International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 3, March-April 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Assessment of Mechanical Properties of Concrete Incorporated with GGBS and MSMW

R. Murugaboopathy

Lecturer, Civil Engineering, P.A.C. Ramasamy Raja Polytechnic College, Rajapalayam, Tamil Nadu, India

ABSTRACT

The construction industries rely heavily on the availability of sand and cement for its operations in the development of houses and other infrastructural facilities. It then turns into extremely complicate for majority of the people to construct their own buildings. Various researchers in the recent past had looked into the utilization of industrial wastes to partially substitute of sand and cement. The partial replacement of cement with GGBS and sand with Mild Steel Metal Waste (MSMW) in the manufacturing of concrete is a greet development in India. The cost of GGBS and MSMW is negligible due to their availability in huge volume from the industries. The utilization of GGBS and MSMW will promote waste management at little cost, reduce pollution and enhance the strength. Therefore it is suggested to determine the mechanical properties of concrete containing various proportions of GGBS and MSMW. The main objective of this study is to investigate the suitability of GGBS and MSMW as partial replacement for cement and sand in concrete. The research results reports that when the cement and sand replaced with GGBS and MSMW, the maximum compressive strength of concrete cube was achieved when the cement and sand are replaced using both GGBS and MSMW at 5% respectively. At the same time, maximum splitting tensile strength of concrete cylinder was obtained when the cement and sand are replaced using both GGBS and MSMW at 10% respectively.

KEYWORDS: *GGBS, MSMW, Cube compressive strength, Cylinder splitting tensile strength*

How to cite this paper: R. Murugaboopathy "Assessment of Mechanical Properties of Concrete Incorporated with GGBS and MSMW" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-3, April 2022, pp.2130-2136, URL: www.ijtsrd.com/papers/ijtsrd49866.pdf

IJTSRD49866

1. INTRODUCTION

Concrete is a composite material, it consists of gravel and sand, both are used as filling materials, cement used as binding material, and water used to produce chemical reaction [1]. Concrete is a most important material used in construction industries. It contributed enormously to the growth of society for the construction of infrastructure, bridges, road pavements and underground sewerage system works. Concrete has massively gain from the consuming of fly ash, GGBS and Silica fumes even though it is costly, it has also improves the durability and strength of concrete [2]. The need to overthrow the cost of disposal of industrial waste materials and the increasing the cost of construction materials has direct the way to intensive research towards the useful consumption of industrial waste materials for construction works. The protected discharge of industrial waste products demands vital and gainful solutions because of the incapacitating effect of these waste materials on the environment and the health problems. The over faith on the industrial waste materials continued to prevent the weak and poor nations of the world from providing good quality structures to meet the need of rural dwellers that compose large percentage of their population [3].

The GGBS is an excellent replacing material for cement because the molten slag has consists of important chemical composition of 30% to 40% SiO_2 and about 40% CaO, which are very close to the chemical composition of cement. The micro-structure of concrete incorporated with GGBS becomes denser which improves the durability performance of concrete. The concrete manufactured with GGBS has high volume of strength-enhancing calcium silicate hydrates than ordinary concrete [4-6]. The use of industrial waste will significantly minimize the cost of construction and as well as eliminate the environmental problems caused by such industrial wastes [7-14]. Combination of GGBS and MSMW concrete is the innovative composite material used in construction. The use of GGBS and MSMW as a partial replace for production of concrete mix is one option that can alleviate sludge disposal problem and has been studied widely in recent years. Despite of the recent studies, there are still many unknowns with the use of GGBS and MSMW. In this connection, there is lack of knowledge in the research area for the contribution of GGBS and MSMW for the manufacturing of concrete. This study also aims to determine the most suitable mix proportion that can produce concrete of desirable strength without compromising engineering performance and quality. Hence, it is proposed to utilize the GGBS and MSMW for the replacement of cement and sand respectively for the manufacturing of concrete. This research works endeavours to examine the mechanical characteristics such as Cube Compressive Strength and Splitting Tensile Strength of concrete incorporated with GGBS and MSMW.

2. OBJECTIVE OF STUDY:

- To determine the most suitable concrete mix in terms of percentage of GGBS and MSMW that produces the highest strength of concrete in compression and tension.
- To evaluate the mechanical properties, such as, compressive strength and splitting tensile strength test of concretes containing GGBS and MSMW for the partial replacement of both cement and sand respectively.

3. TESTING OF MATERIALS

Properties of materials used for this investigation are arrived by testing of fine aggregate, coarse aggregate, cement, GGBS, MSMW, water and super plasticizer are given below.

3.1. Fine Aggregate

Size: passing through 4.75mm and retaining on 0.75 micron
Specific gravity: 2.61
Fineness modulus: 3.12
Type : River sand Grade – II with angular shape

3.2. Coarse Aggregate

Size: passing through 20mm and retaining on 10mm sieve.
Specific gravity: 2.86
Fineness modulus: 3.69
Type: Crushed granite with angular shape

3.3. Cement

Fineness: 278m^2/kg
Specific gravity: 3.03
Brand : OPC 43 grade

3.4. GGBS

Specific gravity: 2.71
Bulk density: 1208kg/m^3
Fineness: 336m^2/kg

3.5. MSMW

Average Size: 1.25mm
Specific gravity: 2.69
Fineness modulus: 5.7

3.6. Water:

Ordinary potable water free from impurities with pH value 7.1 was used.

3.7. Super Plasticizer:

Product name: Conplast SP430
Appearance: Brown liquid
Specific gravity: 1.2
pH value: 7 to 8

4. MIX DESIGN:

The mix proportion of 1: 1.78: 3.19 at 0.55 water cement ratio were used were shown in Table 1 and the mix proportions for cube and cylinder specimens for the replacement of GGBS and MSMW were shown in Table 2.

The concrete samples of cube with 150mm×150mm×150mm were casted for various mix proportion as listed in Table 2 to examine cube compressive strength of concrete at the age of 28 days curing and the concrete sample of cylinder with 150mm diameter and 300mm were prepared for various mix proportions to predict the splitting tensile strength of concrete at the age of 28 days curing. The tests were conducted in the Universal Testing Machine with 60 tonne capacity to analyse the compressive strength of the cubes and splitting strength of cylinder. The super plasticizer of conplast SP 430 is used to increase workability of concrete at the rate of 1 litre per m^3 of concrete.

Table 1: Mix ratio of cement concrete

Sl. No.	Materials	Mix Proportions	
		In weight	In parts
1	Cement	357.47kg	1
2	Fine Aggregate	636.30kg	1.78
3	Coarse Aggregate	1140.33kg	3.19
4	Water	196.6lit	0.55

Table 2: Mix proportions for cube and cylinder specimens

S. No.	Sample ID	Cement (%)	GGBS (%)	Sand (%)	MSMW (%)
1	C	100	0	100	0
2	R11	100	0	95	5
3	R12	100	0	90	10
4	R13	100	0	85	15
5	R21	95	5	100	0
6	R22	90	10	100	0
7	R23	85	15	100	0
8	R31	95	5	95	5
9	R32	90	10	95	5
10	R33	85	15	95	5
11	R34	95	5	90	10
12	R35	90	10	90	10
13	R36	85	15	90	10

5. RESULTS AND DISCUSSIONS:

5.1. Compressive strength of concrete cube for the replacement of cement with GGBS and sand with MSMW at the age of 28 days curing

The Fig. 1 shows the testing of cube compressive strength of concrete. The cube compressive strength for control specimen (C) was 24.46N/mm^2 (0% replacement of both GGBS and MSMW). The specimens R11, R12 and R13 are the only replacement of sand using MSMW at 5%, 10% and 15% respectively and the cement is not replaced using GGBS. In this category, the maximum cube compressive strength was achieved when the sand is replaced by MSMW at 5% (R11) alone. The cube compressive strength of specimen R11 was 22.25N/mm^2. The cube compressive strength of other specimen (R12 and R13) was lower than the specimen R11. The compressive strength of all cube specimens (R11, R12 and R13) was lesser than control specimen (C).

Fig. 1: Testing of cube compressive strength of concrete

The specimens R21, R22 and R23 are the only replacement of cement using GGBS at 5%, 10% and 15% respectively and the sand is not replaced using MSMW. In this group, the maximum cube compressive strength was achieved when the cement is replaced by GGBS at 5% (R21) alone. The cube compressive strength of specimen R21 was 30.37N/mm^2. The cube compressive strength of other specimen (R22 and R23) was decreased than the specimen R21. In this category, the compressive strength of all cube specimens (R21, R22 and R23) was higher than control specimen (C).

The specimens R31, R32, R33, R34, R35 and R36 are replaced by both GGBS and MSMW for the replacement of cement and sand respectively. The cement is replaced with GGBS at 5%, 10% and 15%. The sand is replaced with MSMW at 5% and 10%. In this category, the maximum cube compressive strength was achieved when the cement is replaced by GGBS at 5% and the sand is replaced with MSMW at 5% (R31). The cube compressive strength for the specimen R31 was 32.61N/mm^2. The cube compressive strength of other specimen (R32, R33, R34, R35 and R36) was decreased than the specimen R31. It is observed that the cube compressive strength was higher for specimen R32 and R33 than the control specimen C and it was lower for specimen R34, R35 and R36 than control specimen C. The cube compressive strength of concrete specimen at 28 days curing was tabulated in Table 3 and the Fig. 2 shows the variation of cube compressive strength at the age of 28 days curing.

Table 3: Cube Compressive Strength of concrete at the age of 28 days curing

S. No.	Sample ID	Cement (%)	GGBS (%)	Sand (%)	MSMW (%)	Cube Compressive Strength in mpa
1	C	100	0	100	0	24.46
2	R11	100	0	95	5	22.25
3	R12	100	0	90	10	21.75
4	R13	100	0	85	15	20.57
5	R21	95	5	100	0	30.37
6	R22	90	10	100	0	29.14
7	R23	85	15	100	0	27.85
8	R31	95	5	95	5	32.61
9	R32	90	10	95	5	28.78
10	R33	85	15	95	5	26.12
11	R34	95	5	90	10	23.71
12	R35	90	10	90	10	22.24
13	R36	85	15	90	10	21.12

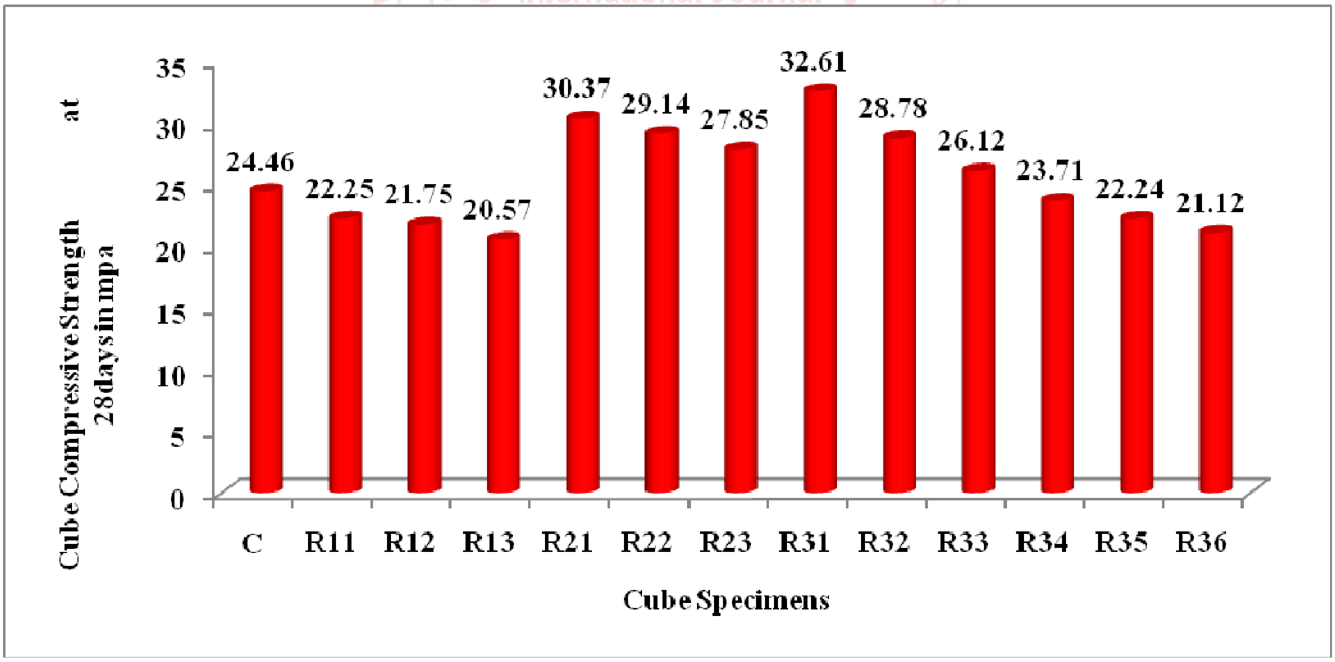

Fig. 2: Variations of cube compressive strength of concrete at the age of 28 days curing

5.2. Splitting tensile strength of concrete cylinder for the replacement of cement with GGBS and sand with MSMW at the age of 28 days curing

The Fig. 3 shows the testing of cylinder splitting tensile strength of concrete. The cylinder splitting tensile strength for control specimen (C) was 2.82N/mm^2 (0% replacement of both GGBS and MSMW). The specimens R11, R12 and R13 are the only replacement of sand using MSMW at 5%, 10% and 15% respectively and the cement is not replaced using GGBS. In this category, the maximum cylinder splitting tensile strength was achieved when the sand is replaced by MSMW at 10% (R12) alone. The cylinder splitting tensile strength of specimen R12 was 3.17N/mm^2. The cylinder splitting tensile strength of other specimen (R11 and R13) was lower than the specimen R12. The splitting tensile strength of all cylinder specimens (R11, R12 and R13) was higher than control specimen (C).

Fig. 3: Testing of cylinder splitting tensile strength of concrete

The specimens R21, R22 and R23 are the only replacement of cement using GGBS at 5%, 10% and 15% respectively and the sand is not replaced using MSMW. In this category, the maximum cylinder splitting tensile strength was achieved when the cement is replaced by GGBS at 15% (R23) alone. The cylinder splitting tensile strength of specimen R23 was 3.04N/mm^2. The cylinder splitting tensile strength of other specimen (R21 and R22) was decreased than the specimen R23. In this category, the splitting tensile strength of all cylinder specimens (R21, R22 and R23) was also higher than that of control specimen (C).

The specimens R31, R32, R33, R34, R35 and R36 are replaced by both GGBS and MSMW for the replacement of cement and sand respectively. The cement is replaced with GGBS at 5%, 10% and 15%. The sand is replaced with MSMW at 5% and 10%. In this category, the maximum cylinder splitting tensile strength was achieved when the cement and sand are replaced with both GGBS and MSMW at 10% (R35). The cylinder splitting tensile strength for the specimen R35 was 3.35N/mm^2. The cylinder splitting tensile strength of other specimen (R31, R32, R33, R34 and R36) was decreased than the specimen R35. It was noted that the cylinder splitting tensile strength was higher for all specimen (R31, R32, R33, R34, R35 and R36) than that of control specimen C. The cylinder splitting tensile strength of concrete specimen at 28 days curing was tabulated in Table 4 and the Fig. 4 shows the variation of cylinder splitting tensile strength at the age of 28 days curing.

Table 4: Cylinder Splitting Tensile Strength of concrete at the age of 28 days curing

S. No.	Sample ID	Cement (%)	GGBS (%)	Sand (%)	MSMW (%)	Cylinder Splitting Tensile Strength in mpa
1	C	100	0	100	0	2.82
2	R11	100	0	95	5	2.94
3	R12	100	0	90	10	3.17
4	R13	100	0	85	15	3.01
5	R21	95	5	100	0	2.88
6	R22	90	10	100	0	2.96
7	R23	85	15	100	0	3.04
8	R31	95	5	95	5	3.21
9	R32	90	10	95	5	3.14
10	R33	85	15	95	5	3.01
11	R34	95	5	90	10	3.27
12	R35	90	10	90	10	3.35
13	R36	85	15	90	10	3.29

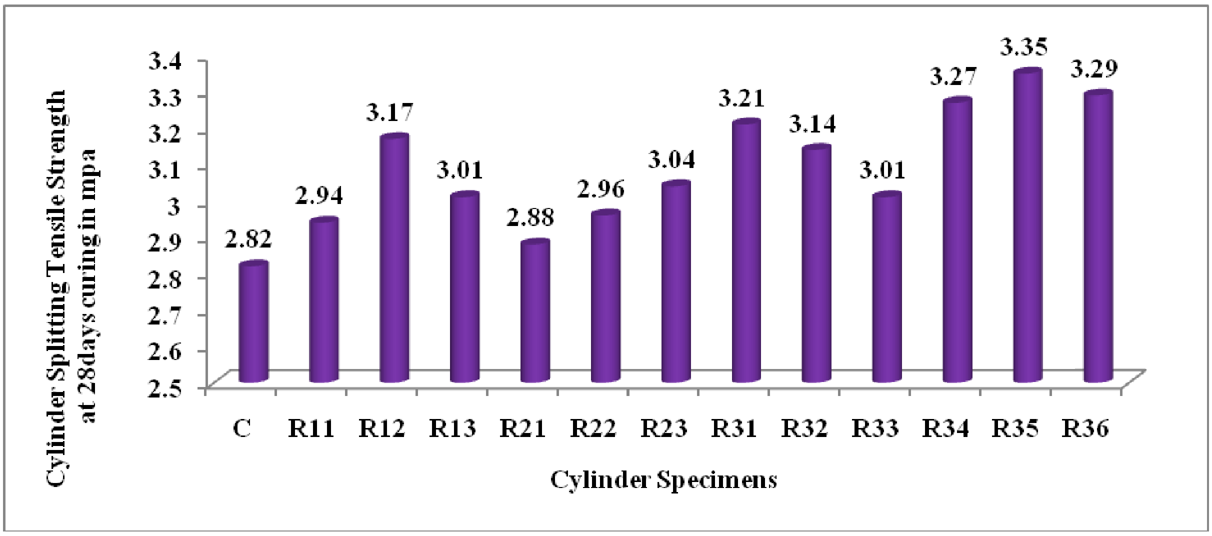

Fig. 4: Variations of cylinder splitting tensile strength of concrete at the age of 28 days curing

6. CONCLUSION

Based on the Research work conducted, the following conclusions were made, such as:

- It was observed that the maximum cube compressive strength of the specimen R31 was 32.61N/mm^2. In this case, the cement and sand is replaced at 5% with both GGBS and MSMW respectively.
- It was examined that the maximum cylinder splitting tensile strength of the specimen R35 was 3.35N/mm^2. In this case, the cement and sand is replaced at 10% with both GGBS and MSMW respectively.
- The replacement of cement and sand is replaced with GGBS and MSMW minimize the environmental pollution and also reduce the cost of construction.

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