



## Experimental Study on Partial Replacement of Msand with Ground Granulated Blast Slag

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### Abstract

Solid waste management is the major threat in these days. There are various sources in which the wastes are generated, among those the major role is played by the industries. The industries manufacture a product by giving so many by-products. These by-products are simply dumped in the land which causes pollution. So, it should be treated as well as reused in one form or another. One such by-product is the Ground granulated blast slag which is obtained from the blast furnaces used to make iron. The demand for the construction materials leads to the replacement of new materials in the concrete. Proposed idea is to use the ground granulated furnace slag in the concrete. An experimental investigation is conducted to study the properties of concrete containing the ground granulated blast slag as the replacement of the fine aggregate. The fine aggregate is the manufactured sand. The manufactured sand is widely used nowadays due to the demand and the cost of the river sand. The GGBS is replaced for the manufactured sand by 30%,35%,40% and 45%. Then the strength is obtained by carrying out compression, split tensile and the flexural tests. Then the optimization value of the GGBS is found as 30% and the effect of size of coarse aggregate is found out with the optimized value of GGBS. Then the durability tests are carried out for the acid action due to sulphate, chloride, etc., Finally, the results are discussed and the conclusions are obtained.

**Keywords:** GGBS, optimization of GGBS, effect of size of coarse aggregate, strength properties.

### 1. Introduction

Concrete is a mixture of cement, aggregates, water, etc. which are economically available, it is made up of granular materials which looks like coarse aggregates embedded in a matrix bound together with cement or binder which fills the space between the particles and glues them together. Almost three quarter volume of concrete is made of aggregates. To meet the global demand of concrete in the future, it is becoming a more challenging task to find sustainable ways of construction. Sustainable construction mainly aims to reduce the negative environmental impacts

generated by construction industry. Over a period of time, waste management is becoming one of the most challenging problem in the world. The rapid growth of industrialization is giving birth to various kinds of wastes which are very dangerous to our environment. The consumption of slags in concrete not only helps in reducing green house gases but also helps in making environmental friendly. During the production of iron and steel, fluxes (limestone and/or dolomite) are charged into blast furnace along with coke as fuel. The coke after combustion produces carbon monoxide, which converts the iron ore into molten iron product. Slag is a non-metallic inert waste consisting of mainly silicates, aluminosilicates and

calcium-alumina-silicates. Iron cannot be prepared in blast furnace without blast furnace slags.[1-4] The use of granulated blast furnace slag (GGBS) aggregates in concrete by replacement of natural aggregates is very promising concept because its impact strength is quite more than natural aggregate. Steel slag aggregates are already being used as aggregates in asphalt paving roads due to their mechanical strength, stiffness, porosity, wear resist and water absorption capacity. Aggregate is considered inert filler, it is an important constituent that determines the concrete thermal and elastic properties and dimensional stability. There are two types of aggregates: coarse and fine aggregates. Coarse aggregates are characteristically greater than 4.75 mm (retained on a No. 4 sieve), while fine aggregate is less than 4.75 mm (passing through the No. 4 sieve). The aggregate compressive strength is considered an important factor in the selection of aggregate. Therefore, it is important to evaluate the effect of aggregate size on the strength of concrete. Somnath Karmakar et al (2015) investigates on Study of Granulated Blast Furnace Slag as Fine Aggregates in Concrete, they has found that the compressive strength of concrete increases with increase in GBFS percentage up to a certain percentage and after that it decrease following a Gaussian Model. Gaussian Equation based on the observed behaviour is developed to estimate the strength in concrete after for a particular percentage of GBFS subjected to normal and marine conditions. He found that the most optimum percentage of GBFS to be used in normal conditions considering both strength and economy factor is from 40% to 50% and for marine conditions its from 50% to 60%. The long term strength development of GGBS concrete is almost double of normal concrete in both normal and marine conditins.[5-8]

Mhatre Deepak S et al (2018) investigates on the effect of partial replacement of GGBS slag as fine aggregate and fly ash as cement on strength of concrete. They found that the compressive strength of M30 grade concrete gradually decrease from 43.42 to 26.71 N/mm<sup>2</sup> as a percentage of GGBFs from 10% to 100%. The compressive strength of M30 grade concrete gradually decrease from 42.292 to 38.94 N/mm<sup>2</sup> as a percentage of GGBS as fine aggregate and Fly ash as a mineral

admixture from 5% to 30%. Split tensile strength of M30 grade concrete gradually decrease from 4.68 to 3.23 N/mm<sup>2</sup> asa percentage of GGBFs from 10% to 100%. Split Tensile strength of M30 grade concrete gradually decrease from 4.25 to 3.23 N/mm<sup>2</sup> as a percentage of GGBFS as fine aggregate and Fly ash as a mineral admixture from 5% to 30% .Sneha Sawant et al (2016) investigates on the Experimental Study on Ground Granulated Blast Furnace Slag in Concrete. They found that with the increase in GGBS replacement level workability of concrete increases. With M40 grade of concrete the compressive strength increases with the increase when cement is replaced by GGBS. At 40% replacement of cement by GGBS the concrete attained maximum compressive strength for M40 grade of concrete. There is increase in flexural strength when cement is replaced with GGBS. The flexural strength was maximum at 40% replacement of GGBS.

NdlangamandlaSabelo et al (2017) investigates on the Effect of Aggregate Size on the Compressive Strength of Concrete. they found that The mean compressive strength of the concrete aggregates was assessed and found to increase with increasing aggregates size. The aggregate sizes 9.5 mm, 13.2 mm and 19.0 mm had mean compressive strengths of 15.34 N/mm<sup>2</sup>, 18.61 N/mm<sup>2</sup> and 19.48 N/mm<sup>2</sup>, respectively. The 9.5 mm and 19.0 mm course aggregate sizes were significantly different ( $P < 0.05$ ; 0.034), while the 13.2 mm and 19.0 mm aggregate sizes had compressive strength that was not significantly different ( $P > 0.05$ ; 0.585).[9-12]

Santosh Kumar Karri et al (2015) investigates on Strength and Durability Studies on GGBS Concrete. They found that The split tensile strength of concrete is increased when cement is replaced with GGBS. The split tensile strength is maximum at 40% of replacement. The flexural strength of concrete is also increased when the cement is replaced by GGBS. At 40% replacement, the flexural strength is maximum. The compressive strength values of acid effected concrete decreases on comparison with of normal concrete, but the effect of acid on concrete decreases with the increase of percentage of GGBS. At 40% replacement of GGBS the resistance power of concrete is more. The compressive strength values of GGBS concrete effected to HCl were greater than the GGBS

concrete effected to H<sub>2</sub>SO<sub>4</sub>. The effect of HCl on strength of the concrete is lower than the effect of H<sub>2</sub>SO<sub>4</sub> on strength of the concrete. Sabir manhas et al (2018) investigates on the vaguely replacement of fine aggregate with GGBS in concrete. They found that With the partial replacement of GGBS with sand, the strength of concrete gradually increases up to a certain limit then it gradually decreases. With the partial replacement of GGBS with sand up to 25%, the initial strength gain in concrete is high. At 35%, there is 19.96% increase in initial compressive strength for 28 days. The initial strength gradually decreases from 35%. Jyoti R. Mali et al (2017) investigates on Partial Replacement of Fine Aggregate with GGBS. They found that The Compressive strength of Cubes are increased with the partial replacement of GGBS upto 40% replace by weight of sand and further any partial replacement of GGBS with sand lead to decrease in compressive strength. The Split Tensile strength of Cylinders are increased with partial replacement of GGBS up to 40% replace by weight of sand and further any partial replacement of GGBS decreases the Split Tensile strength. Thus, we found out the optimum percentage for partial replacement of GGBS with sand is almost 40% for cubes and cylinders.

## 2. Experimental Program

The Experimental investigation is planned as follows.

1. To find the properties of the materials such as cement, M sand, coarse aggregate, water and GGBS.
2. To obtain Mix proportions of OPC concrete for M25 by IS method (10262-2019).
3. To calculate the mix proportion with partial replacement such as 0%, 30%, 35%, 40% and 45% of GGBS with OPC and find the optimum percentage of GGBS.
4. Then the aggregate size is changed with specific percentage and their change in compressive strength is also found out.
5. To prepare the concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength and also cubes for durability studies in laboratory with Optimum replacement of GGBS with OPC for M25 grade concrete.

6. To cure the specimens for 28 days and 90 days.
7. To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength.
8. To evaluate the durability studies of M25 GGBS replacement concrete, with 5% concentrations of Hydro chloric acid (HCl) and Sulphuric acid (H<sub>2</sub>SO<sub>4</sub>).
9. To evaluate and compare the results.

## 3. Material and Properties

### 3.1 CEMENT

The cements used in this experimental works are ordinary Portland cement (53 grade). All properties of cement are tested by referring IS 12269-2013 Specification for Ordinary Portland cement. Test results are presented in Table 1.

**Table.1. Physical Properties of Cement**

S. No	Properties	Result
1	Specific gravity	3.15
2	Fineness of cement	2%
3	Standard consistency of cement	34%
4	Initial setting time	34 minutes

### 3.2 FINE AGGREGATE

Manufactured sand is used as the fine aggregate in this experimental work. Some of the properties of the fine aggregate is tabulated below.

**Table 2 Physical Properties of M Sand**

S.No	Properties	Result
1	Bulk density	1730 kg/m <sup>3</sup>
2	Fineness modulus	2.96
3	Specific gravity	2.7
4	Water absorption	0.5%

### 3.3. COARSE AGGREGATE

The coarse aggregate used in this study is of angular in shape and the maximum nominal size of coarse aggregate is 20mm and is conforming to Table 2 of IS 383- 1970. Some of the properties of coarse aggregate are mentioned in Table 3.

### 3.4 GROUND GRANULATED BLAST FURNACE SLAG

GGBS is used as the partial replacement of M Sand in certain percentages. Some of the properties of GGBS is mentioned in the Table 4.

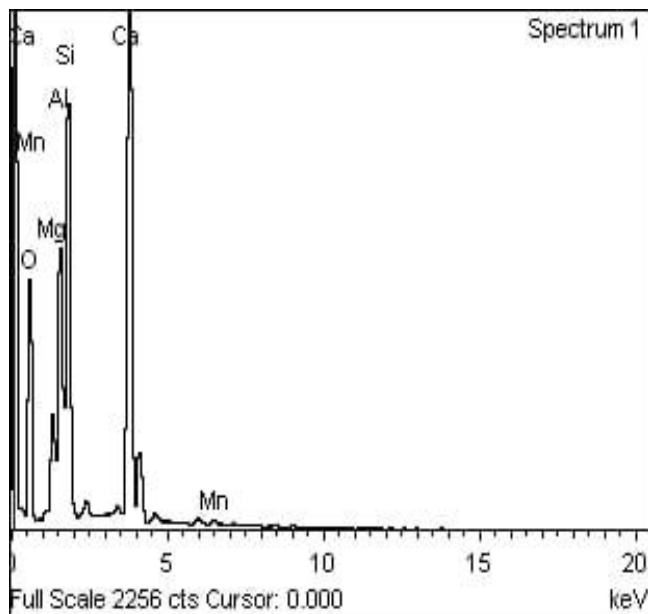
**Table 3 physical properties of coarse aggregate**

S. No	Properties	Result
1	Specific gravity	2.7
2	Water absorption	0.52%
3	Impact value	35%

**Table 4. Properties of GGBS**

S No	Properties	Result
1	Specific gravity	2.85
2	Fineness modulus	2.5

### EDAX FOR GGBS

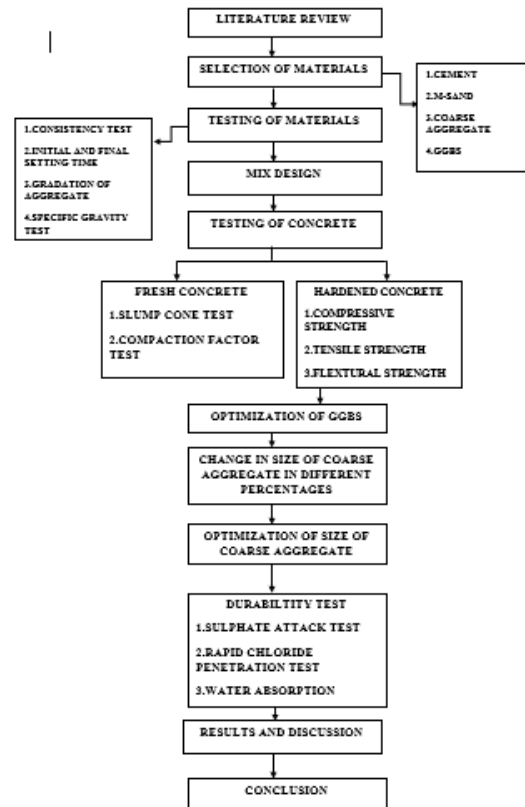


**Fig.1. EDAX for GGBS**

### 3.5 WATER

The potable water available in the laboratory is used in this study. It is also used for the curing.

## 4. Methodology



**Fig 2 Methodology**

## 5. MIX DESIGN OF CONCRETE

In this work the strength of the concrete is taken as M25 and the design mix is calculated. The property of the materials used in the concrete is found out. The design mix is calculated according to IS 10262-2019 and the following mix proportion is obtained. The mix ratio is shown in the following table 5.

**Table 5 Mix proportion of M25**

S No	Material	Quantity in kg/m <sup>3</sup>
1	cement	437.7
2	Fine aggregate	682.29
3	Coarse aggregate	1113.21
4	water	197
5	Water cement ratio	0.45

The ratio of the mix is found to be 1:1.55:2.5

## 6. SPECIMEN PREPARATION AND CURING

The specimens include the cubes, cylinders and prisms for testing the strength and the durability

characteristics of the concrete. first, the mentioned specimens are casted which are mentioned in table 6. The GGBS is partially replaced for the M Sand.

**Table.6 Specimens Casted**

Mix	Percentage
M1	Conventional M25 concrete
M2	30% GGBS replaced with M Sand
M3	35% GGBS replaced with M Sand
M4	40% GGBS replaced with M Sand
M5	45% GGBS replaced with M Sand

Then the optimum strength value is obtained by carrying out compressive, split tensile and flexural test. Then the specimens are tested and the specimen with good strength is taken as optimum. And the cubes and cylinders are casted for durability studies. The testing is carried out on 7, 14, 28 days and the durability tests are carried out after 90 days.

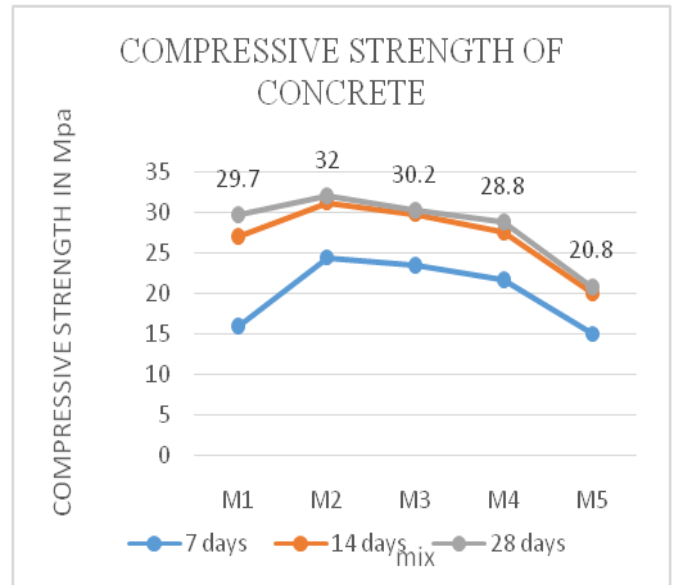
**7. Results and Discussion**

**7.1 Compressive Strength Test**

Cubes of sizes 150X150X150mm were casted. Then after 28 days the cubes are tested. The compressive strength values are obtained.

**Table 7 Compressive Strength of Concrete**

Mix	Specimen	7 Day	14 DAY	28 DAY
1	Conventional concrete	16	27	29.7
2	30% replacement of GGBS for FA	24.4	31.1	32
3	35% replacement of GGBS for FA	23.5	29.7	30.2
4	40% replacement of GGBS for FA	21.7	27.5	28.8
5	45% replacement of FA	15.1	20	20.8



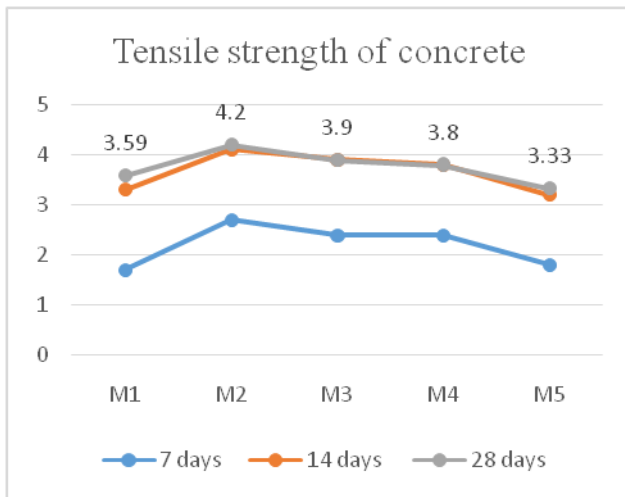
**Fig.3. Compressive Strength of Concrete**

**7.2 Split Tensile Strength Test**

Cylinders are casted of size 150 mm diameter and 30 mm height are casted. And the curing is done for 28 days and the split tensile values are obtained for different percentages of GGBS.

**Table 8 Tensile Strength Of Concrete**

S No	Specimen	7 Days	14 Days	28 Days
1	Conventional concrete	1.7	3.3	3.59
2	30% replacement of GGBS for FA	2.7	4.1	4.2
3	35% replacement of GGBS for FA	2.4	3.8	3.9
4	40% replacement of GGBS for FA	2.4	3.7	3.8
5	45% replacement of FA	1.8	3.2	3.33



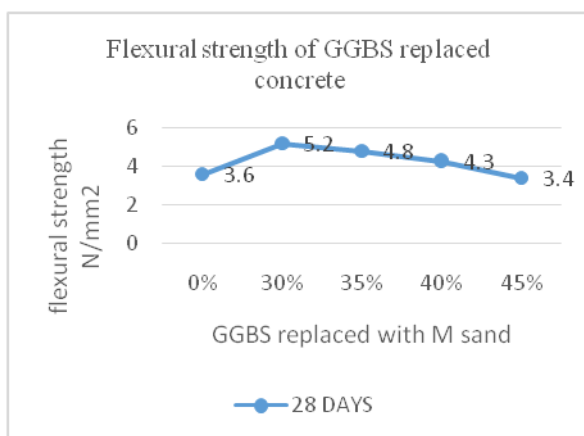
**Fig.4. Tensile Strength of Concrete**

### 8.3 Flexural Strength Test

Concrete beam of size 500x100x100 mm were casted and cured for 28 days and the flexural strength values are obtained.

**Table .9. Flexural Strength of Concrete**

S No	Specimen	28 Days(N/mm <sup>2</sup> )
1	Conventional concrete	3.6
2	30% replacement of GGBS for FA	5.2
3	35% replacement of GGBS for FA	4.8
4	40% replacement of GGBS for FA	4.3
5	45% replacement of GGBS for FA	3.4

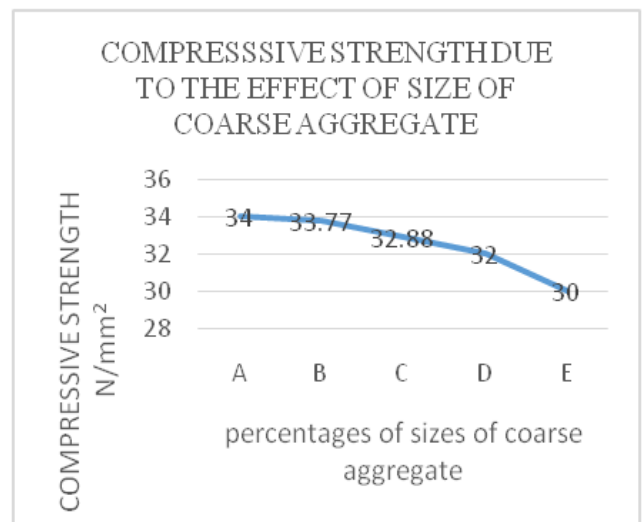


**Fig.5. Flexural strength of GGBS replaced concrete**

### 8.4 Effect of Size of Coarse Aggregate

**Table 10 Effect of Size of Coarse Aggregate in Compressive Strength of Concrete**

S no	% of 12 mm aggregate	% of 20 mm aggregate	Compressive strength at 28 days N/mm <sup>2</sup>
1	0	100	34
2	30	70	33.77
3	40	60	32.88
4	50	50	32
5	100	0	30



**Fig.6. Compressive strength due to the effect of size of coarse aggregate**

A - 100% 20 mm aggregate

B - 30% 20 mm aggregate and 70% 12 mm aggregate

C - 40% 20 mm aggregate and 60% 12 mm aggregate

D - 50% 20 mm aggregate and 50% 12 mm aggregate

E - 100% 12mm aggregate

## 10) DURABILITY STUDIES

### 10.1 Water Absorption Test

Cubes of 100x100x100 mm is taken. The 30% GGBS is replaced with M sand in concrete. The specimens are cured and after curing allowed to dry at climatic temperature. Then the weight is noted and afterwards it is kept in oven for 24 hours and weight is obtained. Then the percentage water absorption is found out.

**Table.11 Water Absorption Test Value**

Mix replacement	Water absorption in %
M1	1.7
M2	2
M3	1.8

**Conclusion**

- 1) Slump value decreases with increase in GGBS.
- 2) The compressive strength increases by 8% when fine aggregate is replaced by 30% GGBS with fine aggregate.
- 3) The tensile strength increases by 17% when fine aggregate is replaced by 30% GGBS with fine aggregate.
- 4) The flexural strength increases by 44% when fine aggregate is replaced by 30% GGBS with fine aggregate.
- 5) The optimum value is found to be 30% as the strength increases at that point.
- 6) When the fine aggregate is replaced with 30% GGBS for M sand, in percentage of increase of 20 mm aggregate the compressive strength increases.
- 7) When aggregate size decreases the strength also decreases.

**Reference**

- [1]. IS: 383-1970, "Specification for coarse and fine aggregates from the natural sources for concrete", Bureau of Indian Standards, New Delhi.
- [2]. IS: 456-2000, "Code of practice for plain and reinforced concrete", Bureau of Indian standards, New Delhi.
- [3]. IS 9103: 1999 – Concrete admixtures – Specification.
- [4]. IS 12269: 2013 – Ordinary Portland Cement, 53 Grade – Specification.
- [5]. K.G.Vinothan et al "Partially Replacement of Fine Aggregate with GGBS" *SSRG International Journal of Civil Engineering (SSRG - IJCE)* – Volume 4 Issue 3 – March 2017
- [6]. Jyoti R. Mali et al "Partial Replacement of Fine Aggregate with GGBS" *IJSRD - International Journal for Scientific Research & Development* | Vol. 5, Issue 01,

- [7]. Sanbir Manhas and Amir Moohmend "A RESEARCH – VAGUELY REPLACEMENT OF FINE AGGREGATE WITH GGBS IN CONCRETE" *International Journal of Civil Engineering and Technology (IJCIET)* Volume 9, Issue 3, March 2018, pp.65–69
- [8]. Mhatre Deepak S *International Journal of Emerging Research & Development* effect of partial replacement of GGBS slag as fine aggregate and fly ash as cement on concrete
- [9]. Dr. G. Dhanalakshmi et al "SIZE EFFECT OF AGGREGATE IN THE MECHANICAL PROPERTIES OF CONCRETE" *International Research Journal of Engineering and Technology (IRJET)* e-ISSN: 2395-0056 Volume: 05 Issue: 02 | Feb-2018
- [10]. Mohad Fedder Musa<sup>1</sup>, A. Aziz bin Saim "The Effect of Aggregate Size on The Strength of Concrete" *The Colloquium 10* (2017) pp.9-11
- [11]. S.O. Ajamu et al "Effect of Coarse Aggregate Size on the Compressive Strength and the Flexural Strength of Concrete Beam" *Int. Journal of Engineering Research and Applications* www.ijera.com ISSN : 2248-9622, Vol. 5, Issue 1 (Part 4), January 2015, pp.67-75
- [12]. Santosh Kumar Karri, G.V. Rama Rao and P. Markandeya Raju, "Strength and Durability Studies on GGBS Concrete", *SSRG International Journal of Civil Engineering (SSRG-IJCE)*, Vol. 2, Issue 10, October 2015, pp. 34-41, ISSN: 2348-8352