GUO Gui-xiang Int. Journal of Engineering Research and Applications www.ijera.com
ISSN: 2248-9622, Vol. 5, Issue 7, (Part - 2) July 2015, pp.138-142

RESEARCH ARTICLE OPEN ACCESS

Summary of Self-compacting Concrete Workability

GUO Gui-xiang11*,Duan Hong-jun22
*(Materials Engineering, Chongqing Jiaotong University, Chongqing 400074, China
**(Bridge and Tunnel Engineering, Chongqing Jiaotong University, Chongqing 400074, China

ABSTRACT
On the basis of a large number of domestic and foreign literature, situation and development of self-compacting concrete is introduced. Summary of the compacting theory of self-compacting concrete. And some of the factors affecting the workability of self-compacting concrete were discussed and summarized to a certain extent. Aims to further promote the application and research of self-compacting concrete
Key words- **Self-compacting concrete Compacting Theory 、Workability**

I. INTRODUCTION

Self-compacting concrete is a new type of high performance concrete with considerably high workability, which mainly used for non-vibrating special engineering. It is often used in the reinforcement of reinforced concrete, narrow section, fine structure, etc. at the same time, it also has the advantages speeding up the construction speed, saving labor, reducing noise pollution, improving the quality of concrete. It provides the technical support for the concrete to the green and high performance, and it is a revolution of the concrete industry. Therefore, to explore the workability of self compacting concrete has important significance. This paper intends to give brief reviews and comments on the academic influence of main views of self-compacting concrete factors of workability. For the future, self-compacting concrete workability tests can provide reference opinions

II. RESEARCH BACKGROUND

Concrete is one of the indispensable engineering structural materials, the development of concrete technology is tend to complex, high strength, high performance direction. The technical requirements of high-performance concrete are more strict and complex. In ensuring the quality of projects, at the same time, speeding up the pace of construction, solving the shortage of skilled labor, eliminating the construction noise, has been unable to meet ordinary concrete. Secondly, for engineering structure with local, tunnel and underground structure reinforcement dense local vibration can not be implemented, the construction is very difficult. Secondly, for engineering structure with local, tunnel and underground structure reinforcement dense local vibration can not be implemented, the construction is very difficult. Therefore, self compacting concrete began to be used and developed [1-2、3]. In China, Professor Feng Naiqian put forward the concept of the flowing concrete in 1987, laid the foundation for the study of this field in our country.

Self-compacting concrete, also known as self leveling concrete, high fluidity concrete, refers to the mixture with a high liquidity and in pouring process without segregation and bleeding, can not by vibration and full of concrete form and wrapped reinforced concrete. Self- compacting concrete breaks through the limitations of traditional vibrated concrete in forming which is compacted by its own weight without or little vibration , assuring complete filling of formwork even when access is hindered by narrow gaps between reinforcing bars. Self compacting concrete can be used in the industrial solid waste such as fly ash, granulated blast furnace slag, silica fume and so on, which can be used for comprehensive utilization of resources and ecological environment protection. Self compacting concrete has been adapted to the requirement of modern concrete, which is the foundation of the concrete to the green, high performance.

III. SCC RESEARCH STATUS

3.1 FOREIGN RESEARCH STATUS

Self-compacting concrete was first developed by the Japan's Professor H.Okamura[4-5], the first known as the "non vibration of high durability concrete ". Since 1988, the first case of self -compacting concrete has been successfully developed in Japan, and SCC has become one of the research directions in the field of civil engineering in the new century. By the end of 1994, Japan has 28 construction companies have mastered the technology of self-compacting concrete. other countries have begun to develop self-compacting concrete. In fact, in the early 1980s Norwegian construction concrete structure in offshore oil platform, because of dense rib and structure was too large lead to vibration of the concrete incompletely, which formulated the concrete is to rely on gravity compaction. France in 1955 began developing vibration-free self-compacting concrete, Sweden, Germany, Singapore, Switzerland and other countries have also been successfully developed and gain application.

Some typical examples of projects are applied. An anchorage construction of a 1000-span Bridge in Japan used self-compacting concrete technology. Self-compacting concrete using the anchorage shorten the construction period by 20%, from 2.5 years reduced to 2 years. 1998 Switzerland completed Cleuson Dixence power projects in water conservancy, tunnel length 15850m3, inclined shaft total length 3920m, between the rocks and steel liner, using a total of 73000m3 of SCC as concrete lining. 1999 Loetschberg long railway tunnel 34642m3, used a total of 800000m3 of SCC [6-8].

3.2 CHINA RESEARCH STATUS

in recent years, China has made many achievements in engineering applications. Beijing, Shenzhen, Nanjing, Jinan, Changsha and other cities have been reported with use of self-compacting concrete and the SCC applications expanded from housing construction to large water conservancy projects, bridges, tunnels and so on. Representative engineering examples are as follows,

1. Simplified Wall of Beijing Capital International Airport's new terminal
2. Transformation project in Xidan commercial district on the eastern side of North Main Street
3. Nuclear waste container construction of the Daya Bay Nuclear Power Station
4. The history protection engineering buildings in Xiamen Jimei
5. Water diversion project for the Yangtze Three Gorges Dam left factory
6. Runyang Yangtze River Bridge E1 north of Anchorage Foundation wall lining
7. The tunnel project in Fujian WanSong-guan
8. Bird's Nest in the structure of ring shaped steel reinforced concrete beams and 78 steels reinforced concrete columns

The application of self compacting concrete in these projects has achieved good technical, economic and social benefits [9-10]

IV. SCC'S COMPACTING THEORY AND WORKABILITY

4.1 SCC SELF-COMPACTING THEORY

According to the theory of rheology[11], the concrete mixtures is roughly in line with the Bingham fluid model, Rheological equation as $\tau = \tau_0 + \eta\gamma$, τ_0 is maximum stress for hinder plastic deformation, caused by the adhesion and friction between the materials, which governs the deformation capacity of the concrete mixture. When $\tau > \tau_0$, concrete will produces flow. η is reflecting the viscous resistance of fulid between the stratosphere which flow direction reverse. It dominates the flow capacity of the mixing concrete. The smaller η, the faster the flow at the same external force. Superplasticizer is used to reducing agent plasticizing and superfine powder mineral admixture to improve the grading of cement material that can reduce η. Then, concrete mixture will be to achieve the desired liquidity which is able to self leveling by its own weight. It must be a reasonable balance between the viscosity and yield shear stress value, in order to reach the required "self-compacting". Ouchi[12] reached show that concrete mixture of self-compacting is related to course aggregate gradation, Coarse aggregate accounts for the proportion of solid volume, mortar deformability ,viscosity and the pressure transmission. Oh[13] is based on excess slurry theory and raised the ideal that the η rheological model which is about excess slurry thickness , the viscosity coefficient, yield τ_0 relationships. There are some report in Sedran[14], etc, that when μ 、 τ_0 is each less 200Pa·S，400Pa, concrete mixture has good mobility. On the current study, using of concrete mixture rheological parameters to guide their engineering practice is not realistic. However , using of two τ_0 and η rheologicals is able to show SCC concrete mixture rheological properties. Results have strong theoretical significance.

4.2 SCC WORKABILITY DISCUSSION

4.2.1 SCC WORKABILITY EVALUATION METHOD

Self-compacting concrete is a new type of high performance concrete with its considerably high workability. Scholars have studied the effect of SCC workability performance factors, which are mainly high liquidity, gap through , filling, segregation resistance and plasticity, etc. High Liquidity means that concrete under gravity to overcome internal resistance and the the adhesion between steel and form. Concrete with high liquidity is able to flow to fill the formwork and reinforcement around. High stability is refers to the concrete quality uniform, that concrete in pouring process of mortar and aggregate will not be segregation, after pouring bleeding not not layered settlement. The ability to pass through the gap refers to the concrete through the gap between the reinforced concrete without obstruction. The SCC indicators and test methods show table1. Bartos[16] has carried on the whole evaluation to the existing test methods. The performance of SCC mixture test method with limited significance.

At present, the workability of SCC is unite with variety of methods.

Table1.Self-compacting work of Indicators and Test Methods

country	Indicators	Test Methods
Japan	Liquidity, U-shaped flow meter height, segregation resistance	Slump flow、T500、U-shaped device、
Guide to Europe /2005	Liquidity / Filling、Cohesiveness、through Capacity、segregation resistance	Slump flow 、 T500 、 L-shaped 、 U-shaped、V-shaped funnel、Orimet、 J ring、Screening、static segregation、 static segregation
UK	Liquidity 、 Cohesiveness 、 through capacity、segregation resistance	Slump flow、T500、L-shaped 、 V-shaped funnel、J ring、 Screening
China	Liquidity、through capacity、segregation resistance	Slump flow 、U-shaped、V-shaped funnel、T500

4.2.2 STUDY ON THE FACTORS OF WORKABILITY OF SCC

According to the theory of rheology[11], the concrete mixtures is roughly in line with the Bingham fluid model, Rheological equation as $\tau = \tau_0 + \eta\gamma$, τ_0 is maximum stress for hinder plastic deformation, caused by the adhesion and friction between the materials, which governs the deformation capacity of the concrete mixture. When $\tau > \tau_0$, concrete will produces flow. η is reflecting the viscous resistance of fulid between the stratosphere which flow direction reverse. It dominates the flow capacity of the mixing concrete. The smaller η, the faster the flow at the same external force. Superplasticizer is used to reducing agent plasticizing and superfine powder mineral admixture to improve the grading of cement material that can reduce η. Then, concrete mixture will be to achieve the desired liquidity which is able to self leveling by its own weight. It must be a reasonable balance between the viscosity and yield shear stress value, in order to reach the required "self-compacting". Ouchi[12] reached show that concrete mixture of self-compacting is related to course aggregate gradation, Coarse aggregate accounts for the proportion of solid volume, mortar deformability ,viscosity and the pressure transmission. Oh[13] is based on excess slurry theory and raised the ideal that the η rheological model which is about excess slurry thickness , the viscosity coefficient, yield τ_0 relationships. There are some report in Sedran[14], etc, that when μ 、 τ_0 is each less 200Pa·S，400Pa, concrete mixture has good mobility. On the current study, using of concrete mixture rheological parameters to guide their engineering practice is not realistic. However , using of two τ_0 and η rheologicals is able to show SCC concrete mixture rheological properties. Results have strong theoretical significance.

Gu Xiang-jun, Li Jun from sand ratio, lightweight aggregate, mineral admixtures have done a self-compacting concrete test performance. They pointed that self-compacting concrete with reasonable fly ash, silica fume or complex mixed have a significant effect on improveing workability performance. The lightweight aggregate is suitable for low density levels, low crushing index, small water absorption and high quality light weight of 5-16mm. Best [18]workability of the volume rate of sand should control in about 48%. When the volume rate of sand decrease, slump flow is reduced slightly, the flow time of L-BOX prolongs and h2/h1, J-ring flow both are reduced slightly. However, J-ring of Inside and outside the height is increased significantly. Thus reducing the percentage of sand mainly affects the ability of concrete through the gap, and a smaller impact on other aspects of SCC workability.

Kasemsalnrarm[21] raised ideal that the key factors of SCC workability is that effective surface area of the free water content, powder and the water retention of aggregate in concrete mixture . Fly ash, silica fume, slag powder and other industrial solid waste are applied to concrete, which has the comprehensive utilization of resources and the protection of ecological environment. A lot of research is also obtained by adding fly ash to self-compacting concrete. The influence of fly ash applied to SCC was discussed by Cui Jun etc. Fly ash surface is smooth and dense which is between cement and aggregate with the "ball" lubrication. It increases the concrete mixture fluidity by reducing the internal friction resistance. Fly ash own micro-aggregate filling effect which increases the fluidity of the slurry by Displacing more free water. Additionally, Fly ash can effectively disperse cement particles, making it release more paste to lubricate the aggregate, mixing material to increase liquidity[22-23]. The influence of different contents of fly ash on mechanical properties and workability performance is different. SCC with fly ash improves workability performance, but decreases concrete early strength to a large extent. So it is not suitable for the large content of fly ash[24]. Also some scholars research on combination of a large amount of fly ash and self compacting concrete. They adopt Maleic acid polycarboxylate superplasticizer in SCC. The water reducing agent is able to promote the early hydration process of cement, to make up for the disadvantages of high volume fly ash about early low strength [25]. Ordinary concrete of the fly ash content is generally not more than 25%. But in SCC, the content of the fly ash in the 30%-35% have a very good workability, and meet the strength requirements [26].

The effect and mechanism of silica fume on SCC is more complex than fly ash. It is better to use different mineral admixture to carry out the SCC workability more than single fly ash. Lu Wen-bin[28] in the paper about study on complex mixed mineral material impact on self-compacting concrete proposed that fly ash and high fineness of slag collective effect is more significance.

V. Shortage and Prospect of Scc

There are still a lot of problems in the development of SCC in china. Huang Zhi-shan et scholars raised that many domestic SCC design even through improve cementitious materials dosage, dosage of cement, water, increasing sand ratio to improve the workability of concrete mixture, increasing the fluidity of concrete mixture. Thus the total amount of cementations materials, cement dosage, water consumption and sand ratio are more higher than International level. But these factors also lead to the mechanical properties and durability of SCC decrease [29-30]. There is no standard method for evaluating a unified SCC workability and rheological properties. Therefore, the evaluation method of SCC workability is need further studied. At the same time, SCC is also faced with the problem of high performance and high cost. And we should develop more affordable of SCC so that the concrete is more widely used by people.

Reference

[1]. WuZong-wei,LianHuizhen.High performance concrete.China Railway Publishing House ,1999:36-180
[2]. Feng Naiqian.High performance concrete. Concrete and Cement Prod-ucts,1993(2):6-10
[3]. H.Okamura,oaci.m.Self-compacting concrete. Journal of Advanced concrete technology. 2003, 1 (1):5-15
[4]. Feng Naiqian..Flowing Concrete[M]. Beijin:China Railway Publishing House,1988.
[5]. H.Okamura.self-compacting High performance concrete in Japan.Buil-ding and Environment.1999(25):123-128
[6]. Zhang Qiusheng.Summary of self-compacting concrete[J].Fujian Architecture,2009(5):53-55
[7]. Li Tingchi.Summary of self-compacting concrete[J].Journal of Hebei Software Institute,2006,8(3):59-61
[8]. Zhang Zhiming. Research and application of self-compacting concrete[J]. Fujian Building Materials,2009(2)
[9]. Gong Hong.Self-compacting concrete in the Qinghai-Tibet Railway [J].Guangdong Building Materials.2006(11):27-28
[10]. Liu Xia, Wu Dong, Wang Xinghui.Research and application of self-compacting concrete at the National Stadium in[J].Concrete.2008(7):107-111
[11]. Chen Jiankui.Principles and Applications of admixtures[M]Beijin:China Planning Press,1997:11-70
[12]. OUCHI Masahiro.Self-compatibility of fresh concrete[J]. RILEM Publica- tion SARL,2005.65-73
[13]. OHSG,TOMOSAWA F.Toward mix design for rheology of self-compacting concrete[J]. RILEM Publication SARL,1988.361-372
[14] model[J].RILEM Publication SARL, 1999. 321-332
[15]. ZhangQiusheng.Summary of self-compacting concrete[J].Fujian Architecture,2009(5):53-55
[16]. BARTOS P J M.Testing new European Standards for fresh SCC[J].R- ILEM Publication SARL,2005.25-45
[17]. Zhao Yinyhui.Self-compacting concrete performance factors[J].Traff- ic World. 2012(19)
[18]. Gu Xiaoshao, Li Jun.Experimental study on performance vibrated concrete free[J].People River.2010,32(9):125-127
[19]. Liu Baoqu, Jin Huashan, Yang Yuanxia. Impact of cementitious materials and sand ratio of self-compacting concrete work performance[J]. Fly Ash..2006(4):22-25
[20]. KASEMSAMRAR N，TANGTERMSIRIKUL S.A design approach for self-compacting

concrete based on deformability，segregation resistance and passing ability models [J].RILEM Publication SARL,2005.47-54

[21]. Wu Hongjuan.Self-compacting concrete for its assessment of[J].Wuh-an Polytechnic University reported.2004(2):68-72

[22]. Cui Jun, Wang Shuaishuai,WangLI, Hou Xunjun.Application of Fly Ash in self-compacting concrete[J]. Concrete. 2010(6):98-100

[23]. Wang Hui.Fly ash in self-compacting concrete[J]. Construction Scien-ce.2004 (12):45-47

[24]. Wang Jun, Ye Huanjun. Zhang Ye.Experimental study of self-compac-ting concrete under different fly ash[J].Forest Engineering.2010,26(5):72-75

[25]. Gong Mingzi, Chen LONG, Jiang Yaqing.Polycarboxylate fly ash on the performance of self-compacting concrete hardening of large water content[J].Fly Ash.2009(4):11-13

[26]. Zhang Li, Yang Xiuwei, Wang Lei.Effects of fly ash on the performa-nce of self-compacting concrete[J].Fujian Building Materials.2010(4):48-49

[27]. Yang Jiahui.Self-compacting concrete test with its applications in engineering[J].Engineering Quality

[28]. Lu Wenbin.Reuse of fly ash and silica fume in self-compacting concrete[J] . Concrete .2009(8):82-84

[29]. Huang Zhishan, Zhou Chunyu. Self-compacting concrete configura-tion technology and application technology to identify data compilation[A].Harbin Institute of Technology, Harbin second constructiodn.

[30]. Xiao Xuwen, Xu Youlin.Green concrete application of new technology and engineering[M].Beijin:Chinese construction industry.201