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# Mechanical Behaviour of Fibre Reinforced Concrete using Shape Memory Alloys

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***Abstract*: Usage of smart materials in concrete is extensively increasing. This study focuses on behavior of fiber reinforced concrete, using shape memory alloys (SMA) fibers. SMA adopted for this study is NiTi shape memory alloy crystals. Concrete is tested for slump and mechanical properties tested are compressive strength for 7 and 28 days. Flexural strength is tested for 28 days. Constant rates of 1% of SMA fibers are added to the concrete mix. Also regular steel fiber reinforced is prepared and test values are compared with SMA fiber reinforced concrete.***

***Keywords: shape memory alloy (SMA), fiber reinforced concrete, mechanical properties, steel fibers.***

## I. INTRODUCTION

Fiber reinforced concrete is one the most used concretes. Different fibers are incorporated in plain concrete members to develop the characteristics of concrete. Most commonly used fibers are glass fibers, plastic fibers, steel fibres, copper fibers. Studies were conducted on fiber reinforced concrete members and its applications were determined.

Smart materials are trending its application in many industries due to their unique behaviour. Generally SMA are materials that undergo deformation in cooling and when heated, they regain to their original position. These materials exhort high elastic properties.

In this paper NiTi shape memory alloy crystals are used as fibers. A general investigation is done on fiber reinforced concrete that elastic properties of SMA have an influence in mechanical behaviour.

## II. EXPERIMENTAL PROCEDURE

### A. Materials

Materials adopted for the fiber reinforced concrete are OPC 53 grade, river sand as fine aggregate, 12mm sized coarse aggregate, admixture for increasing bonding behavior of fibers and concrete. NiTi shape memory alloy crystals of 10mm length and 3mm in width and steel fibers are used.

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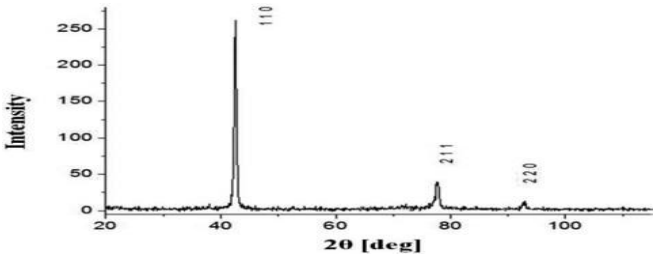



**Fig 1: XRD pattern of NiTi shape memory alloy**

Particle size distribution of coarse and fine aggregates is shown in the Fig 2.

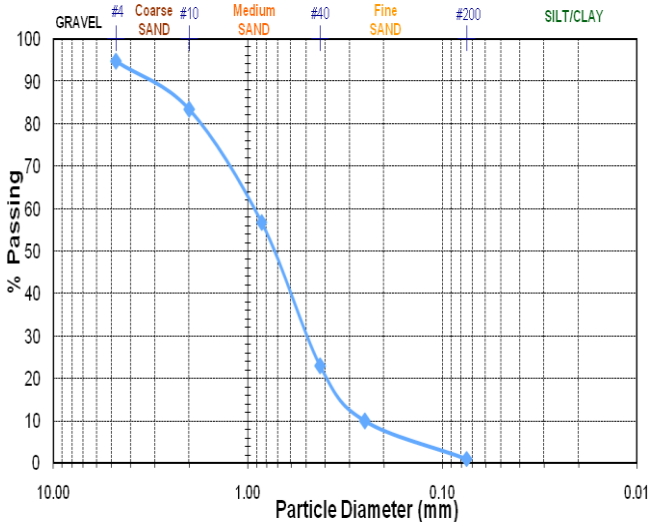



**Fig 2: Particle size distribution curve**

**Table 1:** XRF analysis of OPC

| *COMPOSITION* | *OPC (%)* |
|---|---|
| $SiO_2$ | 14.03 |
| $Al_2O_3$ | 2.68 |
| $Fe_2O_3$ | 2.57 |
| CaO | 42.81 |
| MgO | 0.67 |
| $SO_3$ | 0.40 |
| $Na_2O$ | 0.26 |
| $K_2O$ | 0.32 |
| $Mn_2O_3$ | 0.2 |
| $TiO_2$ | 0.00 |
| Cl | 0.00 |

### B. Mix proportions

Mix proportion used for the study. Batching of concrete is done at room temperature. SMA is mixed at 1% to the weight of the cement for all the mixes.

A reference mix with steel fibres is designed to compare the values of both the concrete.

## III. TESTS CONDUCTED

### I. Workability:

To test the workability of SMA fibre reinforced concrete is done by taking the slump cone test. Fibres are thoroughly mixed with concrete and introduced into slump cone in three stages by tamping for 25 times in every stage

### II. Compression test:

Compressive strength of SMA fibre reinforced concrete is initiated by casting cubes as per IS code i.e., a standard size of 150*150*150mm are casted. Cubes prepared are cured for a period of 7 and 28 days.

### III. Flexural strength:

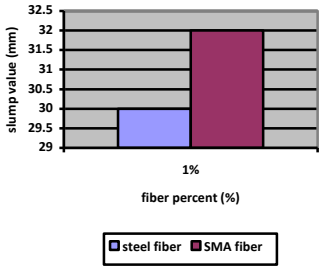
Flexural strength or tensile strength of concrete is tested by casting specimens of size 100*100*500mm. prepared test specimens under two point test arrangement. Flexural strength values are taken for specimens casted for 28 days.

## IV. TEST RESULTS

### I. Workability

Slump values of both steel fibre reinforced concrete and SMA fibre reinforced concrete are compared. Slump values of both concretes does not show a major difference and slump value comparison for both concrete are shown in Fig.2

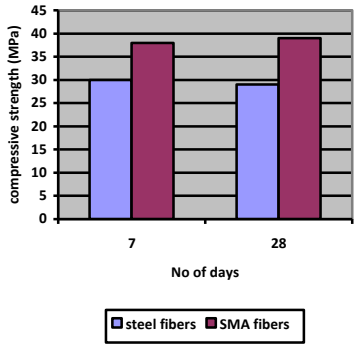
Fig:2 comparision of slump values




### II. Compressive strength

Compressive strength values of both concretes are tested for a period of 7 and 28 days. Compressive strength values for steel and SMA fibres are plotted in Fig 3

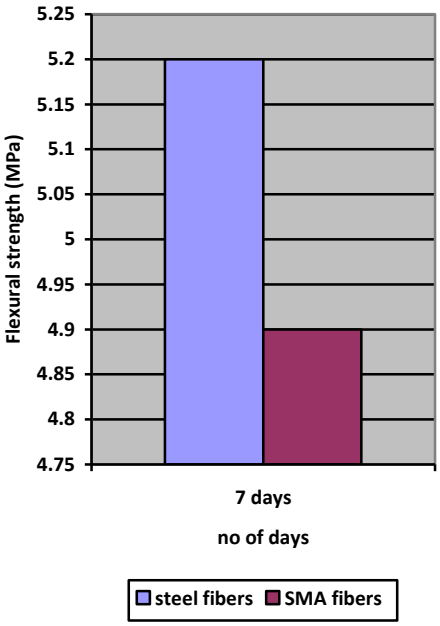
Fig 3: compressive strength values for 7 and 28 days




### III. Flexural strength:

Flexural strength values for both concretes are plotted in Fig 4. Initial values of flexural strength during period of 7 days there is decrease in SMA fibre reinforced concrete values compared to steel fibre reinforced concrete.

Fig 4: Flexural strength values for 7 days




## CONCLUSIONS

From the experimental results following conclusions can be taken

- Slump value shows a difference of 2mm, this may be due to gathering of SMA fibres in single bond.
- Compressive strength values for 7 days is less and for 28 days it is more. Major reason may be due to bonding characteristics and irregular distribution of SMA fibres.
- Flexural strength values at 7 days are less when compared with steel fibres. Reason may be as same as for the compressive strength.
- To get into deep reason in reduction of strength, bonding characteristics of SMA fibres should be analysed

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