TO STUDY THE PHYSICAL PROPERTIES OF LATEX MODIFIED SELF COMPACTING CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH GLASS POWDER

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SUBMITTED BY:

NEERAJ KUMAR TIWARI
(Roll No. 1170444009)

UNDER THE GUIDENCE OF

MR. FAHEEM AHMAD KHAN
(ASSISTANT PROFESSOR)

BBD UNIVERSITY

to the

DEPARTMENT OF CIVIL ENGINEERING
BABU BANARASI DAS UNIVERSITY
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CERTIFICATE

This is to certify that the dissertation entitled **"To study the Physical Properties of Latex Modified self-compacting concrete by partial replacement of cement with glass powder" which** is being submitted by **Mr. Neeraj Kumar Tiwari (1170444009)** in partial fulfillment of the requirements for the award of Degree of **Master of Technology in Structural Engineering** of the BabuBanarasi Das University, Lucknow, is a record of his own work carried out by him under my guidance and supervision. The results embodied in the dissertation have not been submitted for the award of any other Degree or Diploma.

(Mr. FAHEEM AHMAD KHAN)
ASSISTANT PROFESSOR
Deptt. Of Civil Engineering
BabuBanarasi Das University, Lucknow

DECLARATION

I hereby certify that the work which is being presented in this thesis entitled **"To study the Physical Properties of Latex Modified self-compacting concrete by partial replacement of cement with glass powder"** in partial fulfilment of award of degree of **Master of Technology** in **Structural Engineering** submitted in Department of Civil Engineering, Babu Banarasi Das University, Lucknow is an authentic record of my own work carried under the supervision of **Mr. Faheem Ahmad Khan**, Assistant Professor, Babu Banarasi Das University, Lucknow, India.

Date: **(NEERAJ KUMAR TIWARI)**

(Roll No. 1170444009)

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(Roll No. 1170444009)

ABSTRACT

Concrete occupies unique position among the modern construction materials, concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate (usually made for different types of sand and gravel), that is bond by cement and water.

Self-compacting concrete (SCC) is defined as a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. To improve the performance of self-compacting concrete, SBR.latex is mixed with SCC. It has been observed that latex modified self-compacting concrete (LMSCC) is more durable than conventional self-compacting concrete due to superior strength and high durability. There is a current trend in all over the world to utilize the treated and untreated industrial by- products, domestic wastes etc. as raw materials in concrete. These not only help in the reuse of the waste materials but also create a cleaner and greener environment. This study aims 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 latex modified self-compacting concrete.

The fresh and hardened physical properties of SCC were studied, i.e., workability, flow ability, passing ability, filling ability, compressive strength, split tensile strength and flexural.

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CHAPTER 1
INTRODUCTION

1.1 GENERAL

Self-compacting concrete (SCC) as the name suggest is the concrete which get compacted without vibration. The self-compacting concrete was developed in Japan in late 1980's. By the early 1990's Japan has developed and used SCC that does not required vibration to achieve full compaction. Because of its wide advantages by the year 2000, the SCC has become popular in Japan for prefabricated products and ready mixed concrete. Several European countries recognized the significance and potentials of SCC developed in Japan. During 1989, they founded European federation of natural trade associations representing producers and applicators of specialist building products (EFNARC) [1]. To call a SCC successful it must possess following properties:

- Have a fluidity that allows self-compaction without external energy.
- Remain homogeneous in a form during and after the placing process and
- Flow easily through reinforcement.

1.2 ADVANTAGES OF SCC

Self-compacting concrete offers a great advantage over conventional concrete and some of them are listed below:-

- Improved quality of concrete and reduction of onsite repairs.
- Faster construction times.
- Lower overall costs.
- Facilitation of introduction of automation into concrete construction.
- Improvement of health and safety is also achieved through elimination of handling of vibrators.
- Substantial reduction of environmental noise loading on and around a site.
- Better surface finishes.
- Easier placing.
- Thinner concrete sections.

- Greater freedom in design.
- Improved durability, and reliability of concrete structures.
- Ease of placement results in cost savings through reduction equipment and labour requirement.
- SCC makes the level of durability and reliability of the structure independent from the existing on-site condition relate to the quality of labour, casting and compacting systems available.
- The high resistance to external segregation and the mixture self- compacting ability allow the elimination of macro-defects, air bubbles, and honey combs responsible for penalizing mechanical performance and structure durability.

1.3 HOW DOES IT WORK

A self-compacting must:

- Have a fluidity that allows self-compaction without external energy.
- Remain homogeneous in a form during and after the placing process and
- Flow easily through reinforcement

To achieve these performances, Okamura redesigned the concrete mix design process.

His mix design procedure focused on three different aspects:

- Reduction of the aggregate content in order to reduce the friction, or the frequency of collisions between them increasing the overall concrete fluidity.
- Increasing the paste content to further increase fluidity.
- Managing the paste viscosity to reduce the risk of aggregate blocking when the concrete flows through obstacles

In rheological terms, even though a significant amount of research tends to show that SCC viscosity varies with the shear rate and acts as a pseudo plastic material, SCC is often described as Bingham fluid (viscos elastic) where the stress/shear rate ratio is linear and characterized by two constants viscosity and yield stress.

1.4 APPLICATIONS ADVANTAGE OF SSC

Application of self-compacting concrete are as following:

- Bridge(anchorage, arch, beam, girder)

- Box culvert
- Building
- Concrete filled steel column
- Tunnel (lining, immersed tunnel, fill of survey tunnel)
- Dam (concrete around structure)
- Concrete product (blocks, culvert, wall, water tank)
- Diaphragm wall
- Tank (side wall, joint between side wall and slab)
- Fire proof

1.5 LARGE SCALE CONSTRUCTION

Self-compacting concrete is currently being employed in various practical structures in order to shorten the construction period of large-scale constructions.

The anchorages of Akashi-Kalikyo (Akashi straits) Bridge opened in April 1998, a suspension bridge with the longest span in the world (1991 mts), is a typical example. Self-compacting concrete was used in the construction of the two anchorages of the bridge. A new construction system that makes full use of the performance of self-compacting concrete was introduced for the purpose. The concrete was mixed at the batcher plant next to the site, and was then pumped out of the plant. It was transported 200mts through pipe to the casting site, where the pipes were arranged in rows 3 to 5mts apart. The concrete was cast from gate valves located at 5mts intervals along the pipes. These valves were automatically controlled so that the surface level of the cast concrete could be maintained. The maximum size of the coarse aggregate in the self-compacting concrete used at this site was 40 mm the concrete fell as much as 3mts, but segregation did not occur, despite the size of coarse aggregate. In the final analysis the use of self-compacting concrete shortened the anchorage construction period by 20% from 2.5 to 2 years.

Self-compacting concrete was for the wall of a large LNG tank belonging to the Osaka gas company. The adoption of self-compacting concrete in this particular project had the following merits

1. The number of lots decreased from 14 to 10 as the height of one lot of concrete was increased

2. The number of concrete workers was reduced from 150 to 50.
3. The construction period of the structure decreased from 22 months to 18 months.

In addition, a rational acceptance test for self-compact ability at the job site was newly introduced. The concrete casting was complete in June 1998

1.6 NECESSITY FOR NEW STRUCTURAL DESIGN AND CONSTRUCTION SYSTEM

Self-compacting concrete saves the cost of vibrating compaction and ensures the compaction of the concrete in the structure. However, total construction cost cannot always be reduced, except in large-scale construction. This is because conventional construction systems are essentially designed based on the assumption that vibrating compaction of concrete is necessary. Self-compacting concrete can greatly improve construction systems previously based on conventional concrete that required vibrating compaction. This sort of compaction, which can easily cause segregation, has been an obstacle to the rationalization of construction work. Once this obstacle is eliminated, concrete construction can be rationalized and a new construction system including form work, reinforcement, support and structural design, can be developed.

One example of this is the so called sandwich structure, where concrete is filled into a steel shell. Such a structure has already been completed in Kobe, and could not have been achieved without the development of self-compacting concrete.

1.7 SBR LATEX

SBR LATEX is a carboxylate styrene butadiene copolymer latex admixture that is designed as an integral adhesive for cement bond coats, mortars and concrete to improve bond strength and chemical resistance. SBR is often used as part of cement based sub structural (basement) Waterproofing systems where as a liquid it is mixed with water to form the Gauging solution for mixing the powdered tanking material to a slurry. SBR aids the bond strength, reduces the potential for shrinkage and adds an element of flexibility, its offers better durability, reduced shrinkage and increased flexibility, as well as being resistant to emulsification in damp conditions.

1.8 LATEX MODIFIED SELF COMPACTING CONCRETE

Addition of latex to conventional unmodified concrete reduces the amount of water required to achieve the appropriate viscosity for placement of the mix. This lower water requirement results in a cured concrete with higher compressive strength. The latex forms elastic membranes throughout the matrix of concrete, reducing the formation of voids and hairline cracks during the curing stage. The Latex Modified Concrete (LMC) resists penetration of oil, water, salts and aids in the adhesion of new concrete to old. The flexural strength is improved, and there is increased abrasion resistance.

In this dissertation work, latex modified self-compacting concrete compositions containing 5% SBR latex by weight of cement were prepared. Concrete cubes, cylinders and beams were cast using these latex modified self-compacting concrete to perform compressive strength, split tensile strength and flexural strength tests.

1.9 MATERIAL USED IN SELF COMPACTING CONCRETE

1.9.1 Introduction Material

The material used for self-compacting concrete (SCC) are selected from those by the conventional concrete industry. Typical materials used for SCC are coarse aggregate, fine aggregate, cement and admixture (super-plasticizer). Thus we can say that in SCC material which is used are mostly same as normal concrete material, and which played important part for SCC to gain popularity.

1.9.2 Materials

1.9.3 Aggregates

The coarse aggregate are chosen for SCC is typically round in shape, is well graded, and smaller in maximum size than that used for conventional concrete typical conventional concrete could have a maximum aggregate size of 40 mm or more. In general, a rounded aggregate and smaller aggregate particles aid in the flow ability and deformability of the concrete as well as aiding in the prevention of segregation. Gradation is an important factor in choosing a coarse aggregate, especially in typical uses of SCC where reinforcement may be highly congested or the formwork has small dimensions. Gap graded coarse aggregate promotes segregation to a greater degree than well-graded coarse aggregate. As with conventional concrete construction, the maximum size of the coarse aggregate for SCC depends upon the type of construction. Typically, the maximum size of coarse aggregate used in SCC ranges from approximately 10 mm to 20 mm.

Generally aggregate occupy 70% to 80% of concrete and have an natural rock (crushed stone, or natural gravels) and sand, although synthetic materials such as slag and expanded clay or shale are to some extent, mostly in lightweight concretes. In addition to their use as economical filler, aggregates generally provide concrete with better dimensional stability and wear resistance. Although aggregate strength can play sometimes an important role, for example in high strength concretes, for most applications the strength of concrete and mix design are essentially independent of the composition of aggregates.

However, in order instances, a certain kind of rock may be required to attain certain concrete properties, e.g., high density or low coefficient of thermal expansion. In this work 16 mm, 12 mm & 10 mm coarse aggregate is taken with 25%, 25% & 50% respectively, mainly to maintain flow & passing ability of SCC.

1.9.4 Cement

The most common cement currently used in construction is the Portland cement. In the dissertation work which has been performed ordinary Portland cement of 43 grades has been used. Generally three grade of OPC is available i.e. 33, 43 & 53.

It has been possible to upgrade the quality of cement by using high quality limestone, modern equipment, and closer on line control of constituents, maintaining better particle size distribution, finer grinding and better packing. The manufacture of OPC is decreasing all over the world in view of the popularity of blended cement on account of lower energy consumption, environmental pollution, economic and other technical reasons.

1.9.5 Glass Powder

Glass is an amorphous solid that has been found in various forms for thousands of year and has been manufactured for human use since 1200 BC. Glass is one the most versatile substance on earth, used in many applications and in a wide variety of forms, from plain clear glass to tempered and tinted varieties, and so forth. After its usage it is generally dumped in landfills. Since glass is a non-biodegradable material, landfills do not provide a friendly environment.

Waste glass available locally in Lucknow shops is been collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it has to be powdered to desired size. In this studies glass powder ground in ball/pulverizer for a period of 30 to 60 minutes resulted in particle sizes less than size 150 pm and sieved in 75 μm.

As glass powder with particle size less than 75μm possess pozzolanic properties, past investigation reveals that glass powder can be effectively use as partial replacement of cement.

Figure : 1.1 Glass Powder

Table 1.1: Chemical Composition of glass powder

S. No.	Chemical Properties of glass powder	% by mass
1	SiO_2	67.330
2	Al_2O_3	2.620
3	Fe_2O_3	1.420
4	TiO_2	0.157
5	CaO	12.450
6	MgO	2.738
7	Na_2O	12.050
8.	K_2O	0.638
9.	ZrO_2	0.019
10.	ZnO	0.008

Table 1.2: Physical properties of glass powder

S. No.	Physical properties of glass powder	Value
1	Specific gravity	2.6
2	Fineness Passing 150μm	99.5
3	Fineness Passing 90 μm	98
4	Colour	White

1.9.6 Super Plasticizer

Super plasticizer is essential for the creation of SCC. The job of SP is to impart a high degree of flow ability and deformability, however the high dosages generally associate with SCC can lead to a high degree of segregation. Cicoplast super HS is utilized in this project, which is a product of CICO Company having a specific gravity of 1.14. Super plasticizer is a chemical compound used to increase the workability without adding more water i.e. spreads the given water in the concrete throughout the concrete mix resulting to form a uniform mix. SP improves better surface expose of aggregates to the cement gel. Super plasticizer acts as a lubricant among the materials. Generally in order to increase the workability the water content is to be increased provided a corresponding quantity of cement is also added to keep the water cement ratio constant, so that the strength remains the same.

Super plasticizers (high-range water-reducers) are low molecular-water-soluble polymers designed to achieve high amount of water reduction (12.30%) in concrete mixture in order to attain a desired slump (Gagne et al., 2000). These admixtures are used frequently to produce high-strength concrete, since workable mixes with water 0.40 are possible (Whiting, 1979).

1.9.7 Role of Super plasticizers in cement

We know that the main action of S.P. is to fluidity the mix and improve the workability of concrete. Portland cement, being in tine state of division will have a tendency to flocculate in wet concrete. This flocculation entraps certain amount of water used in the mix and there by all the water is not freely available to fluidity the mix. When plasticizers are used, they get absorbed on cement particles.

The absorption of charged polymer on cement particle creates particle to particle repulsive forces, which overcome the attractive forces. This repulsive force is called zeta potential, which depends on the base, solid contents and quality of super plasticizer used. The overall result is that the cement particles are deflocculated and the water trapped inside the flocks gets released and now available to fluidity the mix.

1.9.8 Water

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and allows it to flow more freely. Less water in the cement paste will yield a stronger, more durable concrete; more water will give a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles, and other components of the concrete, to form a solid mass.

1.10 OBJECTIVES OF STUDY

1. To arrive at an appropriate mix design for self-compacting concrete and analyse their physical properties.
2. To investigate the physical properties of latex modified self-compacting concrete.
3. To investigate the effect of latex modified self-compacting concrete by partial replacement of cements using glass powder in various percentages

1.11 METHODOLOGY OF WORK

1. Several, literature were reviewed before starting the work to understand the subject better.
2. Specific test on the material which was used in the dissertation work was made to know the specification and quality of material.
3. Mix designing for M25 grade of self-compacting concrete was done by using EFNARC [1] guideline and IS 10262-2009 [2]
4. Self-compacting concrete was prepared by using the mix design and test were made on the fresh state of SCC to know whether the concrete prepared fall under the criteria of self-compacting concrete or not.
5. The SCC prepared by using above mix was tested for compressive, flexural and split tensile strength after 28 days.
6. Now on the above mix SBR latex is added and the cement was partially replaced by glass powder in different percentage i.e., 2.5%, 5%, 7.5% and 10% and the test for fresh and hardened state for every percentage of glass powder were made

1.12 OUTLINE OF DISSERTATION

Chapter 1: Introduce the reader about different material used in dissertation work.

Chapter 2: Introduce the reader about various developments which have taken place in the earlier year. A comprehensive detail of stipulated work of various researcheis has been incorporated in this section.

Chapter 3: Incorporated the experimental study and research methodology in this project and the mix design of M25 grade of SCC.

Chapter 4: Deals with the result and discussion on the work carried out in the preceding section.

Chapter 5: Deals with conclusion of over all work and reference

CHAPTER 2
LITERATURE REVIEW

2.1 GENERAL

Literature review is one of the most important aspects of any research or dissertation work. It can be defined as the base of any dissertation work. Before taking up the work one has to go through several journals which have been published before on the given topic to know amount of work which has been done on the topic and what can be done in future and how.

Mayur B. Vanjare and Shriram H. Mahure (2012) [1],in their study on the “Experimental Investigation on Self-Compacting Concrete Using Glass Powder.”, found out that addition of glass powder in SCC mixes reduces the self-compatibility characteristics like filling ability, passing ability and segregation resistance. The compressive and flexural strengths of the mixes were observed to decrease with increase in glass powder contents. The average reduction in compressive and flexural strengths for all grades was around 6%, 15% and 20%, 2%, 3.7% and 6.75% for glass powder contents of 5%, 10% and 15% respectively.

Folic R.J. et. al (1998) [2], in their study on the “Experiment Research on Polymer Modified Concrete”. He tested concretes modified with 2.5%, 5% and 7.5% of polymer (Latex) admixture to the cement. The test results showed that the water absorption decrease with the increase of polymer - cement ratio. Although it was in the case of capillary water absorption, such a positive change is important as it influences the increase of concrete durability.

Ahmad Shayan (2002) [3], he concluded that 30% GLP could be incorporated as cement or aggregate replacement in concrete without any long-term detrimental effects. Up to 50% of both fine and coarse aggregate could also be replaced in concrete of 32 MPa strength grade with acceptable strength development properties.

Dr. G. Vijayakumar et al. (2013) [4], in their study on the “Studies on Glass Powder as Partial Replacement of Cement in Concrete Production.”, founded that replacement of glass powder in cement by 20%, 30% and 40% increases the compressive strength by 19.6%, 25.3% and 33.7% respectively and replacement of glass powder in cement by 40% increases the split tensile strength by 4.4% respectively. The effect of replacement of glass powder in cement by 20%, 30% and 40% increases the flexural strength by 83.07%, 99.07% and 100% respectively.

Dhanaraj Mohan Patil and Dr. Keshav K. Sangle (2013) [5],they observed that on the addition of GLP initial the rate of gain of strength is low but at 28th day it meets required design strength. At the level of 20% replacement of cement by glass powder meets maximum strength as compare to that of normal concrete and other percentage of replacement of cement. As the size of GLP particle decreases in concrete the strength of concrete increases. From results it is conclude that particle size less than 90 micron get higher strength than that of particle size ranges from 90 to 150 micron.

Gunalaan Vasudevan and Seri Ganis Kanapathypillay (2013) [6], the main purpose of this research is to check the compressive strength of the concrete using the waste glass powder. In term of strength, concrete with using waste glass powder replacement of 20% averagely have higher strength at 14 days but once the concrete reached at 28 days the control mix give more higher value compare to mix that contained waste glass powder but still give high value of the grade 30. From this research, using waste glass powder is giving positive value even though the value compare to standard mix it just less about l N/mm2, but for the 10% and 15% glass powder mixture which shows not much increment compare to 14 days value as well not achieving the required concrete strength.

Bhupendra Singh Shekhawat and Dr. Vanita Aggarwal (2014) [7], in his research work, it is clear that glass can be used as a partial replacement of cement in concrete because of its increased workability, strength parameters like compressive strength, flexural strength and split tensile strength and also because of its increased durability measured. Utilization of waste glass in concrete will not only provide economy, it will also help in reducing disposal problems.

A Rajathi and G Portchejian (2014) [8], they concluded that flow value decreases by an average of 1.35%, 2.2% and 4.36% for glass powder replacements of 5%, 10% and 15% respectively. The compressive strength decreases with even increase in glass powder contents. The average reduction in compressive strength for the grade was around 6%, 15%

and 20% for glass powder contents of 5%, 10% and 15%, respectively.

Shilpa Raju and Dr. P. R. Kumar (2014) [9], they concluded that as the percentage of glass powder increases the workability decreases. Use of super plasticizer was found to be necessary to maintain workability with restricted water cement ratio. Compressive strength increases with increase in percentage of glass powder up to 20% replacement and beyond 20% strength decreases. Flexural strength also increases with increase in percentage of glass powder up to 20% replacement and beyond 20% strength drops down.

Jitendra B. Jangid and Prof. A.C. Saoji (2014) [10],they observed that higher strength was obtained when 20% cement was replaced by glass powder. Highest percentage increases was about 30% in compressive strength and peak percentage increases was about 22% at 20% replacement by GLP in flexure strength. Cement replaced beyond 20% by GLP shows decrement in compressive strength. Workability decreases as percentage of glass powder increases.

Hongjian Du and Kiang Hwee Tan (2014) [11], they observed that optimum cement replacement of 30% by glass powder for development of compressive strength of concrete after 7 days. Compared to the conventional concrete mix, the mix with 60% glass power exhibited 75% strength at 7 days and 85% strength at 91 days.

Veena V. Bhat and N. Bhavanishankar Rao (2014) [12], they studied the influence of replacement of cement by glass powder and they concluded that replacement of cement by glass powder in concrete increases the compressive strength of concrete. Increase of 27% strength can be achieved when 20% cement was replaced by glass powder in concrete when water/ cement ratio was maintained constant. With the increase in glass content, percentage of water absorption decreases. Considering the strength criteria, the replacement of cement by glass powder is feasible up to 20%.

Ms. Karthika Kishore Koka et al. (2014) [13], in their study on the "Steel Fibre Reinforced Latex Modified Concrete.", founded that addition of latex helps in achieving the highest values for 7 days testing of specimens for compression, tension and flexure so it can be said that, latex helps in increasing the early strength of concrete, It can also be seen clearly that, latex and steel fibres help in achieving a good strength when tested for tension and flexure. It was also observed during testing that the specimens did not fail suddenly. Very few cracks were observed on the specimens.

Er. Kapil Soni and Dr. Y.P Joshi (2014) [14], in their study on the "Performance analysis of SBR Latex on cement concrete mixes" has concluded that by the addition of SBR latex, there is an increase in the workability of concrete as the polymer content increased and the presence of SBR-Latex is proved to be effective to reduce the ingress of water in concrete. However, for the mixes rich in cement, the dosage of SBR-Latex should be so adjusted that the workability of concrete should remain in controlled limits to avoid the highly flowable concrete due to plasticizing effect of SBR latex. The maximum increase in compressive strength at 15 % SBR latex content for concretes is 20.95%. However, the maximum increase in flexural strength is 36.35%, it has been observed from the test results that the optimum content of SBR latex for cement concrete mix is 15% by weight of cement.

Sameer Shaikh et al. (2015) [15], in their study on the, "Effective Utilisation of Waste Glass in Concrete." concluded that Replacement of glass powder in cement as well as crushed glass particles in sand by 5%, 10%, 15% and 20% increases the compressive strength after 28 days by 9.25%, 38.50%, 70.80%, and 33.09% and flexural strength after 28 days by 5.88%, 30%, 44.85% and 13.97% respectively. Replacement of glass powder in cement and crushed glass particles in sand by 15% increases the split tensile strength after 28 days by 4.25%.

Ismail Ansari and Sheetal Sahare (2015) [16], they analysed that Compressive and tensile strength of conventional concrete increases when glass powder is used as partial replacement of cement. It is observed that the strength of concrete is optimum at 20 — 25% partial replacement of cement but Workability is found to be decreases in all types of concrete with increase in glass powder.

Ravi ShankarYadav and Juned Ahmad (2015) [17], they observed that Compressive strength for M25 grade of SCC was found to be 35.07 MPa and modulus of rapture as 7.15. Best result for compressive strength and modulus of rupture was for 10% demolish concrete i.e. 37.52 MPa and 8.47 respectively then glass fibre was added in various percentages to enhance the properties of SCC and it was found that no considerable change in compressive strength was found but the modulus of rupture was found to increase for 0.20%. But with further increase in the % of polypropylene modulus of rupture was found to decrease. Hence 0.20% of wt. of cement of glass fibre should be added for best result for SCC.

Shiva Charan Singh et al. (2015) [18], they observed that replacement of glass powder in cement by 15% and glass particles in fine aggregate by 50% increases the compressive strength after 28 days. While using waste glass as partial replacement of PPC in concrete increased the workability with increased in replacement level. In general, workability of concrete made using as fine aggregate tended to be increased.

Aniket S. Aphale and Sheetal. A. Sahare (2016) [19], in their study on the, "Effect of Particle size of Recycled Glass on Concrete Properties.", found out that increase in glass content as cement replacement material decreases the workability of concrete. Recycled glass can be incorporated as cement replacement up to 20%, further increment will decrease the compressive strength, flexural strength and split tensile strength.

Rakeshsakaleet **al. (2016) [20],**in their study on the, "Experimental Investigation on Strength of Glass Powder Replacement by Cement in Concrete with Different Dosages." founded that cement in concrete is replaced by waste glass powder in steps of 10% 20%, 30%& 40% respectively by volume of cement and the compressive, flexural and split tensile strengths of concrete increase initially as the replacement percentage of cement by glass powder increases become maximum at about 20% and later decrease and workability of concrete also reduces monotonically as the replacement percentage of cement by glass powder increases.

Svvarna Dubey et al. (2016) [21], they concluded that 15% replacement of cement by waste glass showed a 15 % increase in compressive strength at 7 days and 25% raise in compressive strength at 28 days. Cement can be replaced by waste glass up to 15% by weight showing a 9.8 % raise in compressive strength of 28 days. Workability of concrete mix rise with an increase in waste glass content.

Soumendra Mitra et al.(2016)[22], in their study on the "A practical study on Effective Utilization of Waste Glass in Concrete." indicated that waste glass can effectively be used as fine aggregate replacement (up to 40%) without substantial change in strength. The performance test results conducted in this research confirm that the properties of those special mixed concretes are satisfactory. The properties tested include workability, air content, density, compressive strength, tensile strength, and water absorption. Moreover, it is found that water absorption is strongly related to the strength of the concrete. Ultimately, glass is found to be an ideal material as a decorative aggregate in architectural concrete with its satisfactory performances and aesthetic property improvement.

Mohammad Shoeb Sayeeduddin and Mr. F.I. Chavan (2016) [23], they concluded that as the percentage of replacement of cement with glass powder increases strength increases up to 20% and beyond that it decreases. The highest percentage increases in the compressive strength was about 23% and flexural strength was about 17% and split tensile strength was about 18% at 20% replacement level. The increases in strength up to 20% replacement of cement by glass powder may be due to the Pozzolonic reaction of glass powder due to high silica content.

2.2 CONCLUSION OF LITERATURE REVIEW

From the previous studies it can be concluded that latex helps in increasing the early strength of concrete. Latex Modified Concrete overlay for the purpose of Protecting the underlying structural concrete from the deterioration caused by absorption of vehicular chemicals, dicing salts and water. On the other hand Self-compacting concrete is a type of concrete that gets under its self-weight. Which can placed and compacted in to every corner of a formwork; purely means of its self-weight by eliminating the need of either external energy input from vibrators or any type of compacting effort. Latex improves the self-compacting properties of concrete in addition it increases the early strength and minimizes the crack. So the present study focus on use of latex in self-compacting concrete with partial replacement of cement by glass powder.

CHAPTER 3
EXPERIMENTAL PROGRAM

3.1 INTRODUCTION

An extensive experimental program has been executed to ascertain the compressive, split tensile and flexural strength of latex modified self-compacting concrete (LMSCC) when conventional cement is replaced by glass powder in various percentages (i.e. 2.5%, 5%, 7.5% and 10% by weight of total cement).

The various test conducted on the material are as following:-

3.2 TESTS ON CEMENT

Ordinary Portland cement of 43 grade was used throughout the experimental investigation.

3.3 CONSISTENCY

The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould. IS 4031 (part 4): 1988 [26] was consulted for the test.

Procedure

1. Weigh approximately 300gm of cement and mix it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes.
2. Fill the Vicat mould with paste and level it with a trowel.
3. Lower the plunger gently till it touches the cement surface
4. Release the plunger allowing it to sink into the paste.
5. Note the reading on the gauge.
6. Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm

Reporting of Result

Cement taken	=	300gm
Water	=	90gm (30%)
Result	=	6mm

3.4 INITIAL SETTING TIME

The Test block was placed under the rod bearing the needle of the Vicat. Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing it to penetrate the test block. Repeat the procedure till the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould.

The time period elapsing between the time, water is added to the cement and the time, the needle fails to pierce the test block by 5.0 ± 0.5mm measured from the bottom of the mould, is the initial setting time .IS 4031 (PART 5): 1988 [27] was consulted for test.

Procedure

1. Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency.
2. Start a stop-watch, the moment water is added to the cement.
3. Fill the Vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plate and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.

Reporting of Result

Water required to be added	=	0.85x90 = 76.5gm
Result	=	45minute

3.5 FINAL SETTING TIME

Replace the above needle by the one with an annular attachment. The cement should be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression there in, while the attachment fails to do so. The Period Elapsing Between the time, water is added to the cement and time; the needle makes an impression on the surface of the test Block, while the attachment fails to do so is termed as Final Setting Time.

Reporting of Result

Final setting time = 590 minutes (i.e. about 10 hr)

3.6 COMPRESSIVE STRENGTH

The value of Compressive strength of cement at 28 days was found from compression test. The value observed was 43.5 N/mm2 which is satisfactory when compared to the standard value as per IS: 8112:1989 [28] i.e. 43 N/mm^2. Thus it is evident that the cement used satisfied the compressive strength criteria of 43 grade cement.

Table 3.1: Physical Properties of Ordinary Portland Cement:

Characteristics	Observed value
Normal consistency	30%
Initial setting time	45 minutes
Final setting time	590 minutes
Specific gravity	3.15
Compressive strength at 28 days	43.5 MPa

3.7 TESTS ON AGGREGATE

3.7.1 Fine Aggregate

The Fine Aggregate used was locally available coarse sand. The test procedure as per IS 383: 1970 [29] was carried out to determine the properties of Fine aggregate

3.7.2 Sieve Analysis of Fine Aggregate

Table 3.2.1: Sieve Analysis of Fine Aggregate

IS sieve size	Weight retained (gm)	Cumulative wt. retained(gm)	Cumulative wt. % retained	Cumulative % passing
10 mm	0	0	0	100
4.75 mm	41	41	8.2	91.8
2.36 mm	22	63	12.6	87.4
1.18 mm	40.5	103.5	20.7	79.9
600μ	22	125.5	25.1	74.9
300µ	181	306.3	61.3	38.7
150µ	185	491.5	98.3	1.7
Pan	8.5	500	100	0

3.7.3 Fineness Modulus of Sand

Fine Modulus of Fine Aggregate=Summation of % retain on sieve size/100

= (8.2+12.6+20.7+25.1+61.3+98.3)/100

=2.26

Grading Limit of Fine Aggregate:

Fine Aggregate lies in the zone 3

Table 3.2.2: Grading Limit of Fine Aggregate

IS sieve designation	Grading zone 1	Grading zone 2	Grading zone 3	Grading zone 4	Our case
10 mm	100	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100	91.8
2.36 mm	60-95	75-100	85-100	95-100	87.4
1.18 mm	30-75	55-90	75-100	90-100	79.3
600 μ	15-34	35-49	0-79	80-100	74.9
300 μ	5-20	8-30	12-40	15-50	38.7
150 μ	0-10	0-10	0-10	0-15	1.7

3.7.4 Silt Content of Fine Aggregate

Before starting the design mix and concreting, silt content must be ensure; To find the silt content in fine aggregate, put some amount of specimen into measuring cylinder up to one third (approximate). After that, pour water into cylinder up to half point and shake well with closed mouth. And live this for settlement, after an hour read the volume of silt in measuring cylinder which forms top layer. (IS 383: 1970) [29]

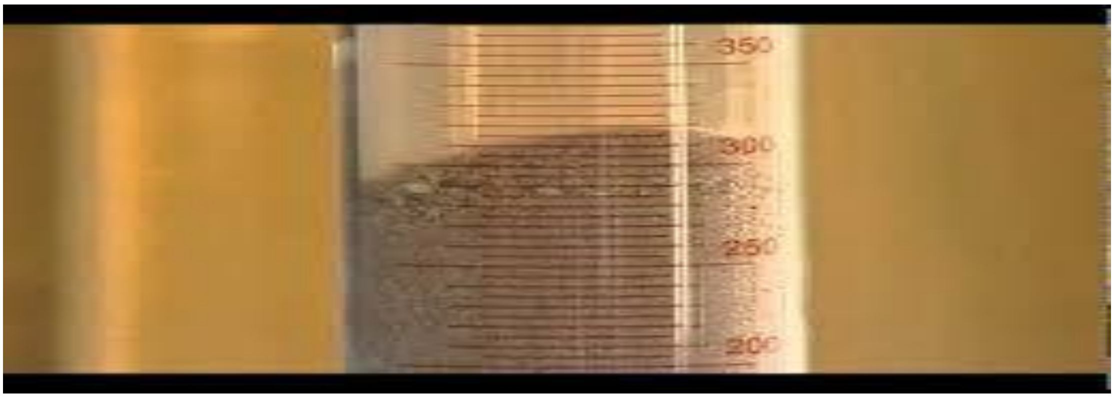


Figure : 3.1 Silt Content of fine aggregate

Silt Content = (Volume of Silt / Total Volume of Specimen) x 100

Total Weight of sand Taken = 300 gm

Volume of Silt = 5 gm

% age of silt = (5/300) x 100

= 1.67%

3.7.5 Specific Gravity of Fine Aggregate

Specific Gravity is defined as the ratio of the weight of a given volume of solid to the weight of an equivalent volume of water at 4°C.

Pycnometer method is most accurate to find specific gravity of fine aggregate.

The specific gravity of solids is determined using the relation:

$$\boldsymbol{G = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}}$$

Weight of Pycnometer = W_1 = 640 gm

Weight of pycnometer + Oven dried soil = W_2 = 1060 gm

Weight of Pycnometer + Oven dried soil + remaining Space completely filled with desired distilled water without any air bubbles =W_3 = 1795 gm

Weight of Pycnometer + full of water =W_4 = 1535 gm

G = (420/160)

= 2.6

Table 3.2.3: Physical Properties of Fine Aggregate

Characteristics	observed value
Grading zone	3
Fineness modulus	2.26
Specific gravity	2.62
Silt content	1.67%

3.8 COARSE AGGREGATE

The locally available crushed stone aggregate, mainly quartzite in mineralogical composition of maximum nominal size of 16mm was used as coarse aggregate. To keep the aggregate free from silt, it was washed before being put to use in concrete as well as testing. The sieve analysis was carried out conforming to IS-383(1970) [29] recommendation and the result are tabulated below.

The Sieve Analysis was Carried out Confirming to IS- 383: 1970 [29] Total Weight of Coarse Aggregate Taken = 5 kg

3.8.1 Sieve Analysis of Coarse Aggregate

Table 3.2.4: Sieve Analysis of Coarse Aggregate

IS sieve size (mm)	Wt. retained (gm)	Cumulative wt. retained (gm)	Cumulative % wt. retained
40 mm	0	0	0
20 mm	460	460	9.2
10 mm	3660	4120	82.4
4.75 mm	880	5000	100

3.8.2 Fineness Modulus of Coarse Aggregate

Fineness modulus of coarse Aggregate = Summation of % retain on Sieve Size /100

= (9.2+82.4+600)/100

= 6.916

3.8.3 Specific Gravity and Water Absorption of Coarse Aggregate

Specific Gravity and Water absorption of Aggregate was determined by Perforated

Basket

Weight of Saturated Aggregate Suspended in water with the basket

$= W_1 = 1030$ gm

Weight of Basket suspended in water $= W_2 = -195$ gm

Weight of Saturated Aggregate in water (W_1-W_2) $= W_s = 1225$ gm

Weight of Saturated surface dry aggregate in air $= W_3 = 1968$ gm

Weight of water equal to the volume of the aggregate $= W_4 = 1960$ gm

Specific Gravity (G) $= \mathbf{W_4 / (W_3-W_s)}$

= 1960/743

= 2.637

Water Absorption = Percent by weight of water absorbed in terms of oven dried weight of aggregate

$= [(W_3-W_4)100]/W_4$

= 800/1960

= 0.408%

Table 3.2.5: Physical Properties of Coarse Aggregate

Characteristics	Observed Value
Fineness modulus	6.916
Specific Gravity	2.637
Water Absorption	0.408%

3.9 Chemical Admixture

Chemical Admixtures (CICO PLAST SUPER-HS @1.2%) are materials in the form of fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. Properties of CICO PLAST SUPER-HS are tabulated below. IS 9103 (1999) [33] was consulted.

Table 3.3: Properties of admixture

Characteristics	CICO PLAST SUPER-HS
Specific Gravity	1.14
Role in Concrete	Improves workability & flow Properties, Produces concrete of very high strength

3.10 TEST ON SELF COMPACTING CONCRETE

3.10.1 Introduction

It is important to appreciate that none of the test methods for SCC has yet been standardized, and the tests described are not yet perfected or definitive. The methods presented here are descriptions rather than fully detailed procedures. They are mainly ad-hoc methods, which have been devised specifically for SCC.

One principal difficulty in devising such tests is that they have to assess three distinct, though related, properties of fresh SCC —its filling ability (flow ability), its passing ability (free from blocking at reinforcement), and its resistance to segregation (stability). No single test so far devised can measure all three properties. All they were performed according to EFNARC [1] guideline.

Various test conducted on SCC are as following :-

- Slump flow test
- J Ring test
- V funnel test
- L box test

3.11 SLUMP FLOW TEST

3.11.1 Introduction

The Slump Flow Test is done to assess the horizontal flow of concrete in the absence of obstructions. It is a most commonly used test and gives good assessment of filling ability. It can be used at site. The test also indicates the resistance to segregation. The higher the flow value, the greater its ability to fill formwork under its own weight. A value of at least 650 mm is required for SCC.

3.11.2 Equipment

- The usual slump cone having base diameter of 200 mm, top diameter 100mm and height 300mm is used.

- A stiff base plate square in shape having at least 700 mm side. Concentric circles are marked around the Centre point where the slump cone is to be placed. A firm circle is drawn at 500 mm diameter.
- A trowel
- Scoop
- Measuring tape
- Stop watch

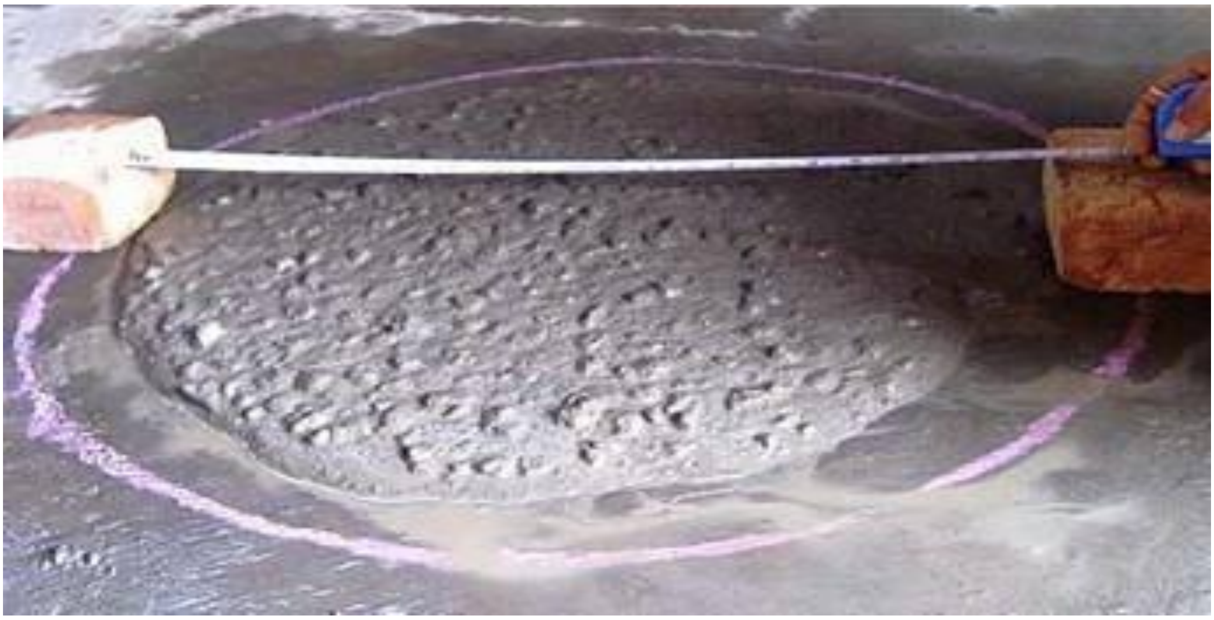


Figure: 3.2. Slump flow test

3.11.3 Procedure

About 6 litre of concrete is needed to perform the test

- Place the base plate on level ground.
- Keep the slump cone centrally on the base plate.
- Fill the cone with the scoop, do not tamp, simply strike off the concrete level with the trowel.
- Remove the surplus concrete lying on base plate
- Raise the cone vertically and allow the concrete to flow freely.
- Measure the final diameter of the concrete in two perpendicular directions and calculate the average of the two diameters.
- This is the slump flow in mm.
- Note that there is no water or cement paste or mortar without coarse aggregate is seen at the edge of the spread concrete.

3.12 J RING TEST

3.12.1 Introduction

J ring test denotes the passing ability of the concrete. The equipment consists of rectangular section of 30 mm x 25 mm open steel ring drilled vertically with holes to accept threaded sections of reinforcing bars 10 mm diameter 100 mm in length. The bars and sections can be placed at different distance apart to simulate the congestion of reinforcement at the site. Generally these sections are placed 3 x maximum size of aggregate. The diameter of the ring formed by vertical sections is 300 mm and height 100 mm.

3.12.2 Equipment

- Slump cone without foot pieces.
- Base plate at least 700 mm square.
- Trowel
- Scoop
- Tape

- J ring rectangular section 30mm x 25mm planted vertically to form a ring 300 mm dia generally at a spacing of 48 ± 2mm

Figure: 3.3. J-Ring test

3.12.3 Procedure

About 6 litre of concrete is needed to perform the test, sampled normally

- Moisten the base plate and inside of slump cone.
- Place base plate on level stable ground.
- Place the J Ring centrally on the base plate and the slump cone centrally inside it and hold down firmly.
- Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel.
- Remove any surplus concrete from around the base of the cone.
- Raise the cone vertically and allow the concrete to flow out freely.
- Measure the final diameter of the concrete in two perpendicular directions.
- Calculate the average of the two measured diameters (in mm).
- Measure the difference in height between the concrete just inside the bars and that just outside the bars.
- Calculate the average of the difference in height at four locations (in mm).

- Note any border of mortar or cement paste without coarse aggregate at the edge of the pool of concrete

3.13 V FUNNEL TEST

3.13.1 Introduction

The test was developed in Japan and used by Ozawa. The equipment consists of a Y-shaped funnel. An alternative type of V- funnel, the O funnel, with a circular section is also used in Japan.

The V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum size of aggregate 20 mm size. The funnel is filled with about 12 litre of concrete. Find the time taken for it to flow down.

After this the funnel can be filled with concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increase significantly.

3.13.2 Equipment

- V-funnel
- Bucket 12 litres
- Trowel
- Scoop
- Stopwatch

Figure: 3.4. V funnel test

3.13.3 Procedure

About 12 litre of concrete is needed to perform the test, sampled normally.

Set the V-funnel on firm ground.

- Moisten the inside surfaces of the funnel.
- Keep the trap door open to allow any surplus water to drain.
- Close the trap door and placed a bucket underneath.
- Fill the apparatus completely with concrete without compacting or tamping; simply strike off the concrete level with the top with the trowel.
- Open within 10 sec after filling the trap door and allow the concrete to flow' out under gravity.
- Start the stopwatch when the trap door is opened, and record the time for the discharge to complete (the flow time). This is taken to be when light is seen from above through the funnel.
- The whole test has to be performed within 5 minutes.
- The procedure for the flow time at T5 minutes.
- Do not clean or moisten the inside surfaces of the funnel again.
- Close the trap door and refill the V-funnel immediately after measuring the flow time.

- Place the bucket underneath.
- Fill the apparatus completely with concrete without compacting or tapping, simply strike off the concrete.
- Level the top with the trowel.
- Open the trap door 5 minutes after the second fill of the funnel and allow the concrete to flow out under gravity.
- Simultaneously start the stopwatch when the trap door is opened and record the time for the discharge to complete (the flow time at T5 minutes). This is taken to be when light is seen from above through the funnel.

3.14 L-BOX TEST

3.14.1 Introduction

This test is developed in Japan. The test assesses the flow of concrete, and also the extent to which the concrete is subjected to blocking by reinforcement.

3.14.2 Equipment

- L-box
- Trowel
- Scoop
- Stopwatch

Figure: 3.5. L-box test

3.14.3 Procedure

About 14 litre of concrete is required for this test.

- Ensure that sliding gate can open freely and then close it.
- Moisten the inside surface and remove all surplus water
- Fill the vertical section of the apparatus with concrete
- Leave it standing for 1 minute.
- Lift the sliding gate and allow the concrete to flow out into the horizontal section.
- Simultaneously start the stopwatch and record the time taken for the concrete to reach 200 and 400 mm marks.
- When the concrete stops flowing, the heights H_1 and H_2 are measured.
- Calculate H_2/H_1, the blocking ratio.
- The whole test has to be performed within 5 minute

Table 3.4: Acceptance criteria for SCC by EFNARC [1]

S. No.	Method	Unit	Range of values
1	Slump flow	Mm	650 to 800
2	J ring	Mm	0 to 10
3	V funnel	Sec	8 to 12
4	L box	(h_2/h_1)	0.8 to 1.0

3.15 Compaction Factor Test

3.15.1 Introduction

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete.

The compaction factor test is used for concrete which have low workability for which slump test is not suitable.

3.15.2 Equipment

- Compaction factor apparatus consists of trowels

- hand scoop (15.2 cm long)
- A rod of steel or other suitable material (1.6 cm diameter 61 cm long rounded at one end)
- A balance.

Figure: 3.6 Compaction Factor Test

3.15.3 Procedure

- Place the concrete sample gently in the upper hopper to its brim using the hand scoop and level it.
- Cover the cylinder.
- Open the trapdoor at the bottom of the upper hopper so that concrete fall into the lower hopper. Push the concrete sticking on its sides gently with the road.
- Open the trapdoor of the lower hopper and allow the concrete to fall into the cylinder below.
- Cut of the excess of concrete above the top level of cylinder using trowels and level it.
- Clean the outside of the cylinder.
- Weight the cylinder with concrete to the nearest 10 g. This weight is known as the weight of partially compacted concrete ($\mathbf{W_1}$).
- Empty the cylinder and then refill it with the same concrete mix in layers approximately 5 cm deep, each layer being heavily rammed to obtain full compaction.

- Level the top surface.
- Weigh the cylinder with fully compacted. This weight is known as the weight of fully compacted concrete (**W_2**).
- Find the weight of empty cylinder (**W**).

3.16 MIX DESIGN

3.16.1 Introduction

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining with the object of producing concrete of certain minimum strength and durability as economically as possible.

Mix design for M25 grade Self-Compacting Concrete has been done with trial method by making the use of specification and guideline given by EFNARC and IS 10262-2009 [2].

3.16.2 Test Data of Materials

- Specific gravity of cement = 3.15
- Specific gravity of fine aggregate = 2.62
- Specific gravity of coarse aggregate = 2.637
- Fineness modulus of coarse aggregate = 6.916
- Fineness modulus of fine aggregate = 2.26

3.16.3 Steps taken in mix proportioning

1. Target mean strength for M25 grade concrete

   $f_{ck}^* = f_{ck} + K_s$

   $f_{ck}^* = 25 + 1.65x4$

   $= 31.6\ N/mm^2$

   Where,

K = probability factor for various tolerances (5%) = 1.65 from table 10.4

s = standard deviation for different degrees of control = 4 from table 10.6

2. The water cement ratio required for the target mean strength of 31.6Mpa is 0.45.

3.16.3.1 Trial 1 for SCC

1. Adopting water cement ratio as 0.45
2. For 10 mm size aggregate select maximum water content = 208 kg

Reduce water content up to 5%

3. Cement content = (208x0.95)/(0.45)

= 440 kg

(a) Volume of concrete = 1 m3

(b) Volume of cement = (440/3.15)x(l/l 000)

= 0.1397 m3

(c) Volume of water = (197.6/1)x(l/1000)

=0.1976 m3

(d) Volume of admixture =1.1 % of mass of cement

= 1.1% x 440

= 4.84 kg

= (4.84/1.14)x(l/l 000)

= 0.00424

(e) Volume of all aggregate = (a)-(b+c+d)

= 1- 0.1397 - 0.1976 - 0.00424

= 0.65846

4. Mass of coarse aggregate = 0.65846x0.48x2.637x1000

= 833.45 kg/m^3

5. Mass of fine aggregate = 0.65846x0.52x2.62x 1 000

897.08 kg/m^3

Now converting mix design into SCC mix design.

Total aggregate = 833.45 + 897.08

= 1730.53 kg/m^3

Fine aggregate = 58% of T.A

= 1003.71 kg/m^3

Coarse aggregate = 42% of T.A

= 726.82 kg/m^3

Ratio 1: 2.281: 1.652

3.16.3.2 Trial 2 for SCC

1. Adopting water cement ratio as 0.45
2. For 10 mm size aggregate select maximum water content — 208 kg

   Reduce water content up to 5%
3. Cement content = (208x0.95)/(0.45)

   = 440 kg

(a) Volume of concrete = 1 m^3

(b) Volume of cement = (440/3.15)x(l/1000)

= 0.1397 m^3

(c) Volume of water = (197.6/1)x(l/1000)

= 0.1976 m3

(d) Volume of admixture = 1.2 % of mass of cement

= 1.2% x 440

=5.28 kg

= (5.28/1.14) x (I/1000)

= 0.00463

(e) Volume of all aggregate = (a)-(b+c+d)

= 1- 0.1397 - 0.1976 - 0.00463

= 0.65807

4. Mass of coarse aggregate = 0.65807x0.48x2.637* 1000

   = 832.95 kg/m^3

5. Mass of fine aggregate = 0.65807x0.52x2.62x1000

   = 896.55 kg/m^3

Now converting mix design into SCC mix design.

Total aggregate = 832.95 + 896.55

= 1729.5 kg/m^3

Fine aggregate = 58% of T.A

= 1003.11 kg/m3 Coarse aggregate

= 42% of T.A

=726.39 kg/m^3

Ratio 1: 2.279: 1.650

3.16.3.3 Trial 3 for SCC

1. Adopting water cement ratio as 0.45

2. For 10 mm size aggregate select maximum water content = 208 kg

Reduce water content up to 5%

3. Cement content = (208x0.95)/(0.45)

= 440 kg

(a) Volume of concrete = 1 m^3

(b) Volume of cement = (440/3.15)x(1/1000)

= 0.1397 m^3

(c) Volume of water = (197.6/1)x(1/1000)

= 0.1976 m3

(d) Volume of admixture = 1.3 % of mass of cement

= 1.3% x 4405.72 kg

= (5.72/1.14) x (l/1000)

= 0.00501

(e) Volume of all aggregate = (a)-(b+c+d)

= 1-0.1397-0.1976-0.00501

= 0.65769

4. Mass of coarse aggregate = 0.65769x0.48x2.637x1000

   = 832.47 kg/m3

5. Mass of fine aggregate = 0.65769x0.52x2.62x 1000

   = 896.03 kg/m3

Now converting mix design into SCC mix design.

Total aggregate = 832.47 + 896.03

= 1728.5 kg/m^3

Fine aggregate = 58% of T.A

= 1002.53 kg/m^3

Coarse aggregate = 42% of T.A

= 726 kg/m^3

Ratio 1: 2.278: 1.650

3.16.3.4 Trial 4 for SCC

1. Adopting water cement ratio as 0.45
2. For 10 mm size aggregate select maximum water content = 208 kg

   Reduce water content up to 5%
3. Cement content = (208x0.95)/(0.45)

   = 440 kg

(a) Volume of concrete = 1 m^3

(b) Volume of cement = (440/3.15)x(1/1000)

= 0.1397 m^3

(c) Volume of water = (197.6/1)x(1/1 000)

=0.1976 m^3

(d) Volume of admixture = 1.4 % of mass of cement

=14% x 440

=6.16 kg

= (6.16/1.14)x(l/1000)

= 0.00540

(e) Volume of all aggregate = (a)-(b+c+d)

= 1-0.1397 - 0.1976 - 0.00540

= 0.6573

4. Mass of coarse aggregate = 0.6573x0.48x2.637x1000

= 832 kg/m^3

5. Mass of fine aggregate = 0.6573x0.52x2.62x 1000

= 895.50 kg/m^3

Now converting mix design into SCC mix design.

Total aggregate = 832 + 895.50

= 1727.5 kg/m^3

Fine aggregate = 58% of T.A

= 1002 kg/m^3

Coarse aggregate = 42% of T.A

= 725.55 kg/m^3

Ratio 1: 2.277: 1.6489

3.16.3.5 Trial 5 for SCC

1. Adopting water cement ratio as 0.45
2. For 10 mm size aggregate select maximum water content - = 208 kg
   Reduce water content up to 5%
3. Cement content = (208x0.95)/(0.45)
   = 440 kg

(a) Volume of concrete = 1 m^3

(b) Volume of cement = (440/3.15)x(l/1000)

= 0.1397 m^3

(c) Volume of water = (197.6/l)x(l/l000)

= 0.1976 m^3

(d) Volume of admixture =1.5% of mass of cement

= 1.5% x 440

= 6.60 kg

= (6.60/ 1.14)x(1/1000)

= 0.00578

(e) Volume of all aggregate = (a)-(b+c+d)

= 1 - 0.1397 - 0.1976 - 0.00578 = 0.65692

4. Mass of coarse aggregate = 0.65692x0.48x2.637x1000

= 831.50 kg/m^3

5. Mass of fine aggregate = 0.65692x0.52x2.62x1000

= 895 kg/m^3

Now converting mix design into SCC mix design.

Total aggregate = 831.50 + 895

= 1726.50 kg/m^3

Fine aggregate = 58% of T.A

= 1001.37 kg/m^3

Coarse aggregate = 42% of T.A

= 725.13 kg/m^3

Ratio 1: 2.275: 1.648

Table 3.5: Mix Design Trial of Self-Compacting Concrete for 1 m^3 of Concrete:

Trial	Cement (kg)	W/C (kg)	F.A. (Kg)	C.A. (Kg)	C.A. /F.A. ratio	Admixture (%)	Admixture (kg)	Slump Value (mm)	V funnel (sec)	L box (H2/HI)	J ring (mm)
CC	440	0.45	1003.71	726.82	0.7241	1.1	4.84	600	20	0.5	18
CC	440	0.45	1003.11	726.39	0.7241	1.2	5.28	610	16	0.6	17
CC	440	0.45	1002.53	726.00	0.7241	1.3	5.72	630	15	0.5	15
CC	440	0.45	1002.00	725.55	0.7241	1.4	6.16	650	13	0.7	11
CC	440	0.45	1001.37	725.13	0.7241	1.5	6.60	700	10	0.9	8

Table 3.6: Mix Design Trial of latex modified self-compacting Concrete for l m^3 of Concrete:

Trial	SBR Latex %	Cement (kg)	W/C ratio	F.A. (kg)	C.A. (kg)	Admixture (%)	Slump Value (mm)	V funnel (sec)	L box (H2/HI)	J ring (mm)	Remark
LMSCC 1	5	440	0.45	1001.37	725.13	1.5	Not measurable	7	0.8	16	Bleeding
LMSCC 2	5	440	0.45	1002.00	725.55	1.4	Not measurable	7	0.6	18	Segregation
LMSCC 3	5	440	0.45	1002.53	726.00	1.3	850	8	0.5	11	Flow is more
LMSCC 4	5	440	0.45	1003.11	726.39	1.2	700	10	0.9	9	Flow is good

3.17 PREPARATION OF SPECIMEN

The quantities of the constituents of the concrete were obtained from the trial mix which gave the required result for SCC test according to EFNARC [1], The variation in strength of hardened SCC by addition of SBR latex and using glass powder as a partial replacement of cement in SCC mix is studied by casting cubes, cylinders and beams. The cement, glass powder, fine aggregate and coarse aggregate were mixed in dry state and calculated amount of SBR latex is mixed with required water, to achieve required workability super plasticizer was added and the whole concrete was mixed in wet state. The moulds are screwed tightly to avoid leakage, oil was applied on inner surface of mould. The concrete after mixing was poured into the moulds without tamping. The cast specimens were removed from moulds after 48 hours (because of admixture). After curing the specimen for a period of 28 days, the specimen were removed from the water tank and allowed to dry under shade.

3.18 PREPARATION FOR COMPRESSIVE STRENGTH

To study the Compressive strength of conventional self-compacting concrete, Latex (5% by weight of cement) modified self-compacting concrete and using glass powder as a partial replacement of cement in various fraction (2.5%, 5%, 7.5% and 10%) in LMSCC mix. There are three cubes of size 150mm* 150mm* 150mm were made for each set. The testing was done according to IS 516-1959 [30]

Figure: 3.7. Testing of Cube under Compression Testing Machine

3.19 SPECIMEN FOR SPLIT TENSILE STRENGTH

The split tensile strength of conventional self-compacting concrete and latex modified self-compacting concrete by partial replacement of cement with glass powder in different fraction (2.5%, 5%, 7.5% and 10%) is determined at 28 days on cylinders measuring 150 mm diameter and 300 mm height. These specimens will be cured in water until the date of test according to IS: 5816-1999 [31]. Three specimens of each mixture are to be tested and the mean value is to be reported.

Figure: 3.8. Testing of Cylindrical Specimen under Split Tensile Strength Test

3.20 SPECIMEN FOR FLEXURAL STRENGTH

To study the flexural strength of conventional self-compacting concrete, Latex (5% by weight of cement) modified self-compacting concrete and using glass powder as a partial replacement of cement in various fraction (2.5%, 5%, 7.5% and 10%) in LMSCC mix. There are three beam of size 500mm* 100mm* 100mm are made for each set. The testing was done according to IS 9399:1979 [32].

Figure: 3.9. Testing of specimen under flexure

Table 3.7: Details of specimens

Type and size of specimen (mm)	Type of test	No. of specimens tested	Total no. of specimens
Cube (150 x 150 x 150)	Residual compressive strength	3	18
Cylinder (150 x 300)	Residual split tensile strength	3	18
Beam (100 x 100 x 500)	Residual flexural strength	3	18

3.21 MIXING, CASTING AND CURING

After the preliminary test on the constituents of SCC confirmed the suitability of ingredients and the design mix was found to be satisfactory, the work of casting cubes, cylinders and beams was taken up. Firstly, the coarse aggregate was washed a day before casting in order to make it silt free and was laid to dry. Secondly the coarse aggregate was mixed with the fine aggregate, cement, glass powder and water in the required amount in a mixer. To make a mix of SCC (workable) super plasticizer and SBR latex in required amount were mixed in water and then added to the rotary mixer and the mixing process was carried for 2-3 minutes. The concrete was filled in all the moulds without compaction.

The cubes, cylinders and beams were demolded after 48 hours later and after making were put under water for a period of 28 days for curing. After 28 days, the concrete specimen were taken out and dried sufficiently and tested

3.22 LATEX MODIFIED SELF-COMPACTING CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH GLASS POWER.

Cement was partially replaced by glass powder in different proportions (0%, 2.5%, 5%, 7.5% and 10%). Details of replacements are tabulated in the table below.

Table 3.8: LMSCC by partial replacement of cement with glass powder

S. N.	% replacement of glass powder	SBR latex %	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Glass powder (kg)	Water (w/c = 0.45) (kg)	Admixture (gm)
1	0	0	440	1003.11	726.39	0	198	5.28
2	0	5	440	1003.11	726.39	0	198	5.28
3	. 2.5	5	429	1003.1 1	726.39	11	198	5.28
4	5	5	418	1003.1 1	726.39	22	198	5.28
5	7.5	5	407	1003.11	726.39	33	198	5.28
6	10	5	396	1003.11	726.39	44	198	5.28

Show in Figure a, b and c Mixing of Material Self Compacting Concrete on the site

(a)

(b)

(c)

CHAPTER 4
RESULTS AND DISCUSSION

4.1 GENERAL

The study is conducted to analyze the compressive, split tensile and flexural strength of M25 grade latex modified self-compacting concrete with partial replacement of cement by glass powder in various percentages (2.5%, 5%, 7.5% and 10%). There were total 18 specimens of cubes (150 mm x 150 mm xl50 mm), 18 Cylinder Specimens (150 mm x 300 mm), and 18 Beam specimens (100 mm x 100 mm x 500 mm). All the specimen was tested for compressive strength, split tensile strength and flexural strength after curing for 28 days. The results of all the tested specimen is given below.

4.2 CALCULATION TABLE FOR COMPRESSIVE STRENGTH OF CUBE

Table 4.2.1 for Nominal Mix

S. No.	Load at failure (N)	Mean load (N)
1	708.20 x 1000	712.10 x 1000
2	716.65 x 1000	
3	711.47 x 1000	

Table 4.2.2 for Latex modified self-compacting with 0% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	740.78 x 1000	741.98 x 1000
2	738.87 x 1000	
3	746.27 x 1000	

Table 4.2.3 for Latex modified self-compacting concrete with 2.5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	787.03 x 1000	785.47 x 1000
2	781.25 x 1000	
3	788.14 x 1000	

Table 4.2.4 for Latex modified self-compacting concrete with 5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	792.57 x 1000	787.72 x 1000
2	789.42 x 1000	
3	781.15 x 1000	

Table 4.2.5 for Latex modified self-compacting concrete with 7.5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	791.72 x 1000	797.62 x 1000
2	801.57 x 1000	
3	799.56 x 1000	

Table 4.2.6 for Latex modified self-compacting concrete with 10% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	763.28 x 1000	758.25 x 1000
2	753.17 x 1000	
3	758.26 x 1000	

4.2.1 Calculation of Compressive strength of concrete at 28 days

Compressive strength of cube = $\frac{load\ at\ failure}{surface\ area\ of\ cube}$

For nominal mix:

Compressive strength of cube = $\frac{\mathbf{712.10\ x\ 1000}}{\mathbf{22500}} = \mathbf{31.64 N/mm^2}$

For LMSCC with 0% Glass powder:

Compressive strength of cube = $\frac{\mathbf{741.98\ x\ 1000}}{\mathbf{22500}} = \mathbf{32.98\ N/mm^2}$

For LMSCC with 2.5% Glass powder:

Compressive strength of cube = $\frac{\mathbf{785.47\ x\ 1000}}{\mathbf{22500}} = \mathbf{34.91\ N/mm^2}$

For LMSCC with 5% Glass powder:

Compressive strength of cube = $\frac{\mathbf{787.72\ x\ 1000}}{\mathbf{22500}} = \mathbf{35.01\ N/mm^2}$

For LMSCC with 7.5% Glass powder:

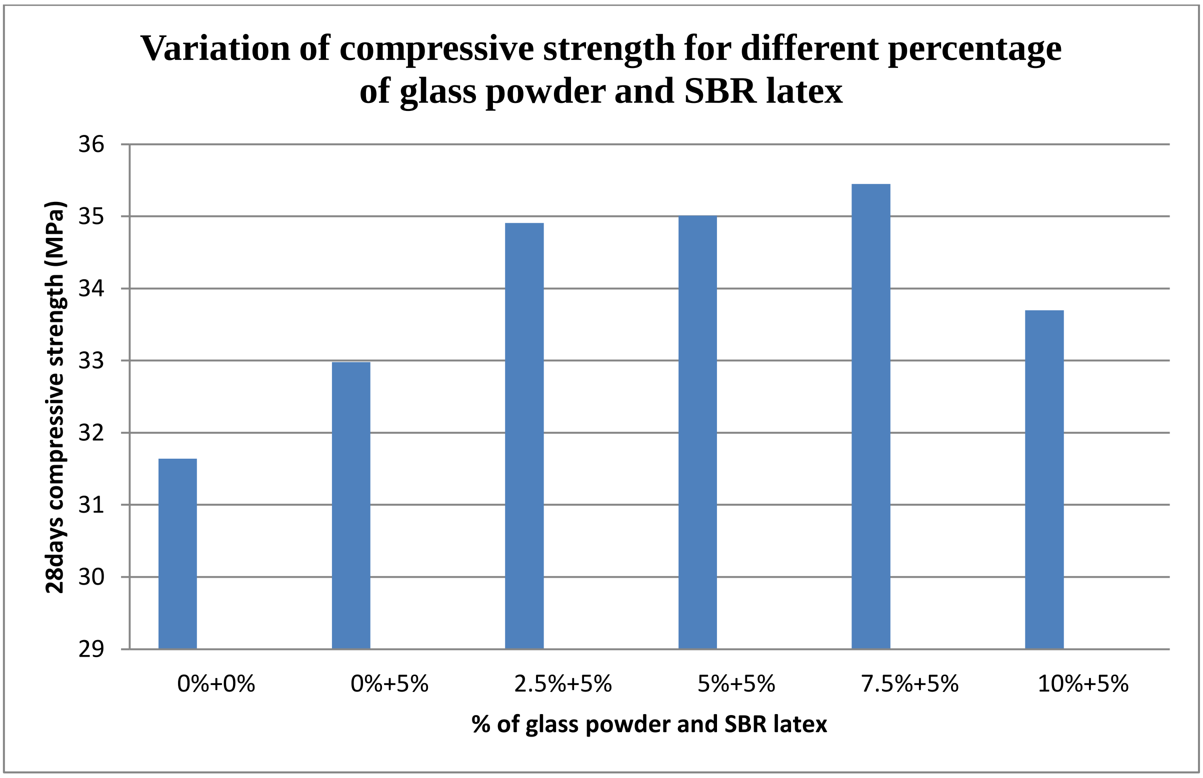
Compressive strength of cube = $\frac{\mathbf{797.62\ x\ 1000}}{\mathbf{22500}} = \mathbf{35.45\ N/mm^2}$

For LMSCC with 10% Glass powder:

Compressive strength of cube = $\frac{\mathbf{758.25\ x\ 1000}}{\mathbf{22500}} = \mathbf{33.70\ N/mm^2}$

Table 4.2.7 Compressive Strength of concrete at 28 days

% Replacement	Compressive Strength in N/mm^2	% Increase in Strength
Nominal mix	31.64	0
0	32.98	4.2
2.5	34.91	10.33
5	35.01	10.65
7.5	35.45	12.04
10	33.70	6.51



Graph: 4.1 Compressive Strength For different %age of glass powder and SBR latex

4.3 CALCULATION TABLE FOR SPLIT TENSILE STRENGTH OF CYLINDER

Table 4.3.1 for Nominal Mix

S. No.	Load at failure (N)	Mean load (N)
1	253.47 x 1000	225.75 x 1000
2	251.56 x 1000	
3	262.44 x 1000	

Table 4.3.2 for Latex modified self-compacting concrete with 0% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	262.38 x 1000	260.80 x 1000
2	261.57 x 1000	
3	258.46 x 1000	

Table 4.3.3 for Latex modified self-compacting concrete with 2.5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	264.37 x 1000	261.63 x 1000
2	262.54 x 1000	
3	258 x 1000	

Table 4.3.4 for Latex modified self-compacting concrete with 5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	269 x 1000	264.57 x 1000
2	264.36 x 1000	
3	260.18 x 1000	

Table 4.3.5 for Latex modified self-compacting concrete with 7.5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	269.67 x 1000	272.07 x 1000
2	275.36 x 1000	
3	271.18 x 1000	

Table 4.3.6 for Latex modified self-compacting concrete with 10% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	266.87 x 1000	260.80 x 1000
2	259.68 x 1000	
3	255.86 x 1000	

4.3.1 Calculation of Split Tensile Strength of concrete at 28 days

Split tensile strength of Cylinder $= \frac{2p}{3.14Id} \boldsymbol{MPa}$

Where

P = load at failure

L = length of cylinder in mm

D = diameter of Cylinder in mm

For nominal mix

Split tensile strength of Cylinder$= \frac{2 \, x \, 255.75 \, x \, 1000}{3.14 \, x \, 300 \, x \, 150} = \mathbf{3.62}$MPa

For LMSCC with 0% Glass powder

Split tensile strength of Cylinder$= \frac{2 \, x \, 260.80 \, x \, 1000}{3.14 \, x \, 300 \, x \, 150} = \mathbf{3.69}$ MPa

For LMSCC with 2.5% Glass powder

Split tensile strength of Cylinder$= \frac{2\ x\ 261.63\ x\ 1000}{3.14\ x\ 300\ x\ 150} = \mathbf{3.70}$ MPa

For LMSCC with 5% Glass powder

Split tensile strength of Cylinder$= \frac{2\ x\ 264.51\ x\ 1000}{3.14\ x\ 300\ x\ 150} = \mathbf{3.74}$ MPa

For LMSCC with 7.5% Glass powder

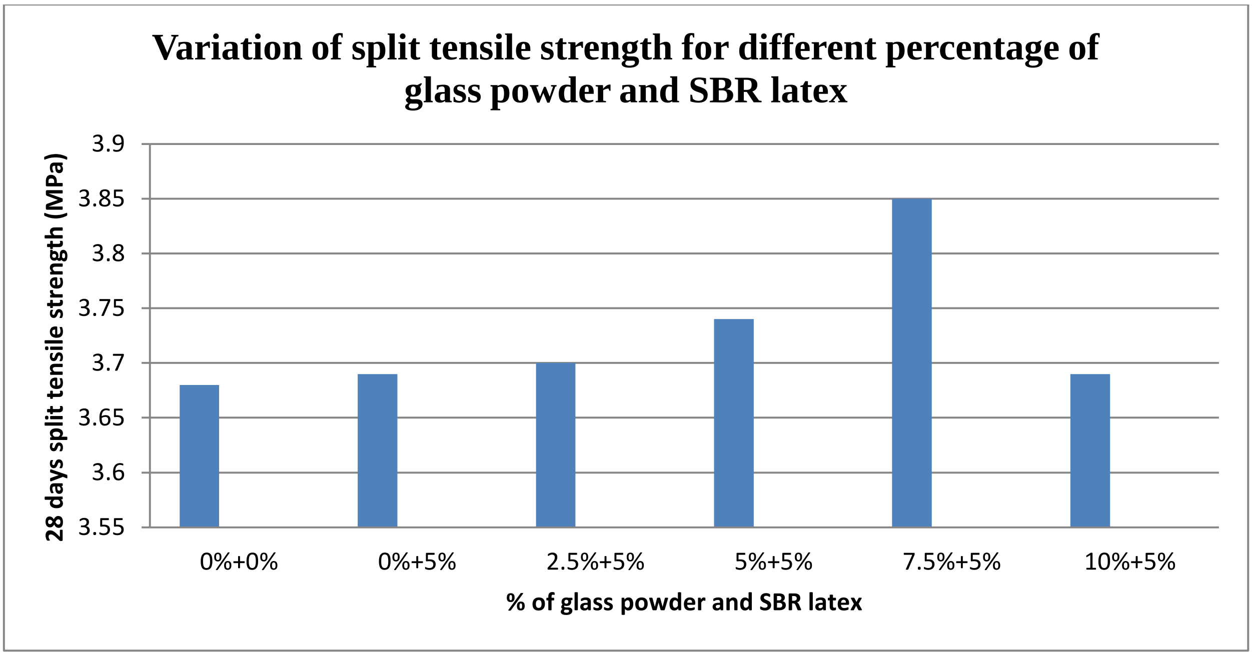
Split tensile strength of Cylinder$= \frac{2\ x\ 264.51\ x\ 1000}{3.14\ x\ 300\ x\ 150} = \mathbf{3.84}$ MPa

For LMSCC with 10% Glass powder

Split tensile strength of Cylinder$= \frac{2\ x\ 260.80\ x\ 1000}{3.14\ x\ 300\ x\ 150} = \mathbf{3.69}$MPa

Table 4.3.7 Split Tensile Strength of concrete at 28 days

% Replacement	Split Tensile Strength in N/mm^2	% Increase in Strength
Nominal mix	3.62	0
0	3.69	1.93
2.5	3.70	2.20
5	3.74	3.31
7.5	3.84	6.35
10	3.69	1.93



Graph: 4.2 Split tensile strength for different percentage of glass powder and SBR latex

4.4 CALCULATION TABLE FOR FLEXURAL STRENGTH OF BEAM

Table 4.4.1 for nominal mix

S.No.	Load at failure (N)	Mean load (N)
1	6.84 x 1000	6.67 x 1000
2	6.37 x 1000	
3	6.80 x 1000	

Table 4.4.2 for Latex modified self-compacting concrete with 0% Glass powder

S.No.	Load at failure (N)	Mean load (N)
1	6.88 x 1000	6.786 x 1000
2	6.63 x 1000	
3	6.85 x 1000	

Table 4.4.3 for Latex modified self-compacting concrete with 2.5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	6.94 x 1000	6.90 x 1000
2	6.87 x 1000	
3	6.90 x 1000	

Table 4.4.4 for Latex modified self-compacting concrete with 5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	7.17 x 1000	7.03 x 1000
2	6.96 x 1000	
3	6.98 x 1000	

Table 4.4.5 for Latex modified self-compacting concrete with 7.5% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	7.37 x 1000	7.36 x 1000
2	7.46 x 1000	
3	7.26 x 1000	

Table 4.4.6 for Latex modified self-compacting concrete with 10% Glass powder

S. No.	Load at failure (N)	Mean load (N)
1	6.91 x 1000	6.85 x 1000
2	6.88 x 1000	
3	6.76 x 1000	

4.4.1 Calculation of flexural Strength of concrete at 28 days

Flexural Strength of beam $= \frac{3pl}{2bdd}$

Where

P = load at failure

L = length of beam in mm

B = width of beam in mm

D = depth of beam in mm

For nominal mix

Flexural Strength of beam $= \frac{\mathbf{3\ x\ 6.67\ x\ 1000\ x\ 500}}{\mathbf{2\ x\ 100\ \ x\ 100\ x\ 100}} = \mathbf{5.00}$ MPa

For LMSCC with 0% Glass powder

Flexural Strength of beam $= \frac{\mathbf{3\ x\ 6.786\ x\ 1000\ x\ 500}}{\mathbf{2\ x\ 100\ \ x\ 100\ x\ 100}} = \mathbf{5.09}$ MPa

For LMSCC with 2.5% Glass powder

Flexural Strength of beam $= \frac{\mathbf{3\ x\ 6.90\ x\ 1000\ x\ 500}}{\mathbf{2\ x\ 100\ \ x\ 100\ x\ 100}} = \mathbf{5.17}$ MPa

For LMSCC with 5% Glass powder

Flexural Strength of beam $= \frac{\mathbf{3\ x\ 7.03\ x\ 1000\ x\ 500}}{\mathbf{2\ x\ 100\ \ x\ 100\ x\ 100}} = \mathbf{5.27}$ MPa

For LMSCC with 7.5% Glass powder

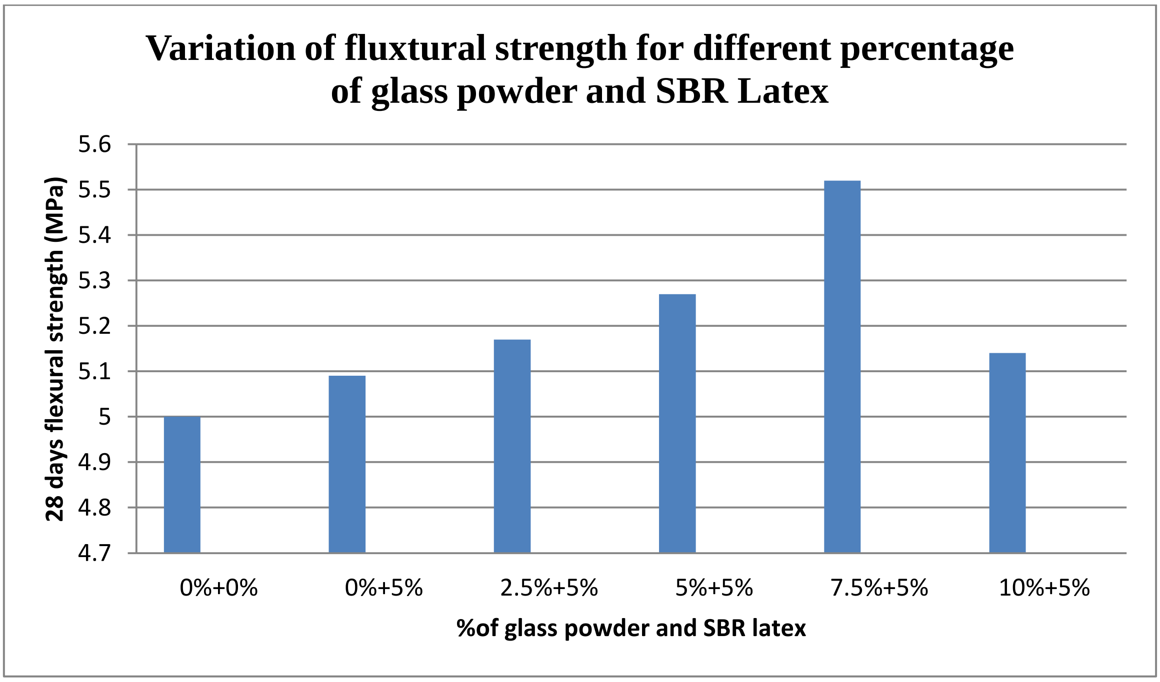
Flexural Strength of beam $= \frac{\mathbf{3\ x\ 7.36\ x\ 1000\ x\ 500}}{\mathbf{2\ x\ 100\ \ x\ 100\ x\ 100}} = \mathbf{5.61}$MPa

For LMSCC with 10% Glass powder

Flexural Strength of beam $= \frac{\mathbf{3\ x\ 6.85\ x\ 1000\ x\ 500}}{\mathbf{2\ x\ 100\ \ x\ 100\ x\ 100}} = \mathbf{5.14MPa}$

Table 4.4.7 Flexural Strength of concrete at 28 days

% Replacement	Flexural Strength in N/mm^2	% Increase in Strength
Nominal mix	5.00	0
0	5.09	1.8
2.5	5.17	3.4
5	5.27	5.4
7.5	5.61	10.4
10	5.14	2.8



Graph : 4:3 Flexural strength for different percentage of glass powder and SBR latex

4.5 DISCUSSION ON GRAPHS

The graphs obtained from above study shows that the variation in compressive strength, split tensile strength and flexural strength for various replacement of cement by glass powder.

It is observed that 10 % glass powder can be used as partial replacement of cement along with 5 % of SBR latex is added to increase the workability of concrete.

CHAPTER 5
CONCLUSION

1. The following important result can be summarized by the investigation carried out on the SCC made by using SBR latex and glass powder: The SCC made with 5% of SBR latex replaced by weight of cement gave satisfactory result after the 28 days of testing. Compressive strength for M25 grade of SCC was found to be 32.98MPa, split tensile strength as 3.69MPa and flexural strength as 5.09 MPa.

2. On the above mix glass powder was added in various percentages (2.5%, 5%, 7.5% & 10%) to enhance the properties of SCC and it was found that when 5% SBR latex is added along with 7.5% Glass powder dosage, maximum strengths are obtained. The compressive strength is increased by 12%, split tensile strength by 6.35%, & flexural strength by 10.4% when compared to their nominal strength.

3. The maximum strength was achieved for 7.5% replacement of cement with glass powder in latex modified self-compacting concrete. Further addition of glass powder reduces the strength.

4. One of the main disadvantage of SCC is its high cost, and in this work cement has been replaced by glass powder which has reduce the cost of production of SCC in comparison to conventional SCC.

5. SBR latex has been extensively used in this work because we know that crack plays an important role as they change concrete structures into permeable elements and consequently with a high risk of corrosion. Cracks not only reduce the quality of concrete and make it aesthetically unacceptable but also make structures out of service. If these cracks do not exceed a certain width, they are neither harmful to a structure nor to its serviceability. Therefore, it is important to reduce the crack width and this can be achieved by adding SBR latex to concrete.

Scope for future work

There is a lot of scope for future work in self-compacting concrete as it is not been explore much in India. Some suggested future works are:

1. Self-compacting concrete can be made with combination of different materials such as SBR latex and glass powder.

REFERENCES

[1] EFNARC (European Federation of national trade associations representing producers and applicators of specialist building products). **Specification and Guidelines for self-compacting concrete**.

[2] IS 10262-2009, **"Guidelines for concrete mix design proportioning".** Bureau of Indian Standards, New Delhi.

[3] Mayur B. Vanjare, Shriram H. Mahure. "**Experimental Investigation On Self Compacting Concrete Using Glass Powder",** International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 3, May-Jun 2012, pp. 1488-1492.

[4] Vijayakumar, G., Vishaliny, H. and Govindarajulu, D. "**Studies on Glass Powder as Partial Replacement of Cement in Concrete Production**.", International Journal of Emerging Technology and Advanced Engineering, 3(2), 153-157 (2013).

[5] A Rajathi and G Portchejian. "**Experimental Study on Self Compacting Concrete Using Glass Powder.",** International Journal of structural and civil Engineering Research ISSN: 23 19 — 6009 www.iiscer.com Vol. 3, No. 3, August 2014.

[6] Shilparaju and Dr. P.R.kumar "**Effect of Using Glass Powder in Concrete"**, International journal of innovative research in science, Engineering and Technology. [IC - I ASET 2014].

[7] Ismail Ansari and Sheetal Sahare.**''Utilization of Glass Powder as a Partial Replacement of Cement and its Effect on Concrete Strength.** ", Proceedings of 45th IRF International Conference, 13th December 2015.

[8] Gunalaan Vasudevan, Seri Ganis Kanapathypillay, "**Performance of Using Waste Glass Powder in Concrete as Replacement of Cement**." American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-02, Issue-12, pp-1 75-181, 2013.

[9] Ravi ShankerYadav and Juned Ahmad. **"To Study the Properties of Self-Compacting Concrete Using Recycled Aggregate and Glass Fiber",** International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME) Vol. 2, Issue 1, pp: (187-191), 2015.

[10] Aniket S. Aphale and Sheetal. A. Sahare. **"Effect of Particle Size of Recycled Glass on Concrete Properties."** Proceedings of 60th IRF International Conference, 24th July, 2016.

[11] Rakesh Salcale, Sourabh Jain, Seema Singh. **"Experimented Investigation on Strength of Glass Powder Replacement by Cement in Concrete with Different Dosages**.", International Journal of Advanced Research in Computer Science and Software Engineering Volume 5, Issue 12, December 2015 .

[12] Hongjian Du and Kiang Hwee Tan. **"Waste Glass Powder as Cement Replacement in Concrete",** Journal of Advanced Concrete Technology, Volume 12 (2014), pp. 468-477.

[13] Sameer Shaikh, S.S. Bachhav, D.Y. Kshirsagar. **"Effective Utilisation of Waste Glass in Concrete"** Sameer Shaikh et al. Int. Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 5, Issue 12, (Part - 4) December 2015, pp.01-04.

[14] Ahmad SHAYAN. "**Value-added Utilisation of Waste Glass in Concrete."** IABSE SYMPOSIUM MELBOURNE 2002.

[15] Jangid Jitendra B. and Saoji A.C. (2014) **"Experimented investigation of waste glass powder as the partial replacement of cement in concrete product ion**" IOSIl Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X [International Conference on Advances in Engineering and Technology -(ICAET-2014)]

[16] Shivacharan Singh, Vikas Srivastava, V.C. Agarwal. **"Glass Waste in Concrete: Effect on Workability and Compressive Strength"** International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 9, September 2015.

[17] Swarna Dubey S. S. GoliyaO.S. Dhakre3.**"Feasibility of study on effect of waste glass Powder as a partial replacement of cement on compressive strength of concrete"** IJSRD - International Journal for Scientific Research & Development! Vol. **4,** Issue 05, 2016 | ISSN (online): 2321-0613 .

[18] Soumendra Mitra, Alipta Srimany, Braja Gopal Dey. "**A practical study on Effective Utilisation of Waste Glass in Concrete"** International Journal of Science, Engineering and Technology Research (IJSETR), Volume 5, Issue 3, March 2016.

[19] Dhanraj Mohan patil and Dr. Sangle Keshav K (2013) "**Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete"** International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 — 5721, Volume-2, Issue-1, 2013.

[20] Bhupendra Singh Shekhawat, Dr. Vanita Aggarwal**"Investigation of Strength and Durability Parameters of Glass Powder Based Concrete",** International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-01 81 ,Vol. 3 Issue 7, 2014.

[21] Mohammad Shoeb Sayeeduddin, Mr. F.I. Chavan. "**Use of Waste Glass Powder As A Partial Replacement of Cement In Fibre Reinforced Concrete**." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, P-ISSN: 2320-334X, Volume 13, Issue 4 Ver. IV (Jul. - Aug. 2016), PP 16-21 .

[22] Veena V. Bhat and N. Bhavani Shankar Rao. **'"Influence of Glass Powder on the Properties Of Concrete.'"** International Journal of Engineering Trend sand Technology (IJETT) — Volume 16 Number 5 — Oct 2014.

[23] Ms. Karthika Kishore Koka, Mr. Shashi Kumara S R, Dr. D L Venkatesh Babu. **"Steel Fibre Reinforced latex Modified Concrete**" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 3 Issue 9, September-2014

[24] Kapil Soni, YP Joshi, "**Performance analysis of SBR Latex on cement concrete mixes'''** International Journal of Engineering Research and Applications, ISSN : 2248- 9622, Vol. 4, Issue 3(Version 1), pp. 838-844, March 2014, Sati Govt. Engineering College, Vidisha.

[25] R.J Folic, and V.S Radonjanin, **Experiment Research on Polymer Modified Concrete**" , ACI Material Journal, Vol. 95, No.44, pp. 463 -469, July—August, 1998

IS 4031 (Part 4): 1988, **''Determination of consistency of standard cement paste",** Bureau of Indian Standards, New Delhi.

[27] IS 4031 (Part 5): 1988, **"Determination of initial and final setting times**", Bureau of Indian Standards, New Delhi.

[28] IS 8112: 1989, "**Specification for 43 grade Ordinary Portland cement",** Bureau of Indian Standards, New Delhi.

[29] IS 383:1970, **"Specification for Coarse and fine Aggregate from Natural Sources for Concrete"**, Bureau of Indian Standards, New Delhi.

[30] IS 516-1959, "**Method of test for strength of concrete",** Bureau of Indian Standards, New Delhi.

[31] IS 5816:1999, **"Specification for apparatus for split tensile testing of concrete",** Bureau of Indian Standards, New Delhi.

[32] IS 9399:1979, "**Specification for apparatus for flexural testing of concrete**", Bureau of Indian Standards, New Delhi.

[33] IS 9103 (1999): "**Specifications for concrete for admixtures - CED 2: Cement and Concrete".**

[34] IS 456 (2000): "**Plain and Reinforced Concrete — Code of practice CED 2: Cement and Concrete".**

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6. Thesis Preparation Guide was referred to for preparing the thesis. [ ]YES [ ]NO
7. Specification regarding thesis format have been closely followed. [ ]YES [ ]NO
8. The contents of thesis have been organized based on the guideline. [ ]YES [ ]NO
9. The thesis has been prepared without resorting to plagiarism. [ ]YES [ ]NO
10. All sources used have been cited appropriately. [ ]YES [ ]NO
11. The thesis has not been submitted elsewhere for a degree. [ ]YES [ ]NO
12. All the corrections have been incorporated [ ]YES [ ]NO
13. Submitted 3 hard bound copies plus one CD. [ ]YES [ ]NO

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TESTING REPORT

REPORT NO. :AEC/08/2019 REVISED COPY

ISSUED TO	MR. NEERAJ KUMAR TIWARI	DATE OF ISSUE	26/09/2019
PROJECT NAME	TO STUDY ON PHYSICAL PROPERTIES OF LATEX MODIFIED SELF COMPACTING (M25) BY PARTIAL REPLACEMENT OF CEMENT WITH GLASS POWDER		
UNDER THE GUIDANCE OF MR. MOHD. AFAQUE KHAN			

BASIC TEST RESULT

S.NO.	TEST NAME	RESULT	REMARK
1.	FINESS TEST OF CEMENT (OPC 43)	6% RETAINED ON SIEVE NO. 9	OK
2.	FINE AGGREGATE SIEVE ANALYSIS	SAND ZONE 3 CONFORMING	OK
3.	COARSE AGGREGATE SIEVE ANALYSIS	20mm SIZE OF AGGREGATE	OK

PHYSICAL PROPERTIES TEST OF OPC

S.NO.	CHARACTERISTICS	TEST RESULT	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	INITIAL SETTING TIME	45 MIN	NOT LESS THAN 30 MIN	OK
2.	FINAL SETTING TIME	590 MIN	NOT MORE THAN 600 MIN	OK
3.	FINESS MODULUS(OPC 43)	6%	10%	OK
4.	COMPRESSIVE STRENGTH (OPC 43)	43.5N/mm²	NOT LESS THAN 43 N/mm²	OK

CHARACTERISTICS

S.NO.	TEST NAME	SP. GRAVITY	%WATER ABSORPTION	REMARK
1.	COARSE AGGREGATE (20 MM)	2.637	40.8%	OK
2.	FINE AGGREGATE (ZONE 3)	2.62	30.3%	OK
3.	CEMENT (OPC 43)	3.15	-	OK

MAIN TEST

COMPRESSIVE STRENGTH OF CONCRETE (M25) LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 0% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	AREA (mm^2)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	740.78 x 1000	741.98 x1000	22500	32.92	32.98	25 N/mm^2	OK
2.	738.87 x 1000		22500	32.84			OK
3.	746.27x 1000		22500	33.18			OK

COMPRESSIVE STRENGTH OF CONCRETE (M25) LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 2.5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	AREA (mm^2)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	787.03x 1000	785.47x 1000	22500	34.97	34.91	25 N/mm^2	OK
2.	781.25x 1000		22500	34.72			OK
3.	788.14x 1000		22500	35.028			OK

COMPRESSIVE STRENGTH OF CONCRETE (M25) LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	AREA (mm^2)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	792.57 x 1000	787.72x 1000	22500	35.22	35.01	25 N/mm^2	OK
2.	789.42 x 1000		22500	35.07			OK
3.	781.15 x 1000		22500	34.73			OK

COMPRESSIVE STRENGTH OF CONCRETE (M25) LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 7.5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	AREA (mm^2)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	791.72x 1000	797.62x 1000	22500	35.18	35.45	25 N/mm^2	OK
2.	801.57x 1000		22500	35.62			OK
3.	799.56x 1000		22500	35.53			OK

COMPRESSIVE STRENGTH OF CONCRETE (M25) LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 10% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	AREA (mm^2)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	763.28x 1000	758.25x 1000	22500	33.92	33.70	25 N/mm^2	OK
2.	753.17x 1000		22500	33.47			OK
3.	758.26x 1000		22500	33.70			OK

SPLIT TENSILE STRENGTH OF CYLINDERLATEX MODIFIED SELF- COMPACTING CONCRETE WITH 0% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	262.38 x 1000		3.71			OK
2.	261.57 x 1000	260.80 x1000	3.70	3.69	6 N/mm^2	OK
3.	258.46 x 1000		3.65			OK

SPLIT TENSILE STRENGTH OF CYLINDER LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 2.5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	264.37 x 1000		3.74			OK
2.	262.54 x 1000	261.63 x1000	3.71	3.70	6 N/mm^2	OK
3.	258.00 x 1000		3.66			OK

SPLIT TENSILE STRENGTH OF CYLINDER LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	269.00 x 1000		3.80			OK
2.	264.36 x 1000	264.57 x1000	3.74	3.74	6 N/mm^2	OK
3.	260.18 x 1000		3.68			OK

SPLIT TENSILE STRENGTH OF CYLINDER LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 7.5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	269.67 x 1000	272.07 x1000	3.81	3.84	6 N/mm^2	OK
2.	275.36 x 1000		3.87			OK
3.	271.18 x 1000		3.83			OK

SPLIT TENSILE STRENGTH OF CYLINDER LATEX MODIFIED SELF- COMPACTING CONCRETE WITH 10% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	266.87 x 1000	260.80 x1000	3.77	3.69	6 N/mm^2	OK
2.	259.68 x 1000		3.67			OK
3.	255.86 x 1000		3.62			OK

FLEXURAL STRENGTH OF BEAM SELF- COMPACTING CONCRETE WITH 0% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	6.88 x 1000	6.786 x1000	5.16	5.09	10 N/mm^2	OK
2.	6.63 x 1000		4.97			OK
3.	6.85 x 1000		5.14			OK

FLEXURAL STRENGTH OF BEAM SELF- COMPACTING CONCRETE WITH 2.5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	6.94 x 1000	6.90 x1000	5.21	5.17	10 N/mm^2	OK
2.	6.87 x 1000		5.15			OK
3.	6.90 x 1000		5.17			OK

FLEXURAL STRENGTH OF BEAM SELF- COMPACTING CONCRETE WITH 5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	7.17 x 1000	7.03 x1000	5.37	5.27	10 N/mm^2	OK
2.	6.96 x 1000		5.22			OK
3.	6.98 x 1000		5.23			OK

FLEXURAL STRENGTH OF BEAM SELF- COMPACTING CONCRETE WITH 7.5% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	7.37 x 1000	7.36 x1000	5.79	5.61	10 N/mm^2	OK
2.	7.46 x 1000		5.59			OK
3.	7.26 x 1000		5.45			OK

FLEXURAL STRENGTH OF BEAM SELF- COMPACTING CONCRETE WITH 10% GLASS POWDER

SL. NO.	LOAD (N)	MEAN LOAD (N)	STRENTGH (N/mm^2)	STRENGTH OF MEAN LOAD (N/mm^2)	STANDARD RESULT (AS PER IS CODE)	REMARK
1.	6.91 x 1000	6.85 x1000	5.17	5.13	10 N/mm^2	OK
2.	6.88 x 1000		5.16			OK
3.	6.76 x 1000		5.06			OK

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CERTIFICATE OF COMPLIANCE

This is to certify that MR. NEERAJ KUMAR TIWARI has performed the following Tests in our respective laboratory with all means under the supervision of our Technical Incharge to study on physical properties of Latex Modified Self Compacting Concrete (M25) by partial

replacement of cement with glass powder,

- Basic Test (Feb-March 2019)
  - Physical Properties Test of OPC
  - Characteristics Test
- Main Test (May to July 2019)
  - Compressive Strength Of Concrete (M25) Latex Modified Self- Compacting Concrete With Variable Percentage (%) Of Glass Powder.
  - Split Tensile Strength Of Cylinder latex Modified Self- Compacting Concrete With Variable Percentage (%) Of Glass Powder.
  - Flexural Strength Of Beam Self- Compacting Concrete With Variable Percentage (%) Of Glass Powder.

These Variable Percentage (%) mentioned are 0, 2.5, 5, 7.5 & 10 The Test Results of the above mentioned Tests are listed in the Testing Report (Report No.: AEC/08/2019) attached to this Certificate.

Aiecro Engineering Works & Consultants LLP.
Authorised Signatory

Date : 26/09/2019

Er. Mudassir Ahmad Khaiid

(Quality Manager)

1) This certificate refers only to the particular sample submitted for testing.
2) The test result reported in this certificate are valid under the stated conditions of measurements
3) Sample will be destroyed after one months of the date of issue of test report unless otherwise specified.
4) The test results is for the information of client and cannot be used for any legal purpose or produced in any court of law.

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