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Experimental Investigation on High Performance Concrete Using Nano Material

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ABSTACT: The construction business is growing fast and it needs strong and long-lasting materials. High Performance Concrete is a kind of materialthatisbetterthantheusualconcrete.Itisstronger.Lastslonger.ThisstudyisabouthowHigh-PerformanceConcreteworkswhenweaddGroundGranulatedBlastFurnaceSlagandFlyAshtoit.Wewanttoseehowtheseadditionsaffec ttheconcrete.We made mixes of concrete with Ground Granulated Blast Furnace Slag and FlyAsh.We tested these mixes in the lab after 7, 28 and 56days.TheresultsshowthataddingGroundGranulated BlastFurnaceSlagandFly Ashmakesthe concrete stronger overtime. It also helps to reduce the heat that is produced when the concrete is made. This makes the concrete more resistant to damage from sulphates and chlorides. Using Ground Granulated Blast Furnace Slag and Fly Ash is also good for the environment because it reducestheamountofcarbonemissions frommakingcement. Thisstudyshowsthatusing theamounts of Ground GranulatedBlast FurnaceSlagandFlyAshcanmakeHighPerformanceConcretethatisgood,for the environment and workswellforbuildingnew infrastructure.

Keywords: High PerformanceConcrete,GroundGranulated Blast Furnace Slag,FlyAsh, SupplementaryCementitiousMaterials, Compressive Strength, Durability Sustainable Construction

I. INTRODUCTION

Concretehasbeenusedtobuildinfrastructureforoverahundredyears.Itisusedinthingslikehomes,bridges,dams,highwaysand buildings that hold stuff. Concrete is very versatile. It can be moulded into shapes. It is very strong and not too expensive. That is why it is so important in building things. More people are living in cities. Industries are growing. So concrete needs to be even better.

Weneedconcretethat'snotjuststrongbutalsolastslong.Itshouldbegoodfortheenvironment.Canhandletoughconditions. Regular concrete is okay for some things. It has some problems.

- Itletswaterineasily.
- Itcangetdamagedby chemicals.
- Itcancrackeasily.

This can cause problems for buildings. Especially those near the ocean in areas or in places with extreme weather. So we created HighPerformanceConcrete(HPC).HPCisnotstrongconcrete.Itisdesignedtodothings.Likebeingeasytoworkwithverystrong not letting water in and lasting long.

HPCstartedbeingdevelopedinthe1900s.Researchersfoundwaystomakeconcretebetterbyaddingmaterialstoit.Oneimportant thing that affects how well concrete works is how cement reacts with water. When cement mixes with water it creates a gel that makesconcrete strong. Some of the stuff created during this reaction is not good for concrete. That is where FlyAsh and Ground Granulated Blast Furnace Slag (GGBS) come in.They react with the stuff. Make concrete even stronger and more durable. Using waste materials like FlyAsh and GGBS in concrete is good for the environment. It makes concrete better.

Cement production causes a lot of pollution. So, using these materials reduces that. FlyAsh is a residue from coal burning. GGBS isfrom the iron and steel industry. They both make concrete better. They are good for the environment. FlyAsh makes concrete workableand strong.GGBS makesconcretestrong.Itisresistantto chemicalsand goodforstructures.When wecombineFlyAsh and GGBS concrete gets even better. It becomes less porous and stronger.

Thismakesconcretelonger.Itresistsdamage.To makeHPC wealsousechemicalscalled superplasticizers.They help makeconcrete workable without adding water. Less water means durable concrete. Making HPC with FlyAsh and GGBS is good for countries that are building a lot. It helps the environment. It saves money. Makes buildings last longer. Making HPC needs planning and control. We need to make sure we use the amounts of materials and conditions. If not concrete might not be as strong or durable.

ThisstudylooksathowHPCworkswithamountsofFlyAshandGGBS.Wewanttoseehowstrongitis.Wewanttoseehowwell it handles stress and howwell it resists damage.Byunderstanding howthesematerials worktogether wecan createconcretefor buildings.InshortusingFlyAshandGGBSinHPCisastepforconcretetechnology.Itmakesbuildingsstrongerandbetterforthe environment.

Ourresearchwillhelpcreateconcretethat'sdurableeco-friendlyandaffordableforfuturebuildings.TheuseofGGBSandFlyAsh in High Performance Concrete shows a balance between performance and sustainability. Countries can utilize these industrial byproductsfortheirconstructionneeds.ThepropertiesofHPCallowittowithstandconditions.Thecombinationofmaterials used results in strength and durability.

HighPerformanceConcreteintegratingGGBSandFlyAshoffersbothbenefits.ThestudyonHPCaidsincreatinganunderstanding ofit sapplications.Theuseofwasteproductsresultsinenvironmentalimpact.TheoptimizedmixdesignprocessensuresHPCmeets performance requirements.HPCapplicationsrangefromresidentialtolarge-scaleinfrastructureprojects.EngineerscanutilizeHPC for construction needs. The implementation of HPC aligns with sustainability goals. The study contributes to advancements in technology. The characteristics of HPC make it suitable for construction. The research on HPC supports its use in infrastructure development. The development of HPC supports the creation of eco-structures. The study, on HPC provides insights into its performance.

II. RESEARCG SIGNIFICANCE

ThestudyonHighPerformanceConcretewithGGBSandFlyAshisveryimportantfortechnologyandtheenvironmentandmoney. We really need materials that will last for our buildings and roads that are growing fast. Normal concrete can have problems like water getting in and chemicals damaging it and rust eating away the metal.This costs a lot of money to fix. It makes the buildings notlastaslongaswewantthemto.ByusingGGBSandFlyAshofsomeofthecementwecanmaketheHighPerformanceConcrete stronger and better. High Performance Concrete can handlechemicals and last longer which iswhat we need for our buildingsand roads.Makingcementusesalotofenergyandmakesalotofpollutionwhich'snotgoodfortheenvironment.Usingwastelike slag and fly ash is better for the environment because it reduces pollution and helps manage waste and makes construction more ecofriendly.

Theresultsofthisstudywillhelpengineersmakethemixforlastinghigh-PerformanceConcrete.ThisHigh-PerformanceConcrete isgood for buildingsand bridgesand other importantstructuresthose near water.High Performance Concrete with GGBSand Fly Ashisachoice,forourbuildingsandroads.GGBSandFlyAshmaketheHigh-PerformanceConcretebetterandstronger.Engineers can use these findings to build eco-friendly buildings and roads.They can make High Performance Concrete that lasts long and is strong which's what we need for our fast-growing buildings and roads.

III. MATERIALS

A. ORDINARYPORTLANDCEMENT (OPC):-

Ordinary Portland Cement is the thing that holds concrete together. It does this by mixing with water and creating a kind of gel that gives concrete its strength. This gel is called calcium silicate hydrate. Ordinary Portland Cement is really important because it helps stick all the parts of concrete together. We use Ordinary Portland Cement as a standard to compare with materials that we mix with it to make High Performance Concrete.

Fig.OrdinaryPortlandCement[1]

B. FLYASH:-

FlyAshissomething thatisleft over when coal isburned.Itdoesa jobofhelping tomakethingsstronger.FlyAsh reacts with a kind of chemical calledcalciumhydroxide.Thisreaction helpsto make akind of gelthatisreallygood,atmaking thingslastlonger.Thegelfillsinalltheholesandspacessothingsarenotasporous.ThismeansthatFlyAshreallyhelps tomakethingsmoredurable.TheparticlesofFlyAshareshapedlikespheres,whichmakesthemreallyeasytoworkwith.

Fig.FlyAsh[2]

C. GroundGranulatedBlastFurnaceSlag(GGBS):-

GGBS is a type of waste from industry that's very good at mixing with water. When GGBS mixes with water it creates compounds that're similar to cement. This makes GGBS very good at helping to make things stronger as time goes on. GGBS also helps to keep things cool when they are being made. It makes them more resistant, to chemicals. GGBS is really useful because GGBS can do all these things for us.

Fig.GGBS[3]

D. FineAggregate(Sand):-

Fine aggregate is really important for concrete. It needs to be clean and have the mix of big and small pieces. This helps the concrete be strong and last a long time. The fine aggregate fills in the gaps between the pieces of aggregate. It also helpssharetheweightthatisputontheconcrete.Fineaggregateiscrucialfortheconcretetobegood.Itmakestheconcrete strong and able to withstand a lot of weight. Fine aggregate plays a role, in making sure the concrete is durable and will last.

Fig.FineAggregate(Sand)[4]

E. CoarseAggregate:-

CrushedGravelmixeswiththecementpastetoformastrongconcrete.Thismakestheconcretedense.Givesitthestrength to handle heavy weight. The crushed stone and gravel are key here they bind with the cement paste. This combination provides the compressive strength to the concrete.

Fig.CoarseAggregate[5]

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F. Superplasticizer(High-RangeWaterReducer):-

Superplasticizers help concrete mixes with a water-binder ratio to stay workable. This is especially important for High PerformanceConcretemixes.Theymaketheconcretestronger.Keepiteasytoflow.Thelowwaterbinderratiomixturesstayworkablebecause ofsuperplasticizers,which'scrucialforHighPerformanceConcrete.

Ithelpstoincreasethestrength of High Performance Concrete. Superplasticizersare key, in High Performance Concrete mixes as they improve workability and strength.

FigSuperplasticizer[6]

IV. MIX DESIGN

HighPerformanceConcrete(HPC)UsingGGBSandFlyAsh(DesignedasperIS10262:2019andIS456:2000Guidelines)

1) Target Parameters

- GradeofConcrete:M60
- Type:HighPerformanceConcrete
- ExposureCondition:Severe(asperIS456)
- MaximumAggregateSize:20mm
- Workability:100–150mmslump
- MethodofCompaction:Vibration
- CementReplacement:GGBS+FlyAsh

2) TargetMeanStrength

AsperIS10262:2019:TargetMeanStrength

$ft = fck + 1.65S$

Where:

- fck=Characteristicstrength(60MPa)
- S=Standarddeviation(5MPaforM60assumed)

ft=60+(1.65×5)=68.25MPa

Therefore,themixmustachieve **≥68MPa**at28days.

3) Selectionof Water-Binder Ratio

ForM60HPC:

Adopt**w/b=0.30**(lowfordurability&strength)

4) CalculationofBinderContent

Assumewatercontent=150kg/m³(for20mmaggregatewithsuperplasticizer)

Water 150

Binder Content =_______ ____= = 500

kg/m³w/b 0.30

5) *BinderDistribution*

ForternaryblendedHPC:

OPC=50% GGBS= 30% FlyAsh=20%

Material	**%**	**Quantity(kg/m³)**
Cement	50%	250
GGBS	30%	150
FlyAsh	20%	100
TotalBinder	100%	500

6) AggregateProportioning

Assumetotalaggregatecontent≈65–70%oftotalvolume. Using absolute volume method:

Step1:VolumeCalculations

- VolumeofCement=250/(3.15×1000)=0.079m³
- VolumeofGGBS=150/(2.9×1000)=0.052m³
- VolumeofFlyAsh=100/(2.2×1000)=0.045 m³
- VolumeofWater=150/1000=0.15m³
  - VolumeofAdmixture≈0.005m³ Total volume of paste ≈ 0.331 m³ Remaining volume for aggregates:

1−0.331=0.669m³

Step2:FineandCoarseAggregateSplit

ForHPC(20mm aggregate):

- CoarseAggregate= 60%
- FineAggregate=40%

CoarseAggregateVolume=0.401m³Fine Aggregate Volume = 0.268 m³

Converttomass:

- CoarseAggregate=0.401×2.7×1000=1082kg
- FineAggregate=0.268×2.65×1000=710kg

7) SuperplasticizerDosage

- 1–1.5%ofbinder
- Assume1.2%of500kg=6kg/m³

FINALMIXPROPORTION(PERm³)

Material	Quantity(kg/m³)
Cement	250
GGBS	150
FlyAsh	100
Water	150
FineAggregate	710
CoarseAggregate	1080
Superplasticizer	6

Water-BinderRatio=0.30 Mix Ratio (by weight)

Binder:FineAgg:CoarseAgg=

1 :1.42 : 2.16

ExpectedPerformance

- 7DaysStrength:45–50MPa
- 28DaysStrength:68–75MPa

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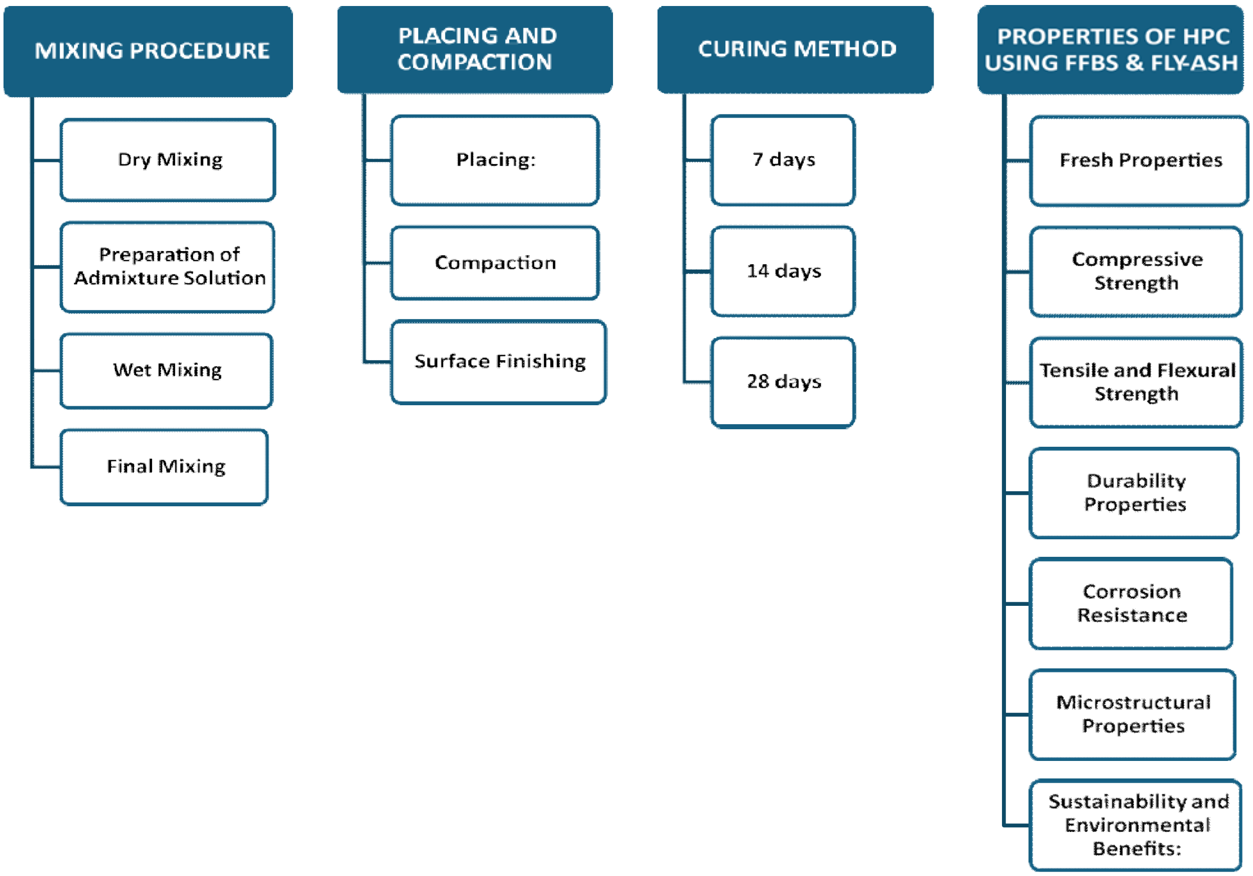
V. METHODOLOGY



A. MIXING PROCEDURE

1) DRYMIXING

In this stage cement, GGBS fly ash, aggregate and coarse aggregate are mixed together in a big container or drum.They are blended for 2to3 minutes.The goalofmixingisto spread outthe extracementmaterialsevenly with the aggregates. When we mix them properly the particles fit together better.This also makes sure that slag. Fly ash are well mixed, with cement before we add water. This way everything is combined uniformly.

2) PREPARATIONOFADMIXTURESOLUTION

To make the Admixture Solution we need to mix an amount of superplasticizer, which is a high-range water-reducing admixture with some of the water that will be used for mixing.Thisisimportant for HighPerformance Concrete because it usually has little water in it. By doing this we can make sure the concrete is workable, without adding water. The Admixture Solution is made separately so that it can be spread out evenly when we add it to the mix.

3) WETMIXING

During mixing, water and a special admixture areadded slowly to the dry mix while themixer is running.Wet mixing is continuedfor3to5minutesuntilauniformandconsistentmixtureisobtained.Thisstepisimportantasitensuresproper hydration of cement and initiates the reaction of fly ash and slag with the cement.

4) FINALMIXING

During concrete mixing, the remaining water is added gradually as required. Mixing is continued until the concrete attains a uniformcolourandconsistency.Themixtureshouldbesmoothandcohesive,withgoodbindingproperties.Itshouldnotcontain any segregation or dry patches.

B. PLACING AND COMPACTION

1) PLACING

Freshly prepared High-Performance Concrete should be placed immediately after mixing to prevent loss of workability.

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The mouldsusedmustbecleanandlightlyoiledbeforecasting.Theconcreteshouldbeplacedinlayerstoensureuniformdistribution and to avoid segregation. Proper handling and care are essential to achieve the desired quality and performance of the High-Performance Concrete.

2) COMPACTION

Eachlayeriscompactedusingatablevibratororaneedlevibratortoremovetheentrappedair.Propercompactionimproves the density of the concrete and ensures good bonding between the paste and aggregates. Care should be taken to avoid over-vibration, as it may lead to bleeding and segregation.

3) SURFACEFINISHING

The top surface is levelled after compaction. It is then finished with a trowel.This helps to get a smooth and even finish. The finish is suitable, for testing and curing the surface.

4) CURINGMETHOD

Curing is really important for making HPC strong and durable especially since it has a water-binder ratio.We keep the specimens inmouldsfor24hours,atroomtemperature.Wecoverthemsotheydonotlosemoisture.Afterwetakethemoutofthemoulds we put them in water that is around 27 degrees. The HPC specimens are cured for 7 days or 14 days or 28 days it depends on when we'regoingtotestthem.PropercuringoftheHPCisnecessaryforthecementtokeepgettinghydratedandfortheslagandflyash to be activated which makes the HPC perform better over time.

C. PROPERTIES OF HP CUSINGGGBS AND FLYASH

1) FRESHPROPERTIES

High Performance Concrete (HPC) containing GGBS and fly ash generally exhibits better cohesiveness and reduced water loss. The spherical shape of fly ash particles improves workability, while GGBS helps in achieving a denser particle packing. Since HPChasalowwatercontent,asuperplasticizerisaddedtoensureproperflowability.Thisisessentialfortheeffectiveutilization of GGBS and fly ash in HPC.

2) COMPRESSIVESTRENGTH

The use of GGBS and fly ash helps to increase the strength over time. GGBS makes the strength better on, through a process that happens after the initial hydration. Fly ash combines with calcium hydroxide to create more of a kind of gel which makes the material denser and stronger. This results in a long-term compressive strength.

3) TENSILEANDFLEXURALSTRENGTH

When the cement pastes and aggregates bond well, the tensile and flexural strength of the concrete improve.This is due to the refinementofthemicrostructure,whichreducescrackformationandenhancestheload-carryingcapacity.Therefore,improved microstructure plays a significant role in increasing the tensile and flexural strength of concrete.

4) DURABILITYPROPERTIES

HighPerformanceConcretewithGroundGranulatedBlastFurnaceSlagandflyashhasafewthingsgoingforit.Foronethingitisnotveryeasyfor watertogetthrough.Italsodoesnotabsorbalotofwater.Thisisbecausethetinystructureof theHigh-Performance Concreteisverydense. Thiskeepsthingslikechloridesandsulphatesfromgettinginanddamaging the High-Performance Concrete.As a result, the High-Performance Concrete can stand up to chemicals better. It will last longer. The dense structure of the High-Performance Concrete is very good, at keeping substances out which means the High-Performance Concrete will have a longer service life.

5) CORROSIONRESISTANCE

The concrete isgood,at keeping water andbad stuffout.It isdense. Has verysmall holes.Thishelpsstop themetal from gettingrusty.So,Bridgesmadewiththisconcretelastlonger.Theconcrete’sabilitytoresistcorrosionisimportant.Ithelps prevent metal damage.This makes reinforced concrete structures stronger and longer-lasting.The corrosion resistance of the concrete really helps. It keeps the metal inside safe from getting damaged.

6) MICROSTRUCTURALPROPERTIES

When you mix slag and fly ash together it makesa strong and uniform structure inside.The special reaction that happens with the fly ash makes the tiny holes smaller. Gets rid of small cracks, which means theMicrostructural Properties of the material are better and it will last longer. The Microstructural Properties are improved because the material becomes stronger and more durable.

7) SUSTAINABILITYANDENVIRONMENTALBENEFITS

Using GGBS and fly ash of some of the cement helps reduce the amount of cement used and lowers carbon dioxide emissions. These are waste materials, from industries. Using them helps save resources. It also supports eco- building practices without affecting how well it works.

VI. APPLICATION

High Performance Concrete that has GGBS and fly ash in it is used a lot in buildings.This is because High Performance Concrete is very strong and lasts a time. People use High Performance Concrete to build buildings and bridges. They also use it to make flyovers and floors in factories.

HighPerformanceConcreteisachoiceforbuildingsneartheseabecauseitdoesnotletwaterineasily.Itisalsogoodfor buildings that hold water, like dams and for sewage treatment plants. High Performance Concrete is used for projects like roads and special parts that are made in factories. It is also used for structures that need to be strong.

The good thing about High Performance Concrete with GGBS and fly ash is that it is good, for the earth. This is because we use cement and that helps our environment.

VII. LIMITATION

High Performance Concrete with GGBS and fly ash is a thing but it also has some problems. One big issue with High Performance Concrete with GGBS and fly ash is that you have to be very careful when you mix it because if you do not get it right it canaffect howwellitworksandhowstrongitis.WhenyouusematerialslikeflyashinHighPerformanceConcretewithGGBSandflyashit can take longer for it to get strong especially if you use a lot of fly ash or slag.

HighPerformanceConcretewithGGBSandflyashalsoneedshelperslikesuperplasticizers,whichcanmakethecostofthe materials higher at first.

To get the results from High Performance Concrete, with GGBS and fly ash you need to take good care of it while it is hardening and make sure the people working with it know what they are doing. If you do not take care of High-Performance Concrete with GGBS and fly ash while it is hardening it may not be as strong and durable as you want it to be.

VIII. CONCLUSION

High performance concrete made with GGBS and fly ash gets stronger. Lasts longer. It performs better too.These materials make theconcretesinternalstructurefiner.Thismeansitislesspronetowaterseepageandmoreresistanttodamageand rust.To getthe results you need to plan the mix carefully and cure it properly. The advantages of high-performance concrete are clear. It has structural performance and is more environmentally friendly. This makeshighperformanceconcreteagoodchoiceforconstructiontoday. WhenyoureplacesomecementwithGGBSandflyashyougetconcretethatisstrongerandlastslonger.Itisalsokindertotheenvironment.Thisis whyhigh-performanceconcreteisamaterial for building infrastructure in the future. High performance concrete that uses GGBSand fly ash isbetter in ways. It isstronger and moredurable. Italso performsbetter in the term.The GGBSand fly ash refine the concretes microstructure.Theyreducepermeability. Make it more resistant to chemical attacks and corrosion. You do need to design the mix and cure it properly. The benefits are worth it. High performance concrete performs better. Is more environmentally friendly. This makes it a great solution for construction. By using GGBS and fly ash of some cement you can make concrete that is stronger and more durable. It is also better for the environment. This is why high-performance concrete is so important, for building infrastructure in the future.

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