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Evaluation of Skid Resistance Characteristics for Pavement Surface

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ABSTRACT

Skid resistance is an extremely important aspect of road safety that needs to be considered when maintaining a pavement. A pavement should have a good amount of skid resistance in order to provide the vehicle's tyre with enough friction when the tyre contacts the pavement when applying brakes. Road accidents can be decreased in large part by having adequate skid resistance, especially in rainy weather. It is one of the most crucial factors affecting road safety as a result. It is the force generated as a tyre that isn't allowed to rotate moves across the pavement. Tyre-pavement interaction leads to pavement friction. Skid resistance is the friction force that develops at the tire-pavement contact zone. It is a safety indicator for driving on the road and plays a significant part in lowering the number of accidents, particularly during rainy seasons.

The sand patch test was used for macrotexture testing in this project, and the British pendulum tester was used for skid resistance testing. Next, using the International Friction Index, friction values at different slip speeds were computed, and the results were correlated with MTD and BPN values (in both dry and wet conditions).

Keywords: Skid resistance, Friction Index, MTD values, BPN values, dry conditions and wet conditions.

1. Introduction

To maintain safe highway operation, it is of highest practical importance, and it is of utmost engineering necessity to be able to offer a comprehensive and suitable analysis and representation of the skid resistance characteristic of a pavement section.

To study the effect of pavement surface micro texture on skid resistance.

To investigate how pavement surface macro texture affects skid resistance.

1.1 NEED OF THE STUDY

A key component of highway driving safety is a pavement surface's capability to provide sufficient skid resistance to moving traffic in wet conditions. Since a pavement's skid resistance tends to decrease over time when subjected to traffic actions, regular measurements and monitoring are required to guarantee that there is enough skid resistance available for secure traffic operations.

1.2 Important aspects of Skid resistance

These pavement types have a specific methodology for the distribution of load on the subgrade. Rigid pavement tends to spread the load over a large area of subgrade since the PCC have high modulus of elasticity (stiffness). The majority of a rigid pavement's structural strength comes from the concrete slab itself. Flexible pavement distributes loads across a smaller area and makes use of a more flexible surface course. For transmitting load to the subgrade, it depends on a number of layer Overall, it may not be entirely clear how one pavement might have been selected over another. Generally, state highway agencies choose the type of pavement based on either policy, economics, or a combination of the two. Periodically ten to fifteen years, flexible pavements frequently need some type of maintenance or rehabilitation. In contrast, rigid pavements commonly survive twenty to forty years requiring little to no preservation or rehabilitation. Therefore, it should not come as a surprise that urban areas with high traffic volumes frequently use rigid pavements. However, there are, of course, trade-offs. For instance, methods for significant maintenance on flexible pavements are often more accessible and less expensive than for rigid pavements.

1.3 MEGA TEXTURE

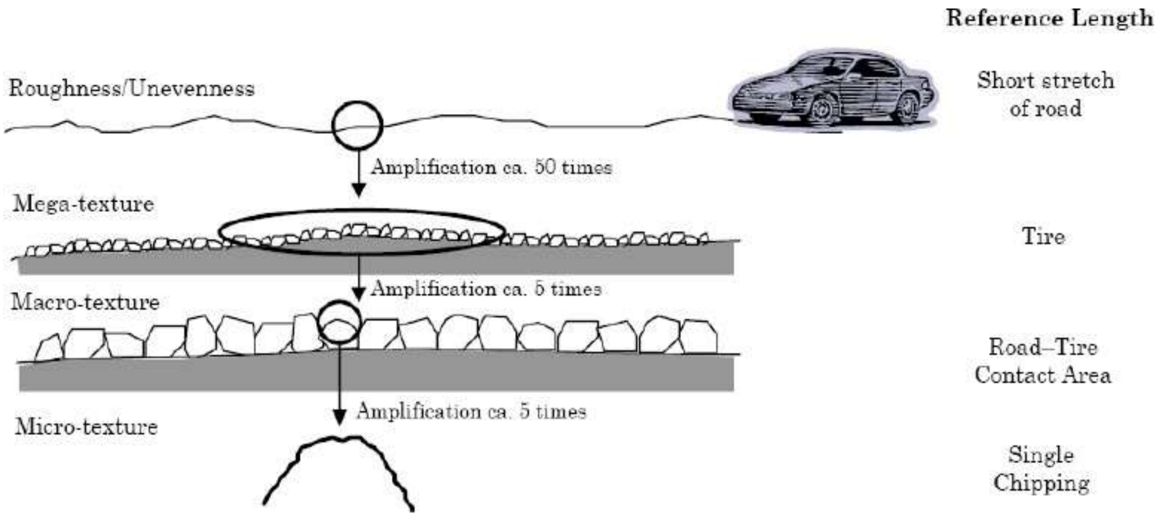
Megatexture is the term used to describe the irregularities (such as distress, defects, or waviness) in the road surface brought on by rutting, potholes, patching, loss of surface stone, and significant joints and cracks. The megatexture affects noise and rolling resistance more significantly than the road surface skid resistance. The texture level assessed in this category is (50 < λ < 500) and (1 < A < 50) (in mm), respectively, in terms of wavelength and amplitude.

1.4 Roughness (Unevenness)

Greater than megatexture, roughness (unevenness) can influence rolling resistance, driving experience, and vehicle running costs. The overall measurement of the state of the surface of the pavement is generally calculated using the International Roughness Index (IRI). This texture level has an amplitude of (1 < A < 200) and a wavelength of (λ > 500) (in mm). Pavement texture attributes are crucial for understanding the tyre-road interactions while taking into consideration a variety of factors, including wet weather, pavement age, binder, noise, tyre wear, rolling resistance, splash or spray, and aggregate geological features. A picture for the ranges of texture types for a given pavement surface is shown in figure 1. About 90% (or above) of the weight of the bituminous mixes and 95% of the total mixture of pavement ingredients is mainly composed of aggregates. The aggregate properties (such as angularity, shape, abrasion and hardness) therefore significantly affect skid resistance.

The hysteresis force of the tyre is produced by the aggregate macrotexture, which also serves to allow water to drain between the tires and the pavement surface area. Additionally, it is applied to the road surface to produce a microtexture that aids in preserving safe friction levels. The geometry of the road, such as the grade and curves, can also have an impact on skid resistance.

To better understand aggregate polishing, which is defined as an abrasion of the microscopic aggregate asperities (microtexture) created by rubbing action after grind and shear caused by repetitive traffic loads, several research have been conducted. One of the most significant pavement texture characteristics that influences the functionality and expected level of skid resistance of the road surface is aggregate polishing. The Polish Stone Value (PSV), which gives information on the vehicle tire's resistance to polishing, can be used to ascertain this.



Ranges of texture types for a given pavement surface (Kumar and Gupta 2021)

1.5 Computed Topography

Based on X-ray attenuation. Each voxel in a 3D voxel reconstruction is given a grey value based on the surface's X-ray absorption and the path taken by the X-ray. It is a type of non-destructive testing. Determination of the inner and outer geometries, high intensity data, and rapid scanning. If the data is accurately recreated, it will have a higher accuracy. The findings of measurement are not traceable and are impacted by numerous variables. There is no accepted testing protocol. It's a highly advanced machine that requires a skilled operator to operate.

1.6 Sand Patch Method

The patch area is calculated by sprinkling a certain amount of sand or spherical glass particles across the surface. By dividing the quantity of a sand or glass spheres (volume) with the anticipated patch area, the mean texture depth (MTD) is calculated. It is the least expensive of the group and is easy to use. Any kind of road surface can be measured with it. It takes a direct measurement of mean texture depth. It is possible to build profiling of the surface in three dimensions (3D). It is incapable of accurately estimating how rough a really rough or permeable surface is. It's also subject to discrepancies in the operators. Measures must be made on a consistent basis. It is a cumbersome system that requires traffic control to protect the operator.

1.7 LiDAR (Light Detection & ranging)

The detection and calculation of parameters pertaining to texture and material information are done using the LiDAR system. It can be installed on automobiles to provide a quick and cost-effective estimate of pavement friction. The accuracy of the test is impacted by weather, markings on roads, and sunlight. More data is needed to improve the friction estimation's accuracy.

2. INTERNATIONAL FRICTION INDEX (ASTM E1960- 07)

In 1992, PIARC funded a global friction harmonisation research that included participants from 16 different nations. The experiment included 51 different measurement systems and took place at 54 different locations throughout the United States and Europe. A variety of friction measuring tools, including pendulum, locked-wheel, side-force, ABS, variable- slip, fixed-slip, and many prototype devices, were evaluated. Surface texture was measured using the sand patch test, laser profilometers (based on the triangulation approach), an optical system (based on the light sectioning technique), and outflow metres. Among the most important results of the PIARC experiment was the development of the International Friction Index (IFI). The assessment of relationship between friction and tyre sliding speed was standardised by the IFI. As a measurement of how much friction relies upon that relative sliding speed of an automobile tyre, the gradients of the friction values obtained above and below sixty kms/h is provided as the outcome of an exponential model for the International Friction Index. The Speed Number (Sp), which describes this gradient, is stated in the range of 1 - 500 kms/h. The PIARC study successfully established Sp as an indicator of the influence of macrotexture on pavement surface friction. Pavement macrotexture is considered as a significant factor in frictional safety aspects for a number of reasons. The ability of macro- texture to hydraulically drain water from wet pavements during or right after a rainstorm is the most well-known justification. This ability also reduces the risk of hydroplaning. The other reason is that Sp's value varies with time for a certain stretch of road, making it possible to assess the macro-texture's deterioration or polishing from Sp. The friction-slip speed curve is regarded as hazardous when it has a distinct peak shape or a steep negative slope. The average driver will notice an unanticipated reduction in braking power when the braking system is depressed to its peak but the brakes power isn't at its peak. The friction-slip speed curve should therefore have the least negative slope feasible or perhaps have a flat form, which can be achieved with the appropriate macro-texture. This index's nomenclature and reporting format are IFI (F60, Sp), which combines the two numbers F60 and Sp. The IFI is supported by the PIARC Friction Model, a mathematical model of the coefficient of friction as a function of macrotexture and slip speed. By using the equations given below, the IFI friction number and speed number are calculated.

2.1 TABLES

Values for Texture depth (Harish H S et al. 2013)

S. No.	Texture (type)	Depth (mm)
1.	Smooth	below 0.3
2.	Medium	between 0.31 to 0.60
3.	Rough	above 0.61

Table1.2 Calibration parameters for some friction measurement systems

S. No.	Parameters	Dynamic Friction Tester	British Pendulum Tester	Skid Tester (Locked Wheel)
1.	S (kmph)	20	10	64
2.	A	0.081	0.056	-0.023
3.	B	0.732	0.008	0.607
4.	C	0	0	0.098

Friction measuring devices

S. No.	Devices	Type of measurement	Mode of Operation	Slip ratio	Test speed (km/h)
1.	Skid Tester (Locked- Wheel)	Dynamic	Locked-wheel	1	64
2.	California Portable Skid Tester	Static	Free-wheel	1	80
3.	Grip Tester	Dynamic	Fixed-slip	0.145	30 to 90
4.	British Pendulum Tester	Static	Slider	1	10
5.	DF Tester	Static	Slider	1	0 to 90
6.	Mu-meter	Dynamic	Side-force	0.13	20 to 80

3. LITRATURE REVIEWS

León et al. (2009) - A study compared and harmonised texture and skid resistance measures taken in 2008 along the Virginia Smart Road by the Virginia Association for Road Surfaces Characteristics (PIARC). A Dynamic Friction Tester, a Griptester, and 2 skid trailers (locked-wheel) were used to gather the data. A circular texture metre was used to collect the macrotexture data. Despite the fact that the PIARC protocols were completely followed, the outcomes were unsatisfactory. From a theoretical viewpoint, all F60 should be equal, however this isn't the situation. Additionally, variations in the estimated International Friction Index values for various instruments suggest that the initial coefficients obtained in the PIARC project for the instruments under study may need to be modified before the International Friction Index can be utilized in various institutions.

Saplioglu et al. (2013) - A research focused on the impact of skid resistance on intersection safety. Urban four-legged signalised intersections in Isparta city were selected for the study. The surface frictional properties were tested using a British Pendulum Tester, and an effort was made to estimate the critical value of skid resistance. The Sand Patch test was used to determine the intersections macrotexture values, and the results showed that surface macrotexture is a contributor in skid resistance. Probability theory-based analysis have been applied for study. The connection between intersection skid resistance and accident rates is explained using this way. After the study's findings are assessed, it becomes clear that pavement roughness is crucial for safety measures at urban intersections.

Harish H S et al. (2013) - In a study, four different road sections were used for the longitudinal skid resistance experiments. The test routes chosen are located in Bangalore and are designed to handle heavy traffic. A british pendulum tester was used to assess skid resistance in the longitudinal direction. Experiments on skid resistance were also conducted for challenging conditions like oil and dry sand on the pavement. Tests were carried out under various pavement surface conditions during the summer and rainy seasons (March and June, respectively). With the use of a portable pendulum skid resistance tester, friction values were collected in a wet environment, and the results were utilized to estimate friction values at 60 km/h by using IFI.

Wang et al. (2013) - In a study, a laboratory model of the evolution of skid resistance of the asphalt pavements was used. Asphalt panels were supplied from a trial path. Aachen Polishing Machine (APM) with real tyre was utilised for polishing in a variety of conditions, and their skid resistance was assessed using the Wehner/Schulze machine (W/S). The removal of the binder and polishing of the aggregate can be precisely characterised using a five-parameter model for skid resistance. It was observed that asphalt panels had different skid resistance characteristics and reached various ending stages under different polishing conditions. It is clear that wet situations, polishing means, and the aggregate-bitumen empathy all had a big impact on the evolution of skid resistance. They could affect the maximum and final values of skid resistance as well as the rate at which the bitumen film is removed. The polishing using the W/S test might lead to exaggerate the expected skid resistance degree if the particle sizes and nature of road dust differ significantly in comparison to the conventional polishing means used in the test. In order to make a realistic estimation of skid resistance, it is advised that the polishing mean having comparable grade with road dust should be used for polishing of asphalt samples.

Ueckermann et al. (2015) - A research focused on an optical texture measuring-based approach for skid resistance assessment of the pavement. In this concept, the surface texture is first measured using an optical measurement method, and then the skid resistance is computed on the basis of texture measured using a rubber frictional model. The fundamental assumptions that underlie the theoretical strategy and the model itself, both of which are founded on Persson's theory, were described. To demonstrate the theoretical approach, the idea was applied to a laboratory instrument known as the Wehner/Schulze (W/S) machine. The outcomes were quite encouraging. The possibility of measuring skid resistance without making contact could be strongly suggested in the future.

Praticò and Astolfi (2017) - Road texture and skid resistance are significant elements impacting traffic safety. Micro-texture and macro-texture have a major impact on pavement skid resistance. The timeliness, affordability, and dependability of the design would be enhanced by skid and texture measurements on samples carried out in a lab early in the design process. Therefore, the aim of this work is to establish and test simple methods on the basis of specimen measurements for measuring skid resistance and road texture. Experiments were carried out, and predicted correlations were found, to explain and anticipate the results. When utilized in specific situations, tests for macro- texture and micro-texture (updated versions of the EN 13036-1 and EN 13036-4) are useful tools for enhancing texture design. Results demonstrate how appropriate the suggested methodology is, and they are advantageous to both researchers and practitioners.

Fwa (2017) - A study developed a mechanically derived three-dimensional finite- element simulation model to describe skid resistance of the pavement under various situations of speed of the vehicle and thickness of water film. Using this method, it is possible to determine how the skid resistance changes with vehicle speed and thickness of water film. By matching the required minimum value with the predicted value of skid resistance of the vehicle moving at a particular speed and thickness of water film, one may use this method to evaluate the wet weather driving threat of a specific vehicle.

Pichayapan et al. (2019) - Through the PSV & asphalt concrete skid resistance, the aggregate frictional performance were evaluated in a study. Here, PSV tests on the limestone and sandy mudstone aggregate and BPT for the skid resistance values of polished Hot Mix Asphalt slabs have been used. According to test results, reducing PSV to 14.5% of sandy mudstone and 47.6% of limestone causes a fall in the skid resistance values of Hot Mix Asphalt slabs of 20.3% and 43.8%, respectively. Consequently, a strong linear regression relationship has been found between the aggregate PSV and the Hot Mix Asphalt slab's skid resistance values.

Pomoni et al. (2020) - By examining data sets of annual skid resistance, macro-texture, and road traffic, a study intended to evaluate the impact of climatic changes over a long period of time and the impact of cumulative road traffic on both skid resistance & macro- texture. Inverse trends in macro-texture and skid resistance were seen in test results under the influence of cumulative road traffic. Finally, it demonstrates the limitations of creating models for forecasting skid resistance under field conditions using only macro-texture data.

Chu et al. (2022) - A study revealed that the British pendulum skid resistance test is a comprehensive conceptual test and that there is a unique one-to-one mechanical relationship between the recorded BPN and coefficient of friction. By creating a 3D finite- element simulating model utilizing physics theories, it is mechanically demonstrated that each test surface with a specified friction coefficient has a specific BPN value. In other words, rather than being an empirical index, BPN is an engineering term with a mechanical connection to the coefficient of friction of the surface to be tested. The theoretical model enables a mechanistic interpretation of the outcomes of laboratory and field studies. The measurement of low-speed coefficients of friction of road surface materials during laboratory design mix and regulation of friction of the in-service roads are two applications where the theoretical validity of the test is particularly applicable.

Zhao et al. (2023) Deep insight on the skid resistance of highway tunnel pavement is vital to driving safety of vehicles. This paper presents a review on the skid resistance of cement concrete pavement in highway tunnel. Firstly, this paper summarizes the pavement working environment in highway tunnel. Secondly, tire-pavement friction mechanism, friction measurement methods and the pavement skid resistance inside and outside highway tunnel are reviewed and discussed. Then, the pavement surface texture and the measurement methods are provided and discussed. The anti-skid evaluation models are also reviewed. Finally, the anti-skid methods of cement concrete pavement including resurfacing techniques, and anti-skid overlays are overviewed. Research results show that hysteresis and adhesion can be considered as the main effects contributing to the overall friction force. But the interface contact issues of rubber are also significant for the tire-pavement friction mechanism, which are recommended for further study.However, the rubber's interface contact problems are also important for the tire-pavement friction mechanism, and more research on these matters is advised. Different application conditions and indicators apply to different friction measurement techniques. Additional study on the normalization of various friction measurement techniques is still required. Non-contact measurement techniques have more promise for use in pavement texture assessment than do contact techniques. Finite element models are more economical and efficient when evaluating tire-pavement interaction than classic empirical models, and they can also offer improved accuracy and reliability. But additional focus is needed because pavement texture morphology—more specifically, pavement micro-texture—plays a big part in examining the micro-contact. Adaptive models provide a great deal of potential for tire dynamics modeling and simulation. Anti-skid overlays can offer greater skid resistance and a longer useful life than resurfacing procedures. Compared to existing anti-skid overlays, the Novachip ultra-thin wearing layer has a more promising future in highway tunnel pavement.

4. STUDY OF METHODOLOGY & DATA COLLECTION

Skid resistance is the force produced whenever a tyre is prevented from rotating and slides onto the road. The interaction of the tyre and the pavement causes pavement friction. Skid resistance is the force of friction generated at the zone of tire-road interaction. It is a key indicator of how safe a road surface is and helps prevent crashes, primarily when it's wet. A survey indicates that 14% of all fatal traffic accidents occur during wet weather conditions. The rate of accidents during wet conditions is inversely variated with the skid resistance for all types of carriageways. Various elements like as pavement surface, tyre properties, and environmental-related parameters influence skid resistance. Dependent on the tyre's rotational speed as well as the pavement surface properties, the tyre may begin to slide when the optimum friction has been reached. Skidding causes a considerable loss in vehicle braking and steering, which has a direct impact on pavement damage and, in the worst cases, human fatalities. As a consequence of hydroplaning phenomena (if a tyre rolls at a greater speed over wet pavement, causing hydrodynamic forces to lift the tyre), this difficulty is worsened when the pavement surface is wet. Skid resistance explains how a pavement surface contributes to the development of friction at the zone of tyre-pavement interaction. Unfortunately, the road surface roughness diminishes with time due to traffic movement and various other factors, resulting in the depletion of skid resistance. Friction is caused by the geometrical characteristics of the vehicle tyre and the road surface. Due to the intricate interplay of the two main components which are hysteresis and adhesion, friction comes into play.

Skid resistance on pavement surfaces is commonly measured using a variety of approaches. Based on the method used, the skid resistance assessment may vary a bit due to unfavourable factors and circumstances. The criterias frequently used to assess skid resistance are as follows:

Procedures for determining skid resistance on-site;

Tests conducted in labs using field specimens or intended to further study objectives;

Modern innovative methods are being used to gather data on a number of subjects, from road characteristics to climate factors, including non-contact sensors that can be used in substantial lab tests or direct on-site assessments.

5. Factors related to the pavement surface.

With the exception of surface ageing, most surface features are thought to be under the control of highway authorities. Road texture, type of surface, aggregate quality, and age of road surface are discussed in this section, and their impact on skid resistance have been discussed further. When a tyre-pavement interacts, the fluctuations present in a smooth and planar surface are considered as road textures. The road surface asperities are something what the texture is all about. The two types of texture that most affects the surface friction are the macrotexture and microtexture. According to previous researches, a deeper pavement texture is required for adequate wet skid resistance, especially in case of vehicles moving with greater speeds. Pavement macrotexture affects skid resistance the most.

5.1 Pavement Microtexture

The asperities produced due to the surface aggregates determines the microtexture of the pavement surface. According to ASTM 867, the fluctuations of road surface with wavelength and amplitude less than 0.55 mm are regarded as microtexture. It is generally the aggregate surface's texture at a microscopic scale, which regulates the tyre rubber's interaction with the pavement. Microtexture is influenced by environmental factors and traffic. It depends on the mineral composition and geology of the aggregates. It is primarily responsible for low speed pavement friction. In warm climates, where bitumen has a low viscosity, the binder becomes molten at a higher temperature and begins to flow and fill micropores, diminishing the road surface microtexture. The microtexture decreases with polishing of the road surface aggregates due to traffic. More is the microtexture level, more will be the surface friction, resulting in better skid resistance level. Studies shows that Coarse aggregate surface tend to have a smooth microtexture as a result of the reduced exposed area of surface, leading to reduction in the value of skid resistance. Since aggregate polishing is a long duration phenomenon, microtexture is particularly significant for aggregate skid resistance in long run. The microtexture appears to rise with the exposing of aggregates to traffic for the first time, as traffic polishing drastically deteriorates the uppermost asphalt binder coating. The same upward tendency may be seen in skid resistance. With time, the aggregates gets more and more polished due to traffic movement, resulting in the diminishing of the pavement skid resistance gradually. Aggregate microtexture also aids in cutting the water depth formed at the tyre-aggregate contact zone, which contributes to wet skid resistance. According to studies, hydroplaning is delayed in the road sections having adequate microtexture.

5.2. Pavement surface type

The change in asphalt mix has a substantial impact on skid resistance since it allows for a large range of aggregate gradation, size and shape of aggregates, angularity of aggregates, and mineralogy of aggregates, as well as a wide range of binder content. Porous surfaces have been found to provide higher resistance to vehicular movement than denser and smoother surfaces. Porous asphalt surfaces have greater macrotexture in comparison to ultrathin surfaces and further ultrathin surfaces have greater macrotexture and thus greater friction due to hysteresis in comparison to stone mastic asphalt, according to studies. As far as adhesion properties are concerned, open graded friction course (OGFC) had better adhesion than stone mastic asphalt (SMA),which in turn had better adhesion than asphalt concrete (AC) pavement. So, it can be said that OGFC pavements shows better resistance to skidding when compared to other pavements of different gradations. Dense graded HMA has lesser depth of macrotexture (usually 0.4–0.6 mm and 0.6-0.12 mm for fine graded and gap graded respectively) in comparison to open-graded and gap-graded mixes. Studies on the influence of mix's binder content on friction shows that on raising the asphalt concentration beyond the optimum value reduces the mix's skid resistance. Researchers also discovered that mixes creating utilizing the Superpave design mix technique have higher skid resistance in comparison to those created utilizing the Marshall design mix technique.

6. Factors associated with vehicle operation

In this part, element related to vehicles such as slip ratio, action of braking, speed of vehicle and inclination of tyre, as well as how they affect the skid resistance of the road surface have been discussed. Slip ratio have been considered as a very important component in determining thee skid resistance at the tyre-road interaction zone. Rest of the elements are thought to be under highway engineer's control but are comparatively not so important as far as their alteration with skid resistance is considered.

6.1 Speed of vehicles

In wet surface conditions, vehicle speed is particularly important because as the speed increases, tyre tread has less time to pass enough water at the tyre-road contact zone. Another factor that increases with increased speed is the vehicle's stopping distance, which is a considerable issue for road users. As the vehicle's speed increases, skid resistance decreases fast, reaching a minimum at 100 km/hr. Vehicles travelling at fast speeds are thought to be at an enhanced risk of skidding in rainy weather conditions. It's because the water that has gathered in the tyre-road contact zone hasn't had enough time to evaporate.

6.2 Slip ratio

The discrepancy between the theoretically predicted forward speed (on the basis of rolling radius and rim's angular speed) and the real speed of the vehicle is known as the slip ratio. Researchers use the phrase "slip ratio" to distinguish between tyre and vehicle velocity. The slip ratio is 0 when the tyre is rolling freely. When the tyre is locked, on the other hand, the slip ratio is 1. Due to the lack of rolling, the locked wheel suffers from localized wear. The conventional friction-to-slip-ratio relationship illustrates that friction decreases continuously after a certain slip ratio value. Investigators attempted for determining the relationship between tyre slip ratio and surface friction, as well as the connection of slip ratio of tyre with the surface sliding friction. Lesser skid resistance values pose danger to driving safety circumstances and can be seen when the wheels are nearly locked. With varying slips, the friction coefficient between the road surface and the tyre changes. When the slip ratio is increased to a peak value, which is normally between 10% and 20%, it climbs rapidly. When the slip ratio is 100 percent, the friction reduces to a certain value termed as sliding friction coefficient. According to research, a tyre with an 86 percent slip ratio has less hysteretic friction than one with a 20 percent slip ratio.

7. Factors related with tyres

A couple of interacting bodies come into contact at the tyre-road interaction zone, which are the tyre and road surface itself. A tyre is a complicated three-dimensional structure that uses tyre inflation pressure to permit loading on the surface of the road. When it comes to the regulation of skid resistance at the tyre-pavement interaction zone, its critical to understand the unique properties of tyre tread pattern and inflation pressure. Tyre tread pattern is a very important element which controls the skid resistance at the interaction zone since tread depth regulates the tyre's drainage ability as well as the area of contact. The following sections discusses how load of traffic, tyre's tread pattern and inflation affect the pavement's ability to resist skidding.

7.1 Tyre tread pattern

The stiff rubber that surrounds a tyre's circumference and makes a direct contact with the surface of the pavement is referred to as tread. It has an impact on the rolling resistance, ride comfort and control, vibrations, and sound characteristics of the interaction between tyre and the pavement. Deep treaded tyres are commonly thought to be a significant measure for channelling water away from the tyre-pavement contact zone. When the depth of the treads reduces, as it does with old-used tyres, the tread's drain-off ability also reduces, posing a major threat to driving security. As a result, many nations have set a Minimum permissible tread depth (for example, 1.6 mm in USA, Canada and UK). Deep treaded tyres have more grip and thus ensure the required friction at the tyre-road contact zone. The tread depth is especially significant for vehicles travelling at high speeds through thick layers of water. In a study, fully worn tyres were found to have a 45 to 70% reduction in wet friction when compared to fresh tyres.

7.2 Tyre inflation pressure

Tyre stiffness is closely related to inflation pressure and the road surface friction characteristics; in fact, pavement's skid resistance and tyre's inflation pressure are directly correlated. Because it has an impact on both efficiency and safety, the tyre inflation pressure's study has always been important in highway engineering. Fuel efficiency, rolling resistance, skid resistance, tyre tread wearing and contact area are all affected by the inflation pressure of a vehicle tyre. As the inflation pressure drops, the tyre-road contact area rises. As a result, there is an increase in the hysteresis and adhesion between the tyre and the pavement surface. And thus, the amount of skid resistance experienced by the moving car also increases. Researchers investigated the impact of changing tyre inflation pressure on pavement skid characteristics and discovered that with a 28.57 percent decrement tyre pressure, there was 48.52 percent increment in rolling resistance. Again with 28.57 percent increment in tyre pressure there was 13.46 percent decrement in rolling resistance. In a separate investigation, it was discovered that lower tyre pressure results in increased rolling resistance.

8. Equipment used

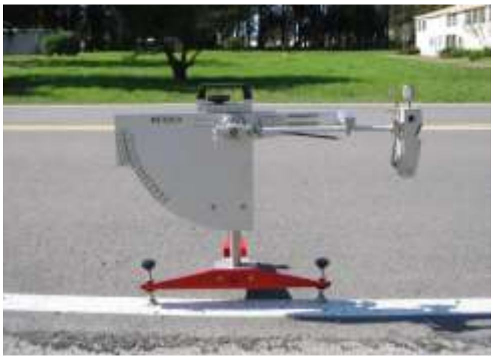
8.1 Grip tester (ASTM E1844 – 08)

This is portable, light in weight, and convenient to use. In this test, braked wheels, fixed slip designed with load and drag are quantified persistently. It may be employed in push modes in addition to any of the regular testing speeds till 130 kmph. For this test, assessment is simple and can be done on-site in only 10 minutes. Data acquisition and presentation is rapid and simple.

8.2 British pendulum tester (ASTM E 303-93)

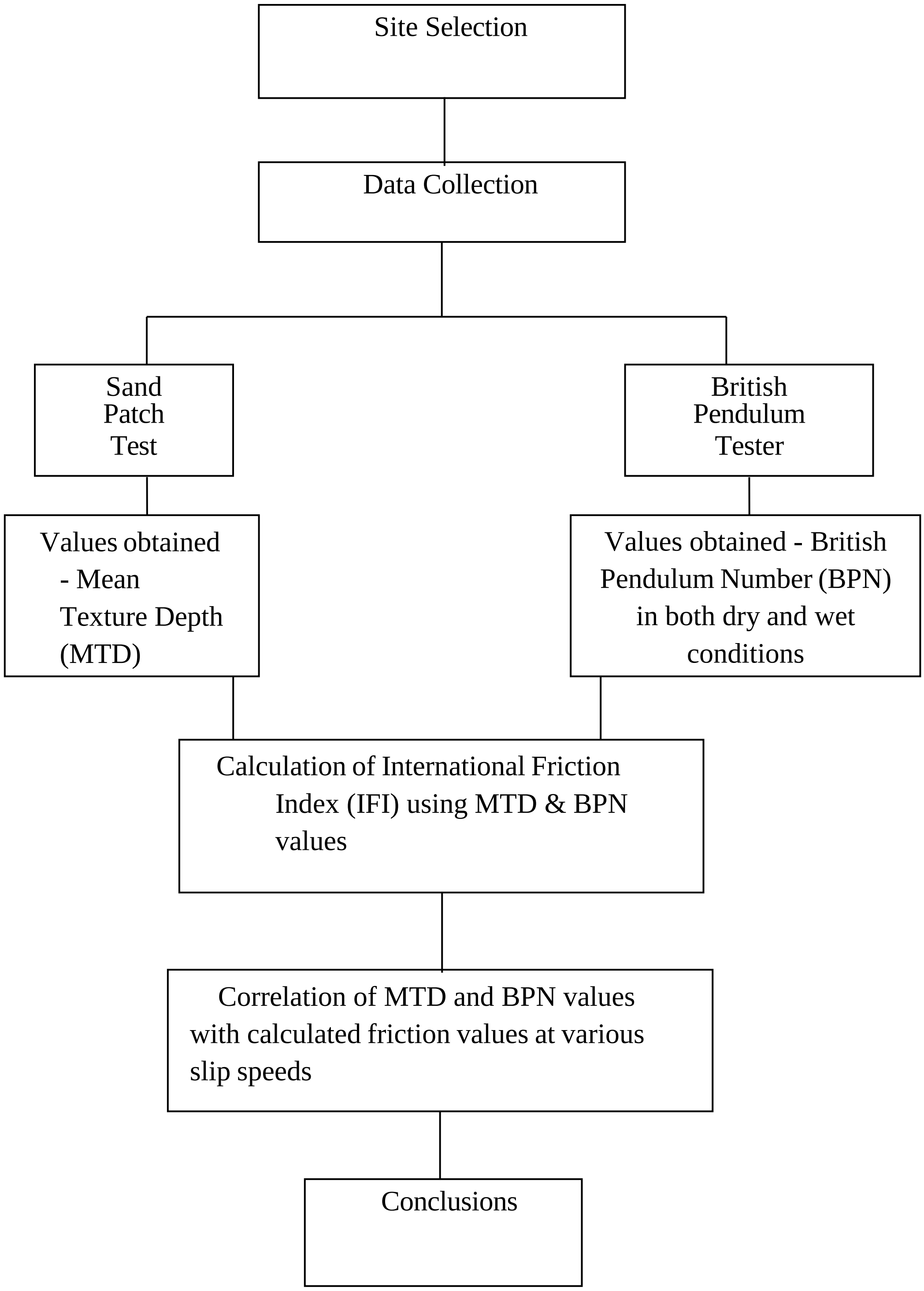
A rubber slider edge is dragged across a testing surface using the British Pendulum Tester, a dynamical pendulum impact-type testing machine, to determine how much energy is lost. The device is suitable for flat surface tests in the lab and out in the field, as well as evaluating polished values on curved lab samples obtained from stone polishing machines. For plain surfaces and polished values for stone polishing machine specimens, the frictional values acquired with the device are represented by the British Pendulum Number (BPN) values

Grip tester

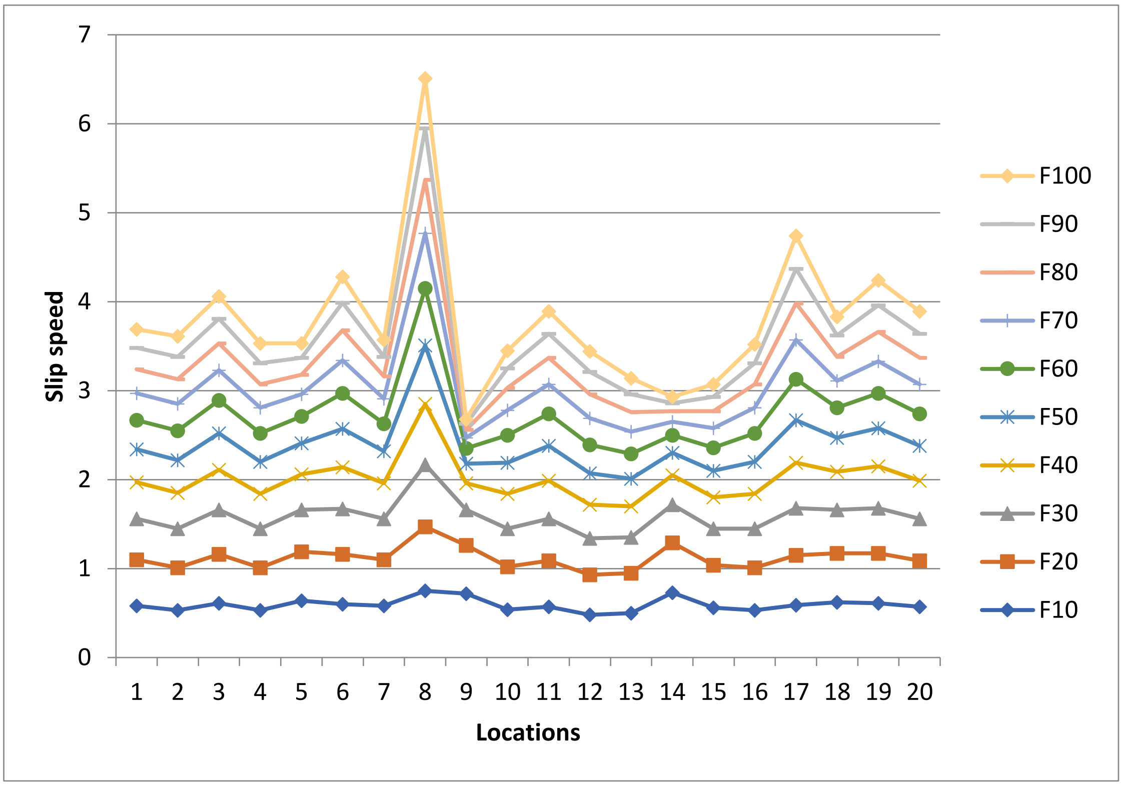


British pendulum tester

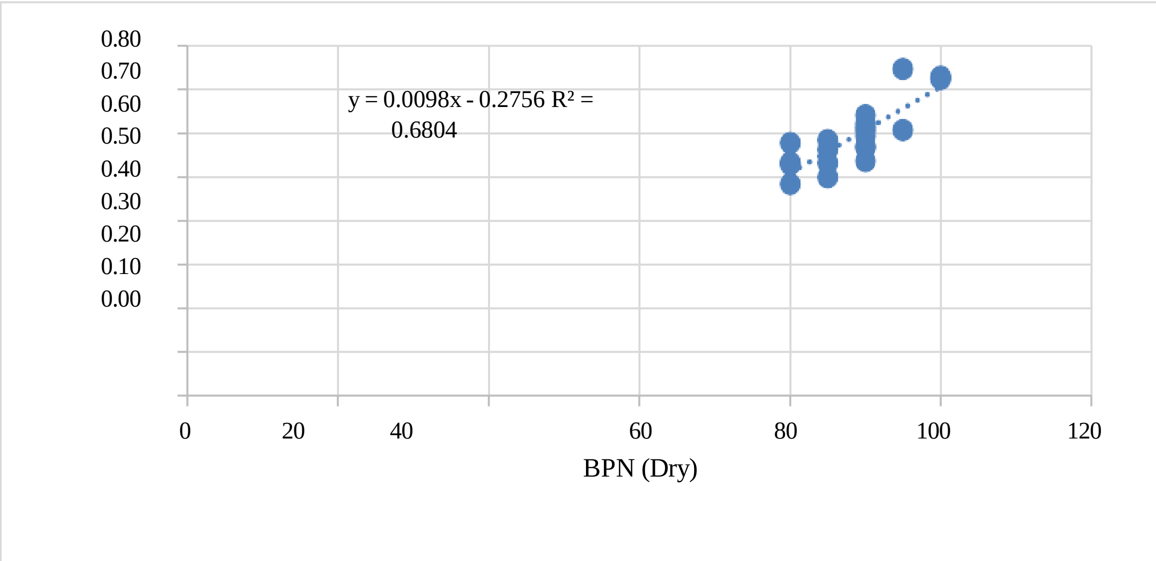
9. FLOW CHART


Site Selection
Data Collection
Sand Patch Test
British Pendulum Tester
Values obtained - Mean Texture Depth (MTD)
Values obtained - British Pendulum Number (BPN) in both dry and wet conditions
Calculation of International Friction Index (IFI) using MTD & BPN values
Correlation of MTD and BPN values with calculated friction values at various slip speeds
Conclusions

10. DATA ANALYSIS



LOCATION V/S SLIP SPEED



CORELLATION BETWEEN BPN (Dry) & F10 VALUES

Mahamaya Inter College Road (Left Side)

MTD		**0.67**
BPN	**Dry**	**90**
	Wet	**65**

Amity School Road (Left Side)

MTD		**1.17**
BPN	**Dry**	**90**
	Wet	**65**

Dabri to Gurugram Road (In front of Manipal Hospital

MTD		**0.66**
BPN	**Dry**	**85**
	Wet	**55**

205 Delhi Road (In front of NISD) Left Side

MTD		**0.97**
BPN	**Dry**	**80**
	Wet	**55**

11. CONCLUSIONS

Macrotexture is a consequence of the qualities of the asphalt mix as well as the manner of placing, while microtexture is a consequence of the mineral composition of the aggregate and the roughness of the aggregates themselves. Numerous researchers looked into the connection of skid resistance and road texture levels and came to the conclusion that while macrotexture contributes to skid resistance when travelling at greater speeds on wet surfaces, microtexture contributes to skid resistance when travelling at lesser speeds on dry surfaces. A key characteristic of macrotexture is the reducing of the hydroplaning phenomena, which happens at greater speeds when the thickness of water film on the road’s surface is more than 0.5 millimeters. This suggests that enough macrotexture must be maintained, especially on motorways and other higher-speed roadways.

The correlation between BPN readings in wet condition and calculated friction values are firstly increasing for slip speed 10-20 kmph and then decreasing. The BPN readings (wet condition) in overall are showing moderate to strong correlation. It can be stated that with higher BPN values the friction values obtained will also be higher.

12. REFERANCE

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