"An Evaluate on Factors Affecting Workability of Concrete With constant water-cement Ratio"

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ABSTRACT

Workability can be defined as the amount of useful internal work necessary to produce full compaction. Consistency, mobility and compactability define workability. Factors such as constituent materials and environmental conditions affect workability. Research works has been done on the factors while field work continues to be starved of knowledge of the effect of time after mixing on workability. To this end, this paper presents an investigation into the effect of time on the workability of different fresh concrete mixtures handled differently. To achieve this, a slump test, compacting factor test and the modified Vebeconsistometer test was carried out under ambient conditions of 29-300C temperature, 95% relative humidity and less windy condition with 250kg, 350kg, 415kg, 545kg and 560 kg of cement and max. aggregate size of 40mm at w/c ratio of 0.46. The results (curves) show that in 1hr times the loss of workability of the un-agitated mixes was remarkable while the agitated concrete still retains an appreciable workability after 1hr but tends to lose its workability totally in 2½hrs time. It showed that the % loss of workability of un-agitated MX1, MX2, MX3, MX4 and MX5 dropped by 75%, 70%,75%, 66.7% and 68.2% after 1hr against the 43.8%, 40%, 40%, 38% and 40.9% of the agitated concretes respectively by slump test. Also, the workability tends to increase as the cement-aggregate ratio increases. The three results showed a similar trend even if no relationship existed between them.

KEYWORDS: Workability; Slump; Compacting factor; Vebe time; Agitated; Un-agitated; Mix ratio

1. INTRODUCTION

The characteristics of fresh concrete which defines workability are consistency, mobility, and compatability. Consistency is a measure of fluidity while mobility is the ability of fresh concrete to flow into a formwork. Compatability is the ease with which entrapped air, voids and segregation can be eliminated from a mix. For a fresh concrete to be stable, it must maintain its uniformity which also depends on its consistency and cohesiveness. Workability in concrete practice offers an insight on plastic behavior of fresh concrete. This explains why a lot of research has been done on the effects of factors like water-cement ratio, aggregate size, shape and grading, admixture, ambient condition etc. on workability. Marar and Eren, (2011) writes that as cement content increases, compacting factor increases and also, a decreasing aggregate/cement ratio increase the compacting ratio. ACI, 238.1 (2008), explainsalso, that the higher the water-cement ratio, the more workable is the mix. Workability is also enhanced by the use of super plasticizers (ACI 238.1, 2008, Duggal, 2012). A well graded aggregate also helps in reducing voids making cement paste available for better lubrication (ACI 238.1, 2008). However, Kaplan, (2015) and Donzar et al, (2002) pointed out that angular and flaky aggregate reduces workability because they have greater surface area and more voids which reduces the available paste for lubrication. Pereira et al (2012) also showed that concrete with super plasticizers produced a superior workability to that without admixtures. Abdullah, (2001) writes that increased temperature increases the rate of hydration and evaporation with attendant loss of workability. This paper presents an experimental investigation into the effect of time delayed after concrete mixture of different constituent proportions under different management conditions.

A. Background

The concrete, when used requires a certain degree of workability. Higher workability is required if the section are thin and heavily reinforced. the workability of concrete depends on the properties of various ingredients of concrete. To enable the concrete to be fully compacted with given efforts, normally a higher water/cement ratio than that calculated by theoretical consideration may be required. that is to say the function of water is also to lubricate the concrete so that the concrete can be compacted with specified effort forthcoming at the site work. the lubrication required for handling concrete without segregation, for placing without loss of homogeneity, for compacting with the amount of efforts forthcoming and to finish it sufficiently easily the presence of a certain quantity of water is vital importance .many research worker tried to define the world workability. But as it signifies much wider properties and qualities of concrete and does not project any one particular meaning .extensively studies the field of compaction and workability, defined workability as the property of concrete which determines the amount of useful internal work necessary to produce full compaction. Another definition which envelopes a wider meaning is that, it is define as the ease with which concrete can be compacted hundred percent having regards to mode of compaction and place of deposition. Assumption of right workability with proper understanding backed by experience will make the concreting operation economical and durable.

B. Motivation

There are different expectations and agendas across the spectrum of the design/construction team when it comes to engineering concrete design. The structural engineer wants higher strength and a good bond with reinforcing steel. The architect obviously wants cosmetic appeal; Strength is attractive to the owner because it allows smaller cross sections of structural elements and therefore more usable floor space. A laborer needs a mix that can be moved, placed and consolidated properly, and a finisher is looking for something that takes a durable, high-quality finish quickly and easily. Designing a concrete mix with good workability brings all these factors together in balance to result in a quality product with long service life.

I. MATERIALS AND METHOD

Materials

The cement used for this investigation in the laboratory was the Ordinary Portland Cement of class 45.2R according to BS 4550. The fine aggregate was the locally available alluvial sand with specific gravity of 2.6. The grading of the aggregate was according to BS 882 (1992). Drinkable water from tap was used for all the mixes. The W/C ratio used was 0.45. No chemical admixture or plasticizer was added. The experimental investigation was carried out under suitable ambient conditions of 29-300C temperature, 95% relative humidity and less windy condition.

Mixing Procedure

Table 1: Sieve analysis of the fine aggregate

S/No	Sieve size (mm)	% passing
1	5.00	100
2	2.36	90.4
3	1.18	62.5
4	0.60	41.4
5	0.30	21.2
6	0.15	5

Table 2: Sieve analysis of the coarse aggregate

S/No	Sieve size (mm)	% passing
1	40	100
2	20	95.2
3	10	22.4
4	5	5.0

1. A laboratory tilting concrete mixer was used as follows:
2. Coarse aggregates, fine aggregates and cement were mixed for two minutes
3. Water was added in thirty seconds and mixing continued for another two minutes
4. Mixing was stopped for one minutes

5. Testing was delayed for eight minutes

The last step was done to allow for the absorption of water by dry aggregates.

Mix Proportions

Table3: Mix Proportion of concrete

Mix Tag		Mix ratio		Mix proportions in kg/m3	
Cement		Sand	Coarse aggregate		Water
MX1	1:3:6	250	720	1400	98
MX2	1:2:4	350	676	1302	138
MX3	1:1½:3	415	620	1240	162
MX4	1:1:2	545	565	1132	210
MX5	-	560	530	1005	220

Test Methods

Two samples of concretes were prepared under same condition, one agitated before test while the other remained un- agitated or undisturbed. The tests for the workability of the different concretes were carried out after ¼hr, ½hr, 1hr and 2½hrs time of mixing.

Slump Test

The test primarily measures the consistency of fresh concrete, hence detecting changes in the workability of concrete. It consists of a 300mm high frustum metal cone of internal diameter, 200mm at the base and 100mm at the top. The procedure was basically done by filling the frustum with fresh concrete in 3 layers of equal volume with each layer compacted with 25 strokes of a tamping rod. Thereafter, the frustum was removed and the concrete subsided. The

slump or subsidence was measured as the difference between the top of the frustum and the subsided concrete according to BS 1881-102, EN 12350-2 (2000).

Compacting factor Test

This test measures the degree of compaction impacted on concrete for a standard workdone which is a reliable assessment of the workability of the concrete. The apparatus consists of upper and lower hoppers mounted on two sittings and a cylinder with a base sitting. The test was performed by placing the fresh concrete in the upper hopper A to its mouth with a hand trowel. The concrete was allowed to fall into the lower hopper B by opening the bottom trap door. Concretes stuck at the sides of the hopper A were pushed down into the lower hopper B with a steel rod. Again, the concrete in hopper B was allowed to fall into the cylinder beneath and weighed. The value recorded as W1. The cylinder was filled with fresh concrete in layers of

50mm compacted by 100%. The cylinder was wiped off, weighed and recorded as W2. The compaction factor was calculated as ratio (W1/W2) according to BS 1881: Part 103 (1993).

Vebe test

This test is suitable for a whole wide range of mixes and it is sensitive to variations in workability of very dry mixes and precast concrete mixes. The test measures the time taken to transform or remold a standard frustum of concrete by vibration to a compacted mass. Thus the time required to perform this action is the vebe time in seconds. The apparatus consists of a slump frustum placed at the center of a metal cylindrical container mounted on a vibrating table whose vibration is sinusoidal. A slump test as described above was conducted first, and then a clear plastic disc was placed on top of the fresh concrete. Then the vebe table is vibrated and the time taken for the remolding of the slump frustum shape to the shape of the metal cylindrical container was recorded as a measure of the consistency. The test is according to BS 1881-104, EN 12350-3 (2000).

II. FACTORS AFFECTING WORKABILITY OF CONCRETE

The single most important nature of workable concrete is its lubricating nature. If a concrete shows more lubricatingnature, then it will have the following advantages, such as

- It will exhibit little internal friction between particle and particle
- It will overcome the frictional resistance offered by the surface of the formwork and reinforcement containedin the concrete
- It can be consolidated with minimum compacting effort.

The factors which help concrete to have more lubricating effect to reduce internal friction for easy compaction aregiven below.

- Water content
- Aggregate/cement ratio
- Size of aggregate
- Shape of aggregate
- Grading of aggregate
- Surface texture of aggregate
- Use of admixture

Let us now discuss each of the above mentioned factors in more detail

1. Water Content [1]

Workability of concrete increases with increase in water content. Higher the water content per cubic meter of concrete, the higher will be the fluidity of concrete, which is one of the important factors affecting workability.Adding more water to concrete also has some disadvantages as given below.

- Increased quantity of water may cause bleeding in concrete.
- Cement slurry also escapes through the joints of formwork
- Strength of concrete may reduce.

2. Aggregate/Cement Ratio [2]

The higher the aggregate/cement ratio, the leaner is the concrete. In lean concrete, less quantity of paste is available forproviding lubrication, hence mobility of aggregate is reduced, resulting poor workability.
But in case of lower aggregate/cement ratio, the richer is the concrete. In rich concrete, more paste is available to makethe mix cohesive and fatty to give better workability.

3. Size of Aggregate [3]

Bigger size aggregates have following advantages as compared to smaller size aggregate.

- It has less surface area
- Requires less amount of water for wetting surface
- Requires less amount of paste for lubricating the surface

So for a given water content & paste, bigger size aggregate will give higher workability.
Note: From the practical point of view, the maximum size of aggregate to be used will depend upon the handling,mixing and placing equipment, thickness of section and quantity of reinforcement.

4. Shape of Aggregate [4]

Workability of aggregate is also affected by the shape of aggregate. Generally aggregate are found in variety of shapes,such as

- Angular aggregate
- Flaky aggregate
- Elongated aggregate
- Rounded aggregate
- Sub-rounded aggregate
- Cubical aggregate
- Etc.

Angular, flaky & elongated aggregate reduces the workability of concrete.Rounded or sub rounded aggregate have following advantages

- For a given volume or weight, it has less surface and less void, so excess paste is available to give betterlubricating effect

- Due to rounded shape it has less friction resistance

Because of the above mentioned reasons rounded aggregate shows a high workability as compared to angular, flaky orelongated aggregates.

Note: River sand & gravel provide greater workability to concrete than crushed sand.

5. Grading of Aggregate [5]

Grading of aggregate have the maximum influence on workability. The better the grading, the less is the amount of void in it. When total void are less, excess paste is available to give better lubricating effect. With excess amount of paste the mixture becomes cohesive and fatty which prevents segregation of particles & least amount of compacting efforts is required to compact the concrete.

6. Surface Texture of Aggregate [6]

Porous and non-saturated aggregate will require more water than a non-absorbant aggregate. For same degree of workability latter will require less water. On the whole this factor is only of secondary importance.

7. Use of Admixture [7]

This is one of the commonly used methods to enhance workability of concrete.Plasticizer and super plasticizers greatly improve the workability.

Air entraining agents are also used to increase the workability. Air entraining agents creates a large number of very minute air bubbles. These bubbles get distributed throughout the mass of concrete and acts as rollers and increases workability.

Pozzolanic materials are also used to improve workability of concrete.

There are different expectations and agendas across the spectrum of the design/construction team when it comes to engineering concrete design. The structural engineer wants higher strength and a good bond with reinforcing steel. The architect obviously wants cosmetic appeal; Strength is attractive to the owner because it allows smaller cross sections of structural elements and therefore more usable floor space. A laborer needs a mix that can be moved, placed and consolidated properly, and a finisher is looking for something that takes a durable, high-quality finish quickly and easily. Designing a concrete mix with good workability brings all these factors together in balance to result in a quality product with long service life.

Factors Affecting Workability [8]

- **Water/Cement Ratio:** a higher proportion of cement or cementitious materials usually mean greater strength, and with the proper amount of water, more paste is coating the surface of aggregates for easier consolidation and a better finish. Not enough water means poor strength development and an uncooperative mix that resists easy placement and finishing. Adding excessive water could be said to increase workability because it makes it easier to place and consolidate. However, the negative impact on segregation, finishing operations and final strength can be so detrimental that it should be approached very cautiously. A water to cementitious material ratio (w/cm) of 0.45 to 0.6 is the sweet spot for production of workable concrete.
- **Aggregate Size and Shape:** As aggregate surface area increases, more cement paste is needed to cover the entire surface of aggregates. So mixes with smaller aggregates are less workable compared to larger size aggregates. Elongated, angular and flaky aggregates are difficult to mix and place and have greater surface area to cover, decreasing workability. Rounded aggregates have less surface area, but lack the angularity to develop sufficient bond strengths with the cement paste.
- **Admixtures:** Many types of admixtures alter the workability of fresh concrete, either by design or as a side- effect. Some surfactants such as super plasticizer reduce attraction between cement and aggregate particles, allowing mixes that can be quite flowable without the negative strength and segregation effects of too much water. Air entraining admixtures for freeze-thaw resistance produce air bubbles of a controlled size that can make for easier finishing, although using too much produces a sticky mix with the opposite effect.

Workability of Concrete by Slump Test [9]

Which brings us to what is by far the most popular (some say overused) measure of workability. The slump test originated as a way for workmen to judge how easy their day was going to be using freshly mixed concrete. A Slump Cone is placed on a solid, level base and filled with fresh concrete in three equal layers rodded in a specified manner to consolidate. The concrete is struck even with the top of the cone, and the cone is carefully lifted away. The concrete then settles or slumps, and the final height is subtracted from the original height of the cone and recorded. This value is considered to be a measure of workability and a rough indicator of water/cement ratio. Slumps of 4 to 6 inches (100 to 150mm) are generally considered to be in a desirable range for typical placement and finishing operations, provided they also have suitable w/cm ratios and meet mix design requirements when placed. The form or profile of the slump is also noted and used to judge the reliability of each test:

- **True slump** - concrete subsides, maintaining its general form
- **Shear slump** - the top portion of the concrete shears off and slips sideways
- **Collapse slump** - the concrete collapses completely, likely from the mix being too wet
- Workability is a property of freshly mixed concrete. Concrete is a mixture of cement, aggregates, water, and admixtures. The properties of concrete, whether in the fresh state or hardened state, are affected by its ingredients and their proportions.
- An understanding and knowledge of the workability are the most important for making a well-designed concrete mix which can be easily placed and compacted with minimum effort.
- Workability is a purely physical property of freshly mixed concrete. Workability of concrete simply means the ability to work with concrete. Fresh concrete is said to be workable if it can be easily transported, placed, compacted, and finished without any segregation. The ease of placing, compacting, and finishing of concretein the desired manner is called its workability.
- Concrete must be workable so that it achieves maximum density with a reasonable amount of compaction effort. If concrete is not workable or relatively less workable, it will not be compacted to its desired density resulting in less strength and porosity ultimately. If concrete is not workable, one will not be able to place it well.
- Adequate compaction of concrete is necessary; if it is not done properly there will be voids. The presence of voids will greatly reduce its strength. Voids in Concrete are either bubbles of entrapped air or spaces left after excess water has evaporated. This phenomenon happens when the non-workable concrete has been placed in the structure. Even 2 percent of air voids may lower the strength by as much as 8-10 percent and 5 percent voids can lower the strength by much as 25-30 percent. Further, the voids will lead to leakage, too.

III. LITERATURE SURVEY

BertilPersson (2001) The concrete, when used requires a certain degree of workability. Higher workability is required if the section are thin and heavily reinforced. the workability of concrete depends on the properties of various ingredients of concrete. To enable the concrete to be fully compacted with given efforts, normally a higher water/cement ratio than that calculated by theoretical consideration may be required. Carried out an experimental and numerical study on workability properties, such as strength, elastic modulus, creep and shrinkage of self-compacting concrete and the corresponding properties of normal compacting concrete. The study included eight mix proportions of sealed or air-cured specimens with water binder ratio (w/b) varying between 0.24 and 0.80. Fifty percent of the mixes were SCC and rests were NCC. The age at loading of the concretes in the creep studies varied between 2 and 90 days. Strength and relative humidity were also found. The results indicated that elastic modulus, creep and shrinkage of SCC did not differ significantly from the corresponding properties of NCC. [1]

Nan Su et al (2001) say the function of water is also to lubricate the concrete so that the concrete can be compacted with specified effort forthcoming at the site work. the lubrication required for handling concrete without segregation, for placing without loss of homogeneity, for compacting with the amount of efforts forthcoming and to finish it sufficiently easily the presence of a certain quantity of water is vital importance .many research worker tried to define the world workability. But as it signifies much wider properties and qualities of concrete and does not project any one particular meaning .extensively studies the field of compaction and workability, defined workability as the property of concrete which determines the amount of useful internal work necessary to produce full compaction. Another definition which envelopes a wider meaning is that, it is define as the ease with which concrete can be compacted hundred percent having regards to mode of compaction and place of deposition. Assumption of right workability with proper understanding backed by experience will make the concreting operation economical and durable.proposed a new mix design method for self-compacting concrete. First, the amount of aggregates required was determined, and the paste of binders was then filled into the voids of aggregates to ensure that the concrete thus obtained has flow ability, self- compacting ability and other desired SCC properties. The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer to be used are the major factors influencing the properties of SCC. Slump flow, V- funnel, L-flow, U-box and compressive strength tests were carried out to examine the performance of SCC, and the results indicated that the proposed method could be used to produce successfully SCC of high quality. Compared to the method developed by the Japanese Ready-Mixed Concrete Association (JRMCA), this method is simpler, easier for implementation and less time-consuming, requires a smaller amount of binders and saves cost. [2].

Bouzoubaa and Lachemi (2001) carried out an experimental investigation to evaluate the performance of SCC made with high volumes of fly ash. Nine SCC mixtures and one control concrete were made during the study. The content of the cementations materials was maintained constant (400 kg/m3), while the water/cementations material ratios ranged from 0.35 to 0.45. The self-compacting mixtures had a cement replacement of 40%, 50%, and 60% by Class F fly ash.
Tests were carried out on all mixtures to obtain the properties of fresh concrete in terms of viscosity and stability. The mechanical properties of hardened concrete such as compressive strength and drying shrinkage were also determined. The SCC mixes developed 28-day compressive strength ranging from 26 to 48 MPa. They reported that economical SCC mixes could be successfully developed by incorporating high volumes of Class F fly ash. [3]

Sri Ravindra rajah (2003) et al made an attempt to increase the stability of fresh concrete (cohesiveness) using increased amount of fine materials in the mixes. They reported about the development of self-compacting concrete with reduced segregation potential. The systematic experimental approach showed that partial replacement of coarse and fine aggregate with finer materials could produce self-compacting concrete with low segregation potential as assessed by the V-Funnel test. The results of bleeding test and strength development with age were highlighted by them. The results showed that fly ash could be used successfully in producing self-compacting high-strength concrete with reduced segregation potential. It was also reported that fly ash in self-compacting concrete helps in improving the strength beyond 28 days.
Self-Compacting Concrete. [4]

Hajime Okamura and Masahiro Ouchi (2003) addressed the two major issues faced by the international community in using SCC, namely the absence of a proper mix design method and jovial testing method. They proposed a mix design method for SCC based on paste and mortar studies for super plasticizer compatibility followed by trail mixes. However, it was emphasized that the need to test the final product for passing ability, filling ability, and flow ability and segregation resistance was more relevant. [5]

ParatibhaAggarwal (2008) et al presented a procedure for the design of self-compacting concrete mixes based on an experimental investigation. At the water/powder ratio of 1.180 to 1.215, slump flow test, V-funnel test and L-box test results were found to be satisfactory, i.e. passing ability; filling ability and segregation resistance are well within the limits. SCC was developed without using VMA in this study. Further, compressive strength at the ages of 7, 28, and 90 days was also determined. By using the OPC 43 grade, normal strength of 25 MPa to 33 MPa at 28-days was obtained, keeping the cement content around 350 kg/m3 to 414 kg/m3. [6]

Girish (2010) et al presented the results of an experimental investigation carried out to find out the influence of paste and powder content on self-compacting concrete mixtures. Tests were conducted on 63 mixes with water content varying from 175 l/m3 to 210 l/m3 with three different paste contents. Slump flow, V funnel and J-ring tests were carried out to examine the performance of SCC. The results indicated that the flow properties of SCC increased with an increase in the paste volume. As powder content of SCC increased, slump flow of fresh SCC increased almost linearly and in a significant manner. They concluded that paste plays an important role in the flow properties of fresh SCC in addition to water content. The passing ability as indicated by J-ring improved as the paste content increased. [7]

E. Todorova, G. Chernev, G. Chernev. The aim of the “influence of metakaolinite and stone flour on the properties of self-compacting concrete” was the manufacture and characterization of mixture for self-compacting concrete with participation of powder additives (metakaolinite and stone flour) and super plasticizers (viscocrete 5370 and viscocrete 5800). The influence of chemical admixtures and powder additives on concrete properties was made by the different methods: sorption ability; sᴇᴍ; ftir and potential. Physical and mechanical properties as compressive strength; spreading and fluidity were measured. Tests for mechanical and physical properties of self-compacting concrete established, that the best appropriate mixtures were these with metakaolinite and 1,25 % Viscocrete 5370, with stone flour and admixture of 1,2 % Viscocrete 5370 and Viscocrete 5800. The strength pressure reaches 71 MPa, 65, 1 MPa and 63, 3 MPa, respectively. SEM micrographs proved evenly distribution of fine fraction in concrete mixture. Metakaolinite and stone flour showed excellent values for each test using for investigation properties of prepared mixtures. They improve the characteristics of self-compacting concrete. Better results showed mixtures with higher content of powder materials and super plasticizers. [8]

Cristian Druta (2003) carried out an experimental study on to compare the Splitting Tensile Strength and Compressive Strength values of self-compacting and normal concrete specimens and to examine the bonding between the coarse aggregate and the cement paste using the Scanning Electron Microscope. In this experiment used mineral admixes Blast Furnace Slag, Fly Ash and Silica Fume and chemical admixes Super plasticizers and Viscosity-Modifying Admixtures, It has been verified, by using the slump flow and U-tube tests, that self-compacting concrete (SCC) achieved consistency and self-compatibility under its own weight, without any external vibration or compaction. Also, because of the special admixtures used, SCC has achieved a density between 2400 and 2500 kg/m3, which was greater than that of normal concrete, 2370-2321 kg/m3.Self-compacting concrete can be obtained in such a way, by adding chemical and mineral admixtures, so that its splitting tensile and compressive strengths are higher than those of normal vibrated concrete. An average increase in compressive strength of 60% has been obtained for SCC, whereas 30% was the increase in splitting tensile strength. Also, due to the use of chemical and mineral admixtures, self-compacting concrete has shown smaller interface micro cracks than normal concrete, fact which led to a better bonding between aggregate and cement paste and to an increase in splitting tensile and compressive strengths. A measure of the better bonding was the greater percentage of the fractured aggregate in SCC (20-25%) compared to the 10% for normal concrete. [9]

Subramanian and Chattopadhyay (2002) are research and development engineers at the ECC Division of Larsen & Toubro Ltd (L&T), Chennai, India. They have over 10 years of experience on development of self-compacting concrete, underwater concrete with ant wash out admixtures and proportioning of special concrete mixtures. Their research was concentrated on several trials carried out to arrive at an approximate mix proportion of self-compacting concrete, which would give the procedure for the selection of a viscosity modifying agent, a compatible super plasticizer and the determination of their dosages. The Portland cement was partially replaced with fly ash and blast furnace slag, in the same percentages as Ozawa (1989) has done before and the maximum coarse aggregate size did not Exceed. The two researchers were trying to determine different course and fine aggregate contents from those developed by Okamura. The coarse aggregate content was varied, along with water-powder (cement, fly ash and slag) ratio, being 50%, 48% and 46% of the solid volume. The U-tube trials were repeated for different water-powder ratios ranging from 0.3 to 0.7 in steps of 0.10.

Mayur B. Vanjare, Shriram H. Mahure (2012) carried out an experimental study on to focus on the possibility of using waste material in a preparation of innovative concrete. One kind of waste was identified: Glass Powder (GP). The use of this waste (GP) was proposed in different percentage as an instead of cement for production of self-compacting concrete. The addition of glass powder in SCC mixes reduces the self-compatibility characteristics like filling ability, passing ability and segregation resistance. The flow value decreases by an average of 1.3%, 2.5% and 5.36% for glass powder replacements of 5%, 10% and 15% respectively. [12]

Suraj N. Shah., Shweta S. Sutar, Yogesh Bhagwat carried out an experimental study on to find out the effect of addition of red mud, which is a waste product from the aluminium industries, and foundry waste sand, which is a waste product from foundry, on the properties of self-compacting concrete containing two admixtures and experimentation combinations of admixtures which is taken Super plasticizer & VMA. It can be concluded that maximum compressive strength of self-compacting concrete with the combination of admixtures (SP+VMA) may be obtained by adding 2% foundry waste sand which is a waste material of ferrous industry (foundry). [13]

N. Bouzouba and M. Lachemicarried out an experimental study on producing and evaluating SCC made with high- volumes of fly ash is presented. The high-volume fly ash self-compacting concretes (except one) have a slump flow in the range of 500 to 700 mm, a flow time ranging from 3 to 7 seconds, a segregation index ranging from 1.9 to 14%, andbleed water ranging from0.025 to 0.129 mL/cm2.

Manu santhanam and Subramanyam (2004) discussed the existing research about various aspects of self-compacting concrete , including materials and mixture design , test methods , construction-related issues, and properties. They summarized that Self-Compacting Concrete is a recent development that shows potential for future applications. It meets the demands places by requirements of speed and quality in construction. [15]

R.V(2003) found that use of fine fly ash for obtaining Self compacting concrete resulted in an increase of the 28 day Compressive Strength Concrete by about 38%. Self-compacting concrete was achieved when volume of paste was between 0.43 and 0.45. [16]

Subramanian and Chattopadhyay (2002) described the results of trails carried out to arrive at an approximate mix proportioning of Self compacting concrete. Self-Compatibility was achieved for Water to Powder ratio ranging from
0.9 to 1.1 when Coarse Aggregate and Sand content were restricted to 46 % and 40% of the mortar volumerespectively. [17]

HardikUpadhyaycarried out an experimental study on different mix design methods using a variety of materials has been discussed, as the characteristics of materials and the mix proportion influences self-compatibility to a great extent. It can be a boon considering improvement in concrete quality, significant advances towards automation and concrete construction processes, shortened construction time, lower construction cost and much improvement in working conditions as it reduces noise pollution. Properties of self-compacting concrete with different types of additives [18]

ZoranGrdic (2008) carried out an experimental study on present's properties of self-compacting concrete, mixed with different types additives: fly ash, silica fume, hydraulic lime and a mixture of fly ash and hydraulic lime. Due to test results, the addition of fly ash to the mixture containing hydraulic lime is quite beneficial, bringing a substantial improvement of the behaviour of SCC FAHL concrete. Also, this mixture has smaller filling capacity and fluidity than other mixtures. [19]

Naik and Singh (1997) conducted tests on concretes containing between 15% and 25% by mass Class F and Class C fly ashes to evaluate compressive strength. The effects of moisture and temperature during curing were also examined. The results of the research showed that concretes containing Class C fly ash and were moist cured at 73°F (23°C) developed higher early age (1 to 14 days) compressive strengths than concretes with Class F fly ash. The long-term (90 days and greater) compressive strength of concretes containing fly ash was not significantly influenced by the class of fly ash. The air-cured concretes containing Class F fly ash did not develop strengths equivalent to air-cured normal concretes and air-cured concretes containing Class C fly ash developed relatively greater compressive strengths than air-cured concretes containing Class F fly ash. For concretes containing either class of fly ash, compressive strengths at 7 days increased with an increase in curing temperature. [20]

Safiuddin (2008) et al. observed that drying shrinkage occurs when concrete hardens and dries out at the early age. It induces potential flow channels in the form of micro-cracks. These cracks provide the access to deleterious agents, and thus affect the durability of concrete. The drying shrinkage of SCC does not differ very much from that of normal concrete. Several studies reported that it could be even lower in SCC. In general, the reduced coarse aggregate content and the increased amount of cementing material are expected to cause more drying shrinkage in SCC. But the porosity also affects the drying shrinkage of concrete. As the porosity is reduced in SCC, it compensates the negative effects of aggregate and binder on drying shrinkage. In addition, the drying shrinkage tends to decrease in SCC since a very small amount of free water is available in the system. Also, SCC has minimum empty voids on concrete surface that are largely responsible for drying shrinkage. [21]

Felekoglu et al. (2005) has done research on effect of w/c ratio on the fresh and hardened properties of SCC. According to the author adjustment of w/c ratio and super plasticizer dosage is one of the key properties in proportioning of SCC mixtures. In this research, fine mixtures with different combinations of w/c ratio and super plasticizer dosage levels were investigated. The results of this research show that the optimum w/c ratio for producing SCC is in the range of 0.84-1.07 by volume. The ratio above and below this range may cause blocking or segregation ofthe mixture. [22]

Nagataki, Fujiwara (1992) performed the slump flow test of SCC mix to find out whether the concrete mix is workable or not. They also performed the segregation test of SCC mix, by using locally available materials, the value ranging from 500-700 mm is considered as the slump required for a concrete to be self-compacted. [23]

IV. CONCLUSIONS

From the results obtained and presented in this paper, the following conclusions were made:

1) Workability tend to decrease with increasing time wastage before placement and compaction

2) The higher the cement-aggregate ratio, the better the workability. This is as a result of more

available paste to facilitate better workability

3) The loss of workability of the concretes was remarkable or sharp for the un-agitated concrete than the agitated mix in 1hr time. Implying that un-agitated concrete loses its workability faster under 1hr time hence concretes should be placed and compacted within a minimum of 1hr after mixing unless optimally agitated before placement and this should be done in 2½hrs.

4) From the slump, compacting factor and vebe test results, the workability of the un-agitated and agitated mixes tend to have the same workability in 15mins time ostensibly because water is still very much available for hydration of cement compounds for bonding.

5) From the slump test, the workability of un-agitated concrete drops by 75%, 70%, 75%, 66.7% and 68.2% for MX1, MX2, MX3, MX4, and MX5 respectively in the first 1hr

6) The agitated concretes tend to retain appreciable workability beyond 1hr due to the disturbance and this is gradually lost in 1-2½hrs time.

7) Therefore, agitating the already mixed concrete before compaction is very vital in keeping the workability of the concrete intact and hence provides an avenue for proper bonding.

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