EFFECT OF PARTIAL REPLACEMENTOF SAND BY STEEL SLAG ON STRENGTH CHARACTERISTICS

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ABSTRACT: *"Steel slags are by-products of the iron and steel production processes. Today this type of slag has been widely used in cement and as an aggregate for civil works. The report presents an investigation into the physical, chemical and mechanical properties, i.e. they are strong, durable, have an excellent angular shape and a high resistance to abrasion and impact. To check the strength and durability of concrete, the compressive strength and fractional tensile strength test are performed for 7 and 28 days with concrete by adding steel slag as a replacement for sand in various percentages, e.g. 10%, 20%. The results show that the strength properties of concrete increase significantly when the sand is partially replaced by steel slag."*

Key Words: *Steelslag, Pavement,Sand, Industrial waste, Aggregate.*

1. Introduction: -

Highly prevalent and the use of alternate uses of new aggregates. Slag is a-product of the process of producing iron and steel. Iron cannot ever be prepared even without output of the it's waste material-product with in blast furnace; blast furnace slag; In addition, steel cannot really be manufactured in a base oxygen furnace (BOF) or an electric arc furnace (EAF) but without by-product; steel slag (www.nationalslag.org). One very exciting idea the use of steel slag concrete aggregates through removing natural aggregates. Thanks to its mechanical strength, rigidity, porosity, tensile strength but water absorption potential, steel slag aggregates are now used as aggregates for road mixes to concrete pavements. And per the National Slag Group, steel slag was usually used it as a base layer including some agricultural applications for bituminous asphalt pavements, Portland cement production including highway construction. Only possible problem the with steel slag aggregate has been its vast properties but unnecessary reactions between slag or concrete components.

Steel processing involves the utilization of excess silicon through mineralization, and carbon through refined or cast iron oxidation. A thick and tough composite very similar to air-cooled iron slag are steel slag. It includes considerable quantities to free iron, that includes a high hardness and strength, make it especially suitable to road building as either an aggregate. The slag was shipped at manufacturing plants, where this is subjected to grinding, grinding and filtering procedures that satisfy the various requirements for use. Processed slag was delivered for immediate use as well as held it out operation to your customer.

Flexible Pavements

Flexible pavements through moving grain to grain via the touch points throughout the grain system, it can relay wheel load stresses to both the lower layers. That wheel load working also on surface will also be spread over a wider area and with depth the burden should decrease. Flexible soils also have many layers, taking advantage of all these stress distribution characteristics. The modular floor design thus reflects the concept of a layered structure. The versatile floor can also be formed in many layers depending upon it, and also the top layer would have to be of the highest quality to survive the full compressive stresses and wear. The lower layers will feel less heat, but the use of poorer quality content would be possible. Flexible floors were built from bituminous materials. "It may be in surface treatments (such as bituminous surface treatments commonly seen on low-volume roads) or asphalt concrete surface layers (usually seen on high-volume roads like national highways). Flexible soil layers reflect that deformation of both the lower layers with in surface layer" (for example, whenever a ripple seems to be in the subsoil it is moved to both the surface layer)In resilient floors that design becomes focused on the general performance of the resilient floor and also the stresses generated must also be held far below the permissible stresses of the each floor layer.

The load becomes transmitted through rigid flooring also by motion of both the slab and the flooring acts like an elastic plate supported on either a viscous material. Hard frames are made with Portland cement (PCC) and must be studied using plate theory instead of sheet theory, assuming an elastic plate rests on even a viscous foundation. That plate theory is indeed a simple example of both the layer theory whereby implies that now the concrete slab is indeed a medium thickness plate which would be flat before loading and then after charging stays flat. Plate deflection due to differences of wheel load or temperature or consequent traction or bending stresses.

(a) Mode of failure:

The failure mode of flexible flooring is due to fatigue and grooves; for rigid floors, on the other hand, these are cracks (due to temperature), fatigue and failure of the joints due to inadequate construction or inadequate reinforcement or interlocking of the aggregates. The high temperature immersion effect severely damages flexible flooring in countries like Bangladesh. Rigid flooring does not exhibit these types of subsidence.

2. METHOD, MATERIAL AND DESIGN METHODOLGY

This research paper deals with both the analysis and findings of several experiments carried out on material used during concrete. An experimental programmer to evaluated the impact with steel slag mostly on compressive strength of concrete was designed in order to meet the goal of both the current research.

MATERIALS

In the laboratory, the properties of both the substance used during the manufacture of concrete mix were calculated in compliance with applicable standards of conduct.

Portland cement

Portland cement "(ordinary Portland cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. OPC is classified into three grades, namely grade 43, and grade 53, depending on the 7-day strength." It was possible to improve the qualities of the cement through the use of high quality limestone, modern equipment, maintaining a better distribution of the grain size, a finer grinding and better packaging. In general, the use of high-quality concrete offers many advantages to make concrete more durable. While they are a bit more expensive than low-grade concrete, they offer a 10-20% savings on concrete consumption and also offer many hidden benefits. One of the most important benefits is the faster speed of strength development.

a) Aggregates

The cement conglomerate is mainly made up of aggregates because these confer dimensional stability to the concrete. Aggregates also are identified in numerous or three sizes, in order tomaximise the intensity of the resulting mixture. The fine aggregate's most significant feature should be to help generate workability or uniformity and in blend. The fine aggregate helps to hold the cement paste throughout suspension with the coars aggregate flakes. This behavior enhances the mix's plasticity and avoids gritty pastes as well as a mixture from being aggregated.Especially where transportation of the concrete from of the refrigeration unit to the positioning is required before a certain distance. Aggregates add approximately 75 per cent to the concrete mass, and their effect therefore is highly significant. We then must comply with some specifications so that concrete can be sustainable, stable, reliable or economical. "The aggregates must be of the correct shape, clean, hard, strong and well classified."

b) Water

In general, safe drinking water is ideal for concrete use. Often, the water from sandy streams of lakes with aquatic life is always sufficient. There was no need to take samples once water is collected according to the above sources mentioned. It is not used in concrete where groundwater is identified as having sewage, mine groundwater and manufacturing or canning plant waste until checks show that this is acceptable. Water from certain sources must be prevented as, due to the lack of water either sporadic the use tap water to pouring, water quality can change. For mixing and hardening concrete, drinking gas is probably deemed sufficient. Consequently, potable water was used during the substance research facility to make the concrete usable. These were clean of destructive contaminants; the sand was fine for drinking quality.

c) Steel Slag

In this work, the Steel Slag is taken from the Iron and Steel Industry located at BalgarhHaryana .It is black in color.

The Sieve Analysis of steel slag is shown in Table 1

Weightof sample taken=1000gm.					
Sr. No.	**IS-Sieve(m**	**Wt.Retained(gm)**	**%ageretained**	**%agepassing**	**Cumulative%retained**

1	4.75	14	1.4	98.6	1.4
2	2.36	28	2.8	95.8	4.2
3	1.18	94.5	9.45	86.35	13.65
4	600µ	189.5	18.45	67.8	32.1
5	300µ	329.5	32.95	34.95	65.05
6	150µ	291.5	29.15	5.8	94.2
7	Pan	58	5.8		
	Total	**1000.00**		**SUM**	**210.6**
				FM =	*2.10*

TEST METHODS

a) Compressive Strength of Concrete

"Bucket samples 150 mm x 150 mm x 150 mm in size were removed from the curing tank at the age of 7 days and tested immediately upon removal from the water (while still in the wet state). The water was cleaned from the surface and the samples were analyzed." The position of the cube during the test was perpendicular to that of the mold. The load was applied gradually without shock until the sample failure occurred and then the compressive strength was found.

The quantities of cement, coarse aggregate (20 mm), fine aggregate, steel slag and water for each batch were weighed separately, i.e. for different replacement percentages of steel slag. That concrete and steel slag is individually blended dry to get a consistent hue. To ensure uniform distribution in the sample, their coarse aggregates are blended. Water was added to both the blend. Next, 50 to 70% water were applied to the mixture and now it is gently mixed and in blender for 3-4 minutes. The concrete from cube mould was then packed with sand and afterwards vibrated and allow consistent compaction. The concrete surface had been finished flush with a trowel at the tip of the mould. That finished specimens was given 24 hours of cure in air. 24 hours since casting, their specimens are removed from the oven rather tightly but positioned throughout the water tank filled of drinking water mostly in laboratory.

Figure 1. Concrete Mix Moulds

b) Trail Mixes

The calculated mix ratios will be checked using trace lots. The viability of Trail Mix No 1 will be measured. The mix must be carefully observed to verify that it does not segregate or bleed and its finishing properties. If Trail Mix No 1's calculated workability becomes inconsistent from either the specified value, therefore the additive or water content will also be changed accordingly. The ratio of both the mixture will also be recalculated with both the change, retaining the proportion for cement-free water also at selected value, which will include Trail Mix n. 2. In addition, two extra Trail Mix n.a. 3 and 4 for the same volume of water. As Blend Trail n. 2 and also to differ the proportion for free water cement through ± 10% of the amount selected.

Mix 2 to 4 typically offers adequate detail, including that of the compressive strength ratio to both the water-cement ratio, where the field track ratios can indeed be derived. The concrete will also be generated also for field paths employing real concrete manufacturing methods.

CALCULATIONS FOR MIX DESIGN OF M25 GRADE

M-25MixDesignsas perIS-10262-2009

	M-25CONCRETEMIXEDESIGN	
	AsperIS10262-2009&MORT&H	
A-1	**StipulationsforProportioning**	
1	**GradeDesignation**	**M25**
2	TypeofCement	OPC43gradeconfirmingtoIS-12269-1987
3	MaximumNominalAggregateSize	20mm
4	MinimumCementContent(MORT&H1700-3A)	310kg/m^3
5	MaximumWaterCementRatio (MORT&H1700-3A)	0.50
6	Workability(MORT&H1700-4)	50-75mm(Slump)
7	ExposureCondition	Normal
8	DegreeofSupervision	Good
9	TypeofAggregate	CrushedAngularAggregate
10	MaximumCementContent (MORT&HCl.1703.2)	425kg/m^3
11	ChemicalAdmixtureType	Steel SlagConfirmingtoIS-9103
A-2	**TestDataforMaterials**	
1	CementUsed	Ambuja CementOPC43grade
2	Sp.GravityofCement	3.15
3	Sp.GravityofWater	1.00
4	ChemicalAdmixture	Steel Slag Factory Balgarh Haryana

5	Sp.Gravityof20mmAggregate	2.8
6	Sp.Gravityof10mmAggregate	2.64
7	Sp.GravityofSand	2.69
8	WaterAbsorptionof20mmAggregate	0.43%
9	WaterAbsorptionof10mmAggregate	0.89%
10	WaterAbsorptionofSand	1.23%
11	Free(Surface)Moistureof20mmAggregate	Nil
12	Free(Surface)Moistureof10mmAggregate	Nil
13	Free(Surface)MoistureofSand	Nil
14	SieveAnalysisofIndividualCoarseAggregates	SeparateAnalysisDone
15	Sp.GravityofCombinedCoarseAggregates	2.882
16	SieveAnalysisofFineAggregates	SeparateAnalysisDone
A-3	**TargetStrengthforMixProportioning**	
1	TargetMeanStrength(MORT&H1700-5)	46N/mm^2
A-4	**SelectionofWaterCementRatio**	
1	MaximumWaterCementRatio(MORT&H1700-3A)	0.50
2	AdoptedWaterCementRatio	0.50
A-5	**SelectionofWaterContent**	
1	MaximumWatercontent(10262-table-2)	186Lit.
2	EstimatedWatercontentfor50-75mmSlump	197Lit.
3	Steel Slagused	0.5%bywt.ofcement
A-6	**CalculationofCementContent**	
1	WaterCementRatio	0.50
2	CementContent(191/0.50)	383kg/m^3
		Whichisgreaterthen320kg/m^3
A-7	**ProportionofVolumeofCoarseAggregate&FineAggregateContent**	

1	Vol.ofC.A.aspertable3ofIS10262	62.00%
2	AdoptedVol.ofCoarseAggregate	62.00%
	AdoptedVol.ofFineAggregate(1-0.62)	38.00%
A-8	**MixCalculations**	
1	VolumeofConcreteinm^3	1.00
2	VolumeofCementinm^3	0.122
	(MassofCement)/(Sp.GravityofCement)x1000	
3	VolumeofWaterinm^3	0.150
	(MassofWater)/(Sp.GravityofWater)x1000	
4	VolumeofAdmixture@0.5%inm^3	0.02025
	(MassofAdmixture)/(Sp.GravityofAdmixture)x1000	
5	VolumeofAllinAggregateinm^3	0.776
	Sr.no.1–(Sr.no.2+3+4)	
6	VolumeofCoarseAggregateinm^3	0.566
	Sr.no.5x0.62	
7	VolumeofFineAggregateinm^3	0.29
	Sr.no.5x0.38	
A-9	**MixProportionsforOneCumofConcrete(SSDCondition)**	
1	MassofCementinkg/m^3	**383**
2	MassofWaterinkg/m^3	**175**
3	MassofFineAggregateinkg/m^3	**401.304**
4	MassofCoarseAggregateinkg/m^3	895.44
5	WaterCementRatio	0.50

CONCRETE MIX DESIGN AND COMPRESSION STRENGTH TEST

Design concrete mix of 1:1.05:1.171 is adopted. The water cement ratio of 0.5 is used. After several trails this mix design was finalized .Thirty cube specimens were casted and tested after curing of 7 and 28 days. For every percentage of replacement 3 cubes have been casted. Totally 60 cubes were casted and tested. These cubes were tested in Compression Testing Machine (CTM) AND Split tensile strength machine (STM).

table-2 Proportions of Concrete Mixtures For M25 Grade

Material	Mix designation				
	SS 0%	SS 10%	SS 20%	SS 30%	SS 40%
Coarse Aggregate (kg/m3)	895.44	895.44	895.44	895.44	895.44
Fine Aggregate (kg/m3)	401.304	360.872	320.44	280.008	239.576
Steel slag (kg/m3)	0	40.432	80.864	121.296	161.728
Cement (kg/m3)	383.04	383.04	383.04	383.04	383.04
Water (kg/m3)	114.912	114.912	114.912	114.912	114.912
Water- Cement Ratio	0.5	0.5	0.5	0.5	0.5

3. RESULTS AND DISCUSSION

This research workit the interpretation of both the results gathered from of the separate experiments conducted on concrete specimens cast with or without steel slag is concerned. The key aim of the research programme has been to consider the strength but toughness dimensions of concrete produced as both a partial substitute for sand utilizing steel slag. An experimental programme was scheduled that research its influence of steel slag on the compressive strength and split tensile through concrete section, in order to achieve the aims of both the following discussion. The experimental programme consists for casting, polymerization or processing at various ages of managed concrete samples and steel slag.

The experimental program included the following:

- Testing of properties of materials used for making concrete.
- Design mix (M25).
- Casting and curing of specimens.
- Tests to determine the compressive strength and split tensile strength of concrete.

Compressive Strength

Concrete is mainly then used endure compressive stresses in certain structural applications. If a section with clear concrete becomes subjected through compression, that component splits all along diagonal through its vertical plane. Vertical crack is caused by lateral deformations in the tensile. A flow throughout the concrete that came in the form of even a micro crack all along vertical axis of the component may occur whenever the axial compressive force is added and therefore will begin to spread due to differential tensile stresses.

Test Procedure and Results

To measure for compressive strength of concrete, specimens of 150 * 150 * 150 mm were cast. For more research, concrete mixtures containing different amounts (0 %, % and %) of steel slag is dumped onto buckets or cylinders in partial substitution of both the fine aggregate (sand).

In either analysis, so first cement with fine aggregate became combined dry to a uniform colour to create concrete, and now the coarse aggregate were applied and blended only with mixture of cement with fine aggregate. And groundwater was applied and combined with the whole amount. Until the concrete were spread, the interior surface of both the moulds as well as the base plate is greased. The tubes were separated from either themoulds after 24 hours, then put at a temperature of 27 ± 20 ° C in clean fresh water. After 7 days for drying, determined from either the moment the water became applied, the written specimens were examined for the dry mix. To monitor against compression, No cushioning material were mounted between some of the system plates and also the sample. Before the specimen failed, its load was axially distributed through shock. The findings of both the concrete compressive strength test containing differing proportions with steel slag replacement at 7 and 28 days of age are published in Table 3 and Table 4.

Table 3 Compressivestrengthofconcrete mixes of specimensize150 ×150× 150withSteelslag

Mix	Compressive Strength (N/mm2)		Average Compressive Strength(N/mm2)	
	7 days	28 days	7 days	28 days

CM	19.89	31.03		
	20.38	32.06	20.36	32.07
	20.57	33.15		
10%	22.35	33.75		
	22.67	34.33	22.8	34.66
	22.96	35.78		
20%	22.87	35.78		
	23.05	36.25	23.46	36.10
	23.69	36.17		

Figure 2 often graphically displays that cube strength effects for concrete mix. As the proportion of steel slag becomes boosted, the compressive strength increases as per the control ratio. Since applying 10% steel slag to both the mix, the rise is 12% since 7 days and 7% after 28 days comparison with the control mix. By adding 20% there is increase of 16%, 13% of 7 and 28 days.

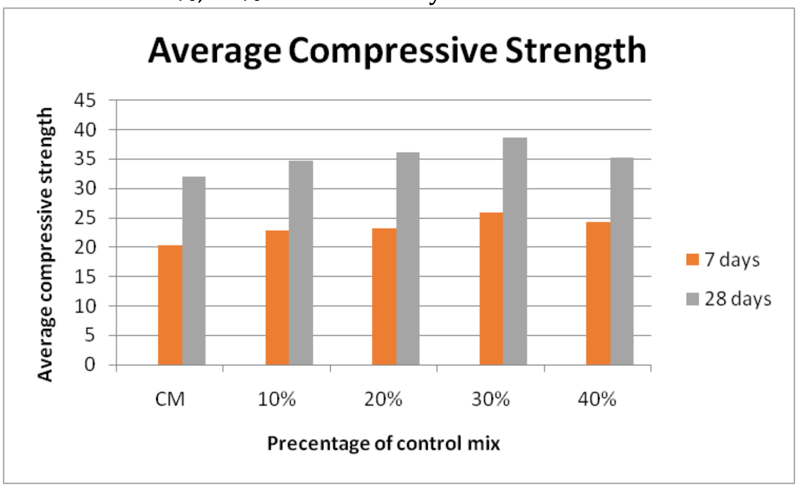

Figure 2 Compressive strength of steel slag concrete

Figure 3 showsthevariationofpercentageincreaseincompressivestrengthwithreplacementpercentageofSteelslag.Ther esultsalsoindicatethatearlyagestrengthgaina t 7 a n d **2 8 days,ishigherwhencomparedtothecontrolmixif30%offineaggregateisreplacedbysteelslag.**

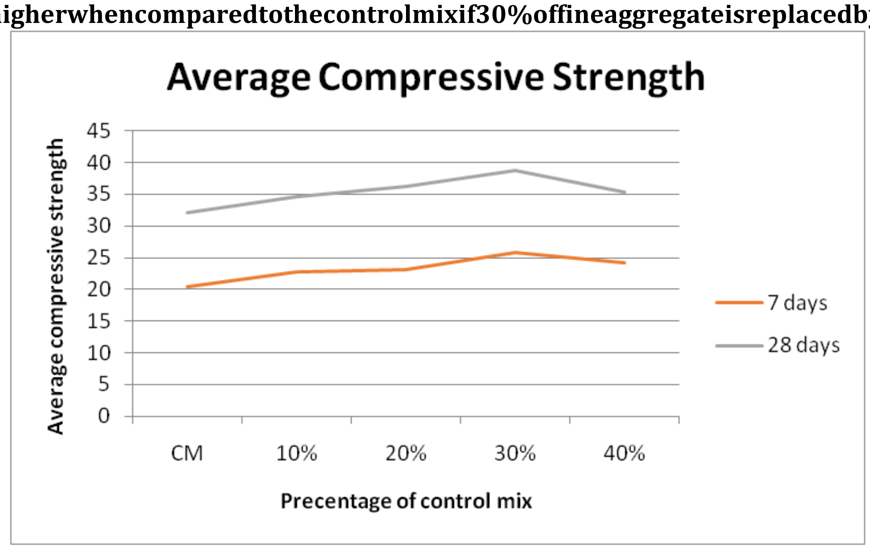

Figure 3Percentage (%) increase in compressive strength of steel slag concrete

Split Tensile Strength Test

Split tensile strength studies were carried out at the age of 7 and 28days. The test results were given below on Table4

Table 4 Splitting tensilestrengthof concrete mixeswithsteel slag

Mix	Splitting Tensile Strength (N/mm2)		Average Splitting Tensile Strength(N/mm2)	
	7 days	28 days	7 days	28 days
CM	1.3	3		
	1.87	2.59	1.50	2.41
	1.59	2.99		
10%	1.58	2.85		
	1.47	2.55	1.72	2.69
	1.52	2.49		
20%	1.9	3.27		
	2	3.5	1.97	3.44
	2.01	3.56		

In Figure 4, its broken tensile strength effects of both the concrete mix are often graphically seen. The results of both the split tensile strength meet a similar trend to the compressive intensity, that is, an improvement of value with such a change in the size of replacement slag. That percent change throughout the separated tensile strength was, nevertheless, less than that of the compressive force. "The split tensile strength increases with the percentage increase in steel slag relative to the control mix. After adding 10% steel slag to the mix, there is a 15% increase after 7 days, a 12% increase after 28 days. By adding 20% of steel slag, a significant percentage increase is obtained, i.e. 31%, 43% respectively after 7, 28 days."

Figure 5 shows the change in the percentage increase in tensile strength divided by the percentage of steel slag replacement. Strength gain at a young age of 7 and 28 days is maximum with 30% slag replacement.

From the point of view of resistance, it can be concluded that at an early age the presence of a greater quantity of steel slag in place of sand in the concrete is useful to improve the resistance characteristics.

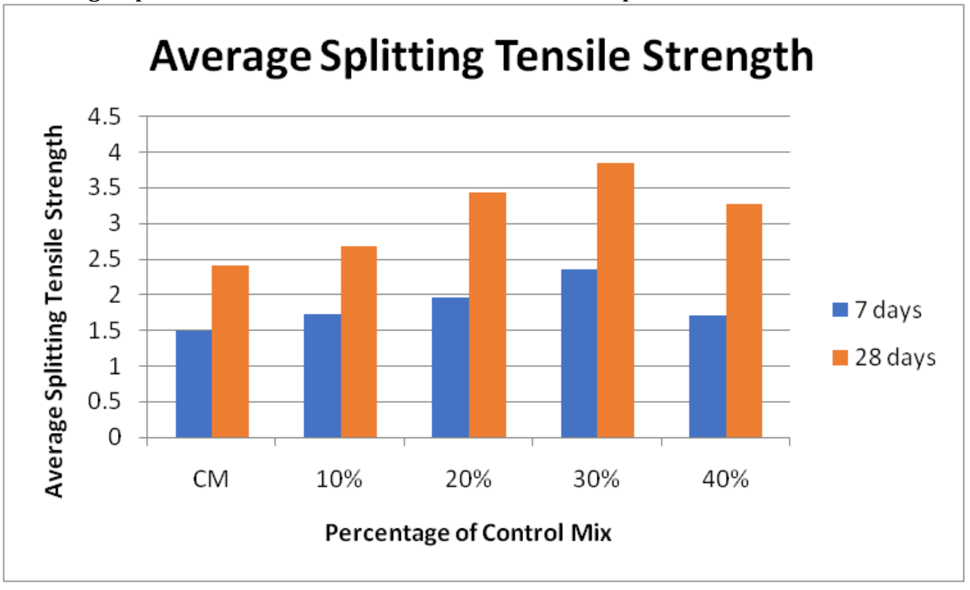

Figure 4 Split tensile strength of steel slag concrete

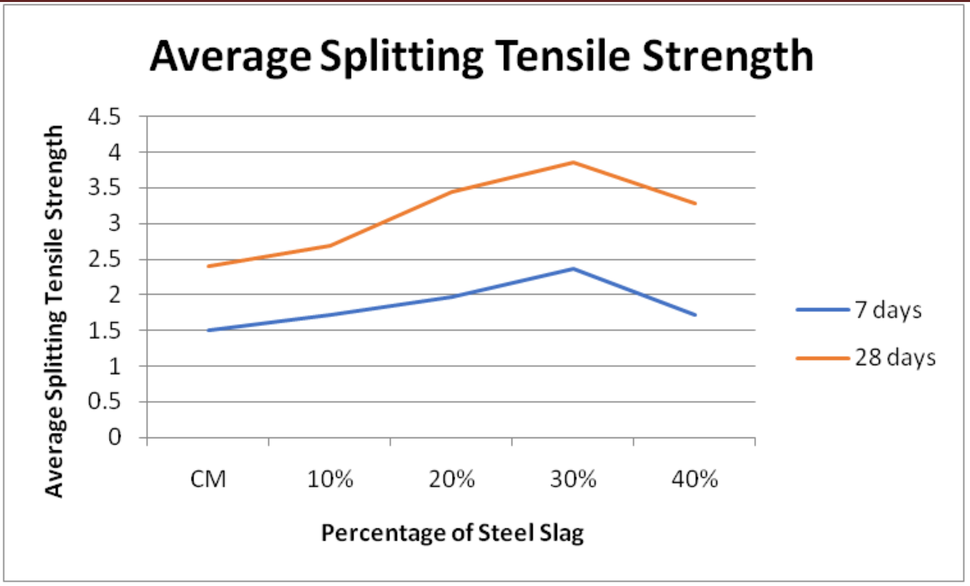

Figure 5 Percentage (%) increase in split tensile strengthof steel slag concrete

4. CONCLUSION

Throughout the present work, that strength and toughness characteristics of concrete mixtures were determined through replacing 10 per cent and 20 per cent steel slag with sand. Following findings are taken from of the current thesis.

COMPRESSIVE STRENGTH

- The Compressive strength tends to increase with increase percentages of steel slag in the mix.
- The early age strength gain is higher as compared to later ages if 30% of fine aggregate is replaced by steel slag.
- After adding 10% steel slag in the mix, there is an increase of 12% after 7 days, 7% increase after 28 days as compared to the control mix. By adding 20% steel slag, there is large amount of increase in percentage i.e. 16%, 27% after 7, 28 days respectively.

SPLIT TENSILE STRENGTH

- The Split tensile strength also tends to increase with increase percentages of steel slag in the mix.
- After adding 10% steel slag in the mix, there is increase of 15% and 12% after 7 and 28 days. By adding 20% steel slag, there is large amount of increase in percentagei.e. 31%, 57%, 60% for 7 and 28 days respectively.
- At early age presence of more amount of steel slag as sand replacement in concrete is beneficial for improving the strength characteristics.

References:

1. Higgins D.D. (2003). "Increased sulfate resistance ofggbs concrete in the presence of Carbonate" Cement and Concrete Composites Vol. 25 pp 913-919.
2. Indian minerals year book 2011, part II "Government of India Ministry of Mines Indian Bureau of Mines Indira Bhavan". Civil lines, Nagpur– 440 102
3. IS: 10262-1982 (Reaffirmed 2004): Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004.
4. IS: 10262-2009: Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004.
5. IS: 383-1970: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, New Delhi-1970.
6. IS: 2386 (Part I, III)-1963: Methods of Test for Aggregates for Concrete, Bureau of Indian Standard, New Delhi-1963.
7. IS: 4031 (Part 4, 5&6)-1988: Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standard, New Delhi-1988.
8. IS: 5816-1999: Methods of test for Splitting Tensile Strength of Concrete, Bureau of Indian Standard, New Delhi-1999.
9. IS: 8112-1989 (Reaffirmed 2005): Specification for 43 Grade Ordinary Portland Cement, Bureau of Indian Standard, New Delhi-2005.

10. RaiA.,PrabakarJ.,RajuC.B.,MorchalleR.K.(2002).“Metallurgicalslagasacomponentin blendedcement.”ConstructionandBuildingMaterialsVol.16pp489-494.
11. Yigiter H.S., Yazici H., Aydm S. (2006). “Effects of cement type, water/cement ratio and cement content on sea water resistance of concrete.” Building and Environment Vol. 42 pp 1770-1776.
12. S.T.Borole, R.V.Shinde, R.B.Mhaske, S.S.Pagare, K.S.Tribhuvan, N.M.Pawar, V.D.Tiwari, A.K.Sanehi, (2016), “Replacement of steel slag by fine aggregate”, Vol.No.2, Issue 3.
13. Shriver Padha, Ravi Kumar (2016), “Utilization of Steel Slag in Concrete as a Partial Replacement to Fine Aggregate”, Vol.No.4, Issue 07, Page No.5542-5552.
14. Mr.pruthviraj.L.Kadam, Anuj.P.Sheetal (2016), “Effect of partial replacement of fine aggregate by steel slag and its impact on compressive strength of concrete”, Vol.07, Issue 02.
15. SubathraDevi.V, Gnanavel.B.K, Murthi.P (2015), “Experimental Investigation on the mechanical properties of steel slag ceramic concrete”, Vol.08, No.08, Page No 915-925
16. Aldea C, M., Young F., Wang K., Shah S. P. (2000).”Effects of curing conditions on properties of concrete using slag replacement.” Cement and Concrete Vol. 30 pp 465-472.
17. Ameri M., Kazemzadehazad.S. (2012)”Evalution of the use of steel slag in concrete”. 25th ARRB Conference – Shaping the future: Linking policy, research and outcomes, Perth, Australia.
18. A Guide to the Use of Iron and Steel Slag in Roads. Revision 2, (2002) Published by: Australasian Slag Association Inc.