# Effect of Manufactured Sand and Metakaolin on Strength characteristics of concrete

Dr.Tummala Suresh babu[1], Muppalla Venkata sai surya pratap chowdary[2],
Professor and principal of Visvodaya Engineering College, kavali, Spsr Nellore, AP, India [1]
PG Student, Structural Engg, Department of Civil Engg, Visvodaya Engineering College, kavali, Spsr Nellore, AP,India [2]

**Abstract** *: This present paper deals with the concrete mix of M25 grade which was made using OPC 53 grade of cement and in which Manufacturing sand is used to replacing the natural sand with 0,25,50,75 and 100 percentages. Concrete specimens are prepared to study fresh and hardened properties of concrete mix for 7, 28 and 60days.The variation of strength increment at different ages are studied and from that appropriate percentage of Manufacturing sand at which mix shows appropriate results. For that mix added Metakaolin in percentages of 0, 5, 10, 15 and 20 percentages to Study the properties of concrete and find out the best mix of Metakaolin with M-sand which shows the appropriate compressive, tensile and resistance to cracking etc*.

**Index Terms:**

***Metakaolin, Concrete Mix, Compressive strength, Split Tensile strength, Manufacturing Sand and Ordinary Portland cement.***

## I.INTRODUCTION

Manufacturing sand is a fine-grained supplementary material of Natural Sand. By natural weathering of rocks over a period of millions of years forms the natural sand and is becoming a scarce commodity. So now a day's need of alternatives of natural sand like manufacturing sand increases. Is a powder form of crushed stone (granite rocks) and is collected from local stone crushing units and was initially dry in condition when collected and was sieved by IS:90microns sieve before mixing in concrete. Metakaolin is a supplement cementituous material of cement which improves the properties like durability, strengthened resistance to cracks etc. It modifies the microstructure and the weak zone is strengthened due to higher bond developed between two phases which are paste phase and aggregate phase. This puzzolonic material available in different varities and qualities and its purity will define the binding capacity (or) free lime. It is generated by calcinations of kaolinite clay at temperature between550$^0$ c to 600$^0$ c. It is creating an amorphous alumino silicate that is reactive in concrete.

Metakaolin is lighter material compare to ordinary Portland cement. It sources are indigenous lateritic soils and sludge from the paper recycling industry. Highly reactive Metakaolin formed by water processing, which removes impurities to make it 100%reactive puzzolonic material. This forms the CSH (calcium silicate hydrate) and CASH (calcium alumino silicate hydrate) when combines with calcium hydroxide produced during cement hydration. In present work, investigation is carried out on properties of concrete in which partial replacement of cement with Metakaolin and natural sand with manufacturing sand. The referral concrete m25 was made using 53 grade OPC and the other mixes were prepared by replacing part of sand with m-sand and the optimized mix is taken and for this Metakaolin added in percentages 0%,5%,10%,15% and 20% for 7,28,60 days.

## II.LITERATURE REVIEW

**1. Mr. Manu Vijay and Mr. Srivasthava HU** in 2017 examined the effect of the alternative materials such as Metakaolin and manufacturing sand on concrete of M30 grade and they reported that these materials improves the strength of concrete and increment of compressive strength and split tensile strength of the mix of concrete up to 15 percent of Metakaolin with Manufacturing sand.

**2. Prof.NaadeemPasha, Muhammad Mehraj, Anil Kumar Mashyal, vedourata and Anand Bana Sode** in 2016 examined the effect of the materials Metakaolin and fly ash on concrete and they reported that these alternatives improves the strength of concrete like compressive strength, split tensile strength and flexural strength up to 20 percent of metakaolin at 5 percent of flyash.

**3. Vikas srivasava, Rakesh Kumar and v.c Agarwal** in 2012 examined the effect on mechanical properties of concrete by inclusion of Metakaolin and they reported that the material Metakaolin inclusion increases the compressive strength, Tensile strength, Flexural strength and bend strength and modulus of elasticity of concrete considerably; however the workability is slightly compromised. This paper presents the review of investigations carried out to find the suitability of Metakaolin in production of concrete.

**4. Tasnia Hoque, Muhammed Harnur Rashid, MDRokon Hassan, EBNA FORHAD MONDOL** in 2013 examined the influence of stone dust as partially replacing material of cement and sand on some mechanical properties of mortar. In this study the properties of mortar are investigated with the replacement of 25%and50% of fine aggregate and also 5% of cement by stone dust.

## III.MATERIALS AND PROPERTIES

**Materials:-**

Raw materials required for the concreting operations of the present work are

1. Cement
2. Metakaolin
3. Fine aggregates
4. Manufacturing sand
5. Coarse aggregates
6. Water

**1. Cement:-**

Cement is a binding material and is responsible for interlock between constituents present in concrete. Cement having argillaceous, calcareous and siliceous compounds and which responsible for formation of calcium hydrates in cement hydration.

In experimental investigation ordinary Portland cement of 53 grade (BHARATHI Cement) was used. Which having properties given below.

Normal consistency=32%
Fineness of cement (Dry sieving method) =98%
Specific gravity of cement=3.15
Initial setting time=30min
Final setting time=358min

2) **Metakaolin:-**

Which is a puzzolonic material and ths combines with free calcium hydroxide produce during cement hydration generating additional cementing compounds contributing to enhanced strength and durability.

Which having following properties

Physical form is powder
Colour is white
Specific gravity=2.46

3) **Fine Aggregates:-**

Natural sand means River sand collected from near and is passing through 4.75mm and is free from clay, silt and other organic matters does not exceed the specified limit.
Which having properties given below.

Specific gravity = 2.65
Fineness modulus =2.6

4) **Manufacturing sand:-**

River sand is used fine aggregate in mortar. This is formed by weathering of rocks over a period of millions of years and is becoming scarce commodity so need of alternatives of it. In this experiment M-sand is taken as the alternative of River sand. Which specific gravity are 2.66.

5) **Coarse Aggregates:-**

Which is angular in shape and size about 20mm is taken for experimental investigation. Which having particle size as are retained on I.S.sieve4.75mm and which occupies large portion of concrete.

Which having following properties are

Specific gravity =2.77
Fineness modulus =7.2

6**) Water:-**

The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life.

Ordinary potable tap water available in laboratory was used for mixing and curing of concrete and is free from impurities and micro-organisms.

## IV.SPECIMEN DETAILS

Cylinder specimen of height 300mm and 150 mm dia is use in this investigation to study the hardened properties of concrete such as compressive strength, split tensile strength and also the stress-strain behaviour of concrete. The mix of M25 in which replacement of natural sand with M-Sand in proportion 0%, 25%,50%,75% and 100% are denoted as M1,M2,M3,M4 and M5 respectively. The appropriate percentage is taken from that and added Metakaolin in proportion of 0%, 5%, 10%, 15% and 20% are denoted as M6,M7,M8,M9 and M10 respectively.

## V.MIX DESIGN OF CONCRETE

### 5.1 MIX DESIGN FOR M25 GRADE OF CONCRETE:

The materials for unit volume are given below table-1 and table-2.

Mix proportion of M25 mix concrete at various proportions of Manufacturing Sand given below.

**Table-1**

| Mix | Water | Cement | River Sand | Manufacturing sand | Coarse aggregates |
|---|---|---|---|---|---|
| M1 | 191.8 | 383.16 | 671.45 | 0 | 1145.13 |
| M2 | 191.8 | 383.16 | 481.08 | 160.36 | 1145.13 |
| M3 | 191.8 | 383.16 | 380.73 | 380.73 | 1145.13 |
| M4 | 191.8 | 383.16 | 160.36 | 481.08 | 1145.13 |
| M5 | 191.8 | 383.16 | 0 | 671.45 | 1145.13 |

Mix proportion of M25 mix concrete at various proportions of Metakaolin at 50% of Manufacturing Sand given below.

**Table-2**

| Mix | Water | Cement | Metakaolin | River Sand | Manufacturing sand | Coarse aggregates |
|---|---|---|---|---|---|---|
| M6 | 191.8 | 383.16 | 0 | 380.73 | 380.73 | 1145.13 |
| M7 | 191.8 | 364.00 | 19.16 | 380.73 | 380.73 | 1145.13 |
| M8 | 191.8 | 344.84 | 38.32 | 380.73 | 380.73 | 1145.13 |
| M9 | 191.8 | 325.69 | 57.47 | 380.73 | 380.73 | 1145.13 |
| M10 | 191.8 | 306.53 | 76.63 | 380.73 | 380.73 | 1145.13 |

## VI.EXPERIMENTAL INVESTIGATIONS

### 6.1WORKABILITY OF CONCRETE:

Slump cone test is considered in this investigation to study the workability of concrete by means of slump. The slumped concrete takes various shapes and according to the profile of slumped concrete, the slump is termed as true slump, shear slump or collapse slump. If a shear or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indication that the mix is too wet.

How workability test is done to get slump at various proportions of Manufacturing Sand and Metakaolin is given below.

Fig .1 Tampering of materials in the slump cone

Fig. 2 slump of concrete mix on the tray

Only a true slump is of any use in the test. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which the slump test is not appropriate. Very dry mixes having slump 0 – 25 mm are typically used in road making, low workability mixes having slump 10 – 40 mm are typically used for foundations with light reinforcement, medium workability mixes with slump 50 – 90 mm, are typically used for normal reinforced concrete placed with vibration, high workability concrete with slump > 100 mm is typically used where reinforcing has tight spacing, and/or the concrete has to flow a great distance.

**6.2 COMPRESSIVE TEST:**

After curing, drying of these specimens for 7, 28 and 60 days are taken to test them to get the peak load at which specimen fails. These specimens are placed in CTM and load is applied gradually until the specimen fails.

Compressive stress at this breaking load=P/A

Where P=Breaking load,

A=Cross Sectional area of the specimen

Fig.3 compressive strength test setup

Fig 4 cylindrical specimen after testing

**6.3 SPLIT TENSILE STRENGTH TEST:**

Splitting tensile strength is an indirect method used for determining the tensile strength of concrete. After curing, drying of these specimens for 7, 28 and 60 days are taken to test them to get the peak load at which specimen fails. These specimens are placed with its axis horizontal between plates of the testing machine CTM and load is applied gradually until the specimen fails that means specimen split in to two pieces.

Split tensile strength at this breaking load=$2P/\pi DL$

Where P=Spit tensile load,

D=Diameter of the specimen,

L=Length of the specimen

The specimens after placing of loads and placing on the ground are shown in below figures 5 and 6.

Fig.5 split tensile strength test setup

Fig. 6 cylindrical specimen after testing

## VII .TEST RESULTS AND DISCUSSIONS

Tables for Concrete mix which shows fresh and hardening properties of concrete given below.

**Table-3**

Properties for Concrete mix for various proportions of manufacturing sand

| %0f M-Sand | Workability Slump(mm) | Compressive strength (N/mm$^2$) | | | Split tensi le strength (N/mm$^2$) | | |
|---|---|---|---|---|---|---|---|
| | | 7-DAYS | 28-DAYS | 60-DAYS | 7-DAYS | 28-DAYS | 60-DAYS |
| 0 | 69 | 20.182 | 29.037 | 29.992 | 1.980 | 2.829 | 3.018 |
| 25 | 64 | 21.117 | 30.557 | 31.500 | 2.122 | 3.018 | 3.159 |
| 50 | 57 | 22.249 | 32.4309 | 33.185 | 2.310 | 3.348 | 3.489 |
| 75 | 49 | 21.315 | 30.746 | 31.863 | 2.169 | 3.018 | 3.206 |
| 100 | 42 | 20.560 | 29.614 | 30.368 | 2.027 | 2.923 | 3.065 |

From this table we get that workability of concrete decreases with the increase of Manufacturing Sand content and the compressive strength and Split tensile strength increases up to 50 percent decreases more than that percent in early and lateral ages also.

At which percent that means 50 percent of Manufacturing Sand properties of the concrete mix are given below.

The Workability of concrete mix by means of slump (mm) =57

At 7-Days, The % of increase of compressive strength =10.241%

The % of increase of Split tensile strength =16.666%

At 28-Days, The % of increase of compressive strength =11.688%

The % of increase of Split tensile strength =17.285%

At 60-Days, The % of increase of compressive strength =10.646%

The % of increase of Split tensile strength =15.606%

Graphs for fresh and hardened properties of Concrete mix with partial replacement of M- Sand

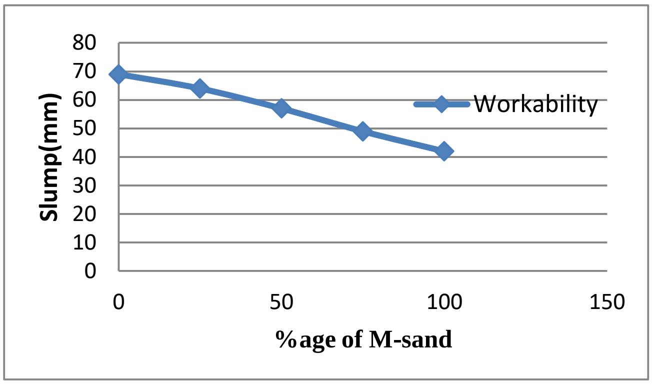


Fig.7 workability of concrete mix with % of M-sand

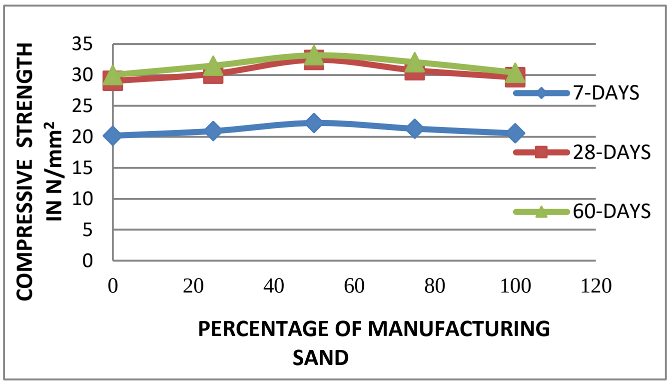


Fig.8 compressive strength of concrete mix with% of M-Sand

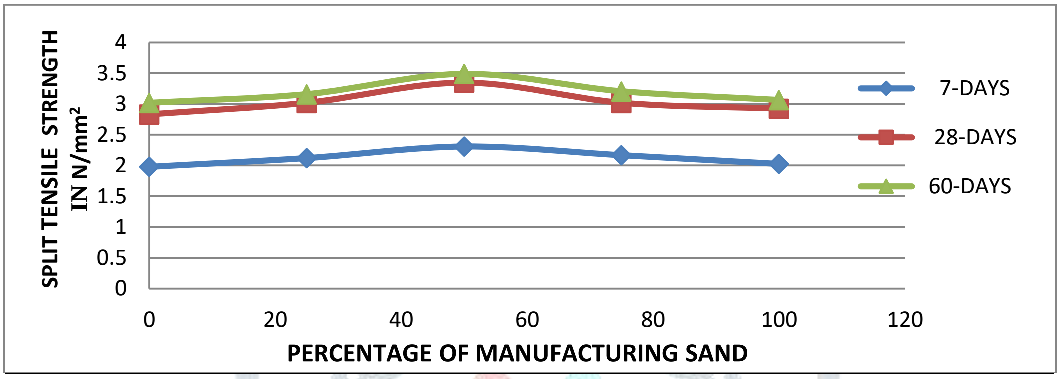


Fig .9split tensile strength of concrete with % of M-Sand

**Table-4**

Properties for Concrete mix for various proportions of Metakaolin at 50% of M-Sand

| %0f Metakaolin | Workability Slump(mm) | Compressive strength (N/mm$^2$) | | | Split tensile strength (N/mm$^2$) | | |
|---|---|---|---|---|---|---|---|
| | | 7-DAYS | 28-DAYS | 60-DAYS | 7-DAYS | 28-DAYS | 60-DAYS |
| 0 | 57 | 22.249 | 32.430 | 33.185 | 2.310 | 3.348 | 3.348 |
| 5 | 53 | 23.191 | 34.127 | 34.882 | 2.405 | 3.536 | 3.725 |
| 10 | 48 | 24.134 | 35.447 | 36.013 | 2.551 | 3.725 | 3.866 |
| 15 | 41 | 23.569 | 34.882 | 35.636 | 2.449 | 3.631 | 3.725 |
| 20 | 35 | 22.814 | 33.750 | 34.882 | 2.357 | 3.348 | 3.536 |

From this table we get that workability of concrete decreases with the increase of Metakaolin at 50% of Manufacturing Sand content and the compressive strength and Split tensile strength increases up to 10 percent decreases more than that percent in early and lateral ages also.

But at 10 of Metakaolin percent the slump is not suitable for normal reinforced concrete so we have to take 5 percent of Metakaolin and at which properties of the concrete mix are given below.

At which the Workability by means of slump (mm) =53

At 7-Days, The % of increase of compressive strength =14.909%

The % of increase of Split tensile strength =21.464%

At 28-Days, The % of increase of compressive strength = 17.529%

The % of increase of Split tensile strength =24.991%

At 60-Days, The % of increase of compressive strength = 16.304%

The % of increase of Split tensile strength =23.426%

The best proportion at which concrete mix shows appropriate results is 10% of Metakaolin at 50% 0f M-Sand,

At which the Workability by means of slump (mm) = 48

At 7-Days, The % of increase of compressive strength = 19.5818%

The % of increase of Split tensile strength = 28.838%

At 28-Days, The % of increase of compressive strength =22.075%

The % of increase of Split tensile strength =31.671%

At 60-Days, The % of increase of compressive strength =20.007%

The % of increase of Split tensile strength =28.098%

Graphs for mechanical properties of Concrete with partial replacement of Met kaolin at 50% M- Sand

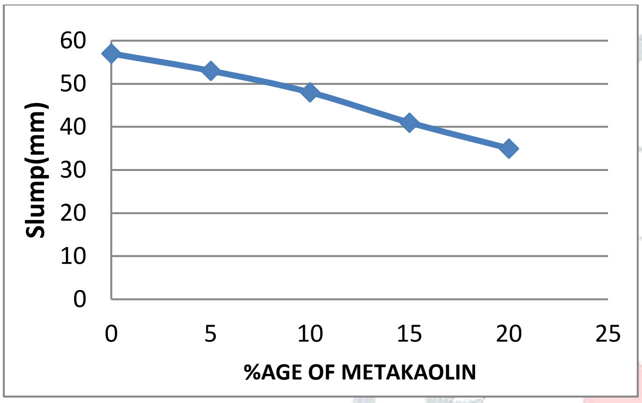


Fig.10workability of concrete mix

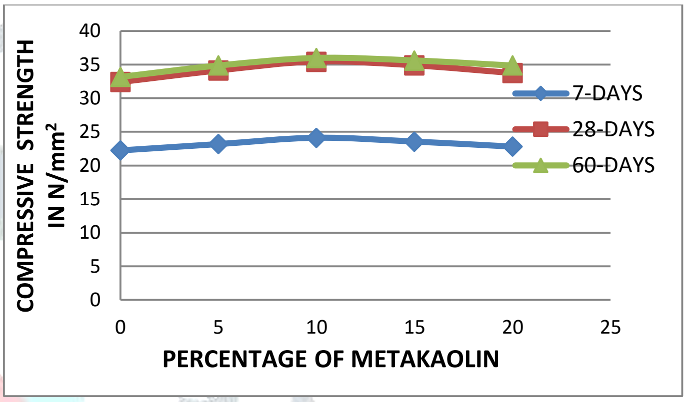


Fig.11 compressive strength of concrete mix

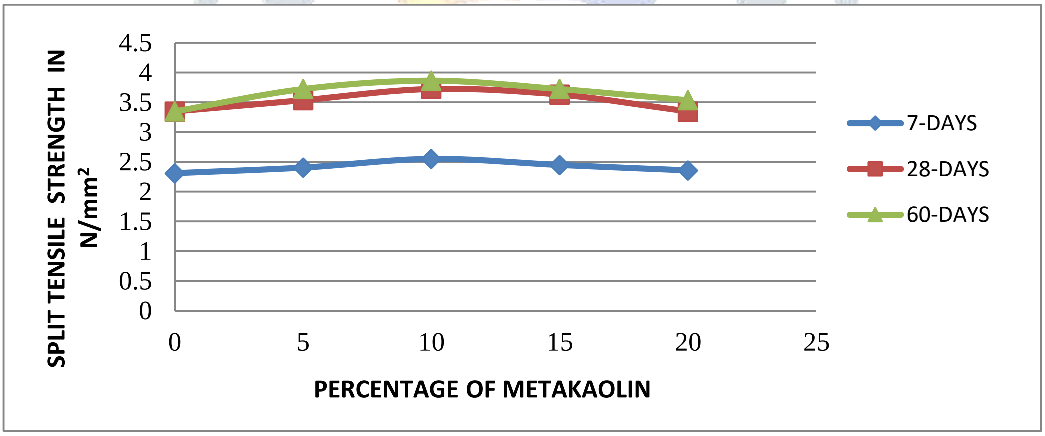


Fig .12 split tensile strength of concrete with % of Metakaolin at 50% of M-Sand

## VIII. CONCLUSION

1. The workability of concrete mix decreases with the increase of the manufacturing sand content and the workability is 57 at 50 percent of manufacturing sand.
2. The compressive strength and split tensile strength values are high at the percentage of manufacturing sand content of 50 percent in early ages with the increase of strength 10.241% and 16.666% respectively.
3. In lateral ages means at 28 days and 60 days the compressive strength high at 50 percent of manufacturing sand with the percentages 11.688% and 10.646% respectively.
4. At ages 28 days and 60 days the Split tensile strength high at 50 percent of manufacturing sand with the percentages 17.285% and 15.606% respectively.
5. The workability of concrete mix decreases with the increase of the Metakaolin at 50 percent of manufacturing sand content and the workability is 53mm of slump at 5percent of Metakaolin and 48mm of slump at 10 percent of Metakaolin.

6. The compressive strength and split tensile strength values are at the 5 percent of Metakaolin at manufacturing sand content of 50 percent in early ages with the increase of strength 14.909% and 21.464% respectively.
7. In lateral ages means at 28 days and 60 days the compressive strength values are at 5 percent of Metakaolin at 50 percent of manufacturing sand with the percentages 17.529% and 16.304%respectively.
8. At ages 28 days and 60 days the Split tensile strength at 5 percent of Metakaolin at 50 percent of manufacturing sand with the percentages 24.991% and 23.426% respectively.
9. The compressive strength and split tensile strength values are high at the 10 percent of Metakaolin at manufacturing sand content of 50 percent in early ages with the increase of strength 19.5818% and 28.838% respectively.
10. In lateral ages means at 28 days and 60 days the compressive strength values are at 5 percent of Metakaolin at 50 percent of manufacturing sand with the percentages 22.075% and 20.007% respectively.
11. At ages 28 days and 60 days the Split tensile strength at 5 percent of Metakaolin at 50 percent of manufacturing sand with the percentages 31.671%and 28.098% respectively.
12. Compressive strength and Split tensile strength of concrete mix increases up to 10 percent of Metakaolin at 50% of Manufacturing Sand content decreases more than that percent in early and lateral ages also. But at 10 percent the slump is not suitable for normal reinforced concrete so we have to take 5% of Metakaolin at 50% of Manufacturing Sand.

## IX. REFERENCES


1. P.Dinakar (2013)"The effect of Metakaolin on high strength concrete" Journal of Material science, 9, pp379-382
2. Tasnia Hoque, Muhammad Harnur Rashid, MD.Rokon Hasan, EBNA FORHAD MONDAL in 2013 examined the influence of stone dust as partially Replacing Material of Cement and sand on some Mechanical properties of Mortar. International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol.2, NO.02, April 2013.IJASE 020203 Copyright@2012 Basha research centre .All rights reserved.
3. N Krishna Raju- concrete mix design.
4. Saeed Ahmad and Shahid Mahmood (2008), "Effects of Crushed And Natural Sand on The Properties of Fresh and Hardened Concrete", 33rd Conference on Our World In Concrete & Structures, Singapore, pp. 25-27
5. Brooks &al.(2010)Influence of specimen geometry on the strengths of laterized concrete, Journal of Research and Reviews in Applied sciences, April 2010,8-17.
6. 6.J. M. Justice, L. H. Kennison, B. J. Mohr, S. L. Beckwith, "Comparison of Two Metakaolin and a silica fume used as a supplementary Cementitous materials", High Performance concrete, 2005, pp: 20- 24.
7. IS: 515-1959,"Indian Standard Code of practice for methods of tests for strength of concrete", Bureau of Indian Standards, New Delhi, India.
8. IS10262-2009 Recommended guidelines for concrete mix design, BIS, NEW Delhi, India, 2009.
9. IS 456-2000,"Plain and Reinforced concrete "code of practice, Bureau Indian standards, New Delhi, India.
10. IS 383-1970 Specification for fine and coarse aggregate from natural source for concrete.
11. MS Shetty-concrete Technology, S.Chand Publishing


Authors

**Dr. Tummala Suresh Babu** awarded B.Tech Degree with the specialization of Civil Engineering from Manipal University, Manipal, awarded M.Tech Degree with the specialization of Structural Engineering from NIT, Warangal and awarded Ph.D. from JNTUH, Hyderabad. At Present working as Professor and Principal at Visvodaya Engineering College, Kavali.

**Muppalla Venkata Sai Surya Pratap Chowdary** awarded B.Tech Degree with the specialization of Civil Engineering from Audisankara College of Engineering and technology, Gudur, Spsr Nellore dt.At Present pursuing M.Tech Degree in Structural Engineering at Visvodaya Engineering College, Kavali.