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Performance of Concrete with Granite Slab Waste as Coarse Aggregate at Elevated Temperatures

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Abstract:- The increased use of concrete can cause the extinction of natural aggregates. So it is necessary to find alternatives for the coarse and fine aggregates used, which should be easily available and economical as well. The paper has been aimed to study the suitability of granite slab waste as coarse aggregate in concrete and also to study its properties at elevated temperatures. Waste pieces from the industry were broken to 20 mm and down size and were used as coarse aggregates for concrete. Concrete specimens were tested after being heated to temperatures of 200^0C, 400^0C and 600^0C and cooled to room temperature, for their compressive strength, split tensile strength, flexural strength and Modulus of Elasticity. A comparative study was done with concrete made with conventional aggregates.

I. INTRODUCTION

Concrete is used more than any other man made material on the planet. The annual consumption of concrete is as much as two tones per person per year globally. This situation has led to a fast depletion of available resources. This has led to the researches on the suitability of waste materials as aggregates for concrete. Recently granite slabs are widely used for flooring of buildings. When these slabs are cut to required sizes and shape, a lot of material is coming as waste. These waste pieces are dumped into the land and it causes many environmental problems. If these waste pieces can be used as aggregates, it become a new source of aggregates and also acts as a waste disposal method. From the literature studies, it is known that relatively few studies are done on Granite Slab Waste. So the project has been aimed to study the suitability of granite slab waste as coarse aggregate in concrete and also to study its properties at elevated temperatures.

Properties to be tested are Compressive Strength Flexural Strength, Splitting Tensile Strength. Conduct an economic study of usage of waste plastic powder as supplementary material in place of cement in ordinary concrete.

II. MATERIALS AND METHODS

Scope of study is limited to testing M_{20} mix specimens with granite slab waste as coarse aggregate at ambient temperature and at elevated temperatures for compressive strength, split tensile strength, flexural strength and modulus of elasticity. Comparison is done with that of conventional concrete of the same mix.

Table I Physical Properties Of Cement

Specific gravity	**3.0**
Standard consistency	36
Initial setting time in minutes	76
Final setting time in minutes	595
Average compressive strength in MPa **7days** **28 days**	 26 33
Brand name	Portland pozzalana cement of Dalmia

Table ii Physical Properties Of Sand

Specific Gravity	**2.884**
Water Absorption	1.81%
Fineness Modulus	2.458
Grading	ZONE I
Bulking	42

Table iii.Sieve Analysis Results Of Fine Aggregate

IS Sieve	Percentage of Passing	IS Limits for zone I
4.75mm	100	100
2.36mm	91.2	90 to 100
1.18mm	71.9	60to 95
600microns	52.9	30 to 70
300microns	29.5	15to 34
150microns	8.7	5 to 20
Pan	0	0to10

Table iv .Properties Of Coarse Aggregate Used In Control Mix

Specific Gravity	**2.63**
Water Absorption	0.5%
Fineness Modulus	8.234
Aggregate Crushing Value	31.1%

Table v .Sieve Analysis Results Of Coarse Aggregate Used In Control Mix

IS Sieve	Percentage of Passing
25mm	100
20mm	75.3
12.5mm	1.3
10mm	0
4.75mm	0

Table vi Properties Of Granite Slab Waste Aggregate

Specific Gravity	**2.81**
Water Absorption	0.2%
Fineness Modulus	8.186
Aggregate Crushing Value	18.5%

Table vii .Sieve Analysis Results Of Granite Slab Waste Aggregate

IS Sieve	Percentage of Passing
25mm	100
20mm	70
12.5mm	8.6
10mm	2.8
4.75mm	0

Superplasticizer

Super plasticizer helps to reduce the water content, thereby effective control on the water cement ratio can be maintained and thus improves strength. In this research work, a commercially available water reducing admixture (Conplast SP-430S) is used as a super plasticizer. Type: Sulphonated Naphthalene Formaldehyde Polymer based SP, Specific Gravity: 1.220 to 1.225 at 30°C. The dosage of this super plasticizer is 0.5% by weight of cement.

III. MIX PROPORTIONING OF M_{20} GRADE CONCRETE

Table viii Materials Required For 1 M^3 Of Concrete

	Control mix	Granite slab waste mix
Cement	360kg	390 kg
Water	162 kg	156 kg
Fine aggregate	835 kg	779 kg
Coarse aggregate	1151 kg	1240 kg
Chemical admixture	1.8 kg	1.95 kg
Water cement ratio	0.45	0.4

IV. HEATING OF SPECIMENS

The specimens which completed 28 days of curing are then placed in an electrically heated air circulating tempering furnace. The inside of oven is cylindrically shaped with 400mm diameter and 600mm height. The working temperature of the furnace is at 750°C to 800°C of power 18KW. At a time 3 specimens were placed in the furnace. The tests were performed at three different temperatures (200^0C, 400^0C and 600°C). After attaining the desired temperature, the specimens were kept in the oven about 40minutes so that the inside portion of the specimen will also attain the same temperature.

V. COOLING THE SPECIMENS

In this study, half of the heated specimens were cooled in water and the remaining were cooled in air (at room temperature) until they were at 28°C.

VI. RESULTS AND DISCUSSIONS

Compressive Strength

Table Ix Cube Compressive Strength In N/Mm^2

Type of cooling		**Air cooled**			**Water cooled**		
Temperature	Ambient temperature	200^0C	400^0C	600^0C	200^0C	400^0C	**600^0C**
Control mix	29.22	24.0	23.4	11.2	27.2	23.7	**11.3**
GSW mix	**31.11**	**27.2**	**26.6**	**11.3**	**26.7**	**22.2**	**9.5**

From the results it can be seen that specimens of both the mixes loses compressive strength at elevated temperatures. For the water cooled specimens of the control mix, strength loss is lesser than that of air cooled specimens. This is because of the gain in strength of the specimens due to rehydration. These specimens were tested after 30 days of their cooling. For the air cooled GSW specimens strength loss is less than that of control mix for 200^0C and 400^0C. However at 600^0C strength loss is slightly greater. But for the water cooled specimens strength loss is more for GSW mix specimens.

Table X Compressive Strength Loss At Elevated Temperatures

Type of cooling	**Air cooled**			**Water cooled**		
Temperature	200^0C	400^0C	600^0C	200^0C	400^0C	**600^0C**
Control mix	18%	20%	62%	7%	19%	**20%**
GSW mix	**13%**	**14%**	**64%**	**13%**	**29%**	**69%**

The loss of strength observed at higher temperatures may be attributed to the loss of bound water, increased porosity, and consequently, the increased permeability. The reduction in the compressive strength of concrete was significantly larger for samples exposed to temperatures 600^0C. This result is due to the lost water of crystallization resulting in a reduction of the $Ca(OH)_2$content,in addition to the changes in the morphology and the formation of micro cracks.

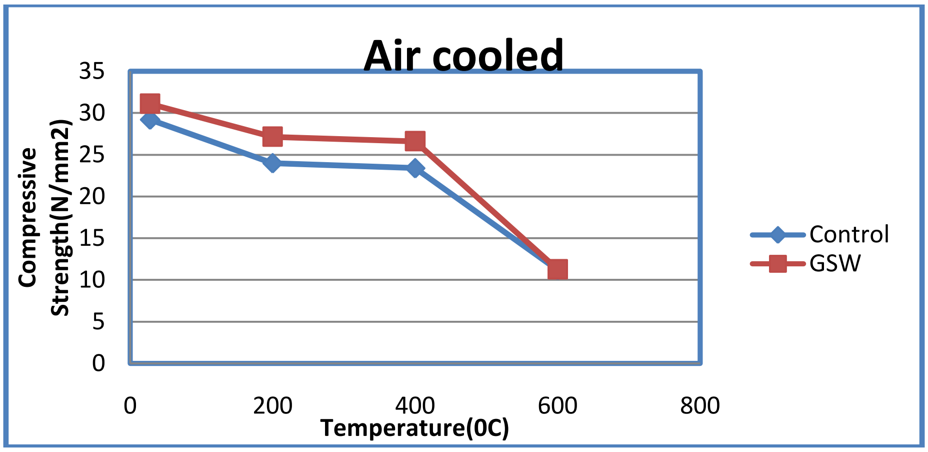

Fig 1 Variation of Cube Compressive Strength for Air cooled Specimens

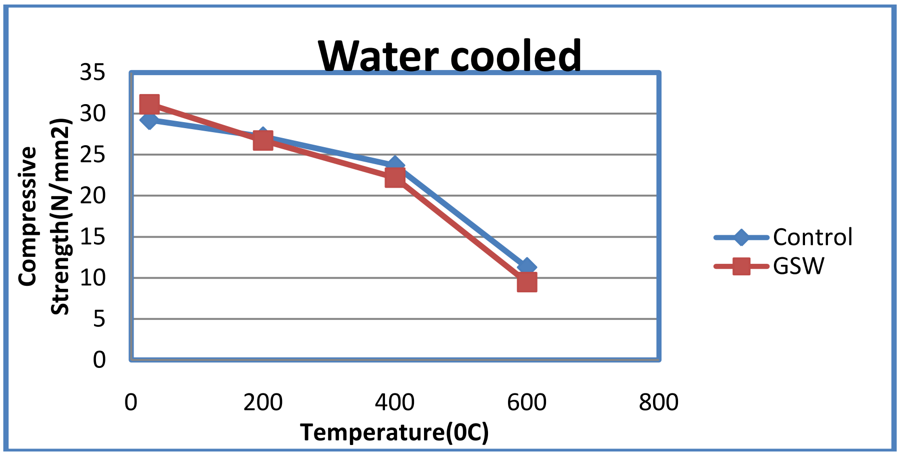

Fig 2 Variation of Cube Compressive Strength for Water cooled Specimens

Split Tensile Strength

Table Xi Split Cylinder Tensile Strength In N/Mm^2

Type of cooling		Air cooled			Water cooled		
Temperature	Ambient temperature	200^{0}C	400^{0}C	600^{0}C	200^{0}C	400^{0}C	**600^{0}C**
Control mix	2.84	2.41	1.89	0.56	2.88	2.05	**0.76**
GSW mix	**3.15**	**2.26**	**1.71**	**0.40**	**3.03**	**1.97**	**0.66**

Table Xii Reduction Of Split Cylinder Tensile Strength At Elevated Temperatures

Type of cooling	Air cooled			Water cooled		
Temperature	200^{0}C	400^{0}C	600^{0}C	200^{0}C	400^{0}C	**600^{0}C**
Control mix	15%	33%	80%	-1.3%	28%	**73%**
GSW mix	**28%**	**46%**	**83%**	**4%**	**37%**	**79%**

From the results and graphs it is clear that split tensile strength for both type of specimens is reduced at higher temperatures. The percentage loss is higher for the GSW specimens. For the water cooled control mix specimen at 200^{0}C,split tensile strength is slightly higher than that at 28^{0}C .Water cooled specimens show higher strength than air cooled specimens due to rehydration. In the case of GSW specimens also water cooled specimens show higher values of tensile strength than air cooled specimens.But gain in strength is less at 600^{0}C.

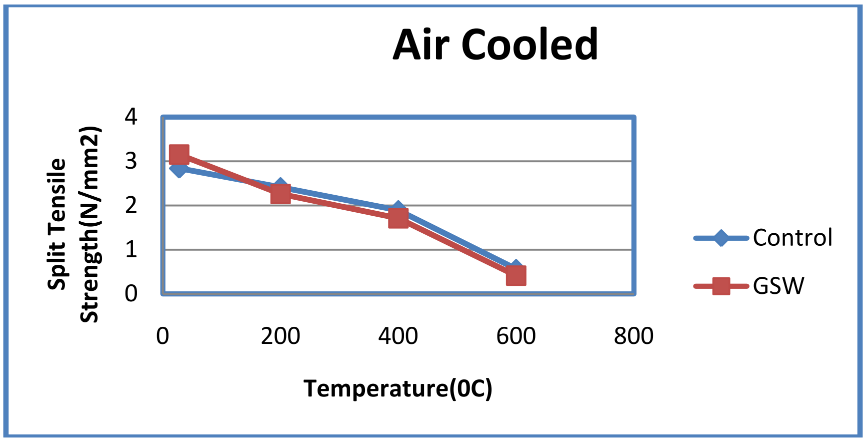

Fig 3 Variation of Split Tensile Strength for Air cooled Specimens

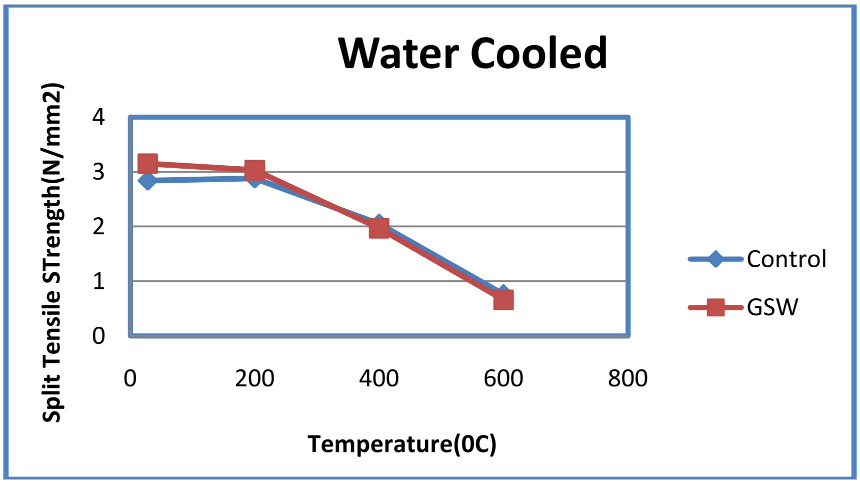

Fig 4 Variation of Split Tensile Strength for Water cooled Specimens

Flexural Strength

Table Xiii Beam Flexural Strength In N/Mm^2

Type of cooling		Air cooled			Water cooled		
Temperature	Ambient temperature	200^{0}C	400^{0}C	600^{0}C	200^{0}C	400^{0}C	**600^{0}C**
Control mix	5.8	5.72	2.98	1.11	5.96	4.22	**1.14**
GSW mix	**5.86**	**5.52**	**2.12**	**0.44**	**5.64**	**2.14**	**0.4**

Table Xiv Reduction Of Beam Flexural Strength At Elevated Temperatures

Type of cooling	Air cooled			Water cooled		
Temperature	200^{0}C	400^{0}C	600^{0}C	200^{0}C	400^{0}C	**600^{0}C**
Control mix	1%	49%	81%	-5.8%	27%	**80%**
GSW mix	**6%**	**64%**	**84%**	**4%**	**63%**	**82%**

From the results,it is clear that flexural strength deccreases with increase in temperature.Strength loss is higher for GSW specimens. In the case of control mix and GSW mix water cooled specimens show higher strength than air cooled specimens due to rehydration.But gain in strength is less for GSW specimens.

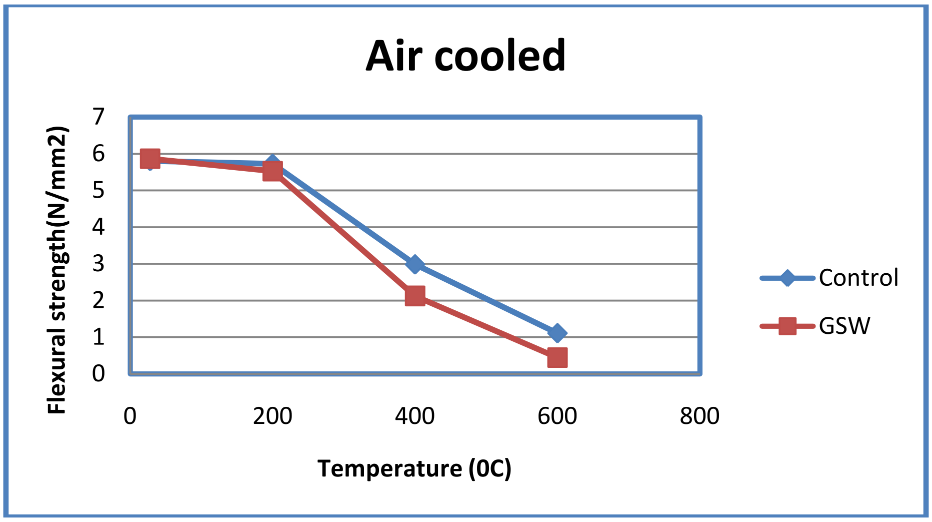

Fig 5 Variation of Flexural Strength of air cooled specimens

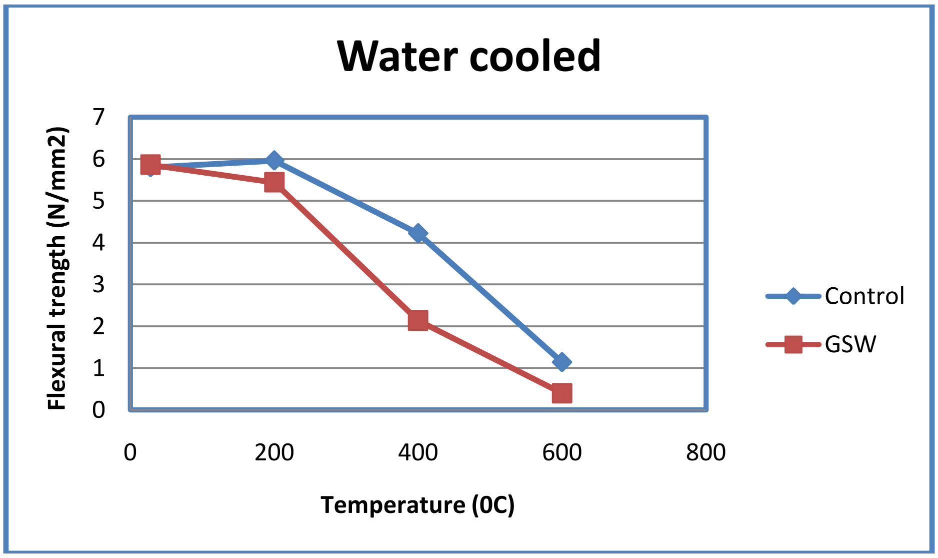

Fig 6 Variation of Flexural Strength of Water cooled specimens

Modulus Of Elasticity

Table Xv Modulus Of Elasticity Of Concrete

Type of cooling		Air cooled			Water cooled		
Temperature	Ambient temperature	200^0C	400^0C	600^0C	200^0C	400^0C	**600^0C**
Control mix	26408	27162	9054	2320	28294	9054	**2433**
GSW mix	**47534**	**41875**	**14524**	**1675**	**47534**	**10752**	**1021**

Table Xvireduction Of Modulus Of Elasticity At Elevated Temperatures

Type of cooling	Air cooled			Water cooled		
Temperature	200^0C	400^0C	600^0C	200^0C	400^0C	**600^0C**
Control mix	-2.8%	66%	91%	-7.1%	66%	**91%**
GSW mix	**12%**	**70%**	**96%**	**0%**	**77%**	**98%**

From the results it is clear that Modulus of elasticity reduces with increase of temperature for control mix and GSW mix. At 200^0C control mix specimens have higher modulus of elasticity than that of 28^0C.But at higher temperatures,Modulus of elasticty is reduced greatly,as much as 91% at 600^0C.For GSW mix specimens reduction is more than that of control mix and reaches upto 98% at 600^0C

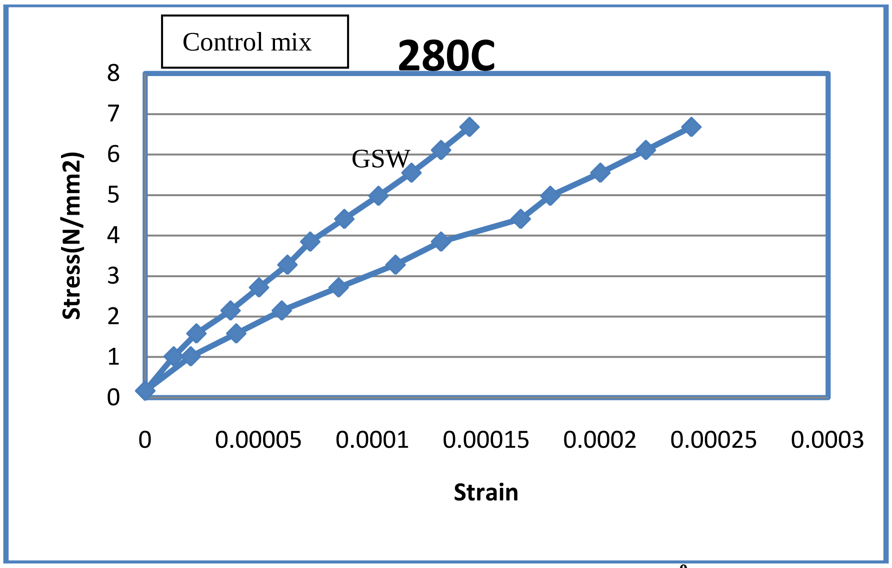

Fig 7 Stress strain graph of specimens at 28^{0}C

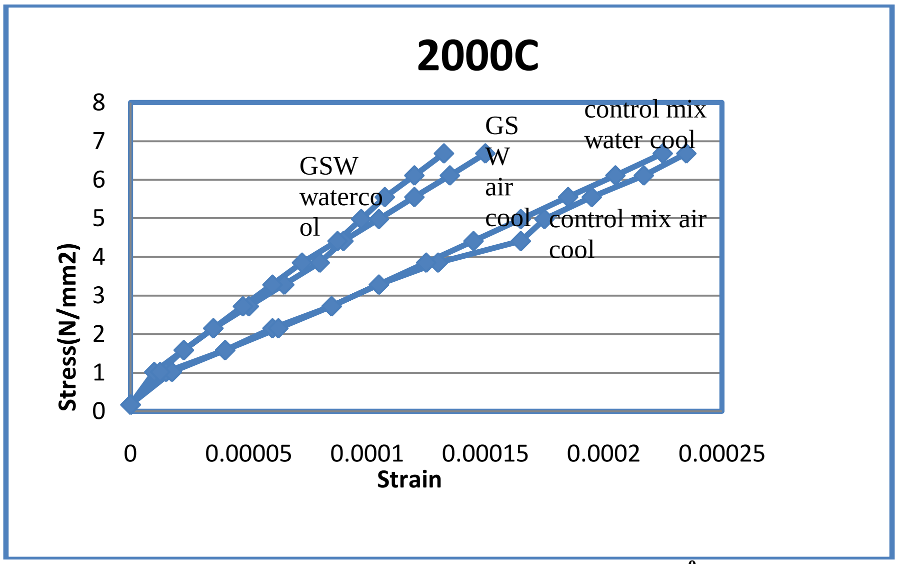

Fig 8 Stress strain graph of specimens at 200^{0}C

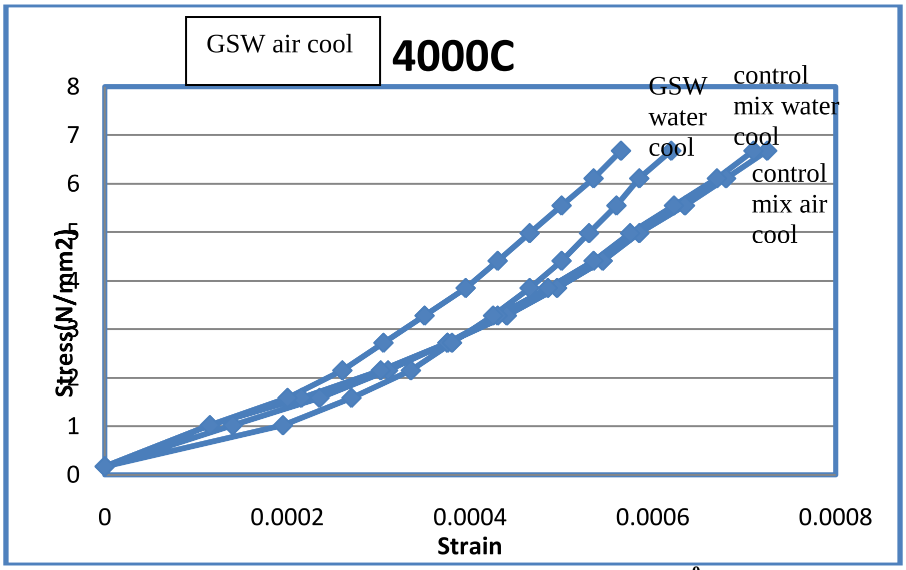

Fig 9 Stress strain graph of specimens at 400^{0}C

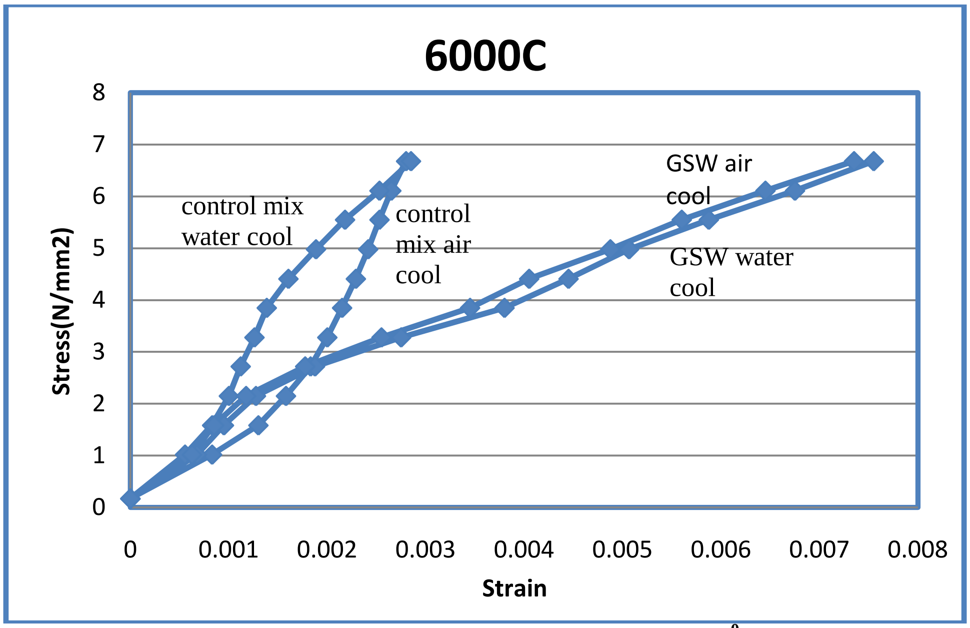

Fig 10 Stress strain graph of specimens at 600^{0}C

VII. CONCLUSIONS

1. Waste pieces of granite slab can be used as coarse aggregates in the normal strength concrete.
2. Compared to normal granite aggregates, GSW aggregates have higher value of specific gravity and crushing resistance.
3. M_{20} mix designed for GSW mix needed 30 kg more cement than that of normal granite mix.
4. In control and GSW mix concrete exposed to elevated temperatures, compressive, split tensile, flexural strength and modulus of elasticity decreases with increase in temperature.
5. Cracks are developed in both type of specimens at higher temperature.
6. Colour was observed on both type of specimens on outside and inside at elevated temperature.
7. Percentage mass reduction at elevated temperature is slightly more for GSW specimens.
8. In general GSW mix concrete can be used for normal strength concrete where it is not subjected to more than 200^{0}C.

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