IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 12, December 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Comparative Study on Compressive Strength Behaviour Of Normal Concrete And Self Compacting Concrete Exposed To Elevated Temperature

Ch Geetha[1], P Hanmandlu[2], N Monica Madhuri[3]

[1]Ellenki College Of Engineering And Technology, JNTU Hyderabad,
Patancheru, Medak (D)-502305
Geethajana108@gmail.com

[2]Ellenki College Of Engineering And Technology, JNTU Hyderabad,
Patancheru, Medak (D)-502305
hanmandlu109@gmail.com

[3]Ellenki College Of Engineering And Technology, JNTU Hyderabad,
Patancheru, Medak (D)-502305
smonicamadhuri@gmail.com

Abstract: Cement is a mind boggling blend of various materials, for which the properties may change in various ecological conditions. The conduct of cement in flame relies on upon its blend extents and constituents. The standard impacts seen in the solid because of hoisted temperatures are misfortune in compressive strength, decrease in weight (or) mass, change in shading and spalling of cement. Because of these progressions there is an extraordinary need of study in this locale. The goal of this constrained review was to give a diagram of the impacts of raised temperature on the conduct of cement. In meeting this target, the impacts of raised temperature on the properties of ordinary concrete and self compacting solid materials are outlined. The compressive strength was resolved at various temperatures, hence giving extent of deciding misfortune/pick up in strength. Also, methods of cooling, variety in various evaluations of cement were contemplated. As the fire influenced concrete can't experience dangerous in down to earth circumstances, Non-Destructive testing (NDT) strategies, i.e., Rebound hammer test were likewise received and the outcomes were co-related.

Key Words: Fire, cooling, NDT, Rebound hammer.

1. Introduction

Fire causes critical individual, capital and creation misfortune in many nations of the world every year. Subsequently, the arrangement of proper fire wellbeing measures for auxiliary individuals is a noteworthy necessity in building outline. Cement is generally utilized as auxiliary material in building development where imperviousness to fire is one of the key contemplations in plan. Cement is a non homogenous material whose fire execution is controlled by its constituent materials, for example, total, cement paste and different fixings. In the course of the last three decades, there have been noteworthy innovative work action in solid innovation and this has prompted enhanced cement blends known as High execution concrete. These High Performance Concrete (HPC), blends incorporate High Strength concrete (HSC), Self Compacting Concrete (SCC), Fiber Reinforced Concrete (FRC) and Fly ash Concrete (FAC) which offer Superior strength, sturdiness and cost focal points. High strength concrete has a compressive strength by and large more noteworthy than 40Mpa. High Strength cement is made by bringing down the water cement proportion to as low as 0.3 because of which the strength, modulus of elasticity of the solid increases. The elements of high strength cement are the same as those utilized as a part of regular cement with the expansion of maybe a couple admixtures, both substance and mineral.1.1 Fire In the realm of construction, fire is unquestionably a threat that has to be counteracted and battled by every conceivable mean. Despite the fact that the likelihood is low, fire may happen anyplace, in any season and in any phase in the lifetime of a building. With reference to the cementitious materials, their conduct in direct strain at high temperatures is as yet a test and the test outcomes accessible in the written works are inadequate to be sure. Due to elevated temperatures, the effects in concrete are 1) spalling of concrete 2) loss of compressive strength 3) loss of weight/mass 4) change in color 1.1.1 Effects 1) There is a lessening found in the compressive strength of solid when the temperatures are raised. This is a result of the diminishment of strength in total, dissipation of dampness in the 9 solid network. The total/cement proportion has likewise an impact, with the diminishment being relatively littler for lean blends than for rich blends. Cement's compressive strength differs with temperature as well as with various different elements, including the rate of warming, the term of warming, regardless of whether the example was stacked or not, the sort and size of total, the rate of cement paste, and the water/cement proportion. By and large, concrete warmed by a building fire dependably loses some compressive strength and keeps on losing it on cooling. Be that as it may, where the temperature has not surpassed 300ºC, most strength in the end is recuperated. 2) The modulus of elasticity is influenced in the same way by the factors mentioned previously for the compressive strength. The reduction as a function of temperature is bigger than the compressive strength because the peak stress-strain increases with the temperature. 3) In fact the tensile strength of the concrete has a tendency to decrease faster with the temperature than the compressive strength. 4) On heating, a change in colour from normal to a pink/red is often observed and this is useful since it coincides with the onset of significant loss of concrete strength. The full development of the pink/red colour is coincident with substantial reduction in compressive strength and the method may be used to define the distance from a heated surface where strength degradation has occurred. 1.2 CHANGES TO CONCRETE IN FIRE Cement does not consume – it can't be 'set ablaze' like different materials in a building and it doesn't discharge any lethal vapor when influenced by flame. It will likewise not deliver smoke or dribble liquid particles, dissimilar to a few plastics and metals, so it doesn't add to the fire stack. Therefore concrete is said to have a high level of imperviousness to fire and, in the larger part of utilizations, cement can be portrayed as basically 'flame resistant'. This fantastic execution is expected in the primary to solid's constituent materials (i.e. cement and totals) which, when artificially consolidated inside solid, shape a material that is basically dormant and, imperatively for flame security configuration, has a moderately poor warm conductivity. It is this moderate rate of warmth exchange (conductivity) that empowers cement to go about as a powerful fire shield between contiguous spaces, as well as to shield itself from flame harm. The rate of increase of temperature through the cross area of a solid component is moderately moderate thus inward zones don't achieve an indistinguishable high temperatures from a surface presented to blazes. 10 At the point when cement is presented to the high temperatures of a fire, various physical and substance changes can occur. These progressions are appeared in the outline underneath, which relates temperature levels inside the solid (not the fire temperatures) to some demonstrative changes in its properties. 1.3 BENEFITS OF USING CONCRETE • Concrete is non-combustible (i.e. it does not burn). • Concrete is inherently fire resistant (i.e. it does not support the spread of fire). • Concrete has a slow rate of heat transfer (making it an effective fire shield). • Concrete does not produce any smoke, toxic gases or emissions in a fire situation. • Concrete does not contribute to the fire load of a building. • Under typical fire conditions, concrete retains most of its strength. 11 1.4 NON-DESTRUCTIVE TESTING Objectives: To establish homogeneity of concrete. Comparison of concrete quality with respect to Standards. Detection of cracks or voids any other imperfections in concrete. Monitoring changes in concrete with passage of time. To establish quality of one element with respect to another. Assessment of exiting structure for rehabilitation planning. As an alternative testing method if cube results raise doubts about concrete quality (Post Mortem).

2.0 LITERATURE REVIEW

2.1 MECHANICS OF DETERIORATION OF RC MEMBERS UNDER FIRE

The conduct of RC individuals under flame is very not the same as that at room temperature essentially because of the way that under flame conditions, connected loads for the most part stays steady, yet the strength and firmness of the part corrupt with flame presentation time. The increasing temperatures prompt continuous debasement of properties in cement and fortifying steel which thus diminishes the strength and firmness of the part. With the movement of flame introduction time, this ascent in temperature reaches out to the internal layers of solid prompting further lessening in strength and firmness, which will proceed till the strength of the part decreases to the level of the connected burdens.

2.1.1 Literature Form Past Studies

Sujith Ghosh Etal[1] examined on the impacts of high temperature up to 232oC and high weights up to 13.8 Mpa on the strength of cement containing different levels of high calcium lignite fly ash and a settled rate of dense silica vapor.

Sarshar R and khoury G.A et al[2] done examinations to asses the impact of material and natural variables on the compressive strength of unlocked cement paste and cement at higher temperatures and found that both material and ecological elements were affecting the strength of cement amid the warmth cycle and in the wake of cooling. The cement part replacements utilized were silica rage, ground granulated blast heater slag and pummeled fuel ash.

Castilo C and Durrania J et al[3] done examinations to concentrate the impact of transient high temperatures on compressive strength of high strength concrete under both emptied and pre stacked conditions and to contrast the conduct and that of typical strength concrete. Based on the outcomes acquired in the review it was reasoned that when presented to temperatures in the scope of 100 to 300°C

M. Saadetal et al[4] examined the impact of temperature on physical and mechanical properties of cement. In their review customary Portland cement has been in part supplanted by proportions of silica smoke. The warmth treatment temperature differed from 100 to 600°C for three hours with no heap. The examples were warmed under comparable conditions for every temperature level. Examinations amongst physical and mechanical properties amid warmth treatment were researched.

Sri Ravindra Rajah R Et al[5] presented the results of an experimental investigation into the effects of high temperature on the residual compressive for high strength concrete made with ordinary Portland cement and blended cement. Concrete specimens wee heated in a muffle furnace to varying temperatures up to 800^{o}C and the changes in the compressive strength, ultrasonic pulse velocity and rebound number were determined.

3.0 EXPERIMENTAL PROGRAM

3.1 OBJECT AND SCOPE OF INVESTIGATION

The study on concrete subjected to elevated temperatures is assuming significance now- adays. The study of literature has revealed changes in mechanical properties of concrete when it is subjected to high temperatures. Further the new concretes that are being developed such as SCC requires the characterization when it is subjected to elevated temperatures .This is required because of the changes in the composition of the material such as the differences in the paste phase and aggregate phase between the NC and new concretes. Such a study is very much necessary to establish the durability of new concrete. The present investigation focuses on study of compressive strength behaviour of NC and SCC subjected to elevated temperatures.

The objective of the investigation tries to answer the following questions:

1) What happens to the compressive strength of concrete when it is subjected to elevated temperatures?
2) Is there a difference in the strength behaviour of SCC compare to NC?
3) How to quantify changes in the strength behaviour of SCC and NC when there are subjected to elevated temperatures?
4) What is effect of use of higher strength concrete on the strength behaviour at elevated temperatures?
5) What is the effect of cooling regime on the strength behaviour of SCC and NC?
6) Is there any risk of spalling of concrete when it is subjected to high temperatures?
7) How the hardness of surface is changing with elevated temperatures?

3.2 INTRODUCTION

The experimental program was designed to investigate study on compressive strength behaviour of normal concrete and self compacting concrete subjected to elevated temperatures. The primary aim of the experimental study is to compare the compressive strengths of NC and SCC of M20

3.3 MATERIALS USED

The different materials used in this investigation are
53 Grade Ordinary Portland cement.
Fine Aggregate. Coarse Aggregate Super Plasticizer (CONPLAST SP430).Fly ash.

3.3.1 Cement Cement used in the investigation was 53 Grade Ordinary Portland cement confirming to IS: 12269[27].The cement was obtained from a single consignment and of the same grade and same source. Procuring the cement it was stored properly. The Specific gravity of the cement is found to be 3.11. 3.3.2 Fine Aggregate The fine aggregate conforming to Zone-2 according to IS: 383[28] was used. The fine aggregate used was obtained from a nearby river source. The bulk density, specific gravity of the sand used were 1.56g/cc and 2.42.The sand obtained was sieved as per IS sieves (i.e.2.36, 1.18, 600,300 and 150). Sand retained on each sieve was filled in different bags and stacked separately for use. To obtain zone-2 sand correctly, sand retained on each sieve is mixed in appropriate proportion according to the mix design and required quantity in which each size fraction is mixed is shown in Table 3.2.

3.4 CONCRETE MIX DESIGN

3.4.1 Introduction The way toward choosing appropriate elements of cement and deciding their relative sums with the goal of creating a solid of the required, strength, sturdiness, and workability as financially as conceivable, is named as solid blend outline. The proportioning of element of cement is administered by the required execution of cement in 2 states, to be specific the plastic and the solidified states. On the off chance that the plastic cement is not workable, it can't be appropriately set and compacted. The property of workability, consequently, is the fate of key significance. The compressive strength of solidified solid which is for the most part thought to be a record of its different properties, relies on many elements, e.g. quality and amount of cement, water and totals; clustering and blending; putting, compaction and curing. From specialized perspective the rich blends may prompt high shrinkage and splitting in the basic cement, and to development of high warmth of hydration in mass solid which may bring about breaking.

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 12, December 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

3.4.2 Requirements Of Concrete Mix Design

The requirements which form the basis of selection and proportioning of mix ingredients are: The minimum compressive strength required from structural consideration. The adequate workability necessary for full compaction with the compacting equipment available. Maximum water-cement ratio and/or maximum cement content to give adequate durability for particular site conditions Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

To produce SCC, the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. As a part of mix design aggregate proportions are calculated using compressible packing model. Cement quantity and fly ash content are obtained from previous literature and these are modified according to EFNARC specifications to get fresh, hardened properties and economical mix

TABLE 3.2:

Sieve size (mm)	% Passing recommended by IS: 383[36]	Adopted grading	%Weight retained	Cumulative % Weight retained	Weight retained in gms.
10-4.75	100	100	-	-	-
4.75-2.36	90-100	100	-	-	-
2.36-1.18	75-100	90	10	10	100
1.18-0.60	55-90	65	25	35	250
0.60-0.30	35-59	40	25	60	250
0.30-0.15	8-30	10	30	90	300
0.15	0-10	0	10	100	100

M20 MIXED DESIGN

1. Requirements
a) Specified minimum strength = 20 N/Sq mm
b) Durability requirements
i) Exposure Moderate
ii) Minimum Ce
ment Content = 300 Kgs/cum
c) Cement
(Refer Table No. 5 of IS:456-2000)
i) Make Chetak (Birla)
ii) Type OPC
iii) Grade 53

d) Workability

i) compacting factor = 0.7
e) Degree of quality control Good

2. Test Data For Materials Supplied
a) CEMENT
i) Specific gravity = 3.05
ii) Avg. comp. strength 7 days = 46.5 more than 33.0 OK
28 days = 55.0 more than 43.0 OK
b) COARSE AGGREGATE
i) 20mm Graded
Type Crushed stone aggregate
Specific gravity = 2.68
Water absorption = 1.46
Free (surface) moisture = 0
c) FINE AGGREGATE (Coarse sand)
i) Type Natural (Ghaggar)
Specific gravity = 2.6
Water absorption = 0.5
Free (surface) moisture = 1.4

Sieve analysis results

IS Sieve size	Percent retained	Cumulative % retained	Percent passing
10 mm	0.00	0.00	100.00
4.75 mm	5.20	5.20	94.80
2.36 mm	3.00	8.20	91.80
1.18 mm	8.60	16.80	83.20
600 microns	25.80	42.60	57.40
300 microns	32.80	75.40	24.60
150 microns	20.70	96.10	3.90

Note : Conforming to grading Zone II of Table 4 of IS:383-1970

3.5 TESTS ON CONCRETE

There are many tests which are conducted to check the quality of concrete. These tests are basically divided into two categories: Tests on fresh concrete Tests on hardened concrete 3.5.1 Various Lab Test On Fresh Concrete(Normal Concrete) Under these, we have the following tests Slump Test - Workability Compacting Factor 3
internal surface of the mould is thoroughly cleaned and applied with a light coat of oil. The mould is placed on a smooth, horizontal, rigid and nonabsorbent surface. The mould is then filled in four layers with freshly mixed concrete, each approximately to one fourth of the height of the mould. 29 Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section). After the top layer is tamped, the concrete is struck off the level with a trowel. The mould is removed from the concrete immediately by raising it slowly in the vertical direction. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height in mm is the slump of the concrete, is shown in fig1.

Fig1: slump cone test

3.5.2 Compacting Factor Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus used is Compacting factor apparatus was shown in figure-2

Fig2 Compaction factor test

3.6.2.1 Slump flow + T50 (Reference method for filling ability)

Principle:

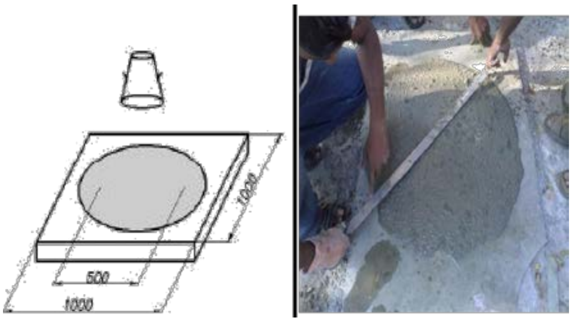
The slump flow test aims at investigating the filling ability of SCC. It measures two parameters: flow spread and flow time T50 (optional). The former indicates the free, unrestricted deformability and the latter indicates the rate of deformation within a defined flow distance.

Equipment:

(a). Base plate of size 900 × 900 mm, made of impermeable and rigid material (steel or Glass)with smooth and plane test surface (deviation of the flatness not exceed 3 mm), and clearly marked with circles of Ø200mm and Ø500mm and Ø600mm at the centre, as shown In Figure 3.12.

3.6 CASTING OF SPECIMENS:

The standards moulds of size 100x100x100mm were fitted such that there are no gaps between the plates of the moulds. If there are small gaps they were filled with plaster of Paris. The moulds then oiled and kept ready for casting. The entire casting was done in two stages each corresponding to M20 and M40 grades of NC and SCC. A pan mixer having 100kg capacity was used for mixing concrete. In case of SCC of M20 and M40 grades super plasticizer was used for workability purpose as per the specifications and calculations. This was dispersed in water in required proportion before mixing the water with the ingredients coarse, fine aggregates, cement and fly ash. The entire mix is mixed in pan mixer for about 3-5min and then poured in moulds. At the end of casting the top surface was made plane using trowel and a hacksaw blade to ensure a top uniform surface. After 24 hrs of casting the moulds were kept for wet curing for 28 days before testing.

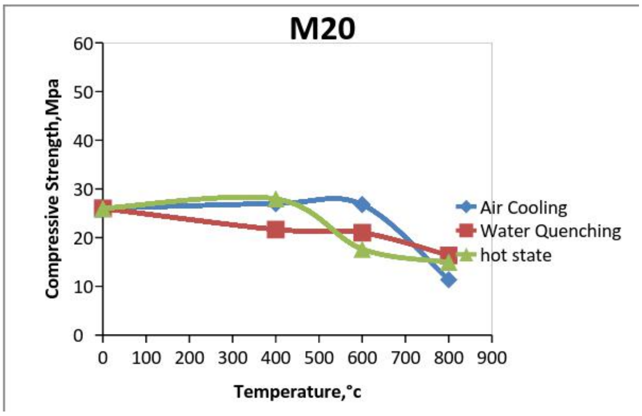


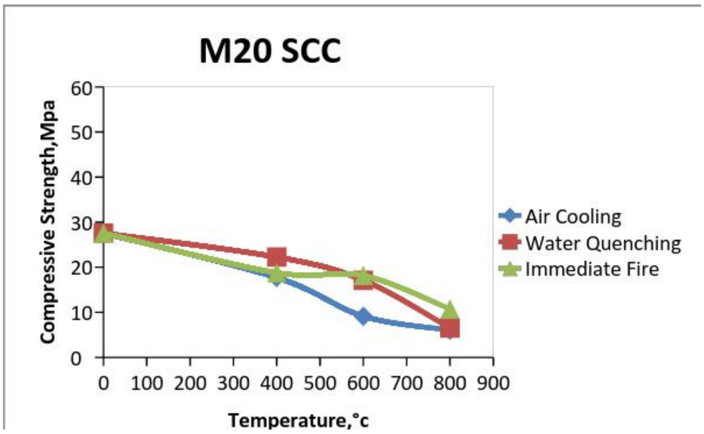
.0 Results and discussion

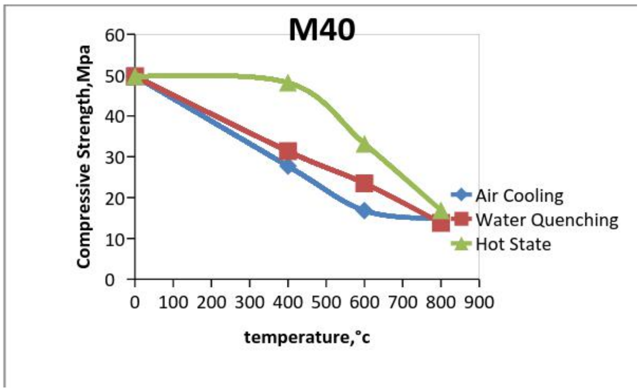
5.1 Graphs representing Compressive Strengths

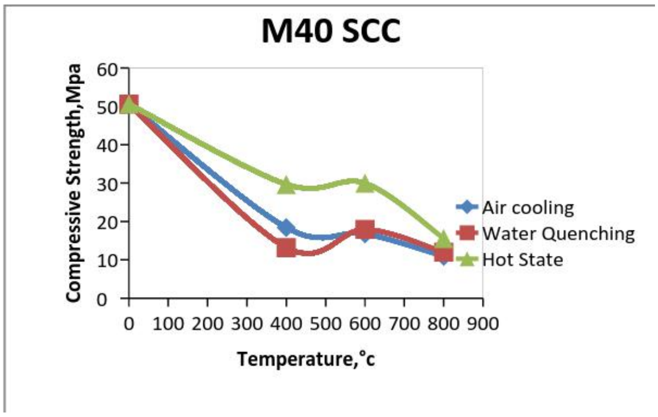
The response curves for various grades of concrete, with different cooling regimes at different elevated temperatures are displayed below:

Curves plotted with values taken from tables.









Analysis and Discussion of results:

In the present examination the investigation of the compressive conduct of the NC and SCC has been done. The strength comes about acquired for various cements and distinctive evaluations with various cooling administrations have been introduced in table no's: 3.26 and 3.27. The percent of strength misfortune were computed for various cements with various cooling administrations. The strength misfortune percent qualities are displayed in table no's: 3.26 and 3.27.The consequences of NDT test i.e. the rebound number qualities gotten for various cements and diverse cooling administrations are introduced in table no's: 3.28 and 3.29.

The discussions of test results on the following aspects are presented:

1) Effect of elevated temperature on compressive strength.
2) Effect of cooling regime on compressive strength.
3) Effect elevated temperature on surface characteristics of concrete.

5.0 CONCLUSIONS

• In general the compressive strength of cement is decreased, when the solid is subjected to raised temperatures.

• The decrease in compressive strength, with raised temperature is more in case of SCC contrasted with NC independent of cooling administrations.

• In case of NC the strength decrease on a normal is seen to be 16.6%, 25.5% and 45% at 400°c, 600°c and 800°c individually, where as on account of SCC, the compressive strength decrease seen to be 29.1%, 45.6% and 71.4% at 400°c, 600°c and 800°c separately.

• In general the percent decrease in strength, with raised temperatures has increased with increase in review of cement i.e. higher strength cements have higher percent misfortune in strength than lower strength concrete. However the distinction turns out to be less noteworthy at temperatures more noteworthy than 400°c.

Of the three states of 'testing of specimens' i.e.

1. Testing after air cooling
2. Testing after water quenching
3. Testing in hot state,

Normally referred to as cooling regimes, more percent decrease in strength was observed in case of 'testing after air cooling' in both NC and SCC. Testing after water quenching resulted in higher loss in strength compared to the strength obtained in testing at hot condition. Rebound number(RN) represents the hardness of the surface and indirectly represents the likely spalling or loosening of surface of concrete.

References

1. ISO 13943:2000. Fire safety–Vocabulary,British Standard Inst. London, 2000.
2. Bakhtiyari S. A functional approach to fire tests on building products, Asian Journal of Civil Engineering (Building & Housing),4(2003) 63-72.
3. Mehta PK, Monterio DJM. Concrete: Microstructure, Properties and Materials, Mc-Graw Hill Book Company, 3rd edition, UK, 2006.
4. Anderberg, Y. Spalling phenomena of HPC and OC, Proceedings of The International Workshop on Fire Performance of High Strength Concrete, NIST, Maryland, 1997,pp. 69-75.
5. Phan LT. High strength concrete at high temperature – An overview, Proceedingsof the 6th International Symposium of Utilization of High Strength/High Performance Concrete,Leipzig,1(2002), pp. 501-18.
6. Aldea CM. Fire tests on normal and high – strength reinforced concrete columns, in: Proceedings of the International Workshop on Fire Performance of High Strength Concrete,NIST, Maryland, 1997, pp. 109-24.
7. Hertz KD. Limits of spalling of fire exposed concrete, Fire Safety Journal, 38(2003)103-16.
8. Okamura Kalifa P. Spalling and pore pressure in HPC at high temperatures. Cement and Concrete
9.Okamura H, Ouchi compacting high performance concrete, StructuralEngineering and Materials,1(1998) 378-83.
10. Okamura H, Ouchi M. Self-compacting concrete, Advanced Concrete Technology, 1(2003) 5-15.
11. Bartos PJM, Grauers, M. Self-compacting concrete, Concrete,33(1999) 9-14.
12. Okamura H, Ouchi M. Self-compacting concrete, Advanced Concrete Technology, 1(2003) 5-15.