論文 Study on Properties of Low Heat and Highly Flowable Concrete

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ABSTRACT: The purpose of this study is to develop the concrete which has both properties of lo heat and high flowability. The high flowability is to guarantee the durability of concrete without ar compactions. Low heat of hydration is to apply this concrete into mass concrete constructions. In th paper, the results of the experiment conducted to investigate the flowability, heat of hydration, settir times and strength of low heat and highly flowable concrete will be discussed.

KEYWORDS: urea, limestone powder, flowability, heat of hydration, self-filling capacity, slun flow, setting time.

1. INTRODUCTION

Normally, materials like Fly ash, Blast furnace slag and limestone powder are being used reduce the heat of hydration in large mass concrete constructions [1]. By replacing a part of cem by these materials, the maximum temperature of concrete can be reduced without changing powder content which is the important factor of mixture proportioning of highly flowable concrete. this study, we used the limestone powder in order to replace a part of cement.

When urea of 200g is mixed with 1 litre water, the temperature of water can be reduced by degree due to endothermic reaction. By using this property, it is confirmed that the temperature concrete can be reduced with mixing urea into concrete. Our first approach is to establish the u replacement ratio into water in which the high flowability of concrete is maintained without segregation, which is a basic requirements of highly flowable concrete [2]. When urea is mixed v concrete, it is found that the flowability of concrete is improved very much.

The mix proportions of the concrete whose slump is more than 25cm and slump flow is 60~70 are used to investigate the temperature, setting time and strength of concrete. As to the hi flowable concrete used in this study, the coarse aggregate does not remain at center of slum concrete and the water also does not bleed at tip of expanded concrete at the slump flow test.

2. OUTLINE OF EXPERIMENT

2.1 MATERIALS

The type of cement is normal portland cement (specific gravity: 3.15). The fine aggrega river sand (specific gravity : 2.61; water absorption : 1.61%; F. M. : 2.51) and coarse aggrega

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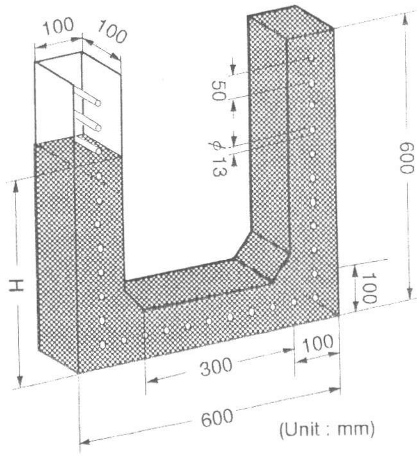

Fig. 1 The U-shaped apparatus

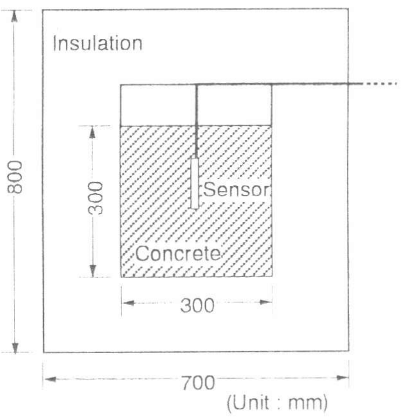

Fig. 2 The semi-adiabatic apparatus

Table 1 Mix proportions of concrete

Unit weight per volume(kg/m³)						Admixture(kg/m³)	
W	C	Lf	U	S	G	S.P.	S.R.
162	300	182	48(36)	688	980	7.05	7.0
153		185		697	993		
144		187		706	1006		
144	300	177	96(72)	670	955	7.05	7.0
126		182		688	980		
108		187		706	1006		
113	300	176	144(108)	665	948	7.05	7.0
99		180		679	967		
86		183		692	987		

S.P. :Superplasticizer
S.R. :Segregation reducing agent
( ) :Volume(litre)

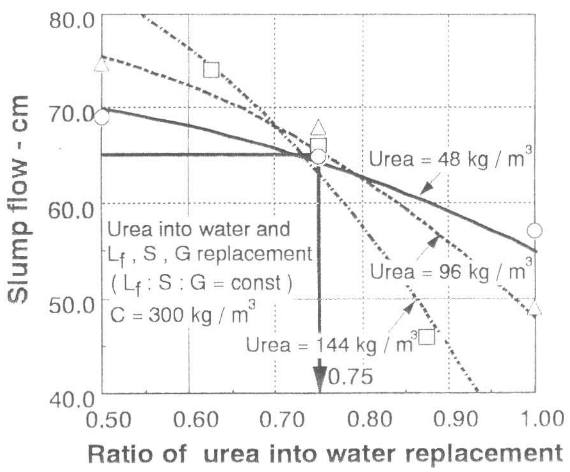

Fig. 3 The slump flow of concrete

crushed stone (specific gravity : 2.75; water absorption : 0.74%; F. M. : 6.47). The specific gravity of limestone powder is 2.73 and specific surface area by blaine is 2,800cm^2/g. The specific gravity of urea is 1.34.

2.2 EXPERIMENT METHODS

The flowability of concrete is measured by a U-shaped apparatus shown in Figure 1. The concrete is poured on one side of the apparatus and due to flowability it rises by its own weight to the opposite side. A distance "H" from the bottom corner of the side is measured. When concrete can rise in the other side, the distance "H" is considered positive, but when concrete can not rise in the other side the distance "H" is considered negative. When concrete reach just at the bottom corner, "H" is taken as zero.

The heat of hydration process and rising temperature of concrete is measured by a semi-adiabatic apparatus shown in Figure 2. The data of concrete temperature is recorded over one week. The setting and hardening process is measured by using a proctor needle penetration instrument in accordance with Japanese Industrial Standard. Initial setting time of concrete is defined as time when penetration resistance is 3.4MPa and final setting time is defined as time when the penetration resistance is 27.7MPa. Compressive strength is measured from 10cm x 20cm cylindrical concrete specimens.

3. RESULTS AND DISCUSSION

3.1 INFLUENCE OF UREA INTO SLUMP FLOW OF CONCRETE

Figure 3 shows the optimum water replacement ratio when cement content is 300kg/m^3. Table 1 shows the mix proportions of the concrete. As it is shown in this table, the ratio of limestone powder content, sand content and gravel content is constant. As evident from Figure 3, when the ratio is 0.75, the slump flow of concrete is between 60 and 70cm. Other levels of cement content, which are 388kg/m^3 and 250kg/m^3, are also investigated. The optimum water replacement ratios of concrete with cement content of 388kg/m^3 and 250kg/m^3 are 0.6 and 0.9, respectively.

3.2 EFFECT OF UREA ON FLOWABILITY

Figure 4 shows the flowability of concrete measured by U-shaped apparatus. A value of "H" above zero is considered that the flowability of concrete is good. These results are obtained from the concrete shown in Table 2. The bottom curve shows the flowability of concrete with no urea. From this figure, it can be observed that the flowability of concrete is influenced by urea plus water content. Both urea and water increase the flowability of concrete but the influence of urea is different from that of water. When the cement content is 250kg/m^3, the change of concrete flowability is very small even if urea plus water content is varied.

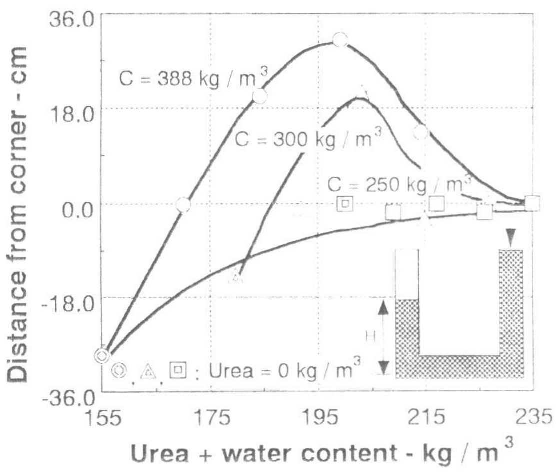

Fig. 4 Water plus urea influence on the flowability of concrete.

Table 2 Mix proportions of concrete

Unit weight per volume(kg/m^3)						Admixture(kg/m^3)	
W	C	L f	U	S	G	S. P.	S. R.
155		179	0	706	1006		
143		177	27(20)	698	995		
131	**388**	175	53(40)	690	983	9.12	1.5
119		173	80(60)	682	972		
107		171	107(80)	674	960		
180		187	0	706	1006		
165		186	27(20)	701	999		
150	**300**	184	53(40)	696	992	7.05	7.0
135		183	80(60)	691	985		
120		182	107(80)	686	977		
200		176	0	706	1006		
182		175	27(20)	704	1003		
164	**250**	175	53(40)	702	1000	5.88	10.0
146		174	80(60)	700	997		
128		174	107(80)	698	995		

S. P. :Superplasticizer
S. R. :Segregation reducing agent
( ) :Volume(litre)

3.3 INFLUENCE OF UREA ON CONCRETE TEMPERATURE

Figure 5 shows the influence of urea on concrete temperature. The cement content of concrete as shown in this figure is 388kg/m^3. It is clear from this figure that both the concrete temperature just after mixing and the maximum concrete temperature are reduced by mixing urea. Furthermore, the time to reach the maximum temperature is delayed by the effect of urea. In the early hours of hydration, concrete temperature is affected by urea but at ending hours of hydration, the concrete

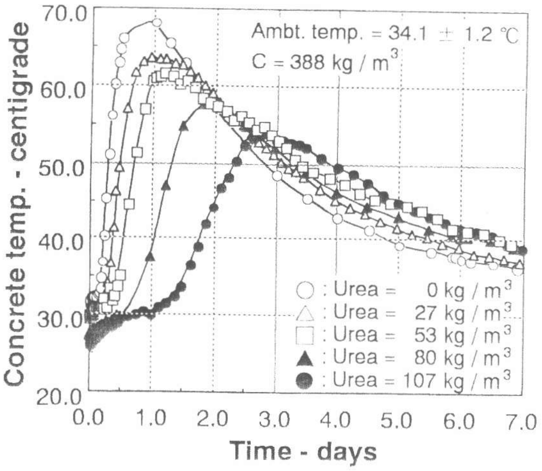

Fig. 5 The rising temperature of concrete

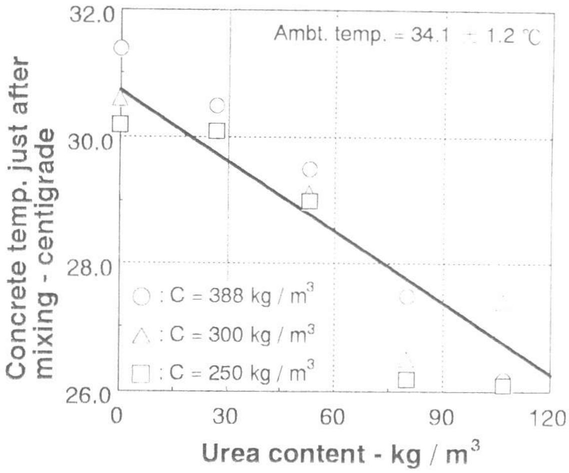

Fig. 6 Temperature of concrete just after mixing

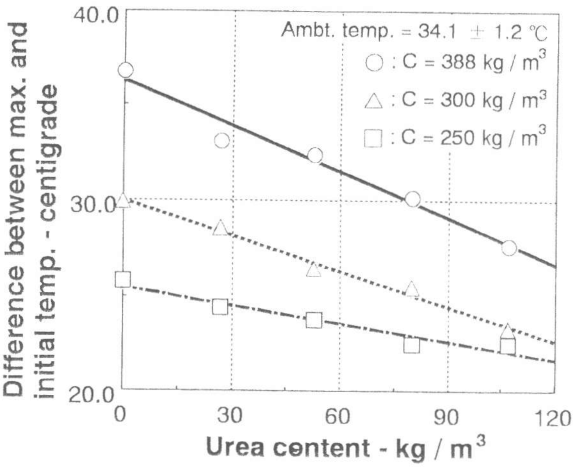

Fig. 7 The difference between max. and initial temp.

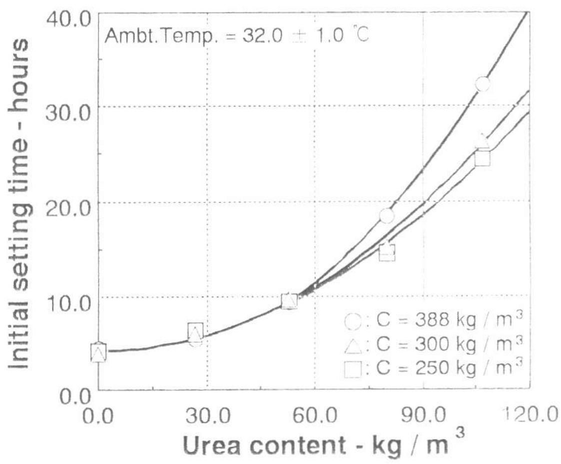

Fig. 8 The initial setting time

temperature is almost same, regardless of the urea content. This shows us that, apart from the fact that urea reduces the concrete temperature by reacting with water endothermically, it also somehow reacts with cement during the hydration process which results to slowing down of the rising temperature of concrete. It has been recognized that other levels of cement content show similar results.

Figure 6 shows the temperature of concrete just after mixing with various urea content. It is observed that the concrete temperature just after mixing is decreased by endothermic reaction between urea and water. A drop of temperature of concrete up to 5°C is observed when higher amount of urea is used. The decreasing temperature is not affected by cement content.

Figure 7 shows the differences between maximum and initial temperatures of concretes with different cement content. It is evident that the effect of urea is comparatively large when cement

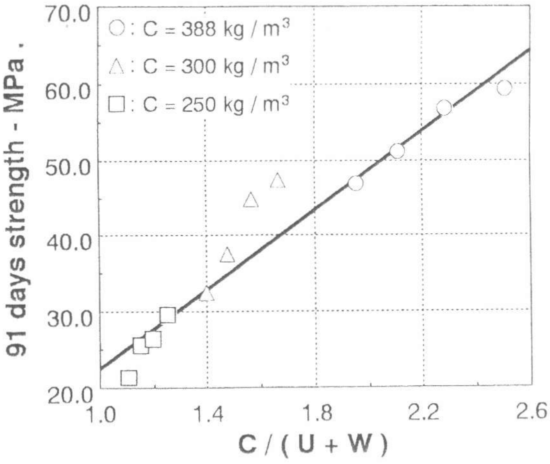

Fig. 9 The relation between 91days strength and cement to urea plus water ratio

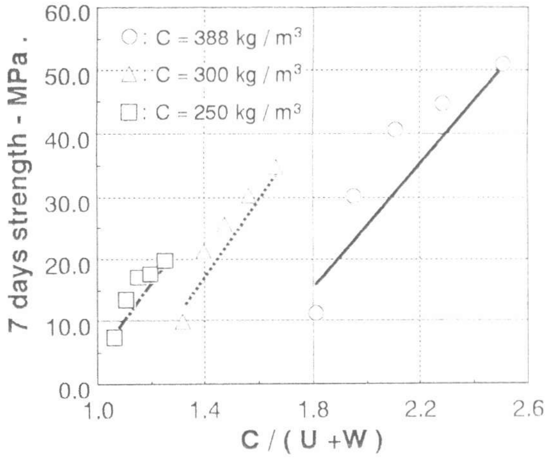

Fig. 10 The relation between 7days strength and cement to urea plus water ratio

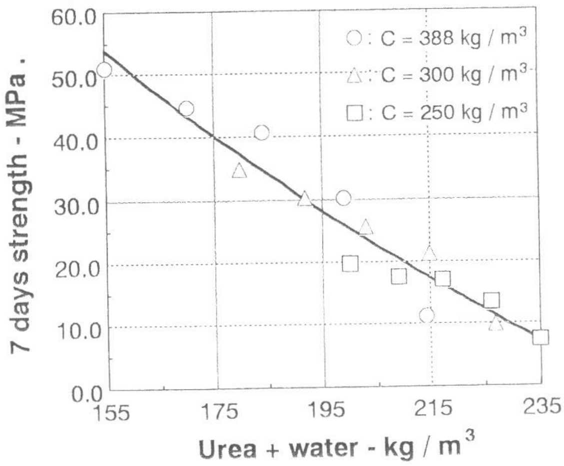

Fig. 11 The relation between 7days strength and urea plus water content

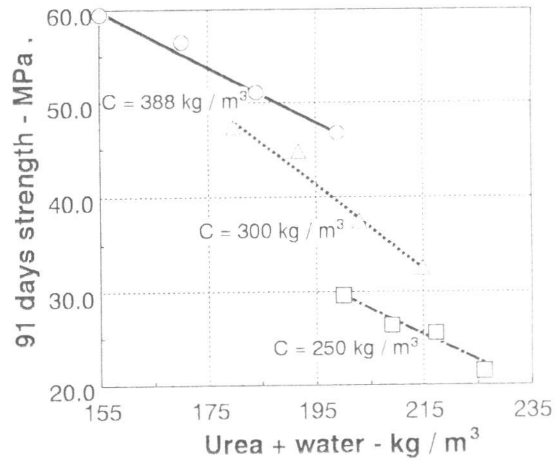

Fig. 12 The relation between 91days strength and urea plus water content

content is high. The difference between maximum and initial temperature of concrete is decreased linearly with the increase of urea content.

3.4 INFLUENCE OF UREA ON SETTING TIME

Figure 8 shows the initial setting time of concrete as the amount of urea is varied. Urea slows down the setting time of concrete. When the amount of urea in concrete is increased, initial setting time also increases. As already observed, urea somehow reacts with parts of cement products during hydration process and thus slows the setting process of concrete. The slowing down is more or less the same regardless of the cement content in concrete.

3.5 INFLUENCE OF UREA ON CONCRETE STRENGTH

Figure 9 shows the 91days strength of concrete represented by the cement to urea plus water ratio. It is clear from this figure that the relation between 91days strength and the cement to urea plus water ratio is linear. So, the effect of urea content on 91days strength of concrete is same as that of water content.

Figure 10 shows the 7days strength of concrete represented by the cement to urea plus water ratio , In this figure, the linear relationship can not be confirmed. Figure 11 shows the 7days strength of concrete represented by the urea plus water content. The relation between 7days strength of concrete and the urea plus water content can be represented by a curve irrespective of cement content. It is evident that this relation is established at young age of concrete and not at 91days as shown in Figure 12. These results mean that the effect of urea on concrete strength is dependent on the concrete age.

4. CONCLUSION

It is possible to produce a highly flowable concrete with low heat of hydration by using urea. The reduction of concrete temperature by urea is not only due to endothermic reaction with water but also a reaction with parts of cement products during hydration process. The effect of urea is large especially when cement content is high.

Both urea and water increase the flowability of concrete, but the influence of urea is different from that of water. The flowability of concrete can be improved by using urea especially into the highly flowable concrete whose water content is low.

The effect of urea on concrete strength is dependent on the concrete age. At the age of 91days, the effect of urea is almost same as that of water, so that concrete strength can be represented by the cement to urea plus water ratio. But, at the age of 7days, concrete strength can be represented by the urea plus water content irrespective of the cement content.

A temperature drop of up to 5°C can be obtained just after mixing which is very useful especially when concrete is casted in summer. Such kind of concrete can be used in mass concrete constructions and also to fill the inner parts in dam construction. High flowability imparts easy pouring into the casting forms and results further reduction of construction costs.

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