

СТРОИТЕЛЬНЫЕ МАТЕРИАЛЫ

УДК

Wu Jilan, Feng Enjie, Ma Yigang, Zhang Renshui

SURVEY ON APPLICATION AND RESEARCH
OF HIGH STRENGTH CONCRETE AND HIGH PERFORMANCE CONCRETE
IN CHINA

1. Introduce

The research and application of HSC began in 1960 in China, when the grade of the concrete used in the reinforced concrete beam in the repair workshop of capital airdrome was C100. But during the succeeding 10 years, there was little study, until 1970, when high range water reducer NF, FDN, SM were produced in China, more and more people began to study high strength (HSC) and high performance concrete (HPC) and published some important articles. Chinese Civil Engineering Association High Strength and High Performance Concrete Institute came into existence in August 1991, after that the application and research of high strength and high performance in China develop very fast. Now, throughout country many civil engineering constructions are built with high strength and high performance, only in Shanghai there are hundreds of high buildings built with HSC.

HSC may bring great benefit, experience in China shows that, if substituted the concrete of C30 ~ 40 with C60, the dosage of concrete may decrease by 40%, that steel by 39%, which will decrease the cost of construction by 20 ~ 35%. To one concrete component, if the strength of concrete increase 10MPa, the coal used for curing can be saved 13Kg/m³, if it increases from 40MPa to 80MPa, both the volume and the weight of building decrease by 30%.

For the HPC, scholars and experts in China consider that the high performance should be the out-standing technique and economic of construction design (mechanics), construction (non-mechanics) and life span (economic), the technique is the high compactness shown in the following:

High impermeability: which chiefly prevent the water and the deleterious ions from entering, and in the other word is the durability. Research shows that if the value of permeability in 6h is less 500 Kulun, we may think the concrete is not permeable.

Volume stability: which is equal to high elastic modulus, low shrinkage and creep and low temperature deformation. The elastic modulus of normal concrete is about 20 ~ 25GPa, which doesn't increase with the increase of strength, but that of HPC of same grade is 40 ~ 45GPa, the deformation of former due to shrinkage and creep is up to 0.08%, but HSC is less 0.04%.

Self-compacting (self-leveling or without vibration): There must be lacuna in the construction of concrete vibrated in the mold, so the mechanical vibration cause impact among in particles of concrete, and the particles vibrate themselves, which change the physical mechanics characteristics, change the gel into sol during the early-days of hydration of cement. The vibration decrease greatly initial gravitation among the mix, the mechanical force and the bond

between grains, which decrease the yielding shearing strength and the consistence of concrete, and vibration force decreases along the radius from center of vibrator, and the steel or the embedded may cause resistance, so some lacuna appears. However to self-compacting concrete, its yielding shearing strength and consistence always keep in ideal range, so aggregates suspend in the paste, don't segregate and bleed, and get across steel, flow freely, fill the mold and self compact.

High compressive strength: it is considered that the compressive strength of HPC should more than 60MPa, Chinese national academician WU Zhongwei proposed that the HPC should include the concrete of medium strength, such as C30, which is very significant in technique and economic.

2. The application of HSC and HPC in China

During the period of the eighth and ninth five years, National Construction Institute made the C50 ~ C80 concrete as an important item to popularize, so C60 ~ C80 concrete is used very widely in big span bridge, in high buildings, in breakwater of port and sea construction, in concrete ware and special construction, some of them are shown in table.

3. Research in lab of HSC and HPC

In China, there are many institutes studying HSC and HPC including some industry and branches of coal, metallurgy, traf-

fic, railway, water conservance, water and electricity, civil planning. Some universities and scientific research academies also take part in this research. The range of research varies widely, including the variety of water reducer and new kind of it, the kind, requirements and ultra pulverization of admixture, expanding agent, polymer latex, fibre material, the mechanism of crack in HSC and its prevention and cure, steel tube concrete, steel-concrete compounding structure and behavior of its point under strength, in addition the theory of interface and structure of cement stone related to the theory of concrete strength. There are many noted scholars:

Chinese National academician WU Zhongwei is one of founders of scientific research and development of cement compound material. And he proposed the design of mix of concrete, umbilicus theory, theory of concrete compensating shrinkage, and the essentiality of developing

green high performance concrete. And he organized to develop air-entrainment admixtures, expanding agent and cement or concrete wares, which boost the innovation in knowledge and techniques of building material in China, and make the national research institutes and universities into the center of basic research, forward explore of advanced technique and strategic research.

Professor PU Xincheng in Chongqing university succeeded in develop a kind of ultrahigh strength and high performance and great fluidity concrete mixed with normal material(R.525 cement, silica fume or pulverized slag and naphthaline high-range water reducer) by normal techniques, whose 28days strength may up to 100~130Mpa and another kind of concrete whose 28days strength was 150MPa, he also mixed ultrahigh strength concrete with ultra-fine sand, in addition he studied new kind of abundant mineral admixtures besides SF,

slag, FA, which are of good pozzolanicity. Besides PU obtained the relationship between compressive and other strength, deformation, and mechanics index of ultra-high strength concrete of different strength, which provided basic data for the application of ultra-high strength concrete.

Professor Huang Shiyuan proposed the concept of lessening of pores, which annotated that the strength of cement paste with 30% content of fly-ash (only 90% hydrated) and 70% of cement (hydrated) is equal to that of cement paste (all cement hydrated).

Professor Zhao Ruopeng in Tsinghua university and Jiang Zhengwu in Tongji university produced a kind of C100 high strength and great fluidity concrete by the way of low W/C (W/B), use of high-range water reducer which don't cause large loss of fluidity and high activity admixture. With compound water reducer, SF and pulverized slag, the shrinkage is very little and disappear in a short time, the

Examples of construction with HSC and HPC

Application Field	Name of buildings	Number of floor	Height or span or depth(m)	Part	Grade of strength	dosage (m ³)	Date of construction
High span bridge	Yangtze river bridge in Wan county of Chongqing province	-	420	Arch circle	C60	20,000	1994
	Yangpu bridge in Shanghai		602	Tower body	C50	-	1990
High or ultrahigh buildings	Jinmao edifice in Shanghai	88	420.5	Base of main body	Pumping C50	13,500	1995
	East Phearl in Shanghai	-	180	Straight canister	C60	16,846	1992
	Jingan center edifice in Beijing	23	-	Column	On ground C60 Under ground C80	50,000	-
Breakwater of port and sea construction	Three gorge construction	-	-	Bank	High performance dam concrete	16,000,000	1998
	Construction moving the south water to north	-	36	Beams	C60	56,000	-
			-	Pre-stress pipe stake	C70		
Piping	Jinqiao mining in Shandong province	-	412	Silo well	C50	16,000	1997

depth of carbonization can't be measured, so its carbonization resistance was very good, the ability of impermeability was more than P40, after 200 times cycles of freezing and thawing, its strength lost only by less 25%, and its weight didn't change. Its original slump was about 20 ± 2 cm, and was 17 cm two hours later, and the alkali resistance was very great.

Professor Feng Naiqian and Yan Peiyu in Tsinghua think that the crack directly affect the permeability, which is related the durability and life-span, and the reason of crack is due to the plastic shrinkage before final set and temperature difference because of heat of hydration.

Professor Zhang Xiong in Tongji university is studying intelligent concrete — emulate self-curing concrete including self-diagnosis, self-tuning, self-adaptive, self-recovery and self-repairing.

4. Conclusion

In the research of HPC, the important is the study of all kinds of mineral ultra-pulverized power, such as ultra-pulverized slag, ultra-pulverized phosphorus, ultra-pulverized zeolite and ultra-pulverized FA etc, which are regarded as the sixth component.

These power can decrease the quantity of cement, reduce cost, benefit environment by use of industry waste and make construction easy by improving workability of concrete, they also can improve performance of physics, chemistry and mechanics and make concrete waterproof, compensate shrinkage, shielding, conduct, in addition they make it possible to produce intelligent concrete, such as self-navigation, self-diagnose, self-regulating damp, self-controlling temperature, self-repairing, self-flexing. One reason of these is that there is less hydrated crystal of cement because waste replaces some of cement, then cement can hydrate very well and plays its role well, the other is that more power can improve the density of concrete and plays its special roles. The sixth component is very useful and worth to study. But we must notice many problems of complicated construction technics, some deleterious component in admixture and the matching with cement, so some further research must be carried on.

The direction of high strength should be HPC, especially GHPC. High performance stands for high strength, but also good workability and durability. It is very in-

spired that UHPC will be made into moulds built up with metal polymer, which shows that the application range of HPC expand greatly. But while we focus on the development of technique and economic benefit, we should pay more attention to Green Cause. Portland cement and normal cement both are not continual material, however, GHPC can save cement and concrete, which make concrete a continual material. To expand the range of application, the lower level of strength of GHPC may be fixed at about 30 MPa temporarily, at the same time we must strengthen of scientific research, increase variety of it, make best use of superiority of high performance to save cement and concrete by diminishing section area because of its high strength and high impermeability, or prolonging its life, to decrease energy cost, material cost during produce and transportation because of its high durability and to decrease degree of destroying environment. China is a country, which produces most cement, so it is more stringent to enlarge produce and application of GHPC than other countries, and the effect will also be more obvious.

□ Авторы статьи:

У Сюй-лань
- магистрант Шаньдунского научно-технического университета КНР

Фэн Эн-цзэ
- старший инженер, зам. директора шахты Донтан Яньчжоуского горнопромышленного блока КНР

Ма И-ган
- старший инженер, директор шахты Хэнхэшахты КНР

Чжан Жэнь-шуй
- доцент Шаньдунского научно-технического университета КНР

УДК

Zhang Renshui, Ma Yigang, Feng enjie, Wu Jilan

STUDY ON SPRAYED CONCRETE MODIFIED BY WASTE RESIDUE

1. Introduction

Currently sprayed concrete is still one of important supporting ways among underground projects. In recent 50 years, this technology has being developed, but one problem---low

strength-has not been solved at all. On the site, the actual strength is only between 10 MPa and 15 MPa, compared with the designed, it is too low, which may influence safe production in mining. To solve them, we must en-

hance management, in addition, one more effective way is to improve concrete strength by adding waste residue.

2. Raw material and experiments

2.1. Raw, material