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# LIGHT WEIGHT CONCRETE BY USING STEEL SLAG& ZINC STEARATE

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*Abstract:* As the growth of population is the main problem faced by world, demand for construction of houses is increased day by day and demand for concrete also increased. In concrete coarse aggregate is used, which adds weight to the concrete. To reduce that weight steel slag is used in the place of coarse aggregate cement is used as a binding material which is responsible for environmental pollution. To reduce that pollution zinc stearate is used in the place of cement varying of strength with different propositions of zinc stearate is studies. By using 100% steel slag replaced with coarse aggregate decreased weight of 19% and zinc stearate is replaced with cement 1%,2%,3%,4%,5% decreased with of 19.3%,19.2%,19.1%,
19%,18.9%.

***Index Terms* – light weight concrete,steel slag, zinc srearate.**

CHAPTER- 1INTRODUCTION

## 1.1 *PORTLANDCEMENT:*

Portland cementis a fine gray powder. Among the various kinds of cement itisthemost commonly used as binding material. It is made of amixtureof chalkorlimestone togetherwithclay.

The limestone or chalk and the clay,in appropriate proportions, are fedintoa"wet grinding mill" and reduced to a creamy substance known as slurry. The slurry ispumped to a large cylindriical "kiln" which is about 90 m long and 3 m in diameter. Theslurry enters the kiln at its upper end while pulverized (crushed) coal, gas or other fuel isblown in at the other end.

## 1.2 *AGGREGATES:*

Aggrregates are defined as inert, granular, and inorganic materials that normallyconsist of stone or stone-like solids. Aggregates can be used alone (in road bases andvarious types of fill) or can be used with cementing materials (such as Portland

*CLASSIFICATIONOFAGGREGATE:*

Aggregatescanbedivided intoseveralcategoriesaccordingtodifferentcriteria.

**A)** *INACCORDANCEWITHSIZE:*

Coarse aggregate: Aggregates predominately retained on the No. 4 (4.75 mm)sieve.Formassconcrete,themaximumsize canbe aslargeas150mm.

Fineaggregate(sand):AggregatespassingNo.4(4.75mm)sieveandpredominatelyretainedon theNo.200(75µm)sieve.

**B)** *INACCORDANCEWITHSOURCES:*

Natural aggregates: This kind of aggregate is taken from natural deposits withoutchanging their nature during the process of production such as crushing and grinding.Someexamplesinthiscategoryare sand,crushedlimestone,andgravel.

Manufactured(synthetic)aggregates:Thisisakindofman-madematerialsproduced as a main product or an industrial by-product. Some examples are blast furnaceslag,lightweight aggregate (e.g. expanded perlite), and heavy weight aggregates (e.g.ironoreorcrushedsteel).

**C)** *INACCORDANCEWITHUNITWEIGHT:*

Light weight aggregate: The unit weight of aggregate is less than 1120 kg/m$^3$. Thecorresponding concrete has a bulk density less than 1800 kg/m$^3$.(Cinder, blast-furnaceslag,volcanicpumice).

## 1.3 *STEELSLAG:*

The current utilization rate of steel slag is only 22% in china, far behind thedeveloped countries. At present, the amount of slag deposited in storage yard adds up to30Mt, leading to the occupation of farm land and serious pollution to the environment.

## 1.4 WATER

Water plays a vital role is achieving the strength of concrete. For completionhydration it requires about 3/10th of its weight of water. It is practically proved thatminimumwatercementratio0.35isrequiredforconventionalconcrete.

CHAPTER2 LITERATUREREVIEW

## 2.1 ORDINARYPORTLANDCEMENT

*ShaswataMukherjee,SarojMandal, Adhikari.U.B*

An experimental investigation has been carried out tostudy the physical andmechanical property of high volume fly ash cement paste. Ordinary portland cement wasreplaced by 0, 20, 30, 40, 50, 60 and 70 % class F fly ash (by weight). Water- binder ratioin all mixture was kept constant at 0.3. Cube specimens were compacted in table vibrator.As expected bulk density decreases with fly ash increment in the mixture. Apparentporosity and water absorption value increases with replacement of cement by fly ash.Results confirm the decrease in compressive strength at 3, 7 and 28 day with fly ashaddition and it is more prominent in case of more than 30% fly ash content mixes.Ultrasonic pulse velocity test results indicate that the quality of the paste deteriorate withincrease offlyashcontentinthemixture

*M.Alexander,B. Elsener, E. GartnerJ.L. Provis,R.*

The aim of Cement and Concrete Research is to publish the best research oncement, cement composites, concrete and other allied materials that incorporate cement.Indoingso,thejournalwillpresent:theresultsofresearchonthepropertiesandperformance of cement and concrete; novel experimental techniques; the latest analyticaland modelling methods; the examination and the diagnosis of real cement and concretestructures; and the potential for improved materials. The fields which the journal aims tocoverare:

CHAPTER 3 MATERIALPROPERTIES

## 3.1 CEMENT:

### 3.1.1 NORMALCONSISTENCYOFCEMENT:

**Aim:**Todeterminethenormalconsistencyofgivencementsample.
**Reference:**IS:269–1976andIS:4031–1968

*Apparatus:*

- Vicatapparatus(confirming to IS:5513–1968)withplunger(10mmdiameter).
- Vicatmould.
- Gaugingtrowel.
- Measuringjar.
- Balance
- Tray

*Fig3.1.1Vicatapparatusfornormalconsistency*

**Theory**

The standard consistency or normal consistency of a cementpaste is defined asthe amountof water (in percentage by weight of dry cement) that permits the vicatplungertopenetratetoadepthof5to7mmfromthebottomofthe vicatmould.

*Procedure*

- Take 400g of cement and prepare a paste with about 28% (by weight of cement) waterby taking care that the gauging time is from 3 to 5 minutes. The gauging time is countedfromtheinstantofadding ofwatertodrycementuntilthemouldisfilled.

*Observations*

**Table3.1:Normalconsistencyofcement**

| Amountof water(%) | Initialreading | Finalreading | Depth ofpenetrationfrom bottom(mm) |
|---|---|---|---|
| 29 | 38 | 36 | 2 |
| 32 | 38 | 34 | 4 |
| 35 | 38 | 32 | 6 |

*Result*

- Normalconsistencyofthe givencementsampleis35%.
- Thiscanbedonebyusing Vicatapparatushaving 10mmdia.ofplunger.
- Wherethedepthofpenetrationofplungerislimitedto5to7frombottomthat%ofwatercanbetreatas consistencyofcement.

***3.1.2*** *INITIALSETTINGTIMEOFCEMENT*

**Aim** :Todeterminetheinitialsettingtimeofthegivencementsample.

**Reference** :IS:269-1976and4031-1968

*Fig 3.1.2 Vicatapparatusforintialsetting*

**Theory**

In order toplace the concrete in position,itis necessary that theinitial settingtime of the cement is not too low. Once it has beam laid, the hardening should be rapid sothatthe structurecanbesubjectedtothe incidentalloadsas earlyas possible.

*Procedure*

- Prepareaneatcementpastbygauging400gmscementwith 0.85Pwater,wherePisthenormalconsistencyofthegivensampleofthecement.
- Thegaugingtimeisbetween3and5minutesthegaugingtimeiscountedfromtheinstantofaddingofwatertodrycement.
- Fillthevicatmouldwiththepreparedpastandlevelistothetopofthemould.Thecementblockthus preparedis know as the testblock.
- Placethetestblockonanonporousplateandsetitbellowthevicatneedle.Lowertheneedle tomake contactwithsurface ofthetestblock.
- Quicklyreleasetheneedleandallowittosink. Notthereading.
- Repeat the experiment until the needle fails piercing the block at a level 5 to 7 mm frombottom.

*Observations*

- Weightofcementtaken:400gms.
- Amountofwater added:119ml.

*Results*

Initialsettingtimeofthegivencementsampleis: 36 **min.**

### *3.1.3 FINALSETTINGTIMEOF CEMENT*

**Aim**:Todeterminethefinalsettingtimeofthegivencementsample.

**Reference** :IS:269-1976and4031-1968

*Fig 3.1.3Vicatapparatus forfinalsetting*

## 3.2 *SPECIFICGRAVITYOFCEMENT*

**Aim:**Todeterminethespecificgravityofgivencementsample.

*Apparatus:*

- Specific gravitybottle of50mlcapacity
- Balance ofaccuracyupto0.1g
- Kerosene

*Precautions*

**Fig3.2Specificgravitybottle**

- Onlykerosenewhich isfree ofwateristo be used.
- Allairbubblesshallbeeliminatedinfillingtheapparatusandinsertingthestopper.
- Thewholeprocedure shallbe doneattemperatureof271˚c.
- Weighingshallbedonequicklyafterfilingtheapparatusandshallbeaccuratetо0.1milligram.
- Precautionsshallbetakentopreventexpansionandoverflowofthecontentsresultingfromtheheatofthehandwipingthesurface oftheapparatus.

*Observations*

Theobservationsareasgivenbelow.

Weightofemptyspecificgravitybottle, W1=44.1gWeightofsp.gr.bottle+wt.ofcement, W2= 70 g

(1/3 rd.to 2/3rd.ofbottlefull)

Weightofsp.gr.bottle+cement+kerosene, W3=106.20gWeightofsp.gr.Bottle+kerosene, W4=83.8gSpecific gravityofkerosene= 0.79

Specific gravityofcement= (W2-W1) / {(W4-W1)-(W3-W2)}

= (70-44.1) / **{83.8-44.1)-(106.2-70)}**

*Result*

Specificgravityofcementis foundtobe = 3.15

*3.3.SIEVEANALYSISZONE*

TheSieveAnalysisofsandiscarriedouttoknowthezoneofthesand.Theresultsofsieve analysis aregiveninTable No.3

*Table3.3Sieveanalysis*

| Sievesize | Weight Retainedingm | %passing |
|---|---|---|
| 4.75mm | 0gm | 100 |
| 2.36mm | 14gm | 98.6 |
| 1.18mm | 149gm | 83.7 |
| 600micron | 564gm | 27.3 |
| 300micron | 208gm | 6.5 |
| 150micron | 56gm | 0.9 |
| 75micron | 09gm | - |
| Total | 1000gm | |

**Fig3.3IS Sieveset**

Fromthesieveanalysisresult,sandfallsunderZoneII.

## 3.4 *SPECIFICGRAVITYANDWATERABSORPTION*

**Aim:-**Todeterminethespecificgravityand waterabsorptionofcoarseaggregate.

*Apparatus:-*

- Balance:capacitynotlessthan3kgs
- Oven
- Wirebasket
- Tray:Ashallowtrayofareanotlessthan325sq.cmair tightcontainer
- Cloths:Twopiecesofsoftabsorbentclothesnotlessthan750mm*450mm

*Fig 3.4.1AggregateAndCloth*

**Fig3.4.2Pycnometer**

*Observations*

Weightofaggregates (A)=504gms

Weightofpycnometer =632gms

Weightofpycnometer+Water (C)=1508gmsWeightofpycnometer+Water+aggregates(B)=1815gmsweightofovendriedsample (D)=497gms

specificgravity = D / {A-(B-C)}

### 3.4.1 *CALCULATIONOFSPECIFICGRAVITYOFFINEAGGREGATE*

Weightofemptypycnometer (W1)=632gms.

Weightofpycnometer +Fineaggregate (W2)=1136gms.Weight of pycnometer + Fine aggregate + water(W3) = 1815gms.Weightofpycnometer+water (W4)=1508gms

1) Dryweightofaggregate (W2-W1)=504gms

2) Weightofequivalentvolumeofwater(W4-W1)-(W3-W2) =197gms

Specificgravity = (W2-W1) / (W4-W1)-(W3-W2)

Water absorption=(A-D) / 100

*Result*

- SpecificGravityoffineaggregateis= 2.55
- WaterAbsorptionofgivenaggregate is= 0.6%

*Result*

- SpecificGravityofcourseaggregateis =2.97
- WaterAbsorptionofgivenaggregate is= 0.34%

CHAPTER 4OBJECTIVESOFINVESTIGATION

### 4.1 *STEELSLAG*

Two common methods are used in steel production as basic oxygen furnace and electricarc furnace.

Electricarcfurnaceisusedmorethan40%ofglobalsteelproductionintheworldbecausescraprecyclingismore economicaland sustainable production.

**4.2** *ZINCSTEARATE*

Zinc stearateischemicalmaterialwhichisperfectlyreplacementwiththe cement.

So,inthisInvestigationZincSteratehasbeenusedasreplacementforCementindifferentpercentagesandvarioustestshas
CHAPTER 5MIXDESIGN

*5.1General:*

Inthepresentwork,IS10262-2009hasbeenusedtogetproportionsforM20grade Concrete,andMixDesignasfollows.

**5.2MixDesignforM20**

Gradeofconcrete$f_{ck}$=20Mpa

| | |
|---|---|
| Maxsizeofaggregate | =20 |
| Degreeofworkability | =0.7(Compactingfactor) |
| Specific gravityofcement | =3.15 |
| Specific gravityofsand | =2.6 |
| Specificgravityofaggregate | =2.68 |

SandbelongstozoneII

**1)Targetmeanstrengthfor design**

$F_{ck}=F_{ck}+T_s$

=20+1.65x4

$F_{ck}$=26.6N/mm$^2$

**2)** **Selectionofwater–cementratio**AsperIS:456–2000,Tableno: 5WaterCementratioadoptedas0.5

*5. Determination ofcoarseaggregateandfineaggregatecontents*

V=[W+C/Sp.C+(1/PxF$_a$/Sp.f$_a$]x1/1000

0.98=[180+360/3.15+(1/0.35xf$_a$/2.6]x1/1000

F$_a$=584.5kg/m$^3$

C$_a$= (1-P)/PxF$_a$xSp.C$_a$/Sp.F$_a$

= (1-0.35)/0.35x584.5x2.68/2.6

C$_a$=1223.8kg/m$^3$

*MixProportion thenbecomes*

| Water:Cement | :Sand | :Coarse |
|---|---|---|
| 180 | :360 | :584.5:1169.4 |
| 0.5 | :1 | :1.62:3.39 |

*For1bagofcement*

| | |
|---|---|
| Water | =50x0.4=20Lit |
| Cement | =50kg |
| Sand | =50x1.62 =81kg |
| Coarse aggregate | = 50x3.39=165kg |

Inthepresentwork,IS10262-2009hasbeenusedtogetproportionsforM40grade Concrete,andMixDesignasfollows.

❖ Requiredwatercontent=180lit/m$^3$

# CHAPTER 6EXPERIMENTALINVESTIGATIONS

## 6.1 DETAILS OF FINAL MIX PROPORTIONS IN M20&M40

Inthisprojectweareusing steelslag asthereplacementofcoarseaggregate.We arereplacingthecoarse aggregatewiththe 100%steelslag.

Zinc stearateischemicalmaterialwhichisperfectlyreplacementwiththe cement.

So,inthisInvestigationZincStearatehasbeenusedasreplacementforCementindifferentpercentagesandvarioustestshas beencarriedout.

It has been used in percentages of 1%, 2%, 3%, 4%, 5% replacements for Cement and several cubeshavebeencastedinthese percentagesforinvestigation.

**Table 6.1 Details of Weights (M20)**

| **Sl.no** | **Cement(Kg)** | | **ZINC STREATE(Kg/m3)** | | **FA (Kg/m3)100 % m20** | **CA Replacement with steel slag(Kg/m3)100 %m20** | **Water(Kg/m3) 100% m20** |
|---|---|---|---|---|---|---|---|
| 1. | 100%NA | 360 | N.A | 0 | 584.5 | 1169.4 NA | 180 |
| 2. | 100% | 360 | 0% | 0 | 584.5 | 1169.4 | 180 |
| 3. | 99% | 356.4 | 1% | 3.6 | 584.5 | 1169.4 | 180 |
| 4. | 98% | 352.8 | 2% | 7.2 | 584.5 | 1169.4 | 180 |
| 5. | 97% | 349.2 | 3% | 10.8 | 584.5 | 1169.4 | 180 |
| 6. | 96% | 345.6 | 4% | 14.4 | 584.5 | 1169.4 | 180 |
| 7. | 95% | 343 | 5% | 18 | 584.5 | 1169.4 | 180 |

*NA= Natural aggregate concrete*

## *6.2 COMPRESSIVESTRENGTHTEST*

Foreachset,twostandardcubeswerecasttodetermine7and28dayscompressivestrengthaftercuring.Alsotwono.of cubeswerecastedtoknowthecompressive strengthofconcrete.The sizeofa cubeisasperthe IS10086–1982.

## *6.3 CONCRETEMIXING*

Thorough mixing is essential for the production of uniform, high quality concrete.For this reason equipment and methods should be capable of effectively mixing concretematerials containing the largest specified aggregate to produce uniform mixtures of thelowest slump practical for the work.

## *6.4 WORKABILITY*

Workability is the ability of a fresh (plastic) concrete mix to fill the form/mouldproperly with the desired work (vibration) and without reducing the concrete’s quality.

## *6.5 CURING*

In all but the least critical applications, care needs to be taken to properly cureconcrete, to achieve best strength and hardness. This happens after the concrete has beenplaced. Cementrequires amoist, controlled environment to gain strength and hardenfully.


*6.6 PRECAUTIONS*

Followingprecautionsshouldbefollowedcarefullywhilemixingandplacingtheconcrete.

1. Theplasticstrawsandsheetstakingshouldbecutuptoourrequirementswithouterrors.
2. Thewaterforcuringshouldbetestedevery 14daysandtemperatureof thewatermustbe at27±2°C.
3. Theconcretemouldsshouldbecarefullyremovedfrommoulds,placedinwaterandtakingtothetestswithoutcausinganyfailure.

*6.7 TestsonHardenedconcrete*

*6.7.1 CompressiveStrengthofConcrete*

Compressivestrengthwasfoundoutasper IS516-1959.Thecompressivestrengthtestwasconductedafter28daysofcuring.Standardcastironmouldsofdimensions 150 x 150 x 150 mm were used to cast the specimen. The capacity of thecompressivestrengthtestingmachineusedwas2000KN.TheCompressiveTesting

*Fig6.6.1CompressiveStrengthwithCTM*

**6.7.2 SplitTensileStrengthofConcrete**

Assuming concrete specimen behaves as an elastic body a uniform lateral tensile stress ofPartelasticity (Ft)action alonethevertical planecausesthefailureof thespecimen,whichcanbecalculatedfromthe formula.

$Ft = 2P/\pi DL.$

WhereP=loadatfailure,D=DiameterandL=lengthofthecube.

*Fig6.6.2SplitTensileTest*

**6.7.3Flexuralstrengthofconcrete**

**Aim:**Todeterminetheruptureoftheconcretebeam

**Materials and equipment**Universal Testing MachineAConcreteBeamSpecimen**Bendingstress**

**Fig6.6.3Flexuralstrengthtest**

CHAPTER 7EXPERIMENTALRESULTS&DISCUSSION OF TESTRESULT

## 7.1 *General*

Inthischaptertheresultsofworkability,compressivestrength,splittensilestrength and Flexural Tests for different Concrete Mix proportions of M40 with varyingpercentageofZincStearate withcementareshown anddiscussed.

## 7.2 *NormalConsistencyofCement*

*Table7.2: Normalconsistencyofcement*

| TRAILNO. | WEIGHTOFCEMENT (gm) | %OFWATERADDED | DEPTHOFPENETRATION (mm) |
|---|---|---|---|
| 1 | 400 | 29 | 2 |
| 2 | 400 | 32 | 4 |
| 3 | 400 | 35 | 6 |

HencetheConsistencyofcementis35**%**.

## 7.3 *Initialsettingtimeofcement*

Weightofcementsampletaken =400gms

Consistencyofcement =35%asobtainedabove

Volumeofwatertobe added =0.85%*35/100*400

Initialsettingtimeobtained =36**minutes.**

## 7.4 *Finalsettingtimeofcement*

Weightofcementsampletaken =400gms

Consistencyofcement =35%asobtainedabove

Volumeofwatertobe added =0.85%*35/100*400ml

**Graph7.7.1 Workability Comparison**
FinalTestResults

### *7.4.1 Workability*

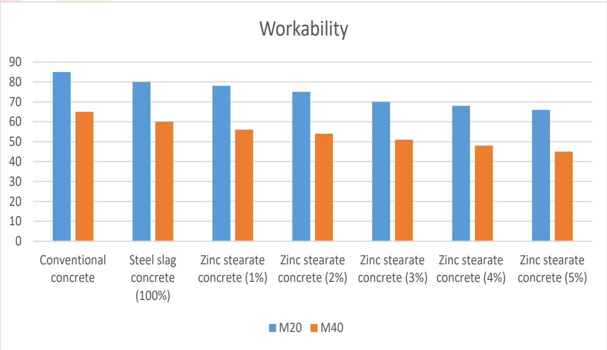
*Table7.7.1: Workability (Slump in mm)Results*

| **Mixproperty** | **Workability(Slump in mm)** | |
|---|---|---|
| **Grade Of Concrete** | **M20** | **M40** |
| **Conventionalconcrete** | **85** | **65** |
| **Steelslagconcrete (100%)** | **80** | **60** |
| **Zincstearateconcrete (1%)** | **90** | **72** |
| **Zincstearateconcrete (2%)** | **96** | **81** |
| **Zincstearateconcrete (3%)** | **104** | **94** |
| **Zincstearateconcrete (4%)** | **110** | **105** |
| **Zincstearateconcrete (5%)** | **117** | **112** |

*7.7.3.Flexuraltest*

Beamspecimenof50cmlength*10cmwidth*10cmheight

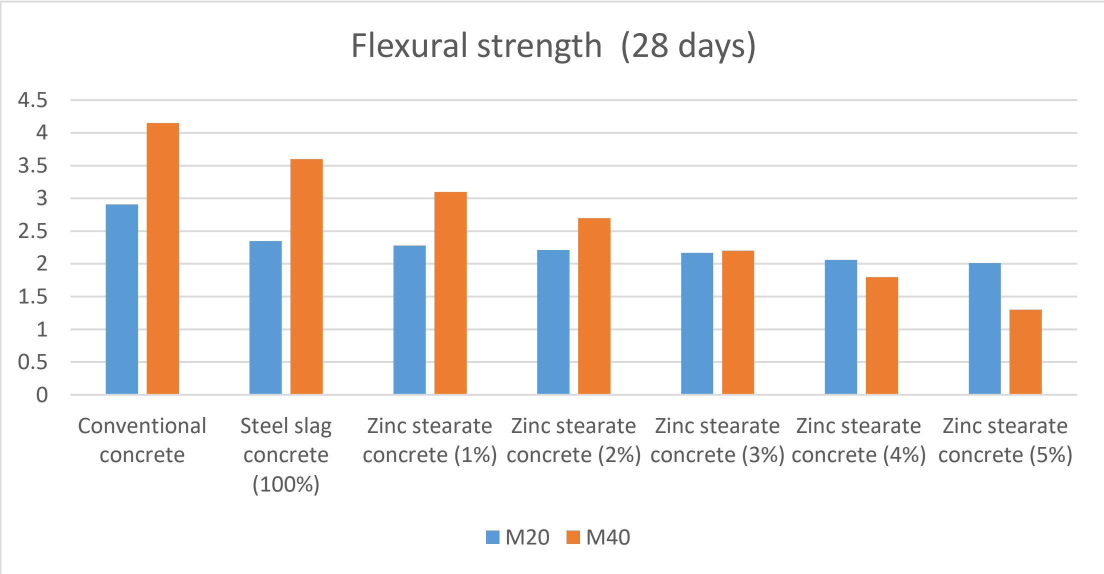
*Table7.7.4:flexuralstrengthresults at 28 days*

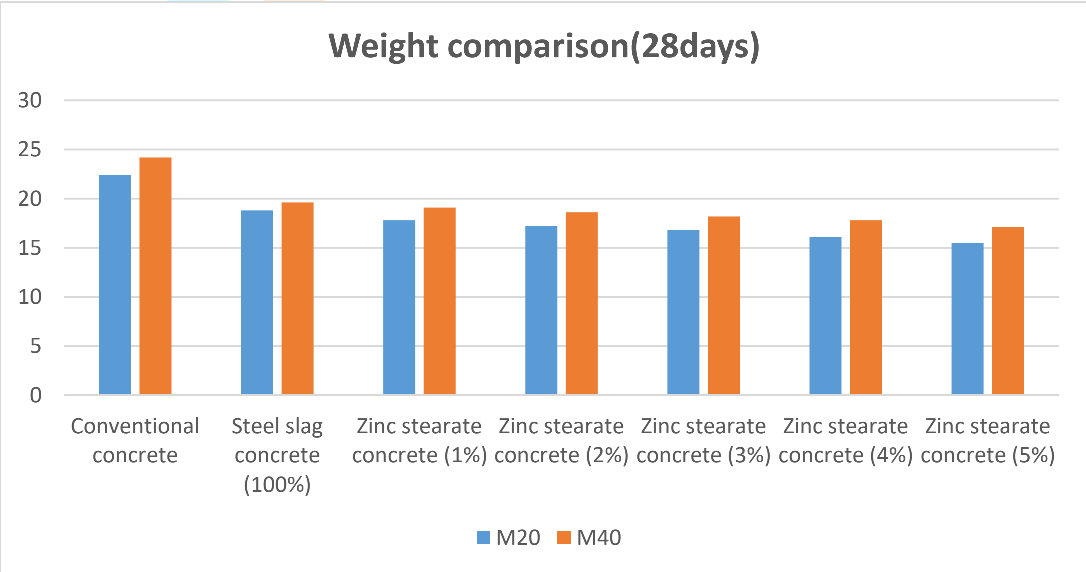



| **Mixproperty** | **Averageflexuralstrength(Mpa)** | |
|---|---|---|
| Grade Of Concrete | M20 | M40 |
| Conventionalconcrete | 2.91 | 4.15 |
| Steelslagconcrete(100%) | 2.35 | 3.6 |
| Zincstearateconcrete (1%) | 2.28 | 3.1 |
| Zincstearateconcrete (2%) | 2.21 | 2.7 |
| Zincstearateconcrete (3%) | 2.17 | 2.2 |
| Zincstearateconcrete (4%) | 2.06 | 1.8 |

| | | |
|---|---|---|
| Zincstearateconcrete (5%) | 2.01 | 1.3 |

**Graph7.7.4flexuralstrength comparison**




**Graph7.7.5weight comparison**

## *7.5 DISCUSSIONOFTESTRESULTS*

**7.8.1Workability**

By replacementof Steel slaginplaceof Coarseaggregate, theWorkability of Concrete is decreased by 6.85% up to 100% replacement. It is also furthervaried with replacement of zinc sterate 1%, 2%,3%,4%&5% Workability is decreased by2.36%,5.11%,6.22%,7.4%,7.9%,8.2%forCC,M1,M2,M3,M4,M5mixeswithzinc sterateof1%,2%, 3 % , 4 % & 5 % replacement

*7.8.4 FlexuralStrength*

*For7days*

By replacement of Steel slag in place of Coarse aggregate, the flexural Strength ofConcrete is decreased by 13.6% up to 100% replacement. It is also further varied withreplacement of zinc sterate 1%,2%,3%,4%,5% flexural Strength is decreased by 6.4%, 7.74%,8.32%,10.5%&12.3%forCC,M1,M2,M3,M4,M5mixeswithzinc sterateof1%,2%,3%,4%,5%replacement

*For28days*

By replacement of Steel slag in place of Coarse aggregate, the flexural Strength ofConcrete is decreased by 13.25% up to 100% replacement. It is also further varied withreplacement of zinc sterate 1%,2%,3%,4%,5% flexural Strength is decreased by 4.81%, 6.74%,8.32%,10.5%&12.3%forCC,M1,M2,M3,M4,M5mixeswithzinc sterateof1%,2%,3%,4%,5%replacement

*8.0CONCLUSION*

- Fromthe resultsacontent ofzincstearates1% to 5% can beusedinconstructionworks.
- If the percentage zinc stearate increases in cement then decreases the strength ofconcretebutreduces self-weight.
- By effective utilizations of the waste material like steel slag the strength aspects can beincreasedandcanreducetheair pollutionbyconvertingthispollutioncausingparticulatematterintousefulbuildingmaterials.

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