

# Evaluation of Skid Resistance Performance Using British Pendulum and Grip Tester

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**Abstract.** A good road surface texture is very important to minimize road accident due to skidding problem. Many tools are used to measure skid resistance of road surface such as British Pendulum and Grip Tester. British Pendulum can be classified as traditional tool while Grip Tester is an advanced equipment. British Pendulum Number (BPN) and Grip Number (GN) are the output values from the respective tools. The main objective of this study was to establish relationship between BPN and GN. The tests were conducted on Asphaltic Concrete Wearing Course (ACW20) road surface located at selected Expressway in Selangor and State Road in Melaka. The results show a very weak correlation between both tests where the regression value was less than 0.19. It is recommended that further investigation and more tests on different types of surface be conducted to improve the correlation between the BPN and GN.

## 1. Introduction

Road plays an important role in the trade and transportation system throughout the world. In Malaysia, pavement infrastructure development is rapidly increasing. Roads under the Federal Roads Ordinance is link the state capitals, airports, railway stations and ports. In 2016, Malaysia has about 238,789.94 km of roads. The roads are divided into two main categories namely federal (including expressway) (19,802.16 km) and state (218,987.78 km) [1]. The life spans are between 10 to 15 years [2]. In term of structure and surface, road can be classified into flexible and rigid pavements. 95% of the whole world's highways are flexible pavement [3]. Sub-grade, sub-base, road base and the surfacing which consist of binder course and wearing course are the common layer of flexible pavement. The wearing course is the exposed topmost layer that provides the travel path, skid resistance, safety and comfort to the road user.

Within the life span, series and routine maintenance need to be conducted to ensure safety and comfortability of the road users. Normally roads will be maintained by responsibility of local authority or agencies responsive for structural or functional failures [4]. Severe load and environmental demands on the road system, resulting in the need to enhance the performance of the existing road [5]. Friction or skid resistance is one of the important parameter used to evaluate the functional failure of road.

Different devices are used by road agencies to evaluate friction or skid resistance measurement. All devices measure the frictional resistance of rubber material (vehicle tire) over the road surface. Measurement cannot be directly compared as each equipment measures under different physical principles [6].



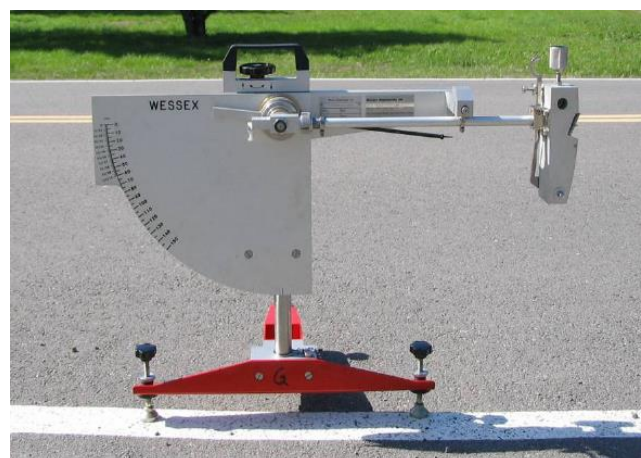
On the other hand, there is a need to compare friction values reported from different international investigations (different country with different devices) for research and improvement purposes [7].

Table 1 shows the generic zone of skid resistance demand. Various testing and environment factors can affect the skid resistance. Understanding the existence factors is important in correlating the result from different devices [7].

**Table 1.** Zones of skid resistance demand [8]

Generic Zone	Recommended minimum level of testing
Low skid resistance demand	Process monitoring (e.g. network laser texture surveys or visual analysis as a minimum)
Medium skid resistance demand	Targeting testing (e.g. portable and towed devices such as British Pendulum, Grip Tester, ROAR as a minimum)
High skid resistance demand	Network monitoring (e.g. SCRIM – where coast effective – portable and low devices as a minimum)
High density urban	SCRIM or Grip Tester for inaccessible sites.

The British Pendulum (Figure 1) is one of the long standing devices and manually operated. It has a small rubber foot (75 x 25 mm) attached to a pendulum that swings over the road surface. The frictional resistance is measured against a scale attached to the equipment. It is extremely versatile in its applications to many test situations and has received acceptance worldwide. The device measure low-speed friction (about 10 km/h) and is commonly used to assess the micro-texture of pavement surface. The pendulum has rubber slider attached to the end, as slider moves across the pavement surface, the frictional force reduces the kinetic energy of the pendulum. The loss in kinetic energy and thus the magnitude of the frictional force in the pavement can be measured from the difference in the height of the pendulum before and after the slider crosses the pavement [9]. Data or value produced from this device is known as British Pendulum Number (BPN).



**Figure 1.** British Pendulum Device [10].

The Grip Tester (Figure 2) is more recent and automated device. Testing can be done using smooth or treaded tires, but for better and more consistent result the smooth tire is preferred. Grip Tester is three wheel machine that is towed by a suitable vehicle with approximately 1 meter long and 60 cm wide. It used tires that rotate at rates less than the tires of the vehicle that the device is attached to. It will produce a braking or sliding action. The braking rate may be fixed or varied and the tire may be straight or set at an angle. Water is supplied to the test wheel as all skid resistance value relate to the wet road surface. The two driving wheels are on single axle, the driving force from this axle is connected to the test wheel but is geared down. The test wheel roll freely, with slip ratio 0%, but when it is locked, its slip ratio is 100%. Test result is automatically recorded which allow more data to be collected and analyzed. The friction coefficient (load/drag) is known as Grip Number (GN) is transmitted to data collection computer [11].



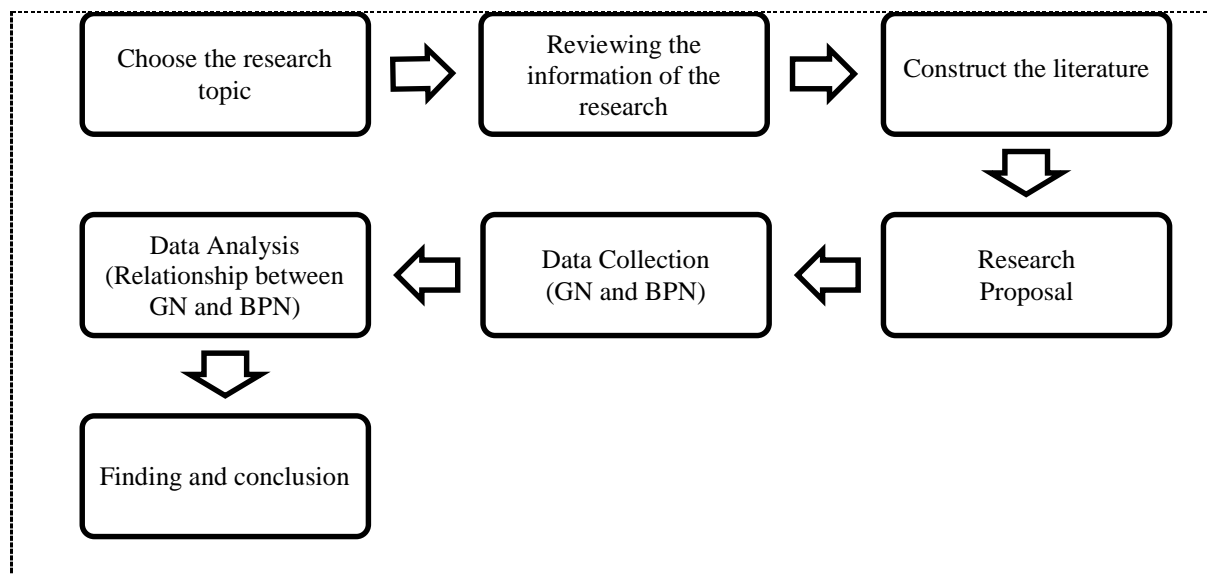
**Figure 2.** Grip Tester Device [10].

Skidding or friction also continues to be a factor in the tendency for accident to take place, more especially when the road surface is wet. Since road agencies usually use different devices to compare friction measurement. Different data might be obtained by the use of different measuring tool. A study conducted in Australia shows that a good correlation ( $R^2 = 0.94$ ) was found between GN and BPN [12]. This paper however, did not give the details of the data, such as the pavement surface type and the test temperature. On the other hand, a study by [13,14] shows a weak correlation between texture depth and the roughness index of the Surface Dressing (SD), Stone Mastic Asphalt (SMA) and Asphaltic Concrete Wearing (ACW) road surfaces. But the general trend shows that higher the texture depth (TD) gives the higher the roughness index (IRI) and the BPN.

Therefore, this study was conducted to get the relationship between two different device namely British Pendulum and Grip Tester and to develop evaluation model to predict the GN based on BPN. This study involved field survey on this ACW20 pavement surface in Selangor and Melaka.

## 2. Methodology

The study involved field survey of two different locations. The first test section was located in Selangor. It was a four lane expressways and the data were collected for both directions. The second test section was a two-lane state road in Melaka. Only one direction data was collected. Figure 3 shows the flow chart of methodology.



**Figure 3.** Flow chart of methodology.

According to BS 7976, the BPN was measured based on the mean of five readings or the constant of three readings. As the stiffness of the rubber slider varied with temperature and a correction was made according to the Table 2.

**Table 2.** Correction of BPN [15].

Category	Indication
40	+3
30	+2
20	0
15	-2
10	-3
15	-5

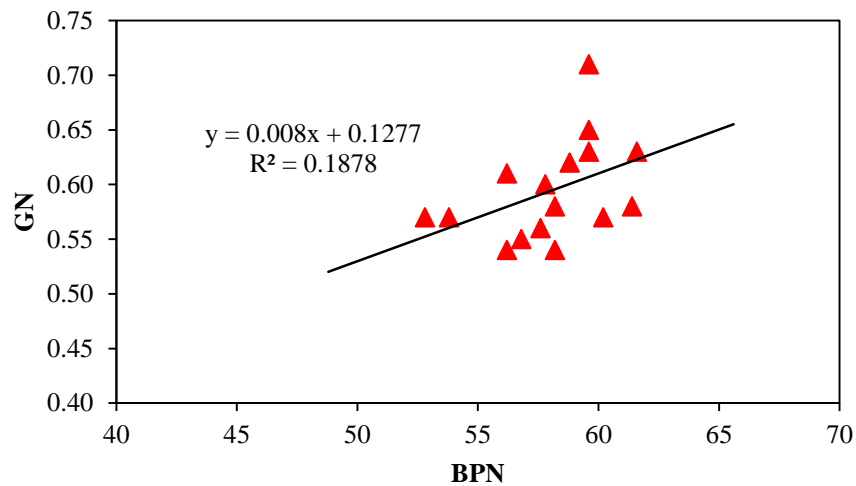
Grip Tester was set to report average skid resistance values at 5 m interval. The target speed for all testing was 50 km/h. Values recorded by Grip Tester at a recorded speed outside 10% of this target speed were discarded during post processing. The target water depth was 0.25 mm. According to the manufacture and standard, a water flow rate 10.4 liter/minute will archive this water depth 50 km/h.

### 3. Results and Discussion

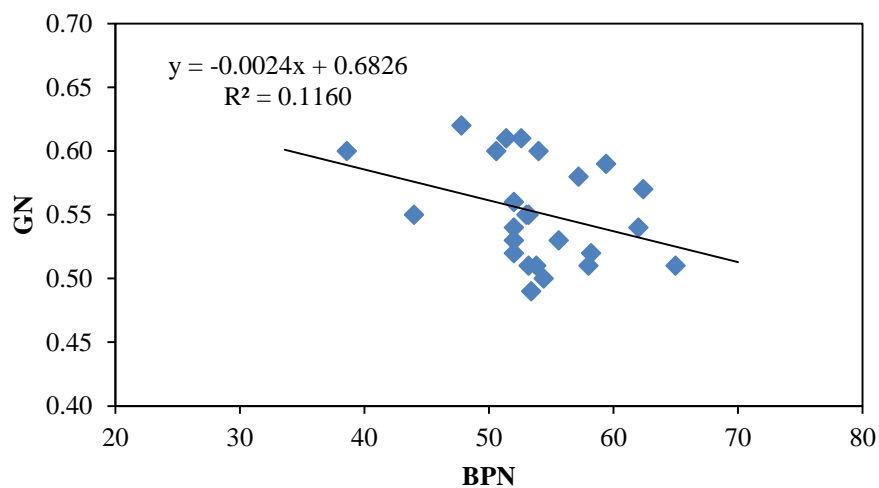
Based on the data, relationship between BPN and GN for both locations show a weak correlation. For road section in Selangor, the highest BPN was 62 and the lowest was 53, while highest GN was 0.71 and the lowest GN was 0.54. For road section in Melaka, the highest BPN recorded was 65 and the lowest was 44. While, 0.62 and 0.49 for the highest and lowest GN respectively. The average BPN for both sections were 58 which was higher than the minimum criteria of 55 for motorways, trunk and class1 roads with heavily trafficked roads in urban areas (carrying more than 2000 vehicles per day) [15].

Figure 4 and 5 show the correlation between the BPN and GN on the ACW20 for Selangor and Melaka site respectively. These data were plotted by BPN as dependent variable and GN as independent variable. The results obtained from these two sections (Selangor and Melaka) were combined and presented in Figure 6.

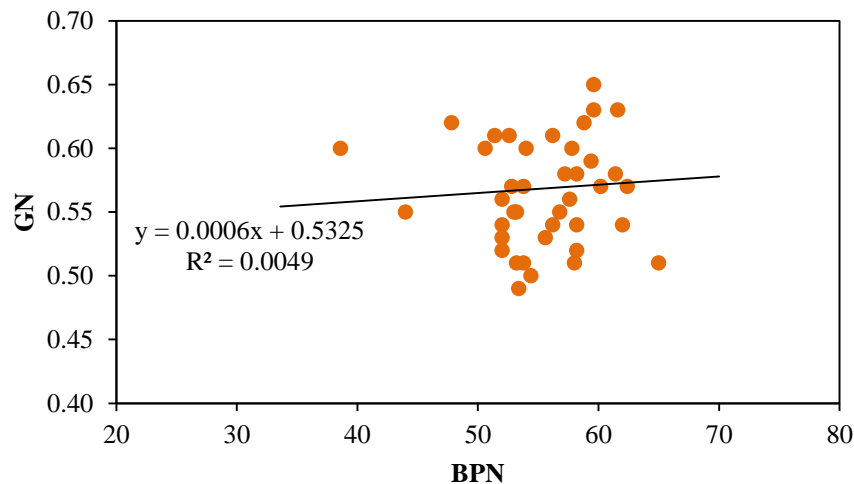
Based on the graph from Figures 4 to 6, the regression value ( $R^2$ ) for Selangor and Melaka road sections were 0.1878 and 0.1160 respectively. The  $R^2$  values clearly indicated that a very weak correlation between GN and BPN. Similar correlation was also found from the combination of both test sections. The findings were contradict with the previous study by Mackey [12]. It may due to several factors such as different type of surface, materials and number of data collected. Thus, no suitable recommendation on the model or prediction equation to correlate GN and BPN could not be established.



**Figure 4.** The correlation between GN and BPN (Selangor).



**Figure 5.** The correlation between GN and BPN (Melaka).



**Figure 6.** The correlation between GN and BPN (Combination Selangor and Melaka).

#### 4. Conclusions

The investigation was undertaken with the objective to develop evaluation model to predict the GN using BPN. In general, very weak or poor correlation was found between both values. Thus, no suitable recommendation on the model or equation to predict GN by using BPN could be established.

#### 5. References

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### **Acknowledgments**

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