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Research Article

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Study on evolving model of concrete failure surface in the freeze-thaw condition

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ABSTRACT

The freeze-thaw failure of concrete in many researches is described by dynamic elastic modulus, which is not applicable to estimating the loss of concrete strength in structural engineering. To avoid the deficiency, the paper attempts to establish an applicable failure surface in principal stress space for concrete to describe concrete strength change under different freeze-thaw cycles. Based on the discussion of meson-state of concrete under freeze-thaw cycles, hypothesis about concrete failure surface under freeze-thaw cycles is brought forward. Then, the damage of concrete and build up evolution equations is presented. Finally, a concrete failure surface model is given to predict concrete strength under different freeze-thaw cycles. Compared with available test data, the validity of new model is proven.

Keywords: Concrete Structure; Freeze-thaw; Strength; Damage; Evolution Equation; Failure Surface

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INTRODUCTION

In water conservancy project, port engineering, road and bridge engineering etc of cold region, concrete works or structures is the main damage during operation progress in the effect of freezing and thawing cycle.Since the development of freezing and thawing damage in the 40's of twentieth Century, American, the former Soviet Union, Japan and some European countries etc promoted failure theory from the view of pure physical model, while some theories were proposed in testing cement paste or mortar. The work in the last 20 ~ 30s of this century mainly starts from the view of material science, as the basic means to test studies properties of concrete, concrete components and the external environment of concrete. Effect of freezing resistance, such as rate of temperature fall [1], water cement ratio [2], the humidity of environment [3], minimum temperature of freeze-thaw cycle [4] and the external force [5] etc. So far, the dynamic elastic modulus has been used the study on the freeze-thaw failure of concrete materials. But the loss of strength is most concerned of engineering structure. At present, there have some research work started from the angle of engineering structure. The technology studies on mechanical properties of concrete under freezing and thawing,frost resistance prediction point of view and the actual engineering of concrete. In complex stress state, concrete after freeze-thawing cycle is under the action of mechanical. Performance is related to the concrete buildings or structures, so we need urgently to master the different times under the mixed freeze-thaw cycles.

Concrete mechanical properties and the engineering structure are most commonly used in the strength of Association Department of concrete, freeze-thaw cycle conditions to study. The evolution of surface damage is an important way to solve the problem.

Xila Liu [12] points out, along with the rapid development of computer, structure engineering has become the theory, experiment and computer three level. Good concrete research ideas should be strict in theory and be convenient in the calculation. At the same time, it needs Parameter that should be able to use the existing (or even in the tradition) measure method which getting from the test. Starting from the above ideas, this article is based on the coagulation.

And this paper carries on concrete freeze-thaw damage in construction of traditional macro parameter level. Direct description to concert freeze thawing damage, establishes principal stress space utility, namely the application of damage mechanics. The freeze-thaw damage of concrete surface evolution model researching the materials science can be directly for structural engineering services.

CONCRETE FAILURE SURFACE ASSUMPTION UNDER THE CONDITION OF FREEZING AND THAWING

The freeze thawing damage of concrete is the essence of porous media. Under the action of temperature, pore solution has phase change, resulting in internal stress acting on the concrete solid skeleton. This kind of concrete moves in circles to mix concrete and irreversible deterioration. In view of the complexity of concrete material, in the Practical applications, it is usually descried in the stress space by several independent materials. The failure surface model with constant controls descries strength characteristics. After being through freezing and thawing cycle, thestrength characteristics of the concrete become more complex. There is not enough data through the destructive test and directly grasp that the change rules of concrete freezing thawing damage surface after different freeze-thaw cycles until now.But that, after a certain number of freezing thawing cycle, the damaged concrete can be regarded as a stable material. According to the Drucker postulate, this kind of material in the effective stress space failure surface should be the same to have a smooth, convex form. Hereby, this paper puts forward the failure of concrete in the condition of freezing and thawing under surface assumption: coagulation Soil material which subjected to freezing and thawing circulation still has concrete failure surface characteristics. It possesses a curved meridian, and deviator plane hydrostatic pressure from the approximate along the triangle to non circle and non affine shape transition.

According to the above assumption, if nondestructive concrete failure surface equation uses Cauchy first stress invariant I1, deviator stress tensor in second. J 2, and deviator stress tensor invariant J 3, it can be expressed as:

$f(I1, J2, J3) = (1)$

If the freeze-thaw damage of concrete is regarded as uniform, the Isotropic materials, the failure surface in the effective stress space is also available. And the effective stress invariants of I 1, J 2, J 3 is expressed as

$f(I1, J2, J3) = (2)$

If you use the Cauchy stress tensor σand the damage tensor ∫D to describe the effective stress tensor σ, it can be expressed as:

$\sigma \hat{} = \sigma(I-D)(3)$

Use of formula (2), (3), Cauchy can be obtained in the stress space.

The damage variable of concrete freeze-thaw damage surface can be described as:

$f(I1, J2, J3; ai(\boldsymbol{D}), i = 1,,\Lambda) = (4)$

Most scholars believe that the freeze-thaw damage is a kind of fatigue damage.

THE DESCRIPTION OF THE CONCRETE FREEZE-THAW DAMAGE

The concrete freezing thawing damage of nature firstly is based on the damage mechanism, that is to say net pressure hypothesis [13] and osmotic pressure hypothesis [14] two main Hypothesis. Despite the two hypotheses, they two hold the view that the structure of the liquid pressure within the concrete hole is a major cause of injury. Liquid pressure Power is isotropic. The Powers structure of cement stone model [15] is regarded as the basic unit of the freeze injury of concrete. In the isotropic effect of liquid pressure, the Powers structure model of cement stone occurs an isotropic damage. From the macroscopic view, concrete can be used as isotropic continuous. And its body size is 100 mm, the Powers structure model of cement stone is about Degree of 1 mm. If they regard the Powers structure of cement stone model as the basic unit of concrete slurry, it can be considered that coagulation Soil freezing thawing damage is properties of isotropic damage. From the perspective of micro cracks, if that role in concrete Part of the liquid phase pressure lead to concrete micro crack is mainly I type crack, it can be considered that concrete freeze-thaw damage is elastic damage. Although the damage index has influence on the mechanic properties of the concrete, according to the view of phenomenology, after the elastic damage occurs concrete also retains the properties of plasterers, i.e. the elastic performance indicators are still independent. There are two separate, other indexes can be used two independent means Standard description. The two indexes of elastic

modulus and Poisson's ratio are the most commonly used. The isotropic damage model mostly uses the scalar form (zero order tensor form), cannot be described the volume damage material. In the concrete freezing and thawing, the test has been observed in the apparent volume expansion and the measurement to the Poisson Ratio. The change of Poisson's ratio and volume can not be ignored, so the higher order damage variable must be established. Using four orders is tropic Tensor Δ to describe the damage concrete freeze thaw, the component form is as follow:

$$\boldsymbol{D}ijkl = D1™ij™\ kl + D2™ik™jl \quad (5)$$

The recession material stiffness usuallybe considered as the most direct influence damaging on the properties of the materials. and the variable [16 to 18]changes in material stiffness can represented as:

$$\boldsymbol{E}ijkl = \boldsymbol{E}ijmn\ (\boldsymbol{I}mnkl - \boldsymbol{D}mnkl\ ) \quad (6)$$

To evolution of elastic modulus and Poisson's ratio, for the problem of freezing and thawing of concrete, it is difficult to test and analysis methods to directly establish the concrete damage in the internal liquid pressure. From the perspective of micro cracks, concrete subjected to freeze-thaw cycle under the isotropic liquid phase pressure, the damage evolution can simulate the approximate damage process of epitaxial tensile concrete. Its essence is to describe the process of formation and development of micro cracks of concrete.

Comparative and experimental data predicts the strength. The failure surface is assumed and isotropic elastic that damages the rationality assumption to test the concrete freezing and thawing, and it needs to be frozen strength and test for measurement of five parameters of William-Warnke thawing damage failure surface model by comparing predicted.

CONCLUSION

Based on the concrete freezing thawing mechanism discussed in view of the fine, the application of damage mechanics from the macroscopic angle establishes freeze-thaw damage practical. Surface model, proposed concrete freeze-thaw damage model, can be in macro skeptical level prediction strength properties of concrete after freezing and thawing circle; the concrete which researches on application of freezing thawing durability has certain significance. From the predicted values and experimental values are compared, coagulation is proposed in this paper. Assume that a soil freeze-thaw failure surface and the isotropic elastic damage are reasonable.

Therefore, based on the concrete strength theory, the freezing and thawing problem researches as a means of mechanics servicing for the structural engineering.

REFERENCES

[1] Pigeon M. Prevost J,Simard J M. *Journal of the American Concrete Institute*,**1985**,82(5):684–692.
[2] SenbuO,Kamada E. Mechanism and evaluation method of frost deterioration of cellular concrete[A]. In : Durability of Building Materials and Components[C]. [s. l.]:[s. n.],**1990**. 241–246.
[3]Moukwa M. *Cement and Concrete Research*,**1990**,20(3):439–446.
[4] Jinyu Li,JianguoCao,WenyuXu,et al. *Journal of Hydraulic Engineering*,**1999**,(1):41–49.(in Chinese))
[5] HaoCai. Prediction model of concrete freeze-thaw durability[Ph. D. Thesis][D]. Beijing:Tsinghua University,**1998**.(in Chinese))
[6] Zhaoli Wang. Frost-resistance of concrete and correlation with permeability[M. S. Thesis][D]. Qingdao:Qingdao Institute of Architecture and Engineering,**2003**.(in Chinese))
[7] Nina Gong. Finite element analysis of concrete freeze-thaw damage[M. S. Thesis][D]. Beijing:Tsinghua University,**2005**.(in Chinese))
[8] Likun Qin, Yupu Song,HaoranChen,et al. *Chinese Journal of Roc Mechanics and Engineering*,**2005**,24(10): 740–1 745.(in Chinese))
[9] PheeraphanT,Leung C K Y. *Cement and Concrete Research*,**1997**,27(3):427–435.
[10] Xila Liu. Status and Prospects of Structural Engineering[M]. Beijing:China Communications Press,**1997**.(in Chinese))