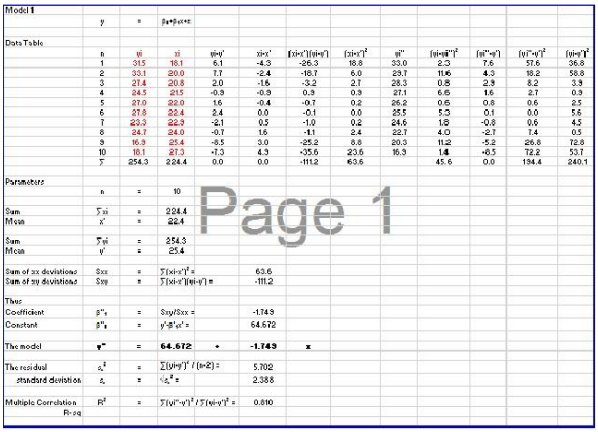
Table 3 Drivers Behaviour Which Contributed To U2 Roads Damage

Y	Road Damage
X1	Date
X2	Time
X3	Type of truck
X4	Loaded or Unloaded
X5	Duration of following
X6	Frequency
X7	Type of access
X8	No of the road that the truck use until reach to U2 road
X9	No of the trucks
X10	frequency and No of trucks
X11	Duration of following and No of roads that the truck driver select till reach to U2 road
X12	Type of truck and loaded or unloaded

Table 4 shown all the variable with R^2

Model No.	Regression Model	Adjusted R^2
1	**y" = 37.697 + -0.348**	0.009
2	**y" = 289.563 + -66.000**	0.000
3	**y" = 38.195 + -0.619**	0.025
4	**y" = 34.364 + 0.818**	0.006
5	**y = 37.437 + -0.468**	0.006
6	**y" = 35.281 + 0.230**	0.011
7	**y" = 35.813 + 0.313**	0.001
8	**y" = 35.728 + 0.082**	0.001
9	**y" = 28.129 + 0.368**	0.024
10	**y" = -57.464 + 3.3129**	0.700
11	**y" = 24.189 + 1.2333**	0.685
12	**y" = 22.956 + 1.6466**	0.291

Screenshot 1 shown a model built in Excel to determine the R^2



6. Conclusion

The significant result obtained from the study, is during working days the average trucks flowing towards city is found to be is more than the U2 roads can carry. It clearly shows that as more trucks using the U2 roads as the U2 road gets more damage.

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