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Ultrasonic testing concrete defect verification test

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Abstract

Three sets of 11 blocks of the same size 100*100*100 were designed and tested by non-metal ultrasonic detector. The concrete test blocks with different artificial defects were tested. The test shows that the concrete contains 20mm diameter. Ultrasonic testing can effectively detect the tube; ultrasonic for the 5-day,20-day ultrasonic testing, the value of the analysis found that the 20-day test results are more stable; for the interior of the concrete containing the pockmark, the ultrasonic test can not be carried out Effective detection.

Keywords

Ultrasonic; internal defects; voids ; detection.

1. Principle of ultrasonic testing

The basic basis for the detection of structural concrete defects using ultrasonic pulse waves is the use of pulse waves to transmit wave amplitudes in time(or velocity)propagating in concrete with the same technical conditions(referred to as concrete raw materials, mix ratio, age and test distance).Relative changes in acoustic parameters such as frequency are used to determine defects in concrete. Because the speed of ultrasonic pulse wave propagation is directly related to the degree of compaction of concrete, for concrete with a certain ratio of raw materials, mix ratio, age and test distance, the concrete speed is high and the concrete is dense. On the contrary, the concrete is not dense. When there are voids or cracks, the integrity of the concrete is destroyed. The ultrasonic waves can only bypass the cavity or crack and propagate to the receiving transducer. Therefore, the distance of propagation increases, and the measured sound is necessarily long or the speed of sound is reduced [1].

In addition, since the acoustic impedance ratio of air is much smaller than the acoustic impedance ratio of concrete, when a pulse wave propagates in concrete, it encounters defects such as honeycombs, voids or cracks, and then reflects and scatters at the defect interface, and the sound energy is attenuated, wherein the frequency is attenuated. Higher component attenuation is faster, so the amplitude of the received signal is significantly reduced, the frequency is significantly reduced, or the high frequency components in the frequency spectrum are significantly reduced. Furthermore, the sound path and the phase difference between the pulse wave signal and the direct wave signal propagated by the defect reflection or the bypass defect interfere with each other after superposition, and the waveform of the received signal is distorted [2].

2. Test piece design and testing equipment

For the ultrasonic detection accuracy and the specific conditions of detecting defects, three batches of 11 test pieces of the same size 100*100*100 were produced, the first batch of 4 pieces, the second batch of 4 pieces, and the third batch of 3 pieces [3]. The test block details are shown in Figure 1.

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Fig.1 test block detail

Table 1 Test block batch table

batch	Test block details	aims
First batch	Four pieces of the same batch of concrete respectively inserted into empty pipe, grouting pipe, steel pipe	Verify the effect of steel and pipe on ultrasonic waves
Second batch	Four blocks of the same batch of concrete, which are into the four sections of thermal insulation plates with cross-section dimensions of 10*25mm,15*25mm,20*25mm, and 30*25mm	Influence of different insulation board thickness on super-wave
Third batch	Two grouting test blocks and one concrete test block in the three test blocks, one of which is placed in the concrete test block and the other is the pure grouting material. The concrete test block is the first batch of the same batch of concrete	Can honeycomb and pockmark be detected in ultrasound

The concrete used in the test was C40 concrete with the same water-cement ratio in each batch (the pressure resistance was 51.8 MPa after 28 days of curing).

The equipment used in the experiment is C62 non-metal ultrasonic detector of Shenzhou Huace Co., Ltd, working frequency is 50/60Hz, sampling period is 0.05us-6.4us. The instrument uses two channels and is detected by two low frequency broadband transducers (transmit, receive) with an amplifier bandwidth of 5 Hz to 500 kHz.

Fig.2 Ultrasonic detector

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3. Test block research

3.1 Influence of steel bars and pipes on ultrasound:

The test points and the operation mode are tested according to CECS21-2000"Technical Regulations for Ultrasonic Testing of Concrete Defects"[4]. Since the defect position and depth are set in advance, a separate placement test is performed for each defect area with a measurement pitch of 10 mm at the time of detection. Three sets of sound velocity values and amplitudes were collected twice in the experiment. After the analysis and comparison, it was found that the sound velocity values were more accurate than the amplitudes to detect the existence and location of the defects.



(overlapping) (separate) (measuring point arrangement)

Fig.3 Steel and pipe drawing

Table 2 Ultrasonic results of steel and pipe

First one group	Steel bars and pipes						
	Steel bars, pipe overlap					Separate pipe	
	Measure (top to bottom)					Measure (up to down)	
	Concrete on the left	Center	Concrete on the right	Steel	Pipe	Pipe	Concrete
Sound speed km/s	5.319	5.102	5.319	5.319	4.902	5.319	5.319
	5.814	5.556	5.556	5.556	5.319	5.556	5.319
	5.814	5.319	5.556	5.556	5.319	5.556	5.556
	5.814	5.556	5.814	5.814	5.319	5.556	5.556
	5.814	5.556	5.814	6.098	5.319	5.556	5.814
	5.814	5.556	5.556	5.814	5.556	5.556	5.814
	5.319	5.102	5.319	5.814	5.319	5.319	5.556
	Mean						
	5.673	5.392	5.562	5.710	5.293	5.488	5.562
First two group	Steel bars and pipes					Separate pipe	
	Steel bars, pipe overlap					Measure (up to down)	
	Measure (top to bottom)						
	Concrete on the left	Center	Concrete on the right	Steel	Pipe	Pipe	Concrete
Sound speed km/s	5.319	5.556	5.319	5.556	5.102	5.102	5.319
	5.556	5.556	5.556	5.814	5.319	5.319	5.814
	5.814	5.814	5.556	5.814	5.556	5.556	5.556
	6.098	5.814	5.556	5.814	5.556	5.556	5.814
	5.814	5.814	5.814	5.814	5.814	5.319	5.814
	5.814	5.814	5.556	6.098	5.556	5.319	5.319

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	5.556	5.814	5.556	5.814	5.556	5.556	5.319
	Mean						
	5.710	5.740	5.559	5.818	5.494	5.390	5.565

Collecting data twice for the same test block is common to the verification data

data analysis:

The data in all groups can be seen that the uppermost data value is smaller than the lower group data, because the uppermost detection point is located at the edge of the test block and the ultrasonic pulse wave is seriously attenuated due to the uppermost unevenness.

In the ultrasonic testing, the pipe has a great influence on the detection, and the pipe diameter is 20 mm. For the concrete thickness of this size, the position can be clearly detected by ultrasonic testing.

The average value of ultrasonic testing at the steel bar is larger than the mean value of concrete. It is judged that the steel bar has a great influence on the ultrasonic testing, and after comprehensively verifying the concrete, the concrete has a great influence on the ultrasonic.

3.2 Influence of insulation thickness on ultrasonic testing:

Four concrete test blocks were made in the same batch, and the thermal insulation plates of different sizes of 10*25mm,15*25mm,20*25mm and30*25mm were inserted respectively, and two sets of data were collected for 5 days and 20 days respectively. Compare.

Table 8 Physical parameters of typical materials

Project	Air	Water	Soil, rock	Concrete	Iron
Density（kg/m3）	1.0	1000	1800~2500	2400	7800
Sound wave velocity（m/s）	340	1450	300~5000	3000~4500	5300
Impedance 106kg/（m2s）	0.00034	1.45	0.54~12.5	7.2~10.8	41.3

The concrete wave speed ranges from 3,000 to 4,500 m/s, the water is 1,450 m/s, the air is 340m/s, and the polystyrene board (insulation board) is around 800m/s, which is between air and water. The void area was simulated during the test.

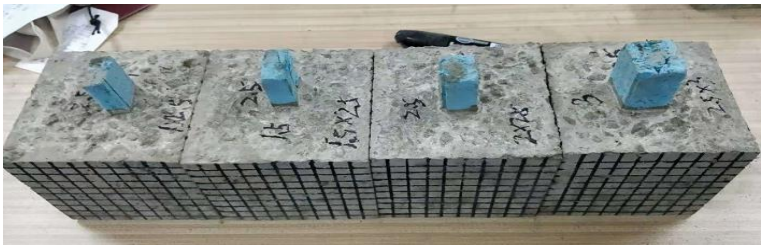

Fig.3 Schematic diagram of different thickness insulation boards

Table 3 Ultrasonic results of different insulation board thickness on the 5th day of concrete

5 days	Influence of insulation board in concrete								
Insulation plate thickness	10 mm			15 mm			20 mm		
Sound speed km/s	4.717	4.717	4.717	4.717	4.386	4.545	4.717	4.386	4.545
	4.902	4.717	4.902	4.902	4.386	4.717	4.902	4.717	4.902
	4.902	4.902	4.717	4.902	4.386	4.717	4.902	4.717	4.902
	4.902	4.717	4.902	5.319	4.717	4.902	5.102	4.717	4.902

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	4.902	4.902	4.717	5.319	4.902	5.102	5.102	4.717	5.102
	4.902	4.902	4.902	4.902	4.902	5.102	5.319	4.902	5.102
	4.717	4.717	4.717	4.717	4.902	5.102	4.902	4.717	5.102
Mean	4.849		4.796	4.968		4.884	4.992		4.937
		4.796			4.654			4.696	
Insulation plate thickness	25 mm			30 mm					
Sound speed km/s	4.717	4.386	4.717	4.902	4.386	4.902			
	4.902	4.717	4.902	4.902	4.717	4.902			
	4.902	4.717	4.902	4.902	4.545	4.902			
	4.902	4.717	4.902	4.902	4.717	4.902			
	5.102	4.717	4.902	4.902	4.717	4.902			
	4.902	4.717	4.902	5.102	4.717	5.102			
	4.717	4.717	4.902	5.102	4.717	4.717			
Mean	4.878		4.876	4.959		4.904			
		4.670			4.645				

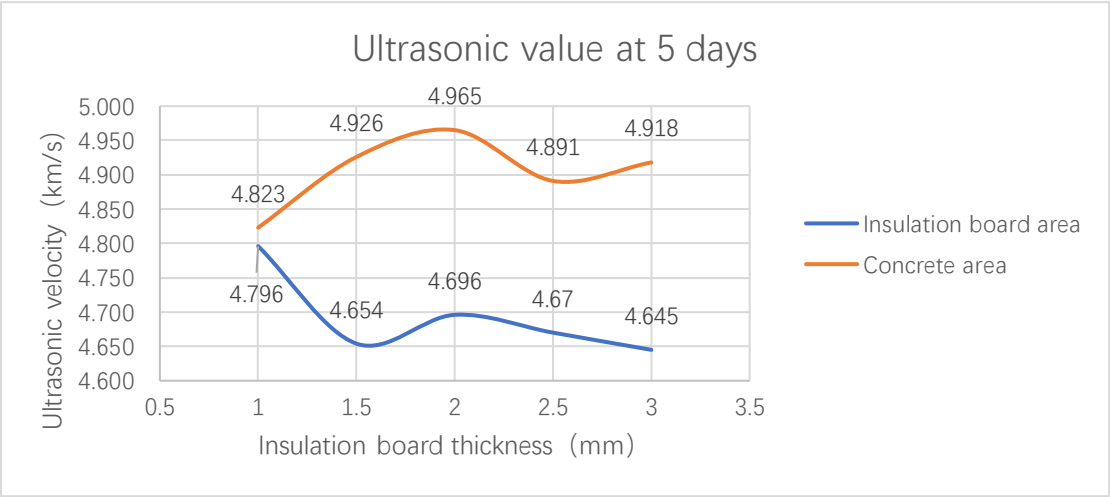

Fig.4 Ultrasonic value of different insulation board thickness on the 5th day of concrete curing

Table 4 Ultrasonic results of different insulation board thickness on the 20th day of concrete curing

20 days	Influence of insulation board in concrete								
Insulation plate thickness	10 mm			15 mm			20 mm		
Sound speed km/s	4.545	4.545	4.545	4.908	4.908	4.908	4.545	4.545	4.545
	4.545	4.545	4.717	4.386	4.386	4.386	4.717	4.717	4.717
	4.545	4.717	4.717	4.545	4.386	4.545	4.717	4.717	4.717
	4.717	4.717	4.717	4.717	4.545	4.545	4.717	4.717	4.717
	4.902	4.717	4.786	4.717	4.717	4.717	5.102	4.717	4.902
	4.902	4.902	4.545	4.902	4.902	4.902	4.902	4.717	4.717
	4.545	4.545	4.545	4.717	4.717	4.545	4.717	4.902	4.545

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Mean	4.672		4.653	4.699		4.650	4.774		4.694
		4.670			4.652			4.719	
Insulation plate thickness	25 mm			30 mm					
Sound speed km/s	4.386	4.386	4.237	4.717	4.386	4.717			
	4.545	4.545	4.545	4.902	4.545	4.902			
	4.902	4.545	4.902	4.902	4.545	5.102			
	4.902	4.717	4.902	4.902	4.717	4.902			
	5.102	4.902	5.102	4.902	4.717	4.902			
	5.102	4.717	4.717	4.902	4.545	4.902			
	4.717	4.717	4.717	4.545	4.545	4.545			
Mean	4.808		4.732	4.825		4.853			
		4.647			4.571				

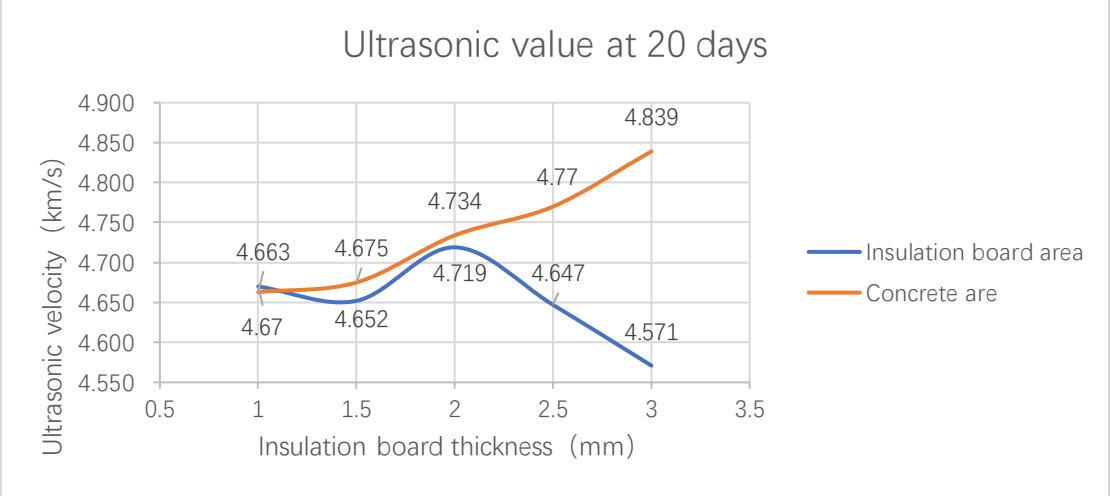

Fig.5 Ultrasonic value of different insulation board thickness on the 20th day of concrete curing

Data analysis:

The ultrasonic value of the thermal insulation board area increases with the thickness of the thermal insulation board. The overall trend of the ultrasonic value is downward. It is proved that as the thickness of the thermal insulation board increases, the ultrasonic sound velocity value decreases.

In the horizontal comparison of the same area at different times, the data of20 days is more stable than the data of 5 days, which proves that with the hydration reaction of concrete. the free water decreases the overall water content decreases, and the value tends to be stable.

This verification test can also prove that the insulation board can be used to simulate internal voids in internal defects and the effect is still ideal.

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3.3 The effect of internal pitting on ultrasound detection

Fig.6 Internal hemp interview block

Table 5 Ultrasonic results of concrete internal pockmark

	Pitted surface			Concrete
Group number	1	2		4.849
Sound speed km/s	4.717	4.386	Sound speed km/s	4.796
	4.902	4.545		4.968
	4.902	4.902		4.884
	5.102	4.902		4.992
	5.102	5.102		4.937
	5.102	4.902		4.878
	4.902	5.102		4.904
Mean	4.961	4.834		4.959
	4.898			4.876
			Mean	4.904

Fig.7 Grouting Material Hemp Interview Block

Table 6 Ultrasound results of flax surface defects of grouting material

	Measure pitted surface defects in grout	
	No defect (upper and lower words)	Defective (Around the word)

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	6.410	6.410	6.098	6.410	6.098	6.410	6.098	6.098	6.098
	6.410	6.410	6.410	6.098	6.410	6.410	5.814	6.098	5.814
	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.098	6.098
	6.410	6.410	6.410	6.410	6.410	6.757	6.757	6.757	6.410
	6.757	6.410	6.410	6.098	6.410	6.410	6.757	6.757	6.098
Mean	6.479	6.410	6.348	6.285	6.348	6.479	6.367	6.362	6.104
	No defect (upper and lower words)			Defective (Around the word)					
	6.410	6.410	6.098	6.098	6.410	6.410	6.098	5.814	6.098
	6.410	6.410	6.098	6.410	6.410	6.410	6.098	6.098	6.098
	6.410	6.410	6.098	6.410	6.757	6.575	6.410	6.410	5.814
	6.410	6.410	6.098	6.410	6.410	6.575	6.410	6.410	6.410
	6.410	6.410	6.098	6.410	6.410	6.575	6.410	6.410	6.410
Mean	6.410	6.410	6.098	6.348	6.479	6.509	6.285	6.228	6.166

Data analysis

Such pockmarks cannot be effectively tested in concrete testing. Since there are many influencing factors in concrete, the concrete is replaced by grout and the same operation is performed. The results prove that such defects cannot be detected in actual situations.

4. Conclusion

When ultrasonic testing is used to detect internal defects of concrete, internal cavity defects and steel bars are close to each other, and ultrasonic testing cannot effectively detect defects her.

For the defects in concrete in different periods, ultrasonic testing found that the more stable the ultrasonic testing value of the concrete with longer curing time, the higher the accuracy of ultrasonic testing with the increase of internal cavity.

If the surface of the concrete member contains pitted surface, it cannot be effectively detected by ultrasonic, and the ultrasonic detection accuracy is not achieved because of the small void inside.

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