# An Experimental Investigation on Bio-Medical Waste Concrete

*K.Malavan*
*PG Student, M.E.Structural Engineering,*
Kumaraguru College of Technology,
Coimbatore, Tamil Nadu, India

*R.Manju*
*Assistant Professor, Department of Civil Engg.,*
Kumaraguru College of Technology,
Coimbatore, Tamil Nadu, India

***Abstract*— Bio-medical waste disposal is one of the major problem in India. These wastes are generated from hospitals, Medical research Centre and other medical sources are causing a real problem for living nature and human world. Some studies disclosed the range of utilization of Bio-medical waste as a partial replacement to sand in concrete. This paper reports the result of an experimental program carried out to study the effects of use of biomedical waste in concrete as partial replacement of sand.**

***Keywords—Bio-Medical Waste, Compressive strength, Split tensile strength, Density, Flexural strength of beam.***

## I. *INTRODUCTION*

Bio-medical waste is the waste liquids, solids, sharps and laboratory waste that are potentially infectious and dangerous. It is a waste from biological sources or is used in the diagnosis, prevention or treatment of disease. Common producers of BMW include health clinics, hospitals, medical research laboratories, physicians, dentists and veterinarians and home health care.

According to ministry of Environment and Forest about 4,05,702 kg/day biomedical waste generated in India out of which around 72% is disposed off, more than 28% is left unattended[1]. Most common process of disposal of biomedical waste is incineration in specifically made for it.

The ash produced in these incinerators are dispose as landfills. For the landfills large land area is required. This land requirements can be reduced by partial replacement of sand in concrete. On other hand the protection of environment by reducing the consumption of natural river sand. In India, at present there are 170 common BMW treatment facilities in which 140 incinerators plants are present [1].

## II. *MATERIALS AND METHODS*

For casting of concrete generally used raw materials are Cement, Fine aggregate (River sand), Coarse aggregate and Water were used. Experimental investigation was carried on Bio-Medical Waste to investigate the effect on properties of concrete on the partial replacement of fine aggregate in concrete on Compressive strength, Split tensile strength, Flexural strength, Density, Young's modulus, Ultrasonic Pulse Velocity and durability studies such as Rapid chloride penetration test, Permeability test.

### *A. Cement*

Ordinary Portland cement were used satisfying all the requirements as per IS 12269:1993, was used in making the concrete. The physical properties of cement were specific gravity - 3.15, Specific area – 319 $m^2$/kg.

### *B. Fine Aggregate*

Sand i.e., fine aggregate obtained locally from nearest river passing through 4.75 IS sieve having fineness modulus - 2.60 & confirming to zone-III as per IS: 383-1970.Its specific gravity was 2.58 respectively.

### *C. Coarse Aggregate*

Blue metal i.e., Coarse aggregate obtained locally. 20 mm Nominal size Graded aggregate having fineness modulus – 3.92 & confirming to IS:383-1970 specification. The physical properties of CA were specific gravity 2.78, Water absorption – 0.9%.

### *D. Bio-Medical Waste*

Biomedical waste ash which was used throughout this experiment was collected from Palladam, Coimbatore incinerator plant, which was grey in colour and lighter in weight and coarser than cement.

**FIG 1: BIO-MEDICAL WASTE ASH**

*E. Concrete*

The concrete mix design was done in accordance with IS 10262: 2009. The cement content used in the mix design was taken as 450 kg/cu.m which satisfies minimum requirement of 340 kg/cu.m in order to avoid the balling affect.

## III. *RESULT AND DISCUSSION*

The result of experimental investigation carried out to determine Density, Compressive strength, Split tensile strength, Flexural strength, are discussed here in after.

*A. Density*

The density of concrete is a measurement of concrete's solidity. The process of mixing and addition of material in concrete can be modified to form a lower or higher density of concrete end product.

It is clearly evident from Fig 1 that the density of concrete decreased with increase in replacement level which may be due to Bio-Medical Waste being lighter than sand.

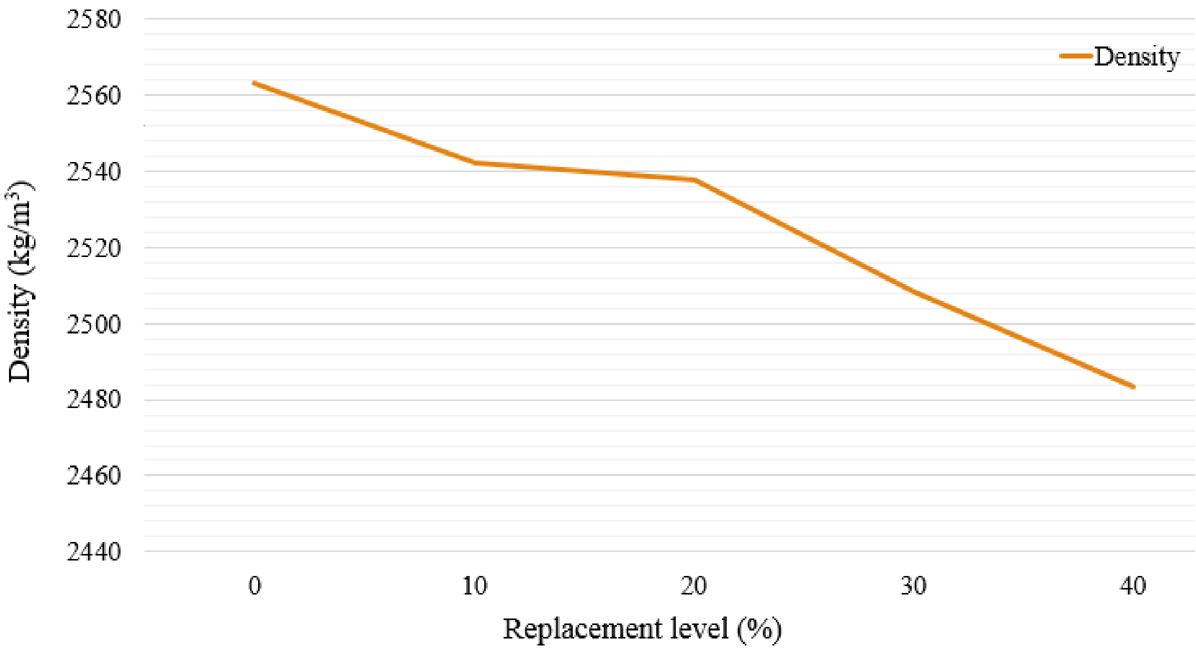


**FIGURE 1: DENSITY OF CONCRETE**

*B. Compressive Strength*

Compressive strength is the Max. Compressive stress under a gradually applied load a given solid material can sustain without fracture. Compressive strength is calculated by dividing the maximum load by the cross sectional area of a specimen in a compression test. The test results are tabulated in Table I.

It is clearly observed that the Compressive strength of concrete made by using BMW with replacement of sand by weight at 7 days and 28 days are decreased with increase in the replacement level as shown in Figure 2

**TABLE I COMPRESSIVE STRENGTH OF CONCRETE**

| Designation of Concrete | Replacement level of sand with bio-medical waste (%) | Average Compressive strength @ 7 days (MPa) | Average Compressive strength @ 28 days (MPa) |
|---|---|---|---|
| CM | 0 | 29.65 | 45.30 |
| BMW 10 | 10 | 27.78 | 37.11 |
| BMW 20 | 20 | 25.17 | 34.92 |
| BMW 30 | 30 | 19.14 | 31.10 |
| BMW 40 | 40 | 15.17 | 25.64 |

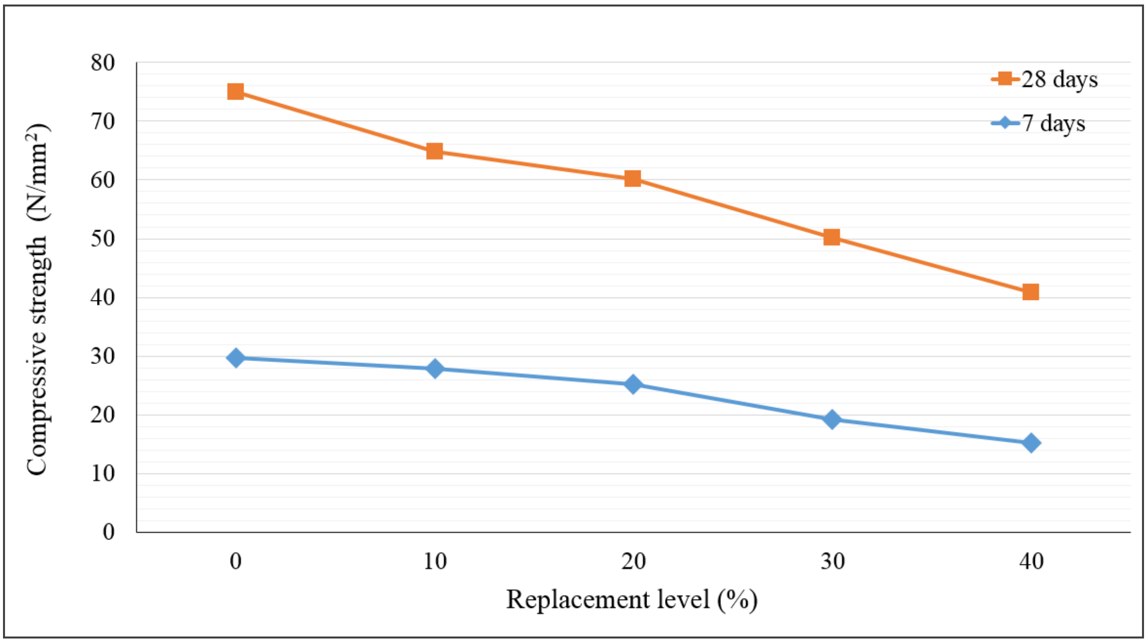


**FIGURE 2: COMPRESSIVE STRENGTH OF CONCRETE**

*C. Split tensile strength*

Splitting tension test is the test carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load is applied gradually till the failure of the cylinder, along the vertical diameter. The test results are tabulated in Table II.

From this experiment, it is clearly observed that the Split tensile strength of concrete made by using BMW with replacement of sand by weight at 7 days and 28 days are decreased with increase in the replacement level as shown in Figure 3.

**TABLE II SPLIT TENSILE STRENGTH OF CONCRETE**

| Designation of Concrete | Replacement level of sand with bio-medical waste (%) | Average Split tensile strength @ 7 days (MPa) | Average Split tensile strength @ 28 days (MPa) |
|---|---|---|---|
| **CM** | 0 | 2.19 | 4.35 |
| **BMW 10** | 10 | 1.69 | 3.61 |
| **BMW 20** | 20 | 1.49 | 3.23 |
| **BMW 30** | 30 | 1.35 | 2.51 |
| **BMW 40** | 40 | 1.14 | 1.96 |

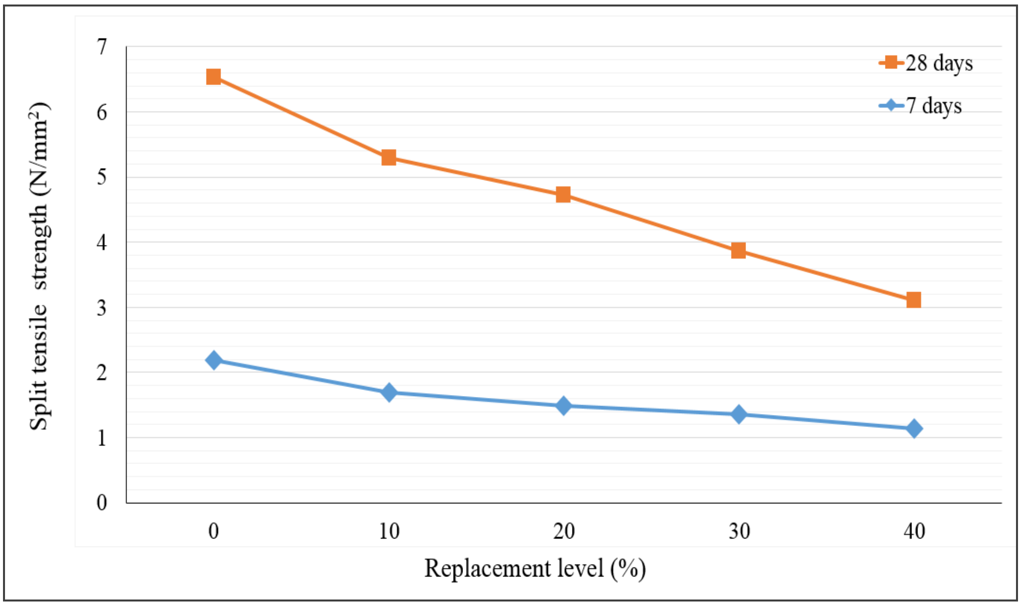


**FIGURE 3: SPLIT TENSILE STRENGTH OF CONCRETE**

## D. Flexural strength

Flexural strength test is carried out on the prism specimen of size 1500 x 100 x 100mm. Prism is placed horizontally and two point loading is applied to it as per IS 516 – 1959.

From this experiment, it is evident that the flexural strength of concrete made by using BMW with replacement of sand by weight at 7 days and 28 days are decreased with replacement level as shown in Figure 4 and Table III.

TABLE III FLEXURAL STRENGTH OF CONCRETE

| Designation of Concrete | Replacement level of sand with bio-medical waste (%) | Average Flexural strength @ 28 days (MPa) |
|---|---|---|
| **CM** | 0 | 4.13 |
| **BMW 10** | 10 | 4.09 |
| **BMW 20** | 20 | 3.81 |
| **BMW 30** | 30 | 3.28 |
| **BMW 40** | 40 | 3.18 |

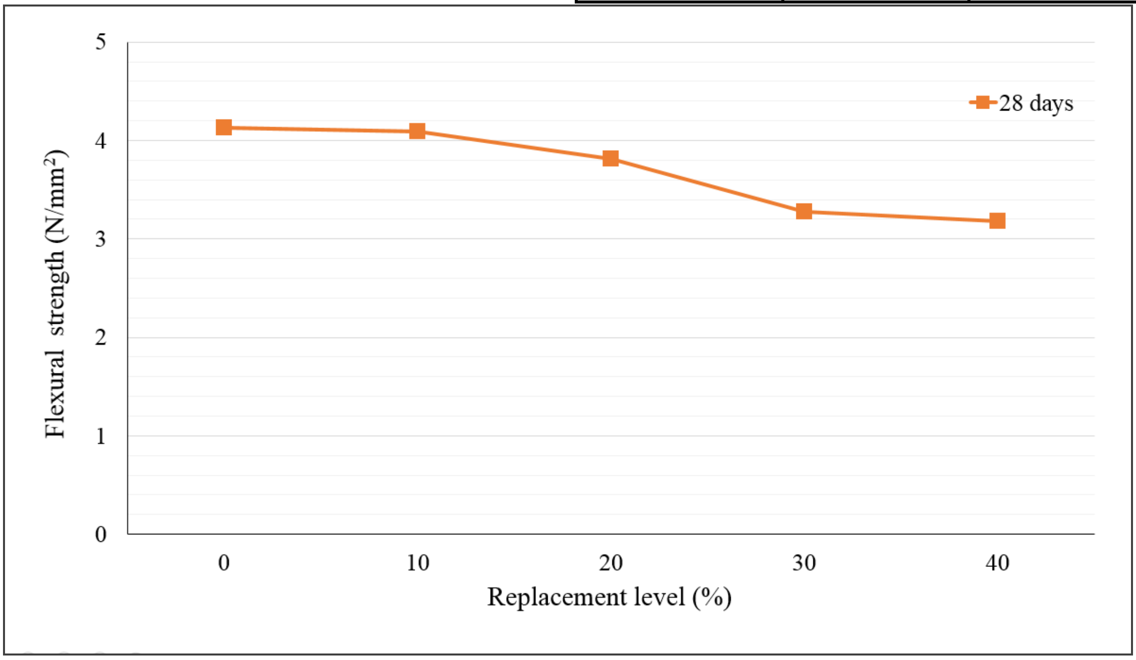


FIGURE 4: FLEXURAL STRENGTH OF CONCRETE

## E. Ultrasonic Pulse Velocity

The Ultrasonic Pulse Velocity test results of all the mixes are given in Table IV. The maximum velocity of 3.7 km/s was observed for the control mix.

According to IS 13311 (Part 2) : 1992, concrete are categorised as excellence, good, medium and doubtful for 4.5km/s and higher, 3.5 – 4.5 km/s, 3 - 3.5 km/s, and less than 3 km/s respectively.

It was concluded from the result that due to the addition of BMW, velocity get decreased. This was due to the presence of voids when compared to the control mix.

TABLE IV ULTRASONIC PULSE VELOCITY TEST

| Designation of Concrete | Pulse Velocity (km/sec) | Concrete quality |
|---|---|---|
| **CM** | 3.7 | Good |
| **BMW 10** | 3.51 | Good |
| **BMW 20** | 3.34 | Medium |
| **BMW 30** | 3.24 | Medium |
| **BMW 40** | 3.14 | Medium |

### F. Young's modulus

The young's modulus test was conducted on cylindrical specimen as per IS 2854: 1990. results of all the mixes are given in Table IV. The maximum velocity of 3.7 km/s was observed for the control mix

From this experiment, it is evident that the young's modulus of concrete made by using BMW with replacement of sand at 28 days are decreased with replacement level as shown in Table V and also compared with the theoretical value (5000 √fck).

**TABLE V YOUNG'S MODULUS OF CONCRETE**

| Designation of concrete | Modulus of Elasticity $E_c$ (MPa) | |
|---|---|---|
| | *Experimental value* | *Theoretical Value (5000 √fck)* |
| **CM** | 32666.67 | 33652.64 |
| **BMW 10** | 28667.67 | 30458.99 |
| **BMW 20** | 27647.06 | 29546.57 |
| **BMW 30** | 25181.82 | 27883.69 |
| **BMW 40** | 23766.67 | 25317.98 |

### G. Rapid Chloride Penetration Test

The Rapid Chloride Penetration Test (RCPT) was conducted on cylindrical specimen of size 100mm diameter and 50 mm height. NaCl and NaOH solution on left and right hand side of the test cell respectively, 60 volt potential was applied for 6 hours.

From this experiment, it is evident that the chloride permeability on concrete is very low for control mix and upto 30% replacement and for 40% replacement the value was Low. It shows the concrete was least permeable. The test results are tabulated in Table VI.

**TABLE VI RAPID CHLORIDE PENETRATION TEST**

| Designation of Concrete | Charge passed (Coulombs) | Chloride permeability |
|---|---|---|
| **CM** | 511 | Very Low |
| **BMW 10** | 475 | Very Low |
| **BMW 20** | 583 | Very Low |
| **BMW 30** | 758 | Very Low |
| **BMW 40** | 1838 | Low |

### H. Permeability Test

The Water Permeability was conducted on cube specimen of size 150mm. Water is applied at a constant pressure of 10kg/sq.cm as per IS 3085: 1965.

From this experiment, it shows the depth of penetration value get increased as compare to control mix.It is evident that the voids get increased as the replacement level get increased. The results are shown in Table VII.

**TABLE VII PERMEABILITY TEST ON CONCRETE**

| Designation of Concrete | Depth of penetration (mm) |
|---|---|
| **CM** | 51 |
| **BMW 10** | 74 |
| **BMW 20** | 102 |
| **BMW 30** | 138 |
| **BMW 40** | 189 |

### I. Flexural behaviour of BMW beam

The beam of size 1500mm x 150mm x 180mm were casted for control mix and optimized BMW mix (10% replacement). After 28 days of curing, the beams were tested as simply supported two point loading beam. Deflection was noted under the load point and also in the center of the beam. The results are tabulated in Table VIII.

**TABLE VII DEFLECTION AT L/2 AND L/3 DISTANCE**

| Load | Deflection at L/2 distance | | Deflection at L/3 distance | |
|---|---|---|---|---|
| | *CM* | *BMW 10%* | *CM* | *BMW 10%* |
| 0 | 0 | 0 | 0 | 0 |
| 10 | 0.13 | 0.11 | 0.07 | 0.11 |
| 20 | 0.26 | 0.24 | 0.15 | 0.24 |
| 30 | 0.38 | 0.40 | 0.24 | 0.43 |
| 40 | 0.47 | 0.59 | 0.32 | 0.60 |
| 50 | 0.58 | 0.77 | 0.43 | 0.77 |
| 60 | 0.79 | 0.91 | 0.64 | 0.90 |
| 70 | 0.93 | 1.13 | 0.75 | 1.10 |
| 80 | 1.18 | 1.47 | 0.99 | 1.40 |
| 90 | 1.40 | 1.76 | 1.20 | 1.64 |
| 100 | 1.65 | 2.05 | 1.43 | 1.90 |
| 110 | 1.88 | 2.38 | 1.66 | 2.19 |
| 120 | 2.13 | 2.60 | 1.88 | 2.38 |
| 130 | 2.40 | 2.87 | 22.09 | 2.62 |
| 140 | 2.71 | 3.13 | 2.42 | 2.85 |
| 150 | 2.94 | 3.48 | 2.61 | 3.15 |
| 160 | 3.12 | 3.75 | 2.79 | 3.38 |
| 170 | 3.40 | 4.01 | 3.01 | 3.62 |
| 180 | 3.64 | 4.25 | 3.20 | 3.85 |
| 190 | 3.93 | 4.61 | 3.49 | 4.11 |
| 200 | 4.17 | 4.94 | 3.74 | 4.46 |
| 210 | 4.51 | 5.46 | 4.01 | 4.90 |
| 220 | 4.84 | 5.91 | 4.30 | 5.24 |
| 230 | 5.30 | 6.45 | 4.70 | 5.76 |
| 240 | 6.50 | 7.34 | 5.23 | 6.56 |
| 250 | 7.50 | 8.45 | 5.73 | 7.35 |

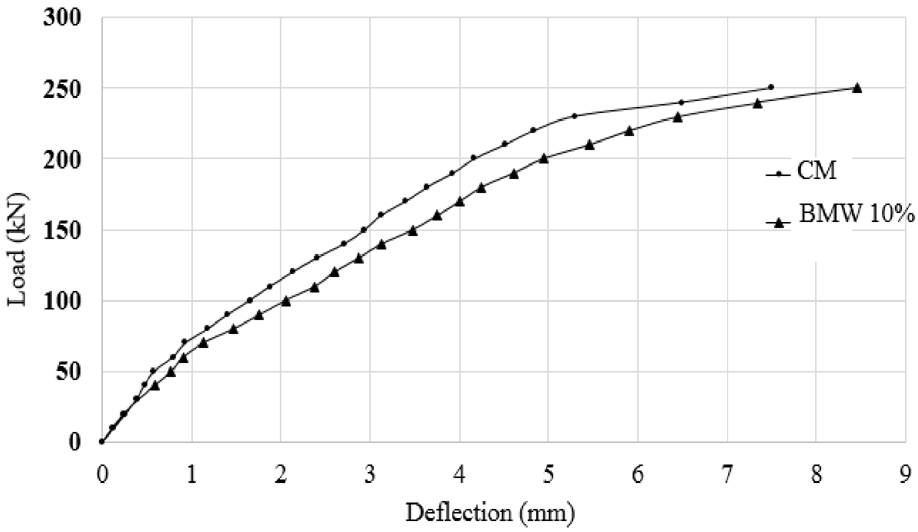


**FIGURE 5: LOAD DEFLECTION CURVE AT L/2 DISTANCE**

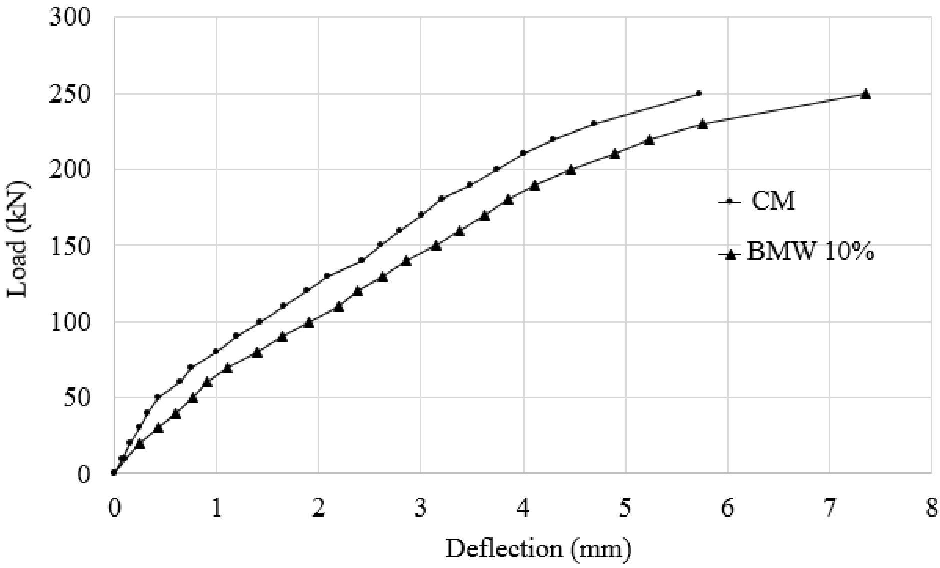


**FIGURE 6: LOAD DEFLECTION CURVE AT L/3 DISTANCE**

The Ultimate load carrying capacity of control mix and BMW 10% concrete beams were 294 & 299 respectively.

## *IV. CONCLUSION*

On the basis of the results obtained during the experimental investigation, following conclusions are drawn

(i) It is observed that density of concrete decreased marginally with the increase in the replacement level of BMW.

(ii) Compressive strength, Split tensile strength, Flexural strength of concrete made using BMW is lesser than that of conventional concrete.

(iii) It is observed that UPV test for control mix and 10% replacement concrete is termed as good quality concrete.

(iv) RCPT result show that the chloride penetration is very low upto 30% replacement level.

(v) The permeability of concrete get increased marginally with increase in replacement level.

(vi) After comparing all the experimental test results, 10% replacement level is taken as the optimized percentage.

(vii) It is evident that load-deflection curve of control mix is similar to that of the optimized percentage.

(viii) The ultimate load carrying capacity of control beam is much more similar to that of the optimized percentage.

## REFERENCES


[1] Al-Rawas AA, Hago AW, Taha R and Al-Kharousi K, "Use of incinerator ash as a replacement for cement and sand in cement mortars." Volume 40, Issue 9, Pages 1261–1266, 2005.

[2] Altin S, Altin A, Elevli B and Cerit O , "Determination of hospital waste composition and disposal methods: a case study." Polish Journal of Environmental Studies Vol. 12, No. , 251-255,2003.

[3] Azni I and Katayon S, "Characteristics of slag produced from incinerated hospital waste." Volume 93, Issue 2, Pages 201–208, 2002.

[4] Azni I, Katayon S, Ratnasamy M and Johari MMNM, "Stabilization and utilization of hospital waste as road and asphalt aggregate." Volume 7, Issue 1, pp 33-37, 2005.

[5] Clozel-Leloup B, Bodenan F and Piantone P (1999). Bottom ash from municipal solid waste incineration: mineralogy and distribution of metals, in: Mehu J, Keck G, Navarro A (ed) STAB & ENV 99.

[6] Cobo M, Galvez A, Conesa JA and de Correa CM, " Characterization of fly ash from a hazardous waste incinerator in Medellin, Colombia ", Volume 168, Issues 2–3, Pages 1223–1232, 2009.

[7] Filipponi P, Polettini A, Pomi R and Sirini P, "Physical and mechanical properties of cement based products containing incineration bottom ash.", Volume 23, Issue 2, Pages 145–156,2003.

[8] Genazzini C, Giaccio G, Ronco A and Zerbino R, "Cement-based materials as containment systems for ash from hospital waste incineration.", Volume 25, Issue 6, Pages 649–654, 2005.

[9] Gidarakos E, Petrantonaki M, Anastasiadou K and Schramm KW, "Characterization and hazard evaluation of bottom ash produced from incinerated hospital waste." Volume 172, Issues 2–3, Pages 935–942, 2009.

[10] IS 12269:1993, Specification for 53 grade Ordinary Portland cement, Bureau of Indian Specifications, New Delhi, India.

[11] IS 383-1970, Specifications for Coarse and Fine aggregates from natural sources for concrete.