

# Review of Research Status of Phase Change Materials in Road Engineering

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**Abstract:** Phase change material is a kind of excellent latent heat energy storage material, which is widely used in the fields of space, building and energy saving. However, the application of phase change materials in road engineering is still in its primary stage. Research status of common phase change materials and composite phase change materials synthesis methods and technical requirements of phase change materials, as well as phase change materials in asphalt mixture and cement concrete are expounded, and the phase change material in road engineering in the direction of development.

**Keywords:** Road engineering; Phase change materials; Asphalt mixture; Cement concrete

## 1. Introduction

In recent years, with the continuous deterioration of the earth's energy and the worsening climate, such as global warming, environmental pollution, the development of new energy and new technology use has become a common concern. The core of these problems is to store the wasted energy and use it when it is needed to make up for it.

The difference between supply and demand. Phase change energy storage technology is a good method, because it has a high energy storage density, so that it does not need a large storage volume. Phase change material is a kind of latent heat energy storage material, and the common phase change material is solid liquid phase change material. Heat transfer occurs when a material is changed from a solid to a liquid state, or when the liquid becomes solid. In the early stage of heat absorption, the solid liquid phase change material is the same as that of the conventional sensible heat storage material, but unlike the latter, the temperature of the phase change material is kept constant during the process of heat absorption and heat release. In addition, the storage capacity of the unit volume phase change material is generally 5 to 14 times that of the same volume thermal energy storage material. Although a large number of phase change materials can be in the range of the required temperature phase transition, but for applications, they should have a good thermal properties, stable chemical properties and economy, etc.. The application of phase change materials in the building has been more research, such as the phase change material embedded in the gypsum board to increase the heat storage capacity of housing. The application of phase change materials in the field of road engineering is still in the initial stage, in view of the fact that the phase change material role in saving energy and improve the engineering structure of the internal tempera-

ture distribution, in the field of road engineering has good application prospect.

This paper summarizes the synthesis methods of commonly used phase change material and composite phase change materials, the use of phase change materials requirements, and an overview of the phase change material in asphalt and concrete research progress. Finally, the application of phase change materials in road engineering prospects are described.

## 2. Common Phase Change Material and Composite Phase Change Material Synthesis Method

According to the composition of the materials, the phase change materials can be divided into organic phase change materials, inorganic phase change materials and mixed phase change materials. Under normal circumstances, the chemical properties of organic phase change materials are stable, there is no too cold phenomenon, which can be further divided into two types of paraffin and non paraffin. The paraffin phase change material has a wide phase transition temperature range, which has a relatively small vapor pressure during the melting process and does not occur phase separation. However, due to its low thermal conductivity, the change in the phase change process is large, so it is not widely used. Non paraffin organic phase change materials include fatty acids, lipids, alcohols and ethylene glycol, they have good thermal properties, but the cost is more than 3 times of the paraffin phase change materials. Inorganic phase change materials can be further divided into hydrated salts and metal compounds. In general, the inorganic phase change materials have high latent heat storage capacity, good thermal conductivity and low cost. However, most of the inorganic phase change materials will be cold and phase separation.

Because of some problems existing in the application of phase change materials in engineering, many domestic and international studies have been devoted to the study of composite phase change materials, in order to improve the properties of phase change materials in applications. At present, the preparation methods of composite phase change materials include direct immersion method, melt blending method, grafting method, micro encapsulation method, sintering method and solution gel method. Direct immersion method using capillary effect and the liquid phase change material immersed in a porous material of composite phase change material, melt blending method is using the compatibility of phase change material and a carrier matrix, melting the second after mixed to form a composite phase change materials, this method has the advantages of simple technology, but there are phase change material is easy to leak. Grafting method using the polymer molecular chain has triggered ability groups directly lead to the monomer polymerization or by atoms or groups of chain transfer reaction the monomer and the backbone of the grafting reaction and the composite phase change material latent heat value is too low. The micro encapsulation method uses the polymer as the microcapsule wall material, and the phase change material is coated as the core material. Will microencapsulation of phase change materials, phase change material and isolated from the external environment, reducing the reaction of phase change materials and the external environment, and increases the heat transfer area, and volume change of PCMs control phase. Sintering process through a series of physical and chemical changes, so that the density and strength of the material increases, while the microstructure and other physical properties can be improved, but it has certain limitations in the use. Sol gel method using inorganic or metal alkoxides as precursor, after solution, sol, gel and solidified, and then by heat treatment to form the required materials, the shortcomings of the method is gel in the presence of many tiny holes, so that the product is easy to produce shrinkage during drying, but its reaction condition is moderate, the process is simple, of composite phase change material has good properties.

### **3. Technical Requirements for Phase Change Materials**

Phase change materials should have good thermal and physical properties, in order to better serve the road engineering. Generally speaking, the phase change material should meet the following requirements.

#### **3.1. Thermodynamic properties**

Suitable phase transition temperature. When phase change materials are applied in road engineering, the phase transition temperature should meet the requirements of a certain range, so as to reduce the road engi-

neering diseases. For example, in the pavement material adding sequence to high-temperature phase transformation thermoregulating agent, when the pavement temperature elevated temperature of phase to phase change material and has not yet reached the failure temperature, phase change materials start melting, pavement material in the heat absorption, makes pavement temperature maintained for a long period of time in the range of low to high temperature failure temperature, greatly reducing the pavement temperature rise rate, delay and shorten pavement failure temperature duration and improve pavement structure temperature adaptability, reduce pavement of high temperature damage. High phase change energy storage capacity. When the phase change material is added to the asphalt mixture or cement concrete, it is inevitable to change the material composition of the original mixture. If the phase change material is too much, it is very likely to result in the physical mechanics of the mixture.

Reduced performance. The high phase change energy storage capacity ensures that the unit volume phase change material can absorb and release heat, which can reduce the volume of phase change materials, thereby reducing the impact on the mechanical properties of raw materials. High specific heat capacity. The higher specific heat capacity can ensure the heat absorption and heat release process of phase change materials in the form of sensible heat.

The ability to adjust the temperature of the mixture. Good thermal conductivity. Phase change materials should have high thermal conductivity, which can ensure the timely absorption and release of heat in the phase change materials. Otherwise, it is not effective to adjust the temperature of the mixture, so as not to alleviate the temperature disease.

#### **3.2. Physical properties**

High-density. Smaller volume change and low vapor pressure, the phase change process should be kept stable. This ensures that the phase change material does not affect the physical and mechanical properties of the mixture during the phase change process. For the mixture, if the phase change material in the phase change material changes in the volume or the generation of large steam pressure, then the phase change material will produce micro cracks. Under the repeated load of the phase change material and the environment and the vehicle, the micro cracks will be extended gradually, which will lead to more serious diseases.

#### **3.3. Chemical properties**

Long term chemical stability, is not easy to occur degradation or chemical changes. Compatibility of materials with asphalt mixture or cement concrete. Phase change materials should have good safety, non-toxic, non flam-

mable. In addition, the phase change material should not be too cold. Because of the large number of raw materials used in road engineering, the source of phase change materials used in road engineering should be wide, easy to produce or get, and should have good economic performance.

#### **4. Application of Phase Change Material in Asphalt Mixture**

Due to its good driving comfort, asphalt pavement is the most widely used high grade pavement structure in the world. However asphalt mixture of viscoelastic plastic so that the asphalt pavement under high temperature and traffic load is prone to rutting of permanent deformation, and under low temperature conditions prone to low temperature shrinkage cracking and other diseases, thus affecting the service level of the asphalt pavement and the service life. Previous studies have indicated that temperature is one of the most important factors that affect the performance of asphalt pavement. Therefore, the influence of temperature on asphalt pavement performance and prolong the service life of road is one of the hot issues in the research of road research workers. In recent years, some domestic scholars in heat storage technology based on, draw lessons from temperature regulation mechanism of phase change material, the incorporation of asphalt mixture and the latent heat of the initiative to adjust the temperature of the asphalt pavement, thus preventing asphalt pavement due to absorb too much heat and excessive heat, under the effect of vehicle load produced permanent deformation, or prevent the asphalt pavement in the sudden drop in temperature or to continuous low temperature cracking.

The feasibility of using polyethylene glycol as a phase change material for asphalt mixture was verified by Hu Shuguang, and the basic properties and temperature sensitivity of polyethylene glycol to matrix asphalt and AC 20 asphalt concrete were studied. The results show that the viscosity of modified asphalt becomes larger with the increase of the amount of polyethylene glycol, but the ductility decreases and the temperature sensitivity decreases. When the content of polyethylene glycol reaches 30%, the modified asphalt can be kept at 5h above 60 degrees. With the change of asphalt mixing of AC20 asphalt mixture has good high-temperature stability, dynamic stability is 2 times higher than that of ordinary AC20 asphalt mixture, and can reduce the surface temperature of 9 degrees centigrade in 39 DEG C high temperature and sunlight conditions. According to the actual situation of asphalt pavement, such as Zhang Yibo, the test and analysis of a variety of phases the influence of material properties on the practical application of asphalt pavement, the results show that polyethylene glycol 4000 can be used as a phase change thermal energy storage material. Cao Changbin et al. Analyzed the influence of

polyethylene glycol on the thermal performance of asphalt and asphalt mixture.

Hybrid physical mixing, adding polyethylene glycol (PEG) of asphalt and calcareous aggregate with good adhesion, preparation of asphalt mixture material with good heat storage capacity. Ma Biao, etc. to carry out the research and application of organic phase change materials in asphalt mixture, results show that incorporation of organic phase change materials of asphalt mixture material with certain temperature effect, but on asphalt mixture road performance also certain influence. Ma Biao, Li Chao, through further analysis, phase change materials with the organic characteristics make it have good compatibility with asphalt and mixture will be diluted bitumen asphalt become soft; in the course of the study although with SiO<sub>2</sub> as the carrier immersion adsorbed phase change material but because of the asphalt mixture high-temperature mixing characteristics, phase change material because of the heat transferred from solid to liquid, part from the SiO<sub>2</sub> carrier leak out, thus affecting the asphalt and asphalt mixture road performance and phase change material actual effect of thermoregulation.

#### **5. Conclusion**

With the continuous development and utilization of new energy, the application of energy storage technology will become more and more extensive. Phase change material is a new type of material which can be used in the field of road engineering, and has good application prospects. At present, the application of phase change materials in asphalt mixture and cement concrete is still in the primary stage. Its application in road engineering has been a fruitful exploration. However the application of phase change materials is still exist many problems, such as the asphalt mixture high-temperature mixing loss of phase change materials, phase change material effect of asphalt mixture and cement concrete mechanical properties, solid-liquid phase change materials after phase state in the process of change in the leakage problem and how to improve the composite phase change material thermal insulation properties. Therefore, the study of the future phase change materials in road engineering will be mainly focused on the following aspects:

To study the compatibility mechanism between phase change materials and road building materials, to improve the compatibility of the two, and to minimize the influence of phase change materials on the mechanical properties and durability of raw materials. Synthesis technology of composite phase change material, to ensure the durability and thermal properties of composite phase change material, and when used in the asphalt mixture high-temperature mixing of phase change material loss. In view of the different climate condition on road use requirements and common diseases of road developed with appropriate phase change temperature field and

phase transition enthalpy, and can experience long-term cyclic phase transformation and stable physical and chemical properties of phase change materials.

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