

# Special Ingredients Concrete for Bridges: A Review

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**Abstract** – India is an advancing country and there is tremendous development in transportation field. Bridges and other elevated transportation structure plays crucial role in smooth functioning of traffic flow. Bridges withstand massive load throughout the service life of the structure and thus it should be casted with high quality concrete having greater compressive strength and durability. Normal conventional concrete hardly fulfills the strength and durability criteria throughout the lifespan of structure. Hence, special ingredients (Micro silica, Poly-propylene fiber, and Bacillus Subtilis) are combined in conventional concrete to enhance the engineering properties of concrete and make it suitable for bridge structure. This review focused on the special ingredients which are used in concrete, their effects and behavior in strengthening the engineering properties of concrete. This study also discusses the role and contribution of each special ingredient in increasing the strength, durability and other properties to improve the quality of structure.

**Key Words:** Concrete, Cracks, Self-healing, Bacillus subtilis, Micro silica, Special Concrete, Poly-propylene fiber, Strength.

## 1. INTRODUCTION

Cracks in concrete are unavoidable and through this cracks moisture enters and corrodes the reinforcement which ultimately reduces the strength and durability of structures. Heavy structures like bridges have high strength requirement and thus it should be casted with high performance special concrete. Special concrete is nothing but combination of conventional concrete and special ingredients. These special ingredients when added in optimum quantity along with conventional ingredients grants more strength, durability and stability to concrete structure. This paper aims to study the behaviour of these ingredients and determine the suitability of concrete for bridges and other heavy structure. Separate study of these ingredients and their role in enhancing the characteristics properties of concrete is reviewed in this paper.

## 2. MECHANISM OF SPECIAL INGREDIENTS CONCRETE

Special ingredients concrete is formulated by selected high quality high standard ingredients which is design, batched, mixed and placed along with normal conventional concrete to improve the standard of concrete and make it more superior for fulfillment of strength and durability criteria of

heavy structures. Special ingredients concrete is specially mechanized for bridges and its precast component for smooth functioning of such heavy structure. One of the most special properties of this concrete is ability to self-heal. Self-healing of concrete is plugging of cracks develops on the surface of concrete by filling it with calcite formation in the presence of moisture. This concrete also have micro silica as one of the ingredients to upgrade the compressive strength of concrete and to reduce the water permeability due to its fine particles. Presence of polypropylene fiber makes concrete more integrate and improve the flexural strength and reduce the micro cracks in concrete.

## 3. REVIEW OF LITERATURE

### 3.1 Blended Polypropylene Fiber for Fiber-reinforced concrete (FRC)

Divya Dharan and Aswathy lal (2016), used blended type Polypropylene fiber (0.5% to 2.0%) in concrete. Various test on compressive strength, flexural strength were conducted and results were compared with conventional concrete specimen. It was found that addition of Polypropylene fiber of 1.5% (blended type) increases the compressive strength of concrete by 17% as compared with conventional concrete. Flexural strength is found to be enhanced by 24% compared to conventional concrete. This study concluded that the 1.5% of blended type polypropylene fiber yields best results when added in concrete.

### 3.2 Use of Micro silica in concrete

Akshaykumar Hirapara et. al (2016) used Micro silica in concrete in various proportion (3% to 15%) by weight of cement and find the optimum proportion of adding micro silica in concrete for maximum results in compressive strength and workability of concrete. In this study various specimen of concrete cubes were casted for different proportion of micro silica and tested after 28 days curing period for compressive strength test and slump test for workability. It was found that 11% of micro silica by weight of cement found to be optimum proportion at which maximum compressive strength is obtained. Compressive strength is enhanced upto 25% compared to ordinary concrete of same grade. Normal consistency also increases about 40% when micro silica is added from 0% to 15%.

### 3.3 Bacteria based self-healing concrete

Kusuma K. et. al (2018) discussed the technique of self-healing of concrete by using *Bacillus megaterium* (Bacterial solution). In this study bacterial solution has a concentration of  $10^5$  cells of *Bacillus megaterium* per ml of water is added in concrete. The bacteria decompose the urea to form the calcite precipitation. Further metabolism of bacteria gives urease which converts urea to ammonia and carbonate. Ultimately this component hydrolyses to form calcium carbonate. Various test such as compressive strength, water absorption and water permeability is conducted on concrete specimen. Result shows the enhancement of compressive strength by 11% and significant reduction in penetration length of water permeability.

### 3.4 Use of Micro silica to improve compressive and flexural strength of concrete

Amar Shitole et. al (2014) used silica fumes in proportion of 0% to 10% as partial cement replacement. In this study various sample of M20 grade concrete having water cement ratio as 0.5 were casted along with partial replacement of cement ranging from 0% to 10%. After 28 days curing period, concrete specimen were tested for compressive strength and results shows 7.5% of partial replacement of cement by micro silica enhance higher strength as compared to normal concrete.

### 3.5 Influence of Polypropylene fiber on strength of concrete

Salahaldeen alsadey et. al (2016) finds the optimum quantity of polypropylene fiber to get highest compressive strength for M25 grade concrete. From the experimental study it was found that the increase in quantity of polypropylene fiber increases the compressive strength significantly. Polypropylene fiber ranging from 0% to 2% is added in concrete and different cube specimens were casted for different proportion and tested after completion of 28 days curing period. Results show the maximum compressive strength is obtained at the proportion of 2%.

Addition of fiber also results in reduction of slump which makes concrete difficult in handling.

### 3.6 Self-healing of Concrete by adding *Bacillus Subtilis*

PradeepKumar.A et. al (2015) investigates the self-healing phenomenon of concrete by adding *Bacillus subtilis* as one of the special ingredients. In experimental study M20 grade is design by adding 30ml of *Bacillus subtilis* solution to obtain the greater strength of concrete specimen. Culturing of bacteria is carried out using nutrients agar slants. The medium composition used for growth culturing is peptone, NaCl, and yeast extracts. Four cubes specimen with 0ml,

10ml, 20ml, and 30ml *Bacillus subtilis* solution were casted and tested for compressive strength test. Further result shows that the compressive strength for M20 grade is found to be higher than even M25 grade concrete and it was noted to be 33.32 Mpa for the proportion of 30ml bacterial solution. Self-healing can be shown on the surface of concrete cubes sample in which initial cracks were found to be healed by formation of calcite layer.

### 3.7 Ultra High Performance Concrete for Bridges

S. Karuppasamy et. al (2019) introduces the ultra-high performance concrete for bridges to withstand strength, durability and stability. Ultra high performance concrete is developed using locally available silica fumes and steel fibers along with super plasticizers. Mix design of concrete is carried out by using 10% proportion of Micro silica and different proportion of steel fiber 4% and 8% by volume and 2.5%, 5%, 7.5% and 10% of steel fiber by weight of cement. Further compressive strength test and tensile strength test is carried out and results shows 7.5% of steel fiber along with 10% of Micro silica attained maximum compressive and tensile strength after 7 days and 28 days cube testing.

### 3.8 Effects of Addition of Micro Silica on properties of High strength Concrete

Sabale V.D et. al (2014) used Micro silica in different proportion for mix design of M60 grade concrete while maintaining the water cement ratio to 0.3. Silica fumes in different proportion such as 0%,5%,10%,15% to the weight of cement were used. Further 7 days and 28 days compressive strength, splitting tensile strength and flexural strength is determined for each sample. From results it was concluded that the partial replacement of cement within 10% increases compressive, tensile and flexural strength and beyond 10% it decreases. Workability decreases with increase in micro silica and thus water requirement is greater in replacement. Application of silica fumes performed exceptionally better as compared to normal concrete.

### 3.9 Investigation on Properties of High Strength Bacterial Concrete

Neha Singla et. al (2016) research on eco-friendly technique of self-healing by using *Bacillus subtilis* as a bacterial agent. Experiment is done by sub-culturing growth using two medium i.e Nutrients-broth medium and Urea medium. Cube specimen is casted by adding *Bacillus subtilis* solution having concentration of Nil,  $10^4$ ,  $10^5$ ,  $10^6$  and  $10^7$ . Compressive strength and split tensile strength is tested for 7 and 28 days. SEM analysis is also carried out and it shows the calcite layer formation in bacterial concrete. Compressive strength is found to be increases by 27% in urea medium.

## 4. ADVANTAGES AND DISADVANTAGES OF SPECIAL INGREDIENTS CONCRETE

### 4.1 Advantages

- 1) Enhances compressive strength, flexural strength of concrete.
- 2) Lowers the porousness of concrete and thus reduces permeability of concrete compared to normal concrete.
- 3) Increases durability and serviceability of structure by reducing corrosion of steel.
- 4) Maintenance cost of special ingredient concrete structure is low as compared to ordinary concrete.
- 5) Due to self-healing properties of this concrete, maintenance cost of structure is very low.
- 6) Presence of polypropylene fiber reduces micro cracks and improves the integrity of structure.

### 4.2 Disadvantages

- 1) Initial cost of this concrete is quite high as compared to normal concrete.
- 2) Availability of special ingredients is one of the concern in some areas.
- 3) Skilled supervision and deep knowledge is required for culturing and growth of bacteria in self-healing phenomenon.
- 4) Examination of calcite layer formation is very difficult and costly.

## 5. APPLICATION OF SPECIAL INGREDIENTS CONCRETE

- 1) Bridges and Elevated Viaducts.
- 2) Pre-stressed concrete girders.
- 3) Flyovers and Precast segments.
- 4) Underground and elevated Metro structure.
- 5) Box culverts, Water retaining structures.

## 6. CONCLUSIONS

- 1) Above review study concludes that the special ingredients when added along with conventional concrete works significantly better in enhancing the compressive strength of concrete.

2) Review study also concludes that *Bacillus subtilis* and other species of bacillus type bacteria, self-heal the cracks formed on the surface of concrete by forming the calcite layer in the presence of moisture.

3) Micro silica also works effectively in increasing the compressive strength of concrete when the optimum proportion is 10% by weight of cement.

4) Study also concludes that Polypropylene fiber (Blended type) if used between 1.5% to 2%, increases the flexural strength and compressive strength effectively.

5) Special ingredients concrete also increases the durability and serviceability of structure by reducing the corrosion of reinforcement.

6) These ingredients when used in optimum proportion improves the quality of concrete, increases the strength and durability and reduces the water permeability of concrete structure.

7) Overall performance of special ingredients concrete makes it suitable and best option for heavy structures like bridge and elevated viaducts.

8) Finally it can be concluded that the special ingredients concrete performs significantly well in fulfilling the each and every aspects required in smooth functioning of bridges structure.

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