The Crack Evolution of Red Clay under Wet and Dry Cycles

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Abstract. The red clay has high moisture content,high plasticity,high void ratio and other special engineering properties,especially when the subgrade surface dehydrates,it shrinks and cracks,caused the subgrade to have some diseases.Taking the subgrade filling from the Liupanshui inner Expressway as the research object,doing the experiment during wet and dry cycles when the red clay on the condition of 105˚C and 34˚C,and researching the relationship between the fissure ratio and the cycle index under wet and dry cycles.Research shown that the fissure ratio increasing with the increasing of the numbers of the wet and dry cycles,in the first two cycles it increased significantly,the last three cycles increased slowly,this phenomenon shows that the influence of the first two cycles on the crack of red clay is larger.That the ratio of the fissure ratio under the condition of 34˚C to under the condition of 105˚C increasing fast with the increasing of the moisture content and then reduce,reaching the maximum when the moisture content is optimum moisture content.

Foreword

Because the red clay has high moisture content, high plasticity, high void ratio and other special engineering properties,with the operation time of the highway growing,the subgrade and pavement has some diseases.The Guiyang-Zunyi Expressway,the Guiyang-Bijie Expressway and some other expressways have a lot of ruts. In the survey we also found that a large number of pavement cracks, the crack size is different and the crack shape is irregular, the most serious crack is the vertical crack caused by sink,the length of the crack is more than a hundred meters, the pavement also has large area subsidence,these all mainly casued by subgrsde subsidence.There also has some problems of different degrees of red clay in other roads has been built outside Guizhou province.Such as 107 National Highway in Moyang,the semi-rigid type base,the surface course and the cement pavement always appear cracks,slab pumping and crack slab.During the construction of the Beijing-Zhuhai Expressway between Moyang and Yizhang using a lot of red clay to filling embankment near Yizhang,making the embankment surface appear serious shape crack and fissure,the crack size is different,the maximum width is up to five to six centimeters, depth is up to twenty-six centimeters.The fundamental reason of subgrade pavement cracking is the red clay shrink because of the soil water loss under wet and dry cycles.So the research of the crack evolution of red clay under wet and dry cycles has a practical significance on highway construction in red clay area.

Basic physical properties of Red clay

The soil samples adopted by this experiment was taken from Liupanshui inner Expressway third section.Soil characteristics as follows:brownish red,wet,the homogeneous soil,the compact structure,with certain small wormholes and the wholes of plant roots.On the grain composition,most is the silty clay.According to the Test methods of soils for Highway Engineering (JTG E40-2007),the basic physical properties of the soil is shown in Table 1.

Table 1 Basic physical properties of red clay

JTG E40-2007	>0.075mm/%	0.074～0.002mm/%		<0.002mm /%	
	17.25	71.41		11.34	
Optimum moisture content/%	Maximum dry unit weight g/cm^3	Plastic limit/%	Liquid limit/%	Coefficient of nonuniformity	Coefficient of curvature
37.2	1.46	38	59	9.38	1.6

Testing Program

(1)Sample Preparation

Using the proctor compaction test to make the sample which the degree of compaction is 75%, the moisture content are 30%, 34%, 37.2%, 40% and 44%. The sample's diameter is 150mm and the height is 120mm.

(2)The test method under wet and dry cycles

Dry process: Under the condition of 34˚C and 105˚C, put the sample in the oven, drying the sample(untill moisture content is less than 1%)

Wet process:Calculating the amount of water needed, use the syringe adding water to the initial water content.The test method under wet and dry cycles shown in Fig. 1.

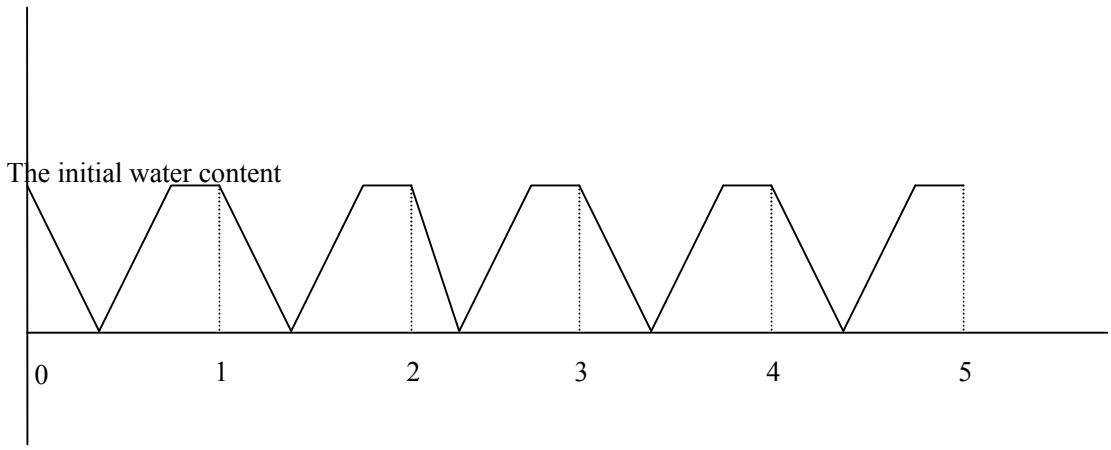

Fig. 1The test method under wet and dry cycles

(3)The definition of the fissure ratio.

$$The\ fissure\ ratio = \frac{The\ number\ of\ black\ pixels}{The\ number\ of\ pixels}$$

$$= \frac{The\ number\ of\ black\ pixels}{The\ number\ of\ black\ pixels + The\ number\ of\ white\ pixels} = \frac{crack\ area}{sample\ area}$$

(4)Image manipulation

Analysing the whole sample area when doing the image processing.The contrast of color between the cracking partial soil sample and the not cracking partial soil sample is obvious.So using the gray entropy do the quantitative analysis to the crack in the soil sample.Taking the great advantage of the function of processing pictures of certain software,by the transformation the grayscale of the original picture,edge detection and median filtering and other measures,ultimately,offering the binary image transformed.The concert process:①Invoking function {imread} to netlist the true color image into MATLAB and transforming it into digital image;② Invoking function {improper},clipping the digital image;③Invoking function {rgb2gray},transforming the digital image into the grayscale image;④Invoking function {im2bw},transforming the grayscale image into the binary image(the dark spot shows the crack,it's grayscale is zero,the white spot is the not cracking partial soil sample,it's gray value is 1）；⑤Invoking function {imfilter} to make the image median filter;⑥Invoking function {[count,x]=imhist},count the white and black pixel in the binary image,the ratio of the black pixel to the totle pixel is the fissure ratio.The process is shown in Fig. 2.

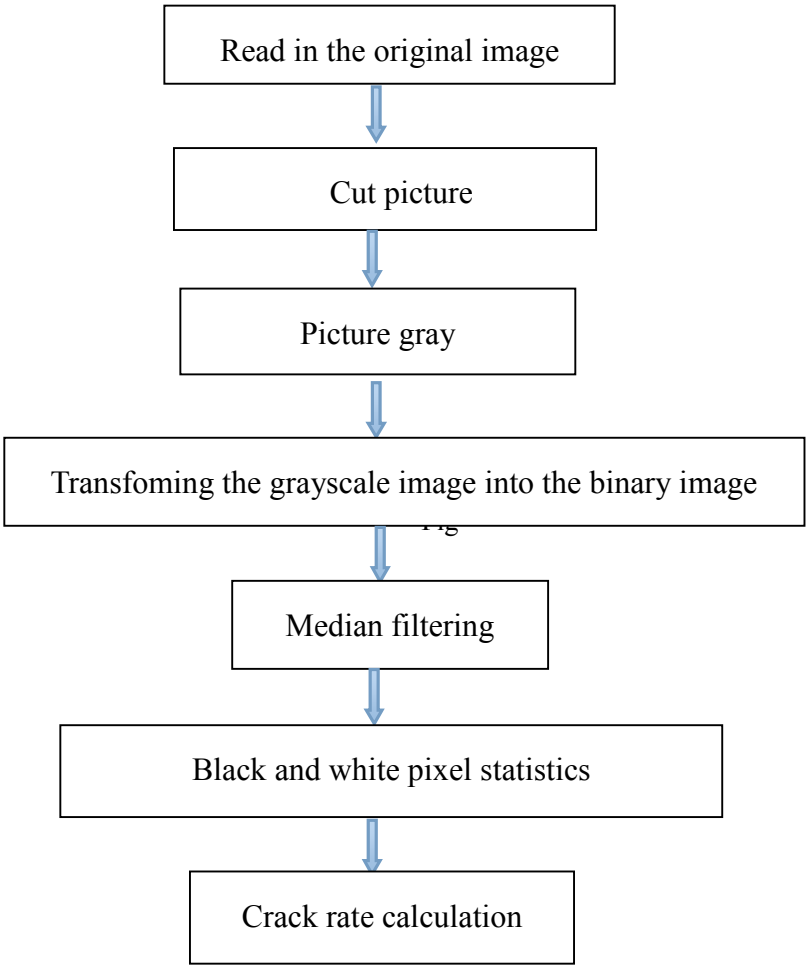

Fig. 2 The process of image manipulation

Testing Results

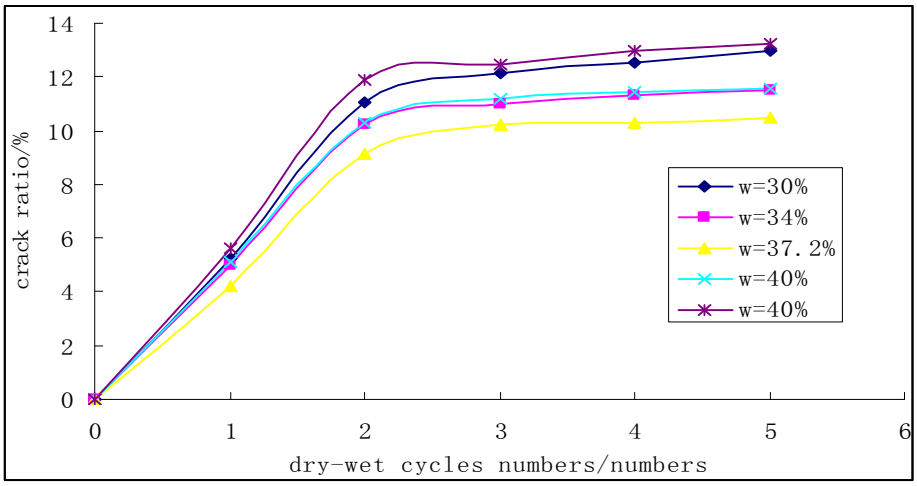

Fig. 3 The relationship between the fissure ratio under the condition of 105˚C and the number of the wet and dry cycles

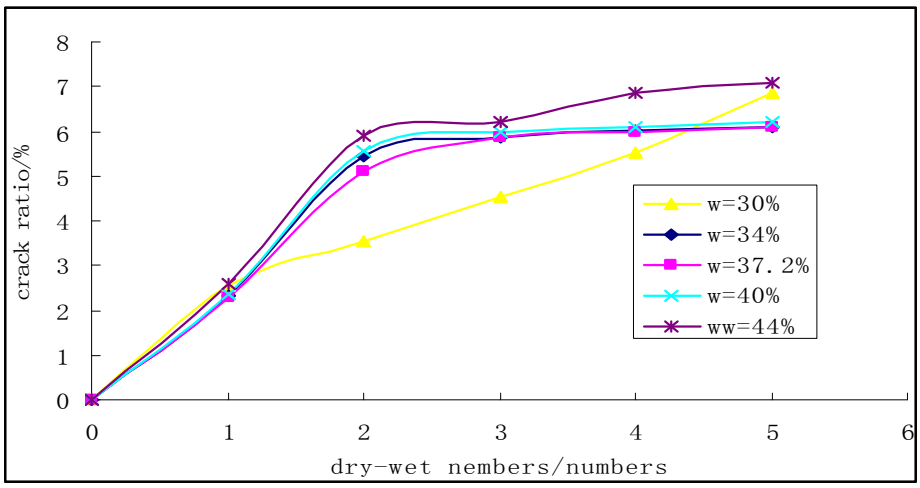

Fig. 4 The relationship between the fissure ratio under the condition of 34˚C and the number of the wet and dry cycles

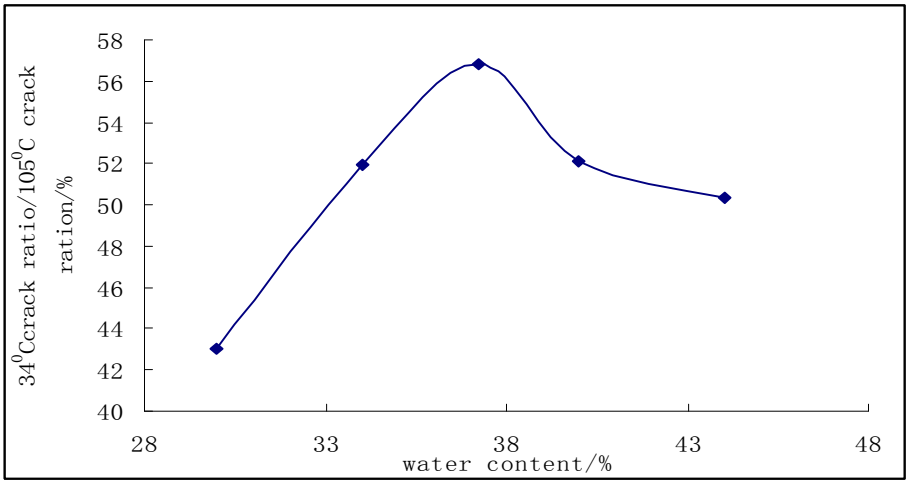

Fig. 5 The relationship between the ratio of fissure ratio under the condition of 34 ˚C to under the condition of 105 ˚C and the number of the wet and dry cycles

The Fig. 3 and Fig. 4 show that no matter under the condition of 105˚C or 34˚C,the fissure rate increasing with the increase of the number of the wet and dry cycles.In the first two cycles,the fissure ratio increased significantly,in the last three cycles the fissure ratio increased slowly,explaining the first two cycles have a greater influence on the crack of the red clay.Fig. 5 shows that the ratio of the fissure ratio under the condition of 34˚C to under the condition of 105˚C increases fast with the increasing of the moisture content and then reduce,reaching maximum when the moisture content is optimum moisture content.

Conclusions

The fissure ratio increased with the increase of the numbers of the wet and dry cycles,in the first two cycles it increased significantly,the last three cycles increased slowly,this phenomenon shows that the influence of the first two cycles on the crack of red is larger.

That the ratio of the fissure ratio under the condition 34˚C to under the condition of 105˚C increases fast with the increasing of the moisture content and then reduce,reaching the maximum when the moisture content is optimum moisture content.

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