



Key steps of carbon emission and low-carbon measures in the construction of bituminous pavement

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Abstract

At present, energy saving and emission reduction have become the main points of social and economic development. According to the field survey of the carbon emission in the highway construction of several provinces in China, this study determines the carbon source and divides the fieldwork construction of bituminous pavement in eight stages. Then the calculation model of carbon emission in the construction of bituminous pavement is established using the energy value, carbon emission factor, and global warming potential as the calculation parameters. Based on energy consumption and carbon emissions survey, weighting coefficients of various aspects are calculated by the method of analytic hierarchy, and the key stages of construction are determined. The result showed that the weighting coefficients of aggregate drying, bitumen heating and bituminous mixture heating, which are defined as the key stages, are 0.4130, 0.2335 and 0.1522, respectively. By analyzing the influencing factors of carbon emission in the process of bitumen heating and aggregate drying, the type of energy used in construction is an important factor affecting the carbon emission of construction. This paper determines the energy conservation and emission reduction combining scheme, carbon emissions can be reduced by more than 30% by implementing the plan to change the aggregate and bituminous heating energy. The research results will provide a reference direction and a theoretical basis for the research of energy-saving and emission reduction technology for bituminous pavement construction.

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Keywords: Bituminous pavement; Carbon emission; Calculating model; Key stages; Energy conservation and emissions reduction

1. Introduction

At present, people have paid more attention to climate change because of global warming and other extreme climate changes, which have seriously affected the lives of people. CO₂ and other greenhouse gases emitted by human activities are closely related to the abnormal weather. The International Energy Agency (IEA) survey shows that the

road construction and operation caused by the greenhouse gas is an important source of climate warming [1]. Based on statistics, the United States needs to invest 3.5 million tons of raw materials for the construction and maintenance of the national highway [2], and the construction of 1 km standard two-lane bituminous pavement needs to consume approximately 7×10^6 MJ of energy, which is equivalent to 240 tons of standard coal energy [3]; the British transport and the infrastructure emissions of greenhouse gases account for 24% [4] of the total domestic carbon emissions, which is not only an important source of carbon emissions but also one of the main targets of energy conservation and emission reduction.

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Relevant research has been conducted by scholars in various countries with regard to the environmental pollution caused by the construction of expressways. Itoya [5] used the LCA method and the PAS2050 carbon emission calculation tool in highway maintenance to delimit the application scope of calculation tools and divide the distance and mode of transport and energy type. Design and infrastructure construction were computed and compared by using the iterative method. And the sensitivity of fuel and design life of pavement are analyzed. Zapata John and Pablo used the life cycle method to study the energy consumption of continuously reinforced concrete pavement and bituminous pavement [6]. Among these, the raw material production is the main energy consumption process of the continuously reinforced concrete pavement (approximately 94%), whereas the bituminous pavement construction energy consumption is mainly concentrated in the mineral material heating and bitumen heating. However, the research of domestic and international carbon emission is confined to the regional, wherein a systematic quantitative analysis system does not exist. Researching the key steps of the construction of bituminous pavement and the energy saving and emission reduction measures can effectively reduce the carbon emissions in the construction of bituminous pavement, and provide a theoretical basis and technical reference for the low carbon construction of highways.

2. Investigation and analysis of carbon source in the construction of bituminous pavement

2.1. Investigation of carbon source in bituminous pavement construction

The research object and the system boundary should be defined in researching carbon emission in the construction of bituminous pavement. The research scope of this paper is the release of greenhouse gases (collectively referred to as carbon emissions) from transporting raw material to the site to completing the bituminous mixture rolling.

Based on the definition of the boundary of carbon emission in the construction of bituminous pavement, the carbon source in construction can be divided into eight stages: aggregate stacking, aggregate supply, aggregate drying and bitumen heating, bituminous mixture mixing, mixture transportation, mixture paving, and mixture rolling, to investigate, calculate, and analyze the carbon emissions of each stage. The carbon emission process of bituminous pavement construction is obtained (Fig.1).

2.1.1. Aggregate stacking

Loader is the main equipment used in the process of aggregate stacking and the energy type of loading machine is diesel oil and the carbon emission is diesel combustion. The main contents of the survey include the loader model, loading capacity, service life, energy consumption, and so on.

2.1.2. Aggregate supply

The construction machinery is mainly used for the loading machine, in which diesel combustion produces carbon emissions. The main contents of the survey are the model of the loader, the service life, the number of loaders, the loading capacity, the energy consumption of the loader, and so on.

2.1.3. Aggregate drying

In the drying process, the type of heating energy is different with the location of the project. Based on the field survey of the project, the main types of energy sources are coal, heavy oil, and natural gas. In the carbon source investigation, the main research contents are the energy type, the heating temperature, the energy consumption, and the energy cost.

2.1.4. Bitumen heating

The viscosity of bitumen at room temperature is larger than that of heated bitumen; with the increase of temperature, the viscosity is gradually decreased. Heating bitumen is necessary to improve the mobility of bitumen. Conductive oil, which is used to heat the oil as the carrier, is used to heat the bitumen, and the energy source of heating conductive oil is mainly heavy oil and coal.

2.1.5. Bituminous mixture mixing

Chinese constructors generally use the intermittent mixing equipment for mixture mixing to ensure the pavement performance of the bituminous pavement construction. In the bituminous mixture mixing process mainly consumes electricity, fossil fuel combustion in the process of generating electricity produce carbon emissions.

2.1.6. Transportation of bituminous mixture

The construction unit based on the local terrain chooses a suitable location to establish the mixing station. The mixed bituminous mixture is transported to the construction site by the transport vehicle. In the course of transportation, diesel consumption produces carbon emissions.

2.1.7. Paving of bituminous mixture

The bituminous mixture should be spread through the paving machine in accordance with the design of the thickness and width of evenly spreading to the sub-layer. The carbon source of paving process mainly comes from two components, which is a mixture of self-emission and diesel exhaust. In surveying carbon sources, the number of paving machines, paving width, thickness, bituminous mixture type, energy consumption, working time, and the self-emission test of the mixture are mainly investigated.

2.1.8. Rolling of bituminous mixture

In the rolling process, carbon source mainly comes from the roller consumption of diesel and the self-emission of the mixture. The survey comprises the number, type, power,

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