Uniaxial Impact Compressive Characteristics of Permeable Asphalt Concrete

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Abstract: In order to investigate the dynamic characteristics of permeable asphalt concrete, a 74mm steel split Hopkinson pressure bar(SHPB) apparatus was used to conduct uniaxial impact compressive test with various strain rates for permeable asphalt concretes with polyester fiber content of 0 and 0. 3 %.The test results showed there is a significant strain rate effect on permeable asphalt concrete and the specimen compression ratio increases in strain rate; the specimen compression ratio of the permeable asphalt concrete with polyester fiber is about 1 .2 times as large as that of the concrete without polyester fiber; the dynamic stress-train curve of permeable asphalt concrete includes 3 stages of elastic deformation stage, plastic deformation one and failure one; observing the failure mode of permeable asphalt concrete, the aggregate fracture is considered as the main reason for permeable asphalt concrete failure; polyester fiber in permeable asphalt concrete can delay cracks appearing and spreading and improve dynamic compressive strength, the largest strength increase can reach 45.1%.

Keywords: Permeable asphalt concrete; SHPB; Polyester fiber; Strain rate; Impact compressive strength

1. Introduction

Voids of porous asphalt pavement rate of 18% to 25%, so the road surface water can enter the pavement transverse discharge or penetrate to the roadbed internal [1], so it can quickly eliminate the road surface water and rain and improve traffic safety and comfort. Its coarse aggregate is as high as 80%, so it has good skid resistance. Therefore, the pervious asphalt concrete pavement has good performance, but also has wide application prospect of [2-4].

The pavement design is usually designed according to the static load, but the impact and impact on the pavement are more serious, such as the braking of heavy haul vehicles, the takeoff and landing of the runway and other impact loads. Under the action of impact load, the properties of concrete are different from those under static or quasi-static conditions [5]. Therefore, the study on the dynamic mechanical properties have been widely concerned. At present, the research on the dynamic mechanical properties of asphalt concrete are mainly concentrated in the dense graded asphalt concrete. Tekalur and other [6] adopt the split Hopkinson pressure bar (SHPB) and its improved device. He studied the strain rate sensitivity of asphalt concrete, and considered that the dynamic strength was significantly higher than the static strength. Liu Jun [7] considers that temperature and loading rate are important factors that influence the dynamic mechanical properties of asphalt concrete. Zeng Xiao [8] study of ordinary asphalt concrete, modified asphalt concrete and fiber Asphalt concrete in different temperature and strain rate impact performance. Huang Hailong [9] studied the impact properties of ordinary asphalt concrete and rubberized asphalt concrete under different temperatures and strain rates. Void ratio and dense graded asphalt concrete permeable asphalt concrete has the obvious difference, so the difference of the dynamic mechanical characteristics of larger, but the scholars on the permeable asphalt pavement material dynamic mechanical properties research.

2. Test Principle and test Parameters

The SHPB test is a research on the dynamic characteristics of materials is one of the basic means of [10], the guide rod should be within the scope of stress wave width of specimen impact response, and through the measurement of the guide rod changes of stress wave to obtain strain rate, strain and stress of the dynamic mechanical properties of materials. In the SHPB test, the inertia and friction effects are smaller when the ratio of length to diameter is about 0.5 [11]. Therefore, the specimen with the diameter of 70 mm and 35 mm height of the cylinder. The test adopts fine grained PAC and 13 permeable asphalt concrete, and the aggregate gradation is shown in Table 1. The transmission waveforms obtained by the two strain gauges are shown in Figure 1.

Table 1. Aggregate Gradation

Sieve/mm	Percentage of mass/%	
	Standard value	actual value
16	100	100
13.2	90-100	95
9.5	50-80	65
4.75	10-30	12
2.36	10-22	14
1.18	6-18	24
0.6	4-15	13
0.3	3-12	26
0.15	3-8	19
0.075	2-6	21

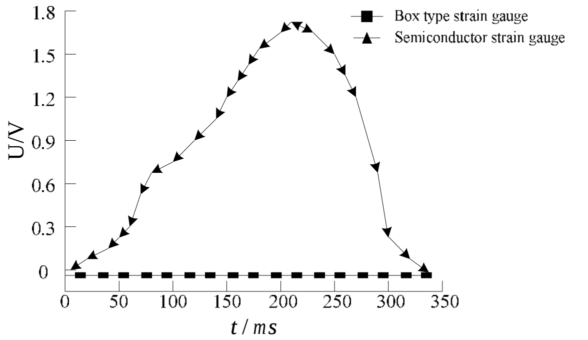

Figure 1. The transmission waveforms obtained by the two strain gauges

The SHPB test is based on the assumption of stress uniformity, and the stress uniformity should be solved in the loading process of specimens. Vaseline was used to shape the pulse, and the amount of Vaseline was determined by repeated trial. The contrast of pulse signals before and after shaping is shown in figure 2.

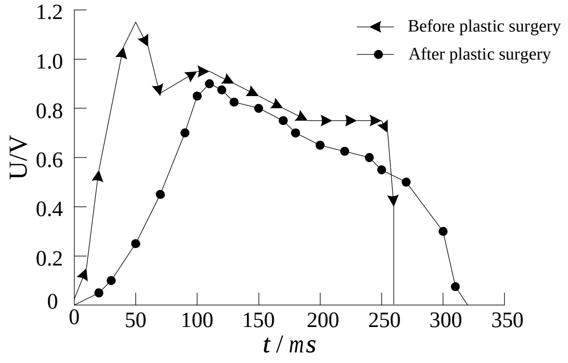

Figure 2. Incident pulse comparison before and after shaping

3. SHPB Impact Compression Test Results

The impact compressive strength refers to the maximum stress value that asphalt concrete material can bear under the external impact compression load, which is used to reflect the ability of asphalt concrete to resist impact damage. In the test, 2 and 3 valid data are obtained at each strain rate, and the test results are shown in Table 2.

Table 2. SHPB Impact Compressive Test Results

Fiber content/%	strain rate/S-1	Impact compressive strength/Mpa	compression ratio/%
0	80.9	21.3	2.1
	70.1	30.1	2.3
	59.3	22.3	2.2
	57.4	25.6	4.3
	74.3	30.1	3.1
	68.2	44.3	3.6
	45.3	26.7	2.7
	87.1	34.3	3.4
	77.9	21.7	2.7
0.3	90.6	31.2	2.9
	89.6	33.6	1.9
	79.8	46.7	1.8
	76.5	49.7	3.1
	36.6	55.4	3.2
	58.6	89.3	3.6
	49.5	67.4	2.6

It can be seen from table 2 that the impact compressive strength of permeable asphalt concrete exhibits a strong strain rate effect. That is to say, whether the asphalt concrete is mixed with cool fiber or not, its impact strength increases with the increase of strain rate. The fitting curve between the impact strength and the strain rate is established by analyzing the experimental data, which is shown in Figure 3.

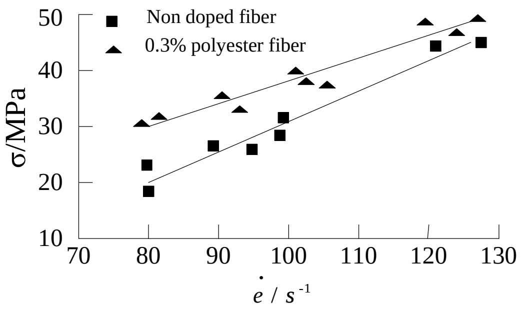

Figure 3. Fitting curve of impact compressive strength and strain rate（图不清楚）

4. The in Fluence of Polyester Fiber

When the doped fiber, with the increase of strain rate, the impact compressive strength increases, and the increase is increasing; when the dosage of 0.3% polyester, the impact compressive strength is also increasing, but the rate of increase has been decreased, and was significantly lower than that without the increase of fiber.

The greater the strain rate is, the more obvious the boundary between the elastic deformation stage and the plastic deformation stage is. When the dynamic load continues to increase, the porosity of permeable asphalt concrete decreases gradually, and gradually reaches the dense state. When the stress reaches the limit value, the stress-strain curve will gradually decline.

5. Failure Mechanism

The cool fibers of non-doped fiber and the mixture of 0.3% pervious asphalt concrete compressive strength and dynamic stress analysis curves of stress and strain relations, we can see that the pervious asphalt concrete form of damage and strain rate are closely related.

Because of the rough set in the pervious asphalt concrete material dosage > 80%, so between the coarse aggregate formation of stone inlaid structure deals. The structure inside there will be more than ordinary dense graded asphalt concrete voids, accompanied by a large number of micro cracks. When the strain rate is small, micro cracks by load will make the surrounding stress relaxation, at the same time as the slower loading rate will be a part of the energy is released, it will gradually develop into one or several main cracks, the failure form of the pervious asphalt concrete for two pieces or chunks.

6. Conclusion

In uniaxial compression test, the impact compressive strength and compressive rate of permeable asphalt concrete show a strong strain rate effect. The compression ratio of the water permeable asphalt concrete with polyester fiber is about 1.2 times of that of the fiber without the addition of the fiber, and the specimens appear compression, cracks and block cracks, and a small amount of specimens appear broken failure forms. The fracture of aggregate is the main reason for the damage of pervious asphalt concrete.

The dynamic stress-strain curve of porous asphalt concrete can be divided into 3 stages, namely elastic deformation stage, plastic deformation stage and failure stage. The permeable asphalt shows a strong plasticity before reaching the peak stress, and then the bearing capacity drops sharply and shows obvious brittleness.

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