

Behaviour of Carbide Waste Concrete at Elevated Temperatures

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ABSTRACT: Concrete is a combination of construction material composed of cement and water combined with fine aggregate, coarse aggregate in proper proportions. The investigation is carried out mainly in two phases. The first phase of investigation is carried out to study the compressive strength of carbide waste concrete for one standard grade (M40) and one high grade (M60) by maintaining the water cement ratio constant and by replacing cement with carbide waste in varying proportions by using absolute volume method. The design mixes were prepared by adopting the IS code, IS: 10262-2009 for M40 and Erntroy and shaklock method for M60 high grade. To know the performance of the carbide waste concrete when compared with the conventional concrete totally 170 cubes are casted which are of 150x150x150 mm size in which 85 cubes are for each grade of concrete. samples with and without carbide at different proportions of 0%,5%,15%,20% were casted. In second phase the compressive strength is found out for each specimen after heated to different elevated temperatures from 200⁰c to 800⁰c for 2 hours and cooled to room temperature.

The experimental results shows for M-40 grade at 10% of carbide waste there is a 11 % of increase of compressive strength when compares to normal concrete, after furnace test there is a 6% of more compressive strength at 200⁰c, 28% more compressive strength at 500⁰c and 31% more compressive strength at 800⁰c. For M-60 grade concrete at 5% of carbide waste there is an 10% increase of compressive strength when compared to normal concrete, after furnace test there is 8% of more compressive strength at 200⁰c, 12% of more compressive strength at 400⁰c and 44% of more compressive strength at 800⁰c.

KEYWORDS: compressive strength, concrete cubes, carbide waste, elevated temperature.

I. INTRODUCTION

The response to fire of reinforced concrete (RC) members is mainly by the characteristics of constituent materials, namely, concrete and reinforcing steel. These responses include (1) thermal properties, (2) mechanical properties, (3) deformation properties, and (4) material specific characteristics such as spalling in concrete. The thermal properties clarifies the extent of heat transfer to the structural member, whereas the mechanical properties of constituent materials determine the extent of strength loss in member. mechanical properties, determine the extent of deformations and strains in the structural member. Fire induced spalling of concrete is a significant charecterstics in the fire performance of RC members. These properties are function of temperature and depend on the composition and characteristics of concrete mainly. Thus, the main focus of this paper is on the effect of temperature on strength properties of concrete.

A. Properties influencing fire resistance

The response to fire of reinforced concrete (RC) members is mainly depends on the characteristics of constituent materials, namely, concrete and reinforcing steel. These chacteristics are (a) mechanical properties, (b) thermal properties, (c) deformation properties, and (d) material specific characteristics such as deteoration of concret like spalling. The extent of heat transfer is determined by the to the structural member, whereas the mechanical properties of constituent materials tells us the extent of strength loss and deterioration of the member. In addition, spalling of concrete due to the temperatures can play a main charestricts role in the fire performance of RC members. These properties determines a function of temperature and depend on the composition and characteristics of concrete as m a i n l y a n d also as those of the reinforcing steel.

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B. Thermal properties

The thermal properties that influence temperature rise and distribution in a concrete structural member are mainly thermal diffusivity, thermal conductivity, and specific heat. Conducting the heat is the property of thermal conductivity. Concrete contains moisture at various forms, and these forms have various influences. Thermal conductivity can be studied by two methods mainly by “steady state” or “transient” test methods. Mostly transient methods are preferred to measure thermal conductivity of moist concrete over steady-state methods. Specific heat is highly influenced by moisture content, aggregate type, and density of concrete.

C. Mechanical properties

The mechanical properties that determine the fire performance of RC members are modulus of elasticity, compressive and tensile strength, and stress-strain response of constituent materials at elevated temperatures. Compressive strength of concrete at various temperatures depends upon water-cement ratio, curing conditions, aggregate type and size, admixture types, and type of stress. Compressive strength of concrete is highly influenced by room temperature strength, rate of heating, and binders in batch mix (such as silica fume, fly ash, and slag). The decrease in strength of HSC is not consistent and there are particular variations in strength loss. The compressive strength of concrete is much greater than tensile strength, due to ease with which cracks can propagate under tensile loads. Tensile strength ratio is further decreased. Therefore, tensile strength of concrete is often neglected in strength calculations at elevated temperatures.

D. Deformation properties

The thermal expansion and creep of the concrete determine the fire performance of reinforced concrete members and reinforcement at elevated temperatures. In addition, transient strain that occurs at elevated temperatures in concrete can enhance deformations in fire-exposed concrete structural members.

E. Need for the present work

Appearance of cracks and spalling of concrete is an unavoidable phenomenon during the aging process of concrete structures when exposed to various weather changes. These types of cracking lead to easy passage for aggressive environment to reach the reinforcement and lead to initiate corrosion. Many admixtures are used for the behaviour of concrete at elevated temperatures. However, the concrete may lead to the appearance of cracks on surface at some particular temperature. This experiment may investigate the structural resistance to elevated temperature.

Generally, we use code-specified stress-strain relation in the analysis and design, but generally they are recommended for normal concretes only. Now, as the advancement in concrete technology has been treated the use of modern concretes like bacterial concrete, fire resistance concrete etc., the behaviour of carbide waste concrete at various temperatures is to be used in design. For structural behaviour of concrete at elevated temperatures, many models based on experimental investigation have been reported in the literature. It is important to propose a similar model for carbide waste concrete also.

F. Objectives of thesis

1. To investigate the compressive strength of concrete with various percentages of carbide waste in cement.
2. To study the compressive strength of the various percentages of carbide waste concrete for one nominal grade (M40) and one high grade (M60) concrete at different elevated temperatures.

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II. RELATED WORK

A. Procurement of materials

The materials used for the investigative study of carbide waste Concrete are given below.

- i. Cement
- ii. Fine aggregate
- iii. Coarse aggregate
- iv. Water
- v. Carbide waste

1) Cement :

Ordinary Portland cement of 53 grade confirming to IS: 12269 were used. Physical properties of cement as per IS :12269-1999 were tested at the concrete testing laboratory in our college. The normal consistency and specific gravity of the cement used are 33.70% and 3.15 respectively Properties of Portland cement for (53 grade) for M-40 and M-60

2) Water :

The least expensive but the most important ingredient of concrete is water. The water which is used for mixing concrete should be clean and free from harmful impurities such as oil, alkali, acid etc. Potable water was used for the mixing and curing work in the project.

3) Carbide waste:

CW is the remnant of oxy-acetylene gas used in welding industries. It is whitish in colour. The whitish colour material which was regarded as waste and ordinarily posed environmental nuisance in open-dump sites located at strategic places within the societies is now considered as binder in partial replacement for expensive. This material is dried in the sun in an open field for a period of one week, grinded and then sieved to cement fineness.



Image of carbide waste

B. Phase II

Phase II is about the mixing of cement mortar and curing of cement mortar specimens.

1) Mixing of Cement Mortar

The following mix cases have been considered for both normal cement mortar and Carbide waste cement mortar for both M-40 and M-60 grade concrete

- i. Normal cement mortar mix with 0% 5%,10%,15%,20% replacement of c/w..

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2) Moulding and Demoulding of specimens

A total 450 specimens were casted during the project work, 225 specimens of M-40 grade and 225 specimens of M-60 grade concrete are casted for each of the five mix cases considered. The specimens of cube size 150mm X 150mm X 150mm were casted. After curing the moulded specimens was stored in the laboratory at the room temperature for 24hours. After this period, the specimens were demoulded and submerged in clean, fresh water of the curing tank.

3) Ages of curing

The specimens were cured for 28days. A total of specimens for each period of curing for each of five mix cases were tested and the recorded details of the testing procedure and the results are given in following sections.

C. Phase III

1) Mixing of cement concrete

Three mix cases with M-40 grade and M-60 grade of concrete have been considered for both normal concrete and carbide waste concrete. The mix design is adopted as per IS: 10262-2009 for M-40 and Erontrou and shacklok method for M-60 mixes as follows.

i. Normal mix case of concrete in M-40 grade as per IS: 10262-2009 by using is IS: 10262-2009 and Erontrou and shacklok method 0% ,5%,10%,15%and 20% of carbide waste was used to replace in place of cement.

2) Test on Fresh Concrete

i. Slump test

The slump test is the most widely used and plays an important role in performance of concrete because of the simplicity of the apparatus required. The slump test indicates the behaviour of the concrete under the action of gravitational forces that further helps us in understanding its behaviour. The test is carried out with a mould called the slump cone. The slump cones placed on a horizontal and a non-absorbent surface and with a standard tamping rod filled in three equal layers of fresh concrete, each layer being tamped 25times. The top layer is levelled and the mould is lifted vertically without disturbing the concrete cone. The decrease in its height of the concrete in millimetres is termed as slump. The slump value gives the measure of the consistency or the wetness of the mix. This test was performed for all the mixes.

ii. Compaction factor test

This test is used to assess the workability of the concrete mix. The degree of compaction called the Compaction factor is measured by the density ratio, i.e., the ratio of the density actually achieved in the test to the density of the same concrete fully compacted. Based on the compaction factor the workability of the mix is evaluated. This test was also performed for all the mixes.

A slump of 50mm to 100mm and percentage of compaction of 0.90 approximately shows the medium workability condition. However the workability is within the limits and it is found that there is no difference in the workability aspects during the formation of normal and carbide waste concretes. The details of workability conditions for both normal or control concrete and carbide waste concretes are tabulated in Table3.6 and Table3.7 respectively as follows.

% of carbide waste	Slump in 'mm'	Percentage of compaction	Degree of Workability
0%	85.00	0.95	Medium
5%	80.00	0.88	Medium
10%	74.00	0.86	Medium
15%	69.00	0.86	Medium
20%	64.00	0.85	Medium

Table.1 Workability, Slump and Compaction factor of Carbide waste Concrete for M-40 grade

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The table 1 shows the results of the workability for M-40 grade concrete . it is clearly observed that the concrete at various proportions shows the medium workability of the concrete. Hence it is acceptable for the construction.

% of carbide waste	Slump in 'mm'	Percentage of compaction	Degree of Workability
0%	33	0.80	Low
5%	28	0.74	Low
10%	25	0.74	Low
15%	22	0.73	Low
20%	20	0.72	Low

Table.2 Workability, Slump and Compaction factor of Carbide waste Concrete for M-60 grade

The table2 shows the results of the workability for M-40 grade concrete . it is clearly observed that the concrete at various proportions shows the low workability of the concrete. Hence suitable measures are to be taken for attaining the suitable workability during construction.

iii. Moulding and Demoulding of Specimens.

A total of 90 cubes were casted during the project work which includes casting of 45cubes specimens of M-40 and 45cubes specimen of M-60 grade at various percentages replacements of carbide waste. The details of dimensions of specimens are specified below. After the moulding specimens were stored in the laboratory at the room temperature for 24hours, there after specimens were demoulded and submerged in clean, fresh water of the curing tank .

iv. Specimens Moulded

Specimens moulded: Cubes specimens

- Cube size: cube moulds of 150x150x150mm size
- Number of cubes : 9cubes at 0% c/w+ 9cubes at 5% c/w+ 9cubes at 10% c/w +9cubes at 15% c/w+9 cubes at 20% c/w
- Total number of cubes cast:45for M-40 and for M-60 =90 cubes

v. Ages of Curing

- The cubes specimens were cured for 28days for normal and carbide waste concrete samples.
- After curing, the cube specimen are tested and the recorded details of the testing procedure and the results are given in the following sections.

D. PHASE IV

- Phase IV is about the testing procedure for evaluating the strength parameters of cement mortar & concrete specimens.

1) Testing Procedure

- The concrete specimens considered in this investigation programme have been subjected to the following tests.

2) COMPRESSION TEST

Compression test has been conducted confirming to IS 516-1959(5), on the concrete specimens in the universal testing 200MT at osmania university laboratory. In this test, cube is placed with the cast faces not in contact with the planes of testing machine i.e., the position of the cube when tested is at right angles to that cast. Load has been applied at a constant rate of stress equal to 15 Mp/min according to relevant IS code and the load at which the specimens failed has been recorded. Thus from the results, compressive strengths of the specimens have been obtained. After obtaining the results of samples, they have been recorded.

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3) Furnace test

In this test each cube of varying proportions i.e. from 200°C to 800°C of carbide waste is heated at different elevated temperature. At each temperature two cubes of same percentage of carbide waste concrete cubes are heated for equal intervals of time and each cube is cooled to normal room temperature after heated. Once the cubes are cooled to normal room temperature each cube is tested under compression using UTM to find out the compressive strength of the each cube.

Compressive strength

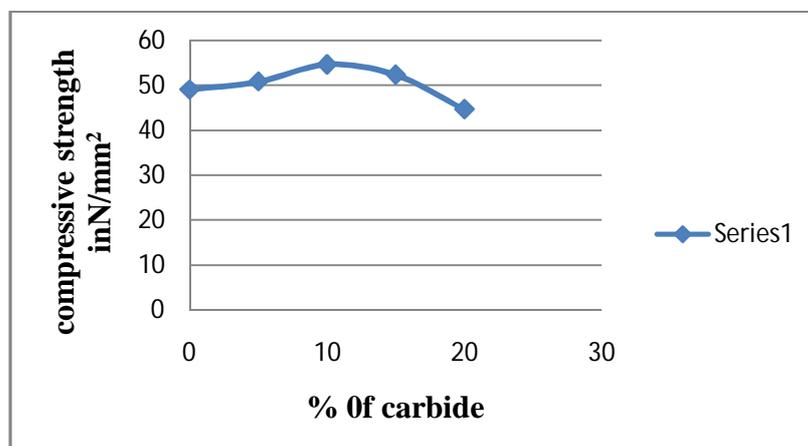
The most common of all the parameters is the compressive strength because it is a desirable characteristics of concrete and also quantitatively related to compressive strength

III. EXPERIMENTAL RESULTS

Serial no	loading values obtained after 28 days of curing in kn					average compressive strength in N/mm ²
	% c/w	Sample 1	Sample 2	Sample 3	Average	
1	0%	1120	1085	1145	1116.66	49
2	5%	1145	1095	1130	1123.33	49.9
3	10%	1220	1235	1235	1230	54.66
4	15%	1200	1125	1260	1195	53.11
5	20%	1025	1010	1020	1018.33	45.52

Table.3. Compressive strength for M40 grade(28 days)

The table 3 shows the various compressive strength of the concrete at various proportions of the carbide waste concrete. It is clearly observed that at 10 percentage replacement of carbide waste the compressive strength of the concrete is maximum.



Graph 1: showing the compressive strength values for various proportions of carbide waste for M40 grade

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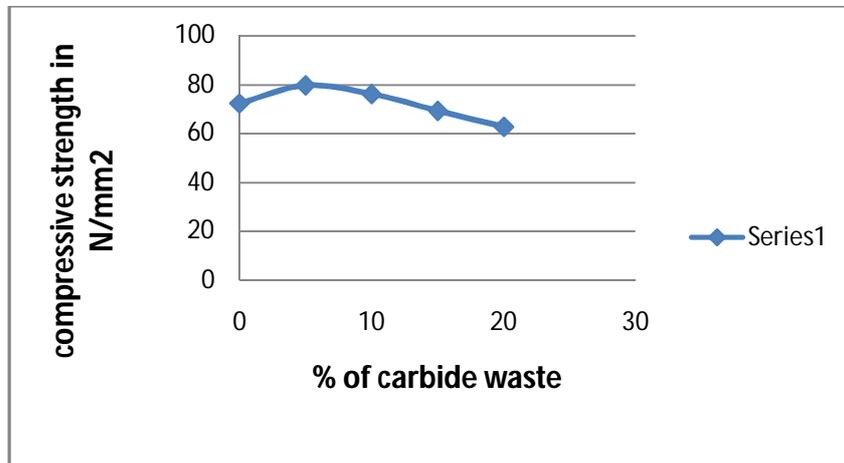
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Serial no	loading values obtained after 28 days of curing in kn					Average compressive strength in n/mm ²
	c/w	Sample1	Sample 2	Sample 3	Average	
1	0%	1655	1625	1625	1635	72.67
2	5%	1770	1800	1795	1788.33	79.48
3	10%	1730	1710	1700	1713.33	76.13
4	15%	1555	1565	1560	1560	69.33
5	20%	1430	1395	1420	1415	62.8

Table 4: Compressive strength values for M60 grade(28 days)

The table 4 shows the various compressive strength of the concrete at various proportions of the carbide waste concrete. It is clearly observed that at 5 percentage replacement of carbide waste the compressive strength of the concrete is maximum



Graph 2: showing the compressive strength values for various proportions of carbide waste for M60 grade

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Serial .no	Loading values obtained after heating the cubes to different temperatures in kn					
	C/W	0%	5%	10%	15%	20%
1	Temp 200°c	1144	1153	1218	1215	1003
2	300°c	1153	1180	1180	1202.5	1002.5
	Avg					
3	400°c	1065	1210	1246	1098	900
	Avg					
4	500°c	998	1213	1288	986	784
	Avg					
5	600°c	928	1172	1233	898	722
	Avg					
6	700°c	856	1093	1158	843	635
	Avg					
7	800°c	815	1008	1063	756	633
	Avg					

Table5: M40 grade loading values after heated to different temperatures which were cooled to room temperature

	Compressive strength values in N/mm ² for various					
	C/W	0%	5%	10%	15%	20%
	Temperature					
1	200°c	50.84	52.3	54.3	54	44.5
2	300°c	51.2	52.4	52.4	53.44	44.55
3	400°c	47.33	53.77	55.33	48.77	40.00

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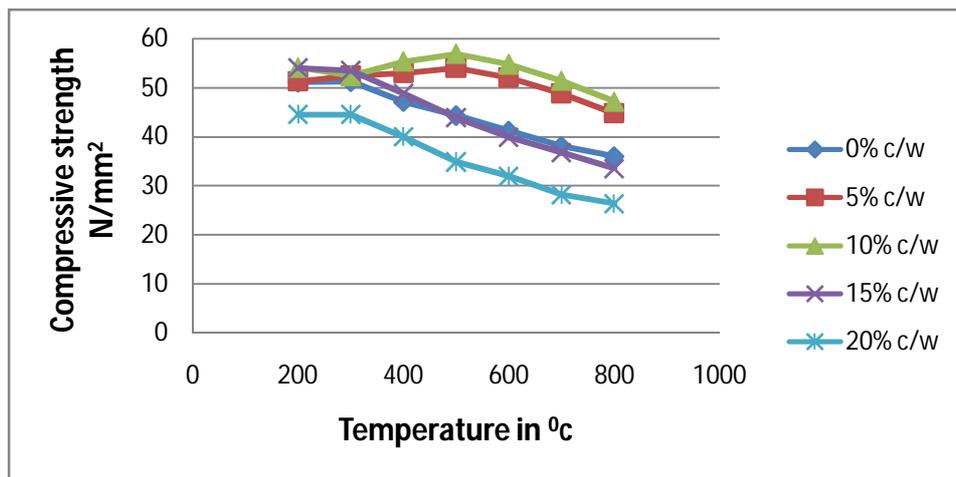
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4	500°c	44.33	53.90	57.29	43.88	34.88
5	600°c	41.22	52.00	54.8	39.9	32.00
6	700°c	38.04	48.57	51.46	37.46	28.22
7	800°c	36.22	44.8	47.24	33.6	28.2

Table6: Compressive strength values of M40 grade after heated to elevated temperatures



Graph 3: M40 Line Graph of Specimen Compressive Strength at Varying Temperatures

Serial .no	Loading values obtained after heating the cubes to different temperatures					
	C/W	0%	5%	10%	15%	20%
1	Temp					
	200°c	1655	1793	1710	1520	1403
	Avg					
2	300°c	1623	1815	1675	1525	1404
	Avg					
	400°c	1622	1810	1664	1518	1283

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3	Avg					
4	500°c	1463	1733	1523	1372	1174
	Avg					
5	600°c	1312	1643	1418	1352	1036
	Avg					
6	700°c	1172	1583	1351	1298	973
	Avg					
7	800°c	992	1444	1332	1123	858
	Avg					

Table.7 Loading values obtained after heating the cubes to different temperatures in KN for M-60 grade

Serial no	C/W	0%	5%	10%	15%	20%
		Compressive strength values in N/mm²				
	Temperature					
1	200°c	73.55	79.6	76	67.55	63.55
2	300°c	72.133	80.66	74.44	67.77	62.4
3	400°c	72.2	80.44	73.94	67.4	57.02
4	500°c	65.02	77.02	67.68	60.97	52.17
5	600°c	58.3	73.02	63.02	60.08	46.04
6	700°c	52.08	70.355	60.02	60.08	46.04
7	800°c	44.08	64.17	59.2	49.9	38.2

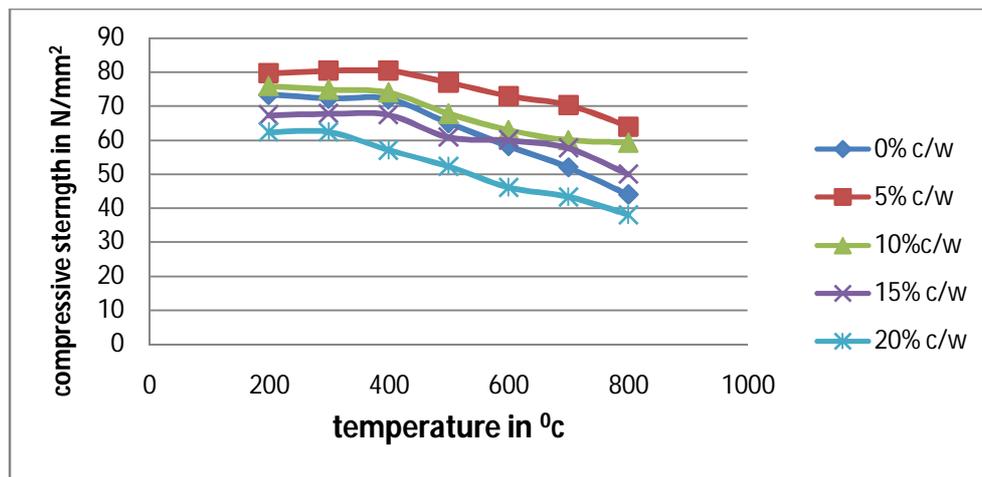
Table .8 Compressive strength values of M-60 grade concrete

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Graph M60 Line Graph of Specimen Compressive Strength at Varying Temperatures

IV. CONCLUSION

A. Compressive Strength of Concrete

The typical development of compressive strength for the control and blended cement concretes thermally treated at various degrees temperature for 2 hours. It was observed that the compressive strength of control specimen increased with temperature up to 300°C for 5% and 10% and for and then decrease up to 800°C. It was also observed that the compressive strength of carbide waste concrete increases as the treatment temperature increased up to 500°C for the partial replacement of 5% and 10% of carbide waste then decrease as the temperature increased up to 800°C. The increase in compressive strength in the control specimen up to 300 °C may be due to the additional hydration of unhydrated cement grains as a result of steam effect under the condition of so called internal autoclaving effect. The increase in compressive strength of the blended cement concrete specimens up to 500 °C may be due to the reaction of the admixture (CW) with the free lime to produce more CSH and CAH which deposit in the pore system. The compressive strength of the control started to decrease at 300°C whereas those of the blended cement started to decrease at 500°C. This phenomenon is contributed to higher volume of CSH and CAH phases formed in the blended cement concrete on one hand and reduction in Ca(OH)₂ contents on the other hand relative to those developed in control specimen

B. CONCLUSIONS

1) Benefits and drawbacks

Based on the present experimental investigation the following conclusions are drawn.

- Addition of carbide waste powder has an effect on workability aspects of concrete or it can be concluded that there is a change in the workability aspects of carbide waste concrete when compared with respect to normal (or) control concrete.
- When the percentage of addition of carbide waste is replaced in the cement increases the workability of the concrete goes on decreasing.
- The partial replacement of carbide waste with 5% ,10%,15% and 20% has shown the 50 to 100mm workability for M-40 grade .

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- The partial replacement of carbide waste with 5% ,10%,15% and 20% has shown the 25 to 50mm workability for M-60 grade.

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