STUDY ON SLUMP RETENTION OF READY-MIX CONCRETE: A REVIEW

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Abstract - *Ready mix concrete industry is facing the problem of slump loss. Slump loss is different for various grades of concrete. Slump loss also varies with time. So, a study is required to determine the factors affecting slump loss in ready mixed concrete. The rate of workability loss is influenced by a number of factors such as cement content, water content, admixtures, weather, volume of concrete etc. The main objectives of this project are to study the variation of slump with time of transportation, temperature and mix and to study the effect of re-dosing of admixture in concrete.*

Key Words: **Ready mix concrete, Slump retention, Slump loss, Temperature, Time**

1. INTRODUCTION

Concrete is a composite material composed of fine and coarse aggregate bonded together with cement paste that hardens with time. When aggregate, Portland cement and water are mixed together, it forms fluid slurry that can be emptied easily and formed into any shape. Reaction takes place between cement, water and other ingredients and forms a hard lattice which holds the materials together and forms a durable stone-like material which has numerous uses.

Fresh concrete/plastic concrete is a newly blended material which can be formed into any shape. The proportion of quantities of cement, aggregates and water, controls the properties of concrete in the wet state and also in the hardened state. The measure of water utilized for mixing concrete will get modified at site which relies on the moisture present on the free surface of aggregates and the absorption properties of porous and dry aggregates. The actual water/cement ratio adopted at site is needed to be adjusted keeping this in mind.

For construction, most of the contractors have to collect the required materials for the construction before actual works starts. These materials need be stored at the site properly. This is made possible only when there will be-more free space at the construction site which is difficult in congested areas. In such situations there is one solution to overcome all these problems is that the use of READYMIXCONCRETE (R.M.C). By using R.M.C we can save the time as well as money required for the labours. Moreover, it offers more quality mix than normal site mix.

2. READY MIX CONCRETE

Ready mix concrete is concrete that is produced in a batching plant, based on a selected mix design, which is then truck mounted in–transit mixers and are used to deliver it to the work site. This gives an exact blend, which allows special concrete mixes to be produced and then implemented on work sites. It is better to use ready mix concrete than on-site mixing of concrete because of the exactness of the mixture and decreased congestions at the construction site. Ready-mix concrete/RMC implies a concrete that is produced for conveyance to the construction site in a plastic/unhardened state. Concrete itself is a blend of cement, water and aggregates. Aggregates include gravel or crushed stone and sand. Ready-mix concrete/RMC is bought and sold by volume - usually it is expressed in cubic meters.

Ready-mix concrete is prepared under controlled methods of operations and transported and placed at construction site using sophisticated equipment. RMC can be used in any major concerting works like bridges, roads, dams, canals, tunnels etc. It can be effectively used for concreting in areas where storage space for materials is not available, sites where high-volume traffic makes problems. The advantages of RMC over conventional concrete are listed below

- Better quality concrete is produced,
- Storage space for materials can be eliminated at site,
- Hiring of plant and machineries for concreting can be eliminated,
- Reduction in wastage of basic materials
- Reduction in labour required for concrete production
- Reduced time consumption
- Reduction in noise and dust pollution at site

2.1 Property Determining the Quality of Concrete.

Workability is the major factor that affects the quality of concrete. Workability is a property of fresh concrete mixture. It means the easiness with which concrete can be mixed, laid, compacted and finished with no segregation. Workable concrete or concrete with good slump is those concrete which has very small internal friction between particle and which beats the frictional opposition offered by the particles, formwork surface, and reinforcement in concrete with just compacting efforts. Workability is the property of all concrete mixes which is related to compaction as well as the strength. The required workability of concrete varies with type of concrete work and mix deign. For thin and heavily reinforced sections, workability required is more when compared to mass concreting [1].

Factors affecting workability are

- **Water content**: Higher is the water content, more the fluidity of mixture and thus workability will be high. The water content of controlled mix cannot be increased significantly, since it adversely affects the strength of concrete.
- **Mix Proportion**: Higher aggregate/cement ratio makes the concrete leaner. For such mixes, the cement paste that is available for lubrication between the aggregates will be lesser, per unit surface area of aggregate and thus their free movement is restrained.
- **Size of Aggregate:** As we use large size aggregate, there is a reduction in the surface area of aggregate and hence quantity of water required for wetting the surface of aggregate turns out to be less and less paste is needed for lubricating the surface of aggregates to lower the internal friction.
- **Shape of Aggregate:** Angular, flaky and elongated aggregate makes the concrete harsher compared to rounded aggregates/cubical shaped aggregates. Rounded aggregates contribute for better workability as it has fewer voids, surface area, and thus lesser will be the frictional resistance by the aggregate.
- **Surface Texture of Aggregate**: The surface area offered by rough textured aggregate is more than that of smooth rounded aggregate of same volume. Rough textured aggregate has poor workability whereas better workability is obtained for smooth or glassy textured aggregate.
- **Grading of aggregate**: The better the grading makes the voids content less and thus will be the workability.
- **Use of Admixtures**: The internal friction between the particles can be reduced by using air-entraining agent which are surface-active. They can also act as artificial fine aggregates with very smooth surface. Similarly, the fine polished pozzolanic materials, regardless of increasing the surface area, offer better greasing up impacts for giving better workability.

Workability can be measured by the following methods

- Slump Test
- Compacting Factor Test
- Flow Test
- Kelly Ball Test
- Vee-Bee Consistometer Test.

The commonly used test among these is slump test, which can be easily conducted on any site.

3. SLUMP LOSS IN CONCRETE

Slump loss is the rapid stiffening of fresh concrete. When admixtures like super plasticizers are used with Portland cement, slump loss become significant. Stiffening of concrete gets accelerated under hot climate. It is due to evaporation of mixing water, hydration of cement and even by the absorption of water by the aggregates. Retarders lower the rate of hydration of cement. But contrary to expected, retarders brought in accelerated slump loss. The water demand is increased and slump loss is accelerated, with the rise of temperature within the range of 21°C to 32°C. The concrete compressive strength linearly increases with the increase in mixing time for up to 180 min. This increase was 10% after mixing for 180 min [2].

By the addition of dispersants, the slump loss can be effectively controlled for cement paste. The quantity of SP added and W/C ratio can affect the properties of cement paste. Addition of 1.0 to 1.5 wt. % of MA-co-AA mixed with NSF can control the loss of slump in cement paste. The dispersant remaining in the aqueous phase can influence slump retention. Rapidly adsorbed dispersant from aqueous phase has higher rate of slump loss than that was absorbed more slowly from aqueous phase [3].

The loss of slump in field can be regained by redosing of superplasticizer in concrete. Redosing does not affect the strength of concrete [4].

3.1 Commonly used admixtures in ready mix concrete

Commonly used mineral admixtures in concrete are fly ash, GGBFS and Silica fume. The addition of fly ash increased the durability of cement concrete. Fly ash is added in concrete as a mineral admixture since it has advantageous properties like pore refinement and pozzolanic reaction. When fly ash is added, calcium hydroxide, produced during hydration of cement, reacts with reactive silica present in the fly ash which forms calcium silicate hydrate(C-S-H) gel [5][6]. The addition of these admixtures reduces workability but improves concrete performance. With the addition of finely powdered mineral admixture there is an increase in the surface area, which increases the water demand. This is the reason for lower workability [7].

Concrete with recycled aggregate had a higher slump loss rate that that of conventional concrete. This slump loss can be reduced by replacing cement with fly ash. The slump loss of the recycled aggregate concrete with fly ash was decreased to lower than that of without fly ash when the fineness of the fly ash was expanded, which expanded the slump loss of the fresh concrete. Finer fly ash showed an increased slump loss also [8].

The mostly used chemical admixtures are plasticizers and super plasticizers. Super plasticizer (SP) is also a water reducer. The main difference between water reducer and super plasticizer is that SP will essentially reduce the required water for concrete mixing. It has the ability to increase the workability of concrete without increasing the water content in the concrete mix [9,10]. Superplasticizers can also increase the carbonation resistance of concrete [11]. Different types of super plasticizing admixtures have different bases, they are: Sulphonated Melamine Formaldehyde (SMF), lignosulphonates, Polycarboxylic ether (PCE) and Sulphonated Naphthalene Formaldehyde (SNF). These all admixtures are based on codal provision laid down by IS9103:1999. These super plasticizers are used in the production of concrete for producing flowable concrete, to make concrete with low water-cement ratio, for producing high performance concrete. Super plasticizing admixtures have affected the concrete by altering its rheology in a positive manner. Interaction takes place between these polymeric behaviour admixtures and cement particles chemically and physically [12]. The adsorption of molecules of the admixture on cement particles surface leads to the physical interaction. This may also be due to stearic effect between neighboring deflocculated, adsorption of polymeric molecules and dispersed cement particles. By taking the strength gains as main concern, addition of admixture more than 3% does not give many benefits [13].

By the addition of dispersants, the slump loss can be effectively controlled for cement paste. The quantity of SP added and W/C ratio can affect the properties of cement paste. Addition of 1.0 to 1.5 wt. % of MA-co-AA mixed with NSF can control the loss of slump.

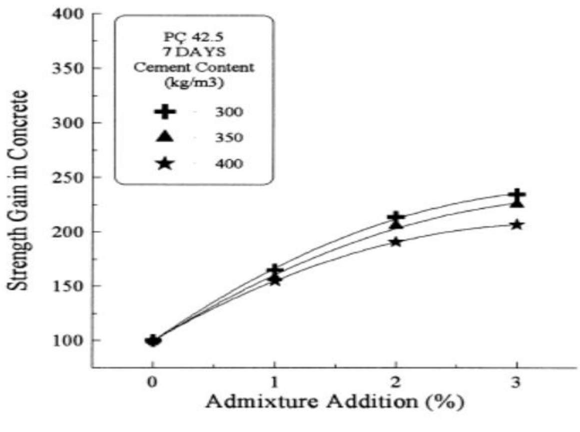

Chart -1: Admixture amount vs. strength gain

On an experimental study on the effect of different type of Polycarboxylate based super plasticizers on self-compacting concrete, slump retention decreased as the side chain number increased. The reason may be due to interlocking of side chains. The highest concrete strength occurred on admixtures with highest slump loss [14]. Even though addition of super plasticizer can increase workability of concrete, its higher dosages can impair the concrete cohesiveness. The effectiveness of slump loss prevention by adding super plasticizer is higher than that of conventional concrete [15]. Another study showed that the introduction of superplasticizers in concrete improved its workability, by decreasing the flow resistance and shear resistance. As the water to cement ratio decreases, the superplasticizer becomes more effective in increasing the workability of the mix when applied at constant dosage [16, 17].

Comparing modified lignosulphonates (PLS), Polycarboxylate (PCE), and polynaphthalene (PNS) based super plasticizers the retarding effect is much stronger in PLS mixture when compared to PNS & PCE mixture. Cement paste being a shear thickening material showed higher thickening rate for PCE & PNS based than that of PLS based cement paste [18].

The C_3A content, cement fineness and degree of polymerization of PNS determines the adsorption capacity of PNS based super plasticizer. Usage of 1% PNS based super plasticizer with 0.4% solid content showed that there is 85-93% adsorption on cement particles, independent of the characteristics of cement. Also, over dosage can reduce the ionic strength and fluidity will be improved [19].

Increasing the super plasticizer dosage can decrease the plastic viscosity, yield stress and Marsh cone flow time in concrete. It also results in increase in the mini slump spread upto the dosage value below saturation point. These parameters become constant beyond the saturation point. [20]

Retarding admixtures delays the setting by decreasing the rate of hydration of the cement. Hence, due to the reduced hydration rate during a given period the water combined with cement becomes less. Therefore, it is clear that the slump loss in such mix corresponding for a particular time will be much lesser than that of without a retarder [21].

The addition of blast furnace slag as a substitute for cement gave an improved workability with an optimum percentage of 20% in self compacting concrete. But the plastic viscosity and yield stress decreased for both super plasticized and slag substituted concrete [22].

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3.2 Effect of temperature on concrete

From the point of construction, it is undesirable to have the effects of atmospheric temperature on fresh concrete properties. Frequently occurring problems such as accelerated slump loss or excessive moisture loss which results in shrinkage can cause extra problems. During moderate weather conditions, concrete need to be workable for a long time to allow its handling, namely transporting, laying, compacting and finishing, with lesser difficulties, thus stiffening of concrete, and the corresponding slump loss, make no real problems. During hot atmospheric conditions, both the rate of stiffening, and the slump loss are increased, with the rise in temperature and the initial and final setting times are decreased. Use of Chemical admixtures in concretes to improve some properties at ambient temperature are common practices at sites [23,24,25].

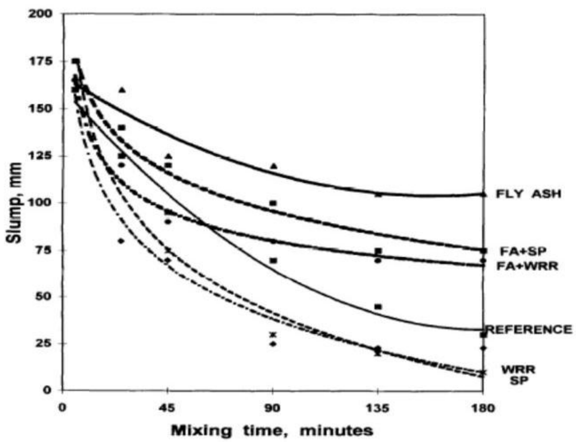

Chart -2: Slump loss of concretes with fly ash and without fly ash and with and without a water-reducing and retarding admixture or a super plasticizer after prolonged mixing at 32°C (90°F).

If super plasticizers are added to concrete, the setting time showed a decrease in its magnitude under the temperature range of 25°C to75°C. This is due to the fact that there is an increase in free lime and non-evaporable water from 25°C to50°C. Also, interaction of Calcium Hydroxide with super plasticizer increased with increase in temperature [26, 27].

At lower dosages of super plasticizer, with the rise in temperature, there is a decrease in fluidity of cement paste. But at higher dosages there is an increasing trend in the fluidity. This can be due to two mechanisms: the increase in the demand of water and decrease in viscosity at higher temperature. Considering Polycarboxylate (PCE), naphthalene (SNF), melamine (SMF) and lignosulphonates (LS) based super plasticizers; PCE has the least sensitivity to temperature while LS has the most. As the temperature increases, water demand and loss in flow with time increases, while setting time decreases [28].

3.3 Commonly used admixtures in ready mix concrete

RMC is subjected to continuous mixing /agitation in transit mixers during transport to the work site from the plant. In the extended mixing the number of drum revolution is more influenced on slump depletion than the elapsed time. For laboratory mixtures, the slump ranged from approximately 70-85% of original slump after 300 DRCs. For the field mixtures slump ranged from approximately 40-50% of the original slump value after 300 truck DRCs [29].

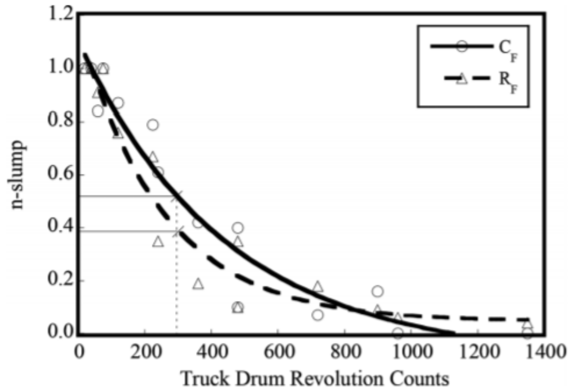

Chart -3: n-slump model for field-mixed concrete.

Slump = n-slump (n) × slump initial

3.4 Effect of retempering

Addition of super plasticizer to increase the workability of concrete which diminishes over passage of time is known as retempering. Both plain and super plasticized concrete can be retempered economically. As the rate of retempering increases the rate of slump loss also increases [30]. Under hot dry environment retempering in RMC plants can cause reduction in strength of concrete. There is a significant reduction in strength in concrete when water added is greater than the specified limit. So retempering in hot weather condition should be discouraged and SP can be used to adjust the workability of concrete [31].

4. CONCLUSIONS

Ready mix concrete is concrete that is produced in a batching plant, based on a selected mix design, which is then truck mounted in–transit mixers and are used to deliver it to the work site. Various factors such as water content, aggregate characteristics, admixtures etc. can affect the workability of concrete. Slump loss is a major problem faced by ready mix concrete. Slump loss is the rapid stiffening of fresh concrete. Slump loss can be controlled by addition of dispersant. The quantity of dispersant used and water to cement ratio can affect the properties of cement paste. Rapidly adsorbed dispersant from aqueous phase has higher rate of slump loss than that was absorbed more slowly from aqueous phase. The incorporation of finely powdered mineral admixture can cause increase in the surface area, which increases the water demand. During hot atmospheric conditions, both the rate of stiffening, and the slump loss are increased, with the rise in temperature and the initial and final setting times are decreased.

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