The initial cold and freeze-thaw cycle test comparative analysis research

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Abstract. After the effects of initial cold, take the strength changes of C30 and C50 concrete block and the result of beam test load, concrete strain, tensile reinforcement strain and deflection of the beam for analysis. The result showed that the trends of concrete C30 and C50 is consistent, which are decreased while the freezing time increased after the initial cold. And the beam reinforcement strain of C30 was less than C50, especially in the initial 90 days. Under the same load function, the flexural performance of the beam with C50 was higher than that of C30 beams in initial 90 days, but the two curves coincide after 120 days.

Introduction

With the increase of high-rise and super high-rise buildings,the winter construction is increasingly common while the project construction period increased. And the concrete soon began to enter the initial cold effect after the pouring completed. The bearing capacity of reinforced concrete members and structures under the initial cold effect has been gaining momentum. So the author took the experimental study for the bearing capacity of reinforced concrete beam, deflection, strain of steel and crack and other mechanical properties are analyzed in detail.

The Test Result

Analyze the strength of concrete test block

Pouring and curing concrete block for 150mm × 150mm × 150mm for three specimens per group under standard conditions .Then take them out of the lab when the intensity values reach their intensity after indoor (15℃) maintenance of a day and the initial cold of the corresponding time and natural conservation. The reinforced concrete beam is 1500mm×100mm× 200mm, which composed by longitudinal reinforcement for 2Φ14, erect ribs for 2Φ6, stirrup for Φ6 @ 75, and the thickness of the protective layer is 25mm. In order to facilitate loading, leaving the ends of each beam 100mm, and the calculation span is 1300mm.

Figure 1 shows the strength variation of C30 and C50 concrete test block in the early period after the cold. It does can be seen: the trends of C30 concrete strength is consistent to C50, both of them are decreased while the freezing time increased.

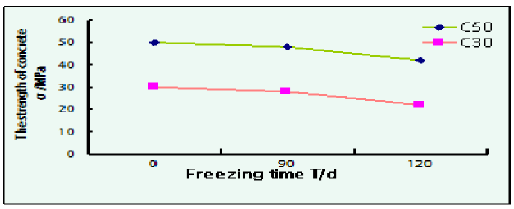


Fig. 1 Concrete block strength contrast

The experimental phenomena

Figure 2 shows the beam's failure forms under load after the initial cold.

Crushed concrete in compression zonePure bending section fracture

Fig. 2 Concrete crack of beam test

At the beginning of loading, the components are in elastic stage. The section is untracked because the bending moment by the load is small, and the performance of the beam characteristics of elastic deformation, the deflection and strain showed a linear change. When the load further increased but within yield load, Concrete C30 beam cracks appeared at first compared to concrete C50 beam, but the cracks develop slow. When the load value reached the limit, a large number of cracks appeared and width rapidly increased. And the concrete in the compression zone are crushed.

In the experiment, the first cracks of concrete C30 beams as well as C50 are vertical in the span position. However, when compared to C50 beam, the cracks of C30 beam appeared earlier and developed faster, the crushed concrete in compression zone is more serious and diagonal cracks appeared. While the C50 beams showed a crack on the side mostly are joints and the number of cracks which are vertical appear to be significantly greater than C30 beam.

The test load analysis

The test used the result of the cracking load, yield load and ultimate load of C30 and C50 beam as the bearing capacity, to analyze the changes of bearing capacity about the ordinary concrete and high strength concrete of reinforced concrete beams after initial freezing.

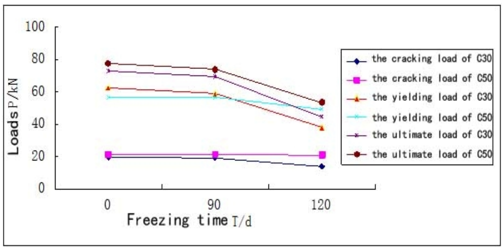


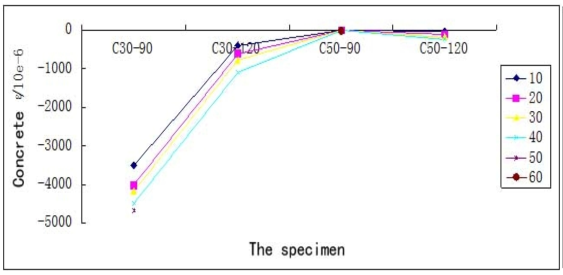
Fig. 3 Contrast figure on beam bearing capacity of C30 and C50

From figure 3 can be found: The initial cold effect has a certain influence on bearing capacity of reinforced concrete beams, and the ultimate load is most prominent. Compared to C30 ordinary concrete beam, C50 high strength concrete beams in cracking load unchanged, that means there is no impact on the role of cold to the cracking load. However, the yield load of beam C50 is less than that of C30 on the condition of normal conservation and initial cold 90 days .Instead, the beam's yield load is greater than C30 after 120 days of initial cold. This illustrates the influence on yield load about initial freezing time on C30 is greater than C50.But the ultimate load value in initial cold 120 days is significantly lower than that of 90 days and the two folding lines are basically parallel, namely the change of both is basicaally the same.

The Test Analysis

Strain of Concrete

From figure 4 can be clearly drawn: The stress in middle section of the beam on C30 is greater than C50's in either load. Because of the intensity values are not the same, so the compression zone of C30 reinforced concrete beams to be significantly higher than the C50.The stress value of C50 concrete beam is almost negligible in the initial 90 days of freezing effect, but it increased in the initial 120 days of freezing effect . This is mainly due to the concrete strength is lowered to cause the neutral axis moves up, and eventually lead to concrete strain values increase . It can determine that C30 concrete commitment to the stress values more and it is also explains the situation that the crack damage is more obvious, and more serious damage crushed to the compression zone.



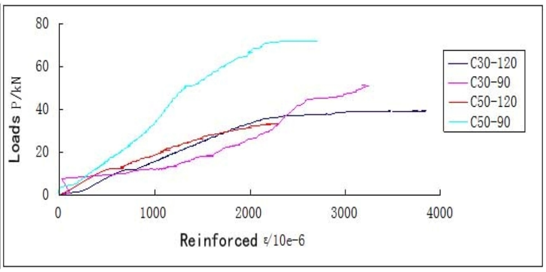


Fig. 4 Maximum compressive strain curves of mid-span section concrete

Fig. 5 Strain curve of the steel

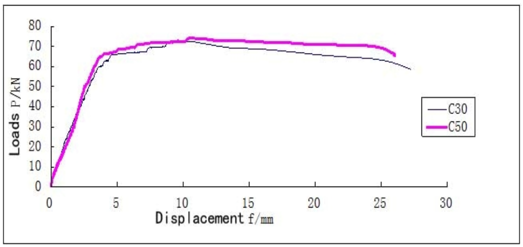
Tensile reinforcement strain analysis

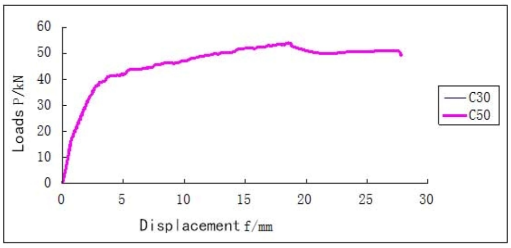
Reinforced concrete structures or structures mainly take advantage of steel tensile strength to achieve better bending performance. Since the tensile strength of concrete in reinforced concrete beams are general neglected in the calculation of bending, the tensile stress are borne by the steel. So testing strain study on reinforcement is an important part of research of reinforced concrete structures

From figure 5 can be found: In terms of development trends, span steel beams strain values of C30 and C50 showed an increasing trend, but with small differences. Strain values of C30 steel beam were less than that of C50, and especially in the initial cold for 90 days prominent most. Combined with the figure 4, almost all steels bear the stress; the main reason is the change of the neutral axis location and the changes to its carrying capacity allocation after cracks. Therefore, in order to compensate the redistribution of stress caused by concrete cracking or neutral axis shift, we must fully consider the steel usage of high strength concrete elements or structures in the initial cold effect in the design and construction

Deflection Analysis

The deflection is an important index to measure the overall performance of reinforced concrete beams .The large deflection would affect the comfort and usability of the component or structure, the deflection is also a index to measure the stiffness of beam ,as well as one of the conditions to judge whether the beam is damaged or not .





Beam load deflection curve in cold for 90days   Beam load deflection curve inoldfor120 days

From figure 6 can be found: Under the same loads, the bending strength of reinforced concrete beam C50 is higher than that of C30 in the initial cold effect of 90 days. However, the two curves overlaps after the initial cold effect for 120 day, that is to say the bending strength of two beams are basically identical.

Compared to Freeze-thaw cycles

Size effect

Chana[1] selected the prototype for the cross-sectional dimensions 200 mm × 400 mm , and take model to testing with the method to reduce the proportion of these models for 1：2、1：3.3. The results show that the size effect of the reinforced concrete beam has no influence to the bearing capacity of bending strength. This is because the bending failure of the beam mainly caused by the yield of tensile of longitudinal reinforcement. In addition, the main factors influencing the size effect is the concrete strength and the bond of concrete and steel. Therefore, the size effects only have a significant impact on the bearing performance of components or structures that the concrete compression strength reaches the limit value.

Through the conclusion above: We can ignore the effects of the bending mechanical properties of concrete simply-supported beam caused by the size effect.

Concrete degeneration contrast

Through this experimental study we can know that the strength of concrete would have the appropriate degree of decreased after the initial cold effect, and it related with the freezing time. A large number of experimental studies have shown that [3-5] the strength of concrete also degenerated after the freeze-thaw cycle, and put forward the corresponding calculation formula with freeze-thaw cycles as a parameter according to the test results.

Yang Zhongwei[2] toke freeze-thaw cycle test with different times for standards cube concrete test block of C20, C30,C40 and C50 four levels and prisms test block for 100 mm × 100mm × 300mm. Toke ordinary concrete for freeze-thaw cycles for 0,25,50,75,100 times, and high strength concrete for 0,25,50,75,100,125 times. Then the concrete stress - strain curve equation and determine the parameters of the formula as follows.

$$f_{d,c} / f_c = a + bn \quad (1)$$

$$a = 0.9981 - 0.00014 f_c$$

$$b = -0.00916 + 0.000131 f_c \quad (2)$$

Type 1 and 2 are applicable to calculate the intensity values of C30 ordinary concrete and C50 high strength concrete after the freeze-thaw cycles.

Wei Yan chao[3] summarized the data in literature [41-43], in a way to take regression analysis, finally draws the relation between the compressive strength of ordinary concrete and freeze-thaw cycles for:

$$\frac{f_N}{f_c} = 1 - qn$$

$$q = 0.0191 - 0.0004 f_c \quad (3)$$

In the formula:

f_N Isthe compressive strength of ordinaryconcrete after freeze-thaw cycles.

f_c Is the compressive strength of ordinaryconcretewithout freeze-thaw cycles.

q Is a coefficient related to the compressive stre- ngth of normal concrete without freeze-thaw.

Zhu Jinpeng [4] made 24 C50 concrete blocks for 100mm × 100mm × 100mm. Then take themethod of freeze-thaw test and concrete meso mechanics numerical simulation analysis, and using least squares fitting for the ultimate compressive strength value after 100, 200, 300 times of freeze-thaw cycle, got the compressive strength reduction equations which relates to the parameter freeze-thaw cycles.

$$f_c = f_0 e^{-0.002N} \quad (4)$$

According to the calculation formula above proposed in the literature, the intensity values of concrete C30 and C50 after initial cold and freeze-thaw cycle effect were compared and analyzed. And the concrete C30 calculations were 0,25,50,75,100 times freeze-thaw cycles, the concrete C50 calculations were 0, 25, 50, 75,100,125times.

The values of the strength concrete obtained by the contrasted test block in this experiment are used to analyze the experimental data, a specific comparison in table 1 to table 3.

Table 1 The testing concrete strength value

Thestrength of concrete(σ/ Pa)	the Freezing time(T/d)	
	90	120
C30	30.05	22.71
C50	50.35	43.42

Table 2 Comparison of concrete strength calculation on C30

The freeze-thaw cycle times	Test block strength calculation source	
	Y.C. Wei	Z.W. Yang
6	27.62448	30.05481024
25	26.0364	27.0476544
50	20.8728	23.0908704
75	15.7092	19.1340864
100	10.5456	15.1773024

Table 3 Comparison of concrete strength calculation on C50

The freeze-thaw cycle times	Test block strengthcalculation source	
	J.P. Zhu	Z.W. Yang
2	50.95576873	50.32028022
25	48.66489736	44.35121792
50	46.29148231	37.86310672
75	44.03382007	31.37499552
100	41.88626533	24.88688432
125	39.84344806	18.39877312

By comparison of Table 1 and Table 2 can be seen: The strength of concrete C30 under the condition of the initial freezing effect for 90 days is equivalent to Yang Zhongwei's computational model of freeze-thaw cycles for 6 times and 5o times when the initial freezing effect for 120 days.

By comparison of Table 1 and Table 3 can be seen: The strength of concrete C50 under the condition of the initial freezing effect in the early 90 days is equivalent to Yang Zhongwei's computational model of freeze-thaw cycles for 2 times and 25 times when the initial freezing effect for 120 days.

The Conclusion

(1) By the comparative test of normal concrete beams with high-strength concrete beam, obtained that initial freezing effect has some influence on the reinforced concrete beam and the limit load is most prominent. The yield load of C50 beam in normal maintenance and in the initial freezing for 90 days is lower than that of the C30, but the yield load of beam is larger than C30 in the initial freezing for 120 days. The ultimate load value in the initial freezing for 120 days was significantly lower than that for 90 days and the two substantially parallel to a line that changes both basically the same .

(2) Under the same load, the bending performance of C50 reinforced concrete beams is higher than that of C30 in the initial freezing effect for 90 days, but the bending performance of the two kinds of beams are basically the same after the initial freezing for 120 days.

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