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Review Article

Effect of thermal variances on flexible pavements

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ABSTRACT

This article presents recent findings on the effect of thermal variances on pavements. It covers temperature measurement in asphalt pavement; the history of asphalt pavement temperature prediction models, determination of asphalt layer depth temperature; main factors contributing to temperature variations in the asphaltic pavement; energy balance in flexible pavements; asphalt pavement design incorporating the temperature factor; the effect of temperature on the structural performance of asphalt pavement; and environmental factors. The study concluded that temperature substantially affects the asphalt pavement layer's mechanical and physical material characteristics. This study has taken a close look at how pavement temperatures are measured and the models used to predict future temperatures. The research shows that temperature significantly affects the mechanical and physical properties of asphalt pavement layers.

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1. INTRODUCTION

When a mechanistic-empirical method is used to design a flexible pavement, the temperature is the factor that has the most effect on the process. While studies have looked into how climate affects pavement designs, not many have looked into whether or if specific temperature indices connect with distress on the flexible pavement.

Seasonal and daily changes substantially influence the stability of flexible pavements, especially the design process's long-term success in terms of ambient air temperatures, solar radiation, pavement materials and shape, convective surface, and precipitation. The precise forecast of the temperature and their variances is essential for pavement deflection evaluation, pavement modulus back-calculations, frost action estimates, and diurnal and seasonal thermal and cooling impacts assessments.

In selecting the level of asphalt used in various works, it is essential to correctly evaluate the thermal stresses between asphalt layers to precisely forecast asphalt pavement temperatures at various depths and horizontal positions based on thermal conditions. This is particularly important when the asphalt pavement is exposed to severe extremes of freeze and thaw [1]. A precise understanding of the pavement temperature combined with the thermal stress distribution enables a more intelligent choice of asphalt binding grades for different pavements. Lower-grade lower-cost binders may thus be specified for lower lifts where more

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minor temperature changes are usually encountered, and lower-grade lower-cost binders are available for lifts with substantial temperature variations. This difference will be a cost-effective answer to increased pavement expenses [1, 2]. A typical Pavement Structure is presented in Figure 1.

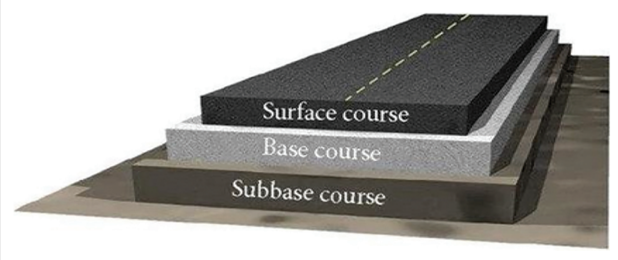

Figure 1. Typical pavement structure [2].

2. TEMPERATURE MEASUREMENT IN ASPHALT PAVEMENT

One significant element for road quality is the asphalt temperature at which the road is constructed but experiences over the past several years indicate a connection between certain other critical variables in road construction, such as compaction, segregation, and temperature [3, 4]. Authorities and construction firms are beginning to think about finding a method to analyze the quality of work and the material by measuring the temperature of the material being supplied and analyzing the thermal variances at different stages from construction to the usage of the pavements [5]. Doing so would better understand a lot, and the process would lead to a better pavement and create new opportunities to improve its quality. Temperature measurement in pavement engineering is fundamental and must not be trivialized. There are many methods and solutions to accomplish it, depending on what and why the pavement temperature needs to be checked or assessed. The temperature is sometimes measured using a sensor in contact with the pavement in question. However, the heat radiation of a substance may also be measured contact-free. This radiation is its infrared surface emission. Both techniques have benefits and are reliable [6, 7].

The binder bitumen is an essential component of asphalt. Bitumen itself is a very temperature-dependent substance. One of the significant reasons why it is essential to pay attention to the temperature of the asphalt material is, On the one hand, asphalt at too low temperatures is not desirable as it leads to many distresses, while on the other hand, excessively high temperatures may have a poor effect on the pavement as it leads to melting of the pavement as is seen in many countries with high temperatures. It is thus essential to operate with asphalt in a specific temperature range [8].

3. CLIMATE AND ENVIRONMENTAL FACTORS

A comprehensive literature analysis was carried out to examine previous studies that captured the impacts of climatic variables on thermal stresses in pavements, particularly concerning ambient air temperature variations. Research indicates that the climate and the environment significantly impact moisture damage and increase distress in flexible pavements [9, 10]. In addition to the quantity of rainfall, sub-surface water in the pavement and other environmental variables may influence the degree of moisture damage to flexible pavements [11].

Below are some climatic and environmental variables contributing to Hot Mix Asphalt (HMA) pavement deterioration.

- Heat after the rainfall may generate blisters on the pavement surface, which can form a depression if ruptured [12].
- High precipitation impacts the water in the pavement [12].
- Freezing and thawing pressure and water motions may break up asphalt and encourage deterioration [12].
- Fatigue or low-temperature cracks may encourage peeling because they enable water to enter [11–13].
- Temperature may also influence moisture damage.

Field experience has shown that pavements installed in cold seasons may be more difficult to compact, thus having a higher air vacuum and a more excellent permeability than pavements placed in warm weather. This may enhance the moisture susceptibility of the pavement [13]. In addition to the above, some other essential points responsible for distresses in pavements to be considered are;

- Aging improves asphalt stiffness, thus reducing the vulnerability to moisture damage [13].
- Research has found that low water pH (i.e., acidic) supports acidic asphalt retention, while high pH (i.e., primary) supports acidic asphalt retention on essential aggregates [14].
- High water table frequently allows moisture/humidity vapor to migrate to a pavement, increasing moisture damage [14–16].
- Microorganisms may also be present in the binder and the surrounding soil [16, 17]. These asphalted bacteria are fed on the hydrocarbons found in the asphalt, thus, allowing the water to reach the binder interface by establishing voids in the structure this water availability in the voids and the pumping action of repeated wheel loads may trigger stripping problems.

The performance of bituminous materials is primarily influenced by the maximum and lowest temperatures and may vary considerably in their mechanical characteristics [18]. The impact may be seen through changes in the bitumen or asphalt mixture stiffness and the life span of the materials. In addition, temperature variations that could negatively affect a pavement may be attributed to weather variables such as air temperature, solar radiation, and wind [19].

4. HISTORY OF ASPHALT PAVEMENT TEMPERATURE PREDICTION MODELS

The prediction of asphalt pavement temperature may be separated into (1) numerical and finite element techniques; (2) theoretical and analytical approaches; and (3) statistical and probabilistic modeling based on the study methods and analysis tools used in the research [20].

Researchers have studied climatic variables' effects on asphalt pavement from an early stage. Moreover, the researchers who studied the temperature of the asphalt pavement focused on the distribution of temperature in various depths; theoretical frameworks based on the one-dimensional thermal driving model and the finite difference method (FDM) have been used to simulate the temperature distribution of the pavement structure [21].

In 1987, in the United States, the long-term pavement performance project (LTPP) measured asphalt pavement temperature [22]. The research focused on a novel data analysis strategy for pavement asphalt. Data, including atmospheric temperature and solar radiation, as well as their relationship with pavement temperature, have been made available, forming a critical database that facilitates and stimulates research in the field by using the regression method to develop models for predicting asphaltic temperature [22].

In the first stage (1950–1990), scientists focused on the fluctuation and distribution of temperatures. A limited number of studies utilized pitching techniques to estimate pavement temperatures. In the 1990s, Canadian and American researchers focused on utilizing a novel technique for analyzing data on asphalt paves. As a result, a valuable database is currently accessible to assist research on pavement temperatures based on many data and information on pavement temperatures and climatic factors, such as air temperature and solar radiation [23].

In that second step, however, most researchers used the reversal technique to build models to forecast the temperature of asphalt by focusing on the lowest and highest asphalt pavement temperatures throughout the service period using the Superpave method. Consequently, many studies have also begun to examine daily pavement temperature forecasts with somewhat varied changes and have been effectively applied in road engineering.The researchers employed statistical methods during a third phase, from 2000 to the present, to develop a regression prediction model in two applications, namely to correct deflection measurements in pavement layers with a back-calculation method and to simulate temperature fluctuation distributions in the structure of the asphalt [23–25]. The third phase of the study is heavily affected by the research results in the preceding phase, despite the significant expansion of the area of inquiry. To sum up, temperature prediction models have been enhanced and improved by the fast growth of the database in the 1990s up till now. At present, the application of big data, artificial intelligence, and the likes has become prevalent in establishing temperatures and the variances in pavements.

5. DETERMINATION OF ASPHALT LAYER DEPTH TEMPERATURE

Three typical techniques are used to determine the temperature through the depth of an asphalt layer, including in-situ tests, the American Association of State Highway and Transportation Officials(AASHTO) method, and the BELLS model [25]. Another method is the indirect measurement, in this method, the temperature of an asphalt layer is measured every 1 to 1.5 hours using a thermometer when a hole to half the depth of the layer is perforated during Falling Wheel Deflectometer (FWD) testing [26]. Drilling the hole provides heat, and for this reason, the test result could be affected by the increased temperature between the instrument used for boring and the adjoining pavement layers, it is thus, recommended that at least 20 minutes of temperature readings should be carried out [25]. On the other hand, halting the FWD tests will decrease the test's effectiveness in detecting the pavement layers' temperature. The measurement of temperature at single points is another drawback of the direct measurement technique, expanding it across a stretch of the road that leads to severe uncertainties' [25, 27].

In addition, the pavement layer thicknesses typically fluctuate throughout the route, thus providing an additional source of inaccuracy for measuring the temperature at the middle depth of the asphalt layer. To develop dynamic modulus master curves of asphalt layers, using a direct measuring technique to estimate the pavement temperature during FWD testing is imperative, a simple method of testing pavement temperature is as demonstrated in Figure 2.

The pavement surface layer temperature is monitored to determine the temperature of the asphalt layer in the AASHTO technique. This is either determined by measuring the temperature at 25 mm depth or by the FWD infrared thermometer reading. Moreover, the prior mean air temperature for five days (i.e., before the FWD test) and the total asphalt layer thickness are revisited. The surface temperature is monitored with this information, and temperatures are calculated using the AASHTO graph at half depths and the bottom of the asphalt layer (AASHTO 1993). This technique defines the depth temperature of the asphalt layer as the average of the three above [26, 28, 29].The climatic changes in the last five consecutive days before testing, which may influence the final temperature of the asphalt layer, are a significant drawback of the AASHTO approach [26]. In addition, no distinction is made between the positive temperature gradient at the beginning of the day, the surface temperature being higher than the depth, and the negative temperature gradient at the end of the day [26].

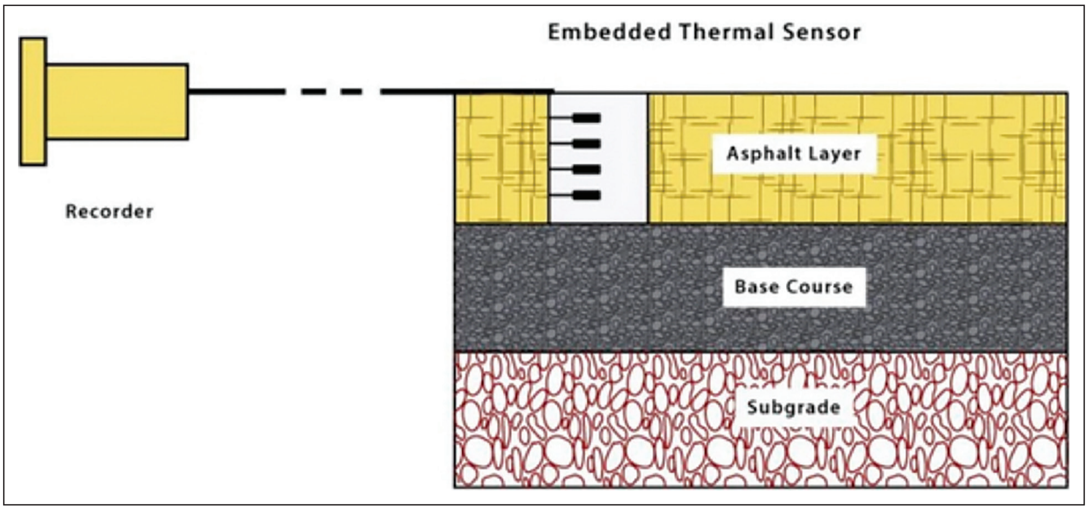

Figure 2. Representation of the method for measuring pavement temperature [2].

6. MAIN FACTORS CONTRIBUTING TO TEMPERATURE VARIATIONS OF ASPHALTIC PAVEMENT

Temperature is an essential indicator for determining the road surface temperature. The historical temperature condition shows that the current temperature of the pavement is a function of different factors and is also meaningful for decision making. However, to calculate the pavement temperature, there is still a debate on the temperature data to be selected. The temperature data of the past five days must be used if a result close to reality is to be obtained.

In addition, some prediction techniques for asphalt pavement temperatures require the previous day's temperature data. The sun's radiation may also raise the road surface temperatures and the temperature but will have an even more significant effect on the asphalt pavement temperature. A numerical method based on finite-difference modeling is proposed by [30], which evaluates temperature distribution in pavements depending on changes in the thermal environment. The model anticipates temperature variations in rates and depth during freezing and thawing cycles. However, the proposed model does not include surface cooling effects owing to precipitation, the influence of the tilt angle of the surface on surface boundary conditions, and internal heat stresses of the pavement due to different temperature levels.

Evaluated various computer algorithms for predicting the temperature of the asphalt-concrete pavement. The research compares the findings produced by the integrated Federal Highway Administration (FHWA) model with actual pavement temperatures [31]. The research shows that ignoring edge effects is not relevant for regular cross-sections but for the shoulders and extreme cross-sections. Researchers proposed an analytical method for examining rigid pavements exposed to temperature load in combination with finite-element algorithms. The pavement is idealized as a thin isotropic platform sitting on an adjustable base of the Winkler type of foundation. The results produced from simulations for both linear and nonlinear temperature changes are given and contrasted. This research indicates that rigid pavement design cannot overlook temperature stresses [32]. Experimental and analytical research is given to create a technique for determining realistic stress caused by the thermal load. The research revealed that the overall temperature distribution throughout the concrete sheet depth is greater than the temperature difference between the extreme sheets [33].

Researchers have examined relationships between climatic variables and structural pavement characteristics in light of data obtained under the Long-Term Pavement Performance Seasonal Monitoring Program. Various statistical studies have been used to study the relationships between structural pavement characteristics and climate variables [33]. Changes to environmental variables may alter paved conditions and thus eventually affect the stiffness and degradation of pavement materials, thus affecting the performance in-service. These variables are always considered in pavement design and construction [34]. For example, the selection of bituminous binder grade is decided to match local temperature conditions to satisfy functional and structural needs [34, 35]. Despite the careful attention paid to environmental variables in pavements, difficulties arising from changes in those parameters are inevitable and frequently significant [36]. In its evaluation of material reactions and projections of long-term performance, the previous researchers examined the impact the environment has on pavement performance and documented effects on pavement environmental variables (e.g., temperature and humidity profiles) [36, 37].

In addition, a rise in the temperature ranges as a consequence of weather and climatic changes increases the thermal stress of asphalt layers and thus might worsen thermal

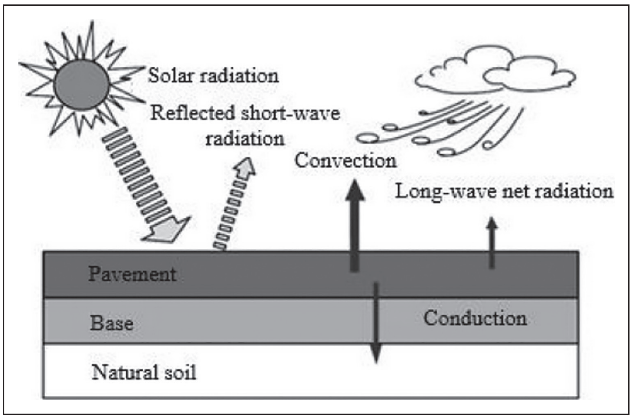

Figure 3. Pavement energy balance [39].

assumptions [37]. Moreover, greater temperatures may lead to a quicker (accelerated) aging of the asphalt layers and because of increased fracture, pavements may become more prone to cracking [37, 38]. Furthermore, low temperatures may lead to asphalt concrete hardening and result in thermal cracking on the road surface; low temperatures promote cracking processes, whereas high temperatures distort plastic deformation processes such as rutting [39].

7. ENERGY BALANCE IN FLEXIBLE PAVEMENTS

The thermal conditions directly influence the temperature profile of the asphalt pavement it is exposed to. The main methods of heat transmission are incident sunlight, heat, and radiation between the pavement's surface and the sky; heat transfer convection between the surface of the pavement and the fluid (air or water). The strength of direct and broad solar radiation depends on diurnal cycles, the sun's position in the sky, and the angle of incidence between the surface and the sun's rays. The pictorial example of the energy balance is shown in Figure 3.

The convective heat flow is determined by the speed and direction of the water. Generally, it is affected by the surface wind speed and direction the most. Whenever the thermal conductivity improves due to incredible wind speeds and wind directions occurring at the right moment, the convection heat flow increases. As a result, when the wind speed is relatively high and the temperatures of the wind are lower than the energy of the pavement surface, convective surface cooling occurs. A far crane is created by thermal and long-wave radiation. This is because profound temperatures are often lower than surface pavement temperatures, resulting in heat transfer in the far crane direction [40].

For the equilibrium of surface energy on a roadway, the sum of all heat gains across the road surface must equal all heat losses inside the pavement surface. The temperature differential determines the pattern of heat flow, convective heat, and thermal radiation between the pavement area and the bulk fluid or sky temperature. Convection and heat transfer are both responsible for heat flow [41]. Suppose the temperature of the sky and the bulk temperature of the fluid are both lower than the temperature of the pavement surface. In that case, the surface cools, but the surface may also be heated by incoming solar radiation at the same time. As a result, the pavement is either heated or cooled, depending on the different heat fluxes involved.

It is possible to suppose that an adiabatic bottom surface exists for sufficiently broad pavement that does not need heat transfer between both the pavement and the sub-grade layers. The same is true for lateral pavement sides (paved edges) for appropriately significant horizontal expansion since increases in the vertical direction are considerably greater than changes in the horizontal direction at pavement edges. Heat transfer through pavement edge surfaces is unaffected [42, 43].

The convection of the heat conduction of the pavement structure and subgrade between the surface of the pavement and the surrounding environment. This is achieved using transmission media such as air or when water reaches the surface [39, 44]. On the other hand, temperature change was the most important factor for changing pavement performance in most studies on climate factors [45]. The causes underlying seasonal fluctuations and their effects on temperature changes are thus essential to understand [45–47]. It is also well-known that the reaction of pavement layers to traffic loads is strongly affected by environmental variables such as temperature and moisture. Any substantial temperature fluctuation may thus have a severe effect on the performance of the asphalt surface and the repair requirements [47].

Temperature, asphalt thickness, and binder qualities all influence whether the pavement cracks or not. Other variables such as aggregate quality, pavement age, pavement width, and friction between asphalt and base track influence thermal cracking severity if a vulnerable asphalt binder is employed. Temperature should be one of the significant factors in the asphalt pavement to prevent thermal cracking [48].

In a transient thermal examination followed by a quasi-static stress analysis, [49] analyses the thermoplastic response of a multi-faceted pavement construction at discrete time intervals using finite element methods. The research analyses the two- and three-dimensional cracking issues numerically. The possibility of heat fractures spreading through the asphalt overlay is evaluated using both a displacement formula and an energy balance concept based on a fracture-mechanics method.

A parametric study on variables leading to the thermal cracking of asphalt pavements [50] has been presented. A semi-analytical model has been constructed to address the multiscale nature of heat cracking pavement, including viscoelasticity effects. The research revealed material homogeneity, ductility, and frictional restriction on the contact and cooling rate as the most significant factors [51]. Studied the effects of nonlinear temperature and wheel load on multi-faceted pavements with a plate consisting of one or more layers resting on a general elastic basis. The resulting bending stress is the amount of bending stress due to the load applied and a linear temperature gradient equivalent, plus the pure heat stress related to the nonlinear portion of the temperature distribution.

Presented research on thermal stress prediction in concrete pavement systems. The analysis is based on measured data on the actual test sections of concrete pavement [52]. The measured strains are divided into axial, curling, and nonlinear components, and each component is examined. The research shows that the curling component dominated cross-sectional stress while the nonlinear component reduced the maximum thermal stress by approximately 25%.

To assess pavement damage, [53] proposed a numerical method utilizing a 3D finite element analysis technique. Field temperature data was collected at 14 locations in the United States at various times of the day to calculate pavement stresses due to curling and wheel loads. A pavement fatigue algorithm was designed to provide comparable damage and effective temperature differentials [54]. Offered an analysis solution in a three-layer pavement system for the determination of slab temperature, subject to a regular change in ambient air or paved surface temperature. The thermal analysis is linked to plate theory and the Winkler foundation to enable curling stress and bending moments to be calculated. The analyses indicated that the distribution of pavement temperatures might be very nonlinear, mainly when the ambient air temperatures vary according to time. The research indicates that the frequency of temperature changes rather than amplitude affected estimated temperature profiles most, leading to thermal stresses in pavements.

8. ASPHALT PAVEMENT DESIGN INCORPORATING THE TEMPERATURE FACTOR

The characteristics of pavement materials, traffic, climate, and service results affect each other in the design process and determine the demand for a necessary mix of pavement structures [43]. The researchers [55] put forward a computer method that uses the Temperature Equivalency Facteurs concept [56] and introduces the Temperature Factor as a significant factor in the asphalt pavement construction method, which translates the design effect times of the axle load into a standard reference temperature.

Before then, generally, the average temperature in the asphalt design technique was dominant, the number of axle loads was realistic in time, and no comparable conversion was performed.

There are also various considerations for the temperature factors of various methods of asphalt pavement, such as taking into account the asphalt pavement experience at low and high temperatures and the associated prediction formula.

When the temperature is gradient, the weighted average temperature is calculated as a pavement temperature based on various pavement temperature depths. According to a more precise technique for considering the non-uniform temperature distribution, the asphalt pavement thickness may be split into multiple levels in the depth of the scope. Analysis indicates that the technique of division level and the method of the asphalt pavement's equivalent temperature provide comparable findings [55–57].

9. THE EFFECT OF TEMPERATURE ON STRUCTURAL PERFORMANCE OF ASPHALT PAVEMENT

The change in asphalt mixing would substantially influence the asphalt pavement's structural capacity and its performance, and asphalt mixture depends on the temperature. It is continuously changing within a day or even a year. Thus the temperature may in the following aspects influence the structural bearing capacity of the asphalt pavement:

- Higher stress is transferred to the base and subbase by the asphalt mixture modulus reduction. Material characteristics of the foundation, however, are linked to stress.

The base material is consolidated under high stress, particularly granular material, although the cohesive ground will become more susceptible. Consequently, the temperature of the asphalt mixture directly influences the material characteristics of the base and base.

- The asphalt mixture module is linked directly to the temperature. The module decreased progressively as the temperature improved, which may cause the structural bearing capacity to be lowered.
- Temperature-change stress: according to a microscopic mechanical model, the contact force between granular base granules would rise in the event of an increase in temperature, resulting in increased volume strain. According to findings from the study by [58], the temperature on the modulus is more critical with a greater degree of compaction and lower starting volume stress levels.
- The rise of the asphalt pavement structure temperature will decrease the top layer pore-water tension.

It may lead to water transfer to the top layer, which reduces pore water pressure. Effective base stress or soil base stress will be reduced. At the same time, the material modulus is reduced. A brief summary of the effect of the extreme thermal effect on pavements is presented in Table 1 and the preventive measures are presented in Table 2.

The findings indicated that the impact of temperature on the asphalt-paved structural bearing capacity is very complex, and it is difficult for the individual component to be distinguished from complicated variables. Asphalt pavement structural bearing capacity changes with the change in temperature. This implies that the stress distribution of

Table 1. Summary of common causes of temperature and effect on pavements

S/No	Causes	Types of effect on pavement
1	Extreme high temperature	Portions of the pavement heat disproportionately
2	Temperature variations	Temperatures alteration or cycle rapidly
3	Less rain and more sunshine	Pavements deteriorate from oxidation effect
4	Ice cold	Pavement (frost heave) melts, thus causing deterioration
5	Freezing temperature	Freezing temperatures can lead to a freezing of water trapped under the pavement, resulting to deterioration
6	Temperature variations	Pavement is exposed to excessive or prolonged heat or cold that leads to quick deterioration especially during cold seasons

Table 2. Methods to protect pavements from adverse thermal effects

S/No	Preventive measure	Explanation
1	Conducting routine inspections	Even the supreme paved roads exhibit aging signs like temperature cracks after a while; keeping eyes on the pavement all year round may help discover areas of concern that may become more problematic. Take notice of cracks, in particular during extremely high temperatures and shallow temperatures in rainy seasons.
2	Preventative maintenance adoption:	While not all pavement damage can be prevented, preventive maintenance is crucial for extending the life span of pavements. Fill or seal small cracks and apply suitable surface treatments to maintain the pavements in an excellent form.
3	Correct deficiencies as early as possible:	Once a major flaw has been discovered, it is appropriate to select the most suitable patches and work with a contractor to fix the damage. It is advised not to wait until the damage gets serious – keeping the damaged pavement in place is a safety risk, and the expenditure only rises as the deteriorations persist.
4	Get the design and construction right as the first step	The design and construction stages are the first stages that need to be gotten right in order to keep pavements in their proper place for the design life before deteriorations. A great deal of preventive work must be done when pavement longevity is to be prioritized.

the pavement changes at various times, even at the same loads. Therefore, the asphalt pavement deterioration model changes with time and temperature effect [58–60].

Find in Table 1 below the summary of common causes of temperature ad effects on pavements.

10. SUMMARY OF THE MECHANISM OF PAVEMENTS' REACTIONS TO THERMAL VARIATIONS

Pavement surfaces resist tremendous impact from vehicles, trucks, and trailers daily. Given the resilience of the pavement, it may seem odd that just temperature changes can cause severe structural damage to roadways and parking lots. However, changes in the weather represent a significant danger to both asphalt and concrete. Temperature changes cause the pavement to expand and contract, which leads to cracks that proliferate if not repaired. Such cracks are not just a tiny annoyance but may develop into warped, uneven surfaces that are a safety risk to vehicles and pedestrians in a facility. These risks are particularly apparent when seasons change due to the possibility of abrupt temperature changes. However, high temperatures may lead to cracking on their own at either end of the range. Therefore, it is essential to be particularly attentive at the summer and winter levels. An awareness of how the pavement responds to variations in temperature may help create a maintenance plan to avoid developing unattractive and hazardous pavement faults. This article discusses the factors leading to a cracking temperature and the measures taken to safeguard the pavement [60].

11. PAVEMENT PROTECTION FROM WEATHER EFFECTS

Temperature variation that leads to pavement deterioration in the true sense of practice is inevitable, but can, however, can minimize with the correct pouring and maintenance; however, the pavement may be protected against the temperature variations as presented in Table 2.

12. CONCLUSION

In conclusion, highlights of the significant areas presented and discussed in the study above are listed here. The study's objective was to discover several ways the asphalt temperature might be estimated to help road design engineers overcome the problems and minimize the dangers of changing temperatures. The conclusion is that analytical techniques offered simple answers but needed precise boundaries. In addition, the above study concluded that temperature has a reasonably substantial effect on the asphalt pavement layer's mechanical and physical material characteristics. It has effectively examined the existing techniques of monitoring temperature and temperature prediction models for pavement construction. Thus, it may be inferred that since the middle of the last century, experts have been trying to forecast asphalt pavement temperatures. However, these models have unique flaws and strengths, and some prediction models are excessively complicated and demand the usage of several factors. Furthermore, heat transfer studies between the ambient and pavement temperatures are thus strongly suggested, considering the impacts of temperature on pavements.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FINANCIAL DISCLOSURE

The authors declared that this study has received no financial support.

PEER-REVIEW

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