STUDY ON ENHANCING THE EFFICIENCY CONCRETE MIX DESIGN FOR ULTRAFINE MATERIAL.

Ms. Rani D. Bhajipale (CE22006), KITS College; Ms. Prachi D. Mohane (CE22014), KITS College; Ms.Diya R.Wadibhasme(CE22048),KITS College; Mr. Hamza M. Siddique (CED2276), KITS College;
Mr. Pranay Basine (CE22021), KITS College;

Mr.Shriniwas V. Rayadu (Assistant Professor), KITS College.

Abstract – The present investigation focuses on improving the performance of concrete through optimized mix design incorporating fly ash and ultrafine materials. Conventionalconcretedesign practicesprimarily emphasize achieving target strength; how ever, aspects such as durability, sustainability, and material efficiency require further consideration.Inthis study, M 40gradeconcretew as proportionedin accordance w ith guidelines ofthe Bureauof Indian Standards. Fly ash w as utilized as a partial substitute for cement in vary ing percentages, along w ith the inclusion of ultrafine materials to enhance particle packing.
Experimentalw orkw ascarriedouttoassessfreshproperties through slump test and hardened properties through compressive strength tests at 7 and 28 days. The findings indicate that partial replacement of cement w ith fly ash improves w orkability and strength up to an optimum level, after w hich a reduction in strength is observed. The study demonstrates that the use of supplementary cementitious materialscontributestosustainableconstructionby reducing cement consumption w ithout compromising performance.
.

Key Words:Concrete mix design, fly ash, ultrafine materials, compressive strength, w orkability, sustainable construction

1. INTRODUCTION

Concrete remains the most extensively used construction material due to its adaptability, strength characteristics, and long service life. The quality and performance of concrete largely depend on the proportioning of its constituents, namely cement, aggregates, water, and admixtures. Traditional approachestomixproportioning,basedonstandardcode recommendations, primarily target strength and basic workability, often overlooking long-term durability and environmental considerations.

construction, there is a growing need to incorporate industrial by-products such as fly ash and other ultrafine materials into concrete. These materials contribute to improved microstructure by enhancing particle packing, thereby reducing voids and permeability. As a result, concrete durability and resistance to environmental exposure are significantly improved.

The present study aims to develop an optimizedmix design for M40 grade concrete by partiallyreplacing cement with fly ash and incorporating ultrafine materials. The investigation focuses on evaluating both fresh and hardened properties of concrete, thereby identifying an optimum mix that balances strength, durability, and sustainability

2. Methodology

2.1 MaterialsUsed

2.1.1 Cement

Ordinary PortlandCement of53grade,conformingtorelevant IS specifications, w as used as the primary binding material. It is know n for its high early strength and suitability forstructural applications.

2.1.2 FineAggregate

Natural river sand passing through a 4.75 mm sieve w as used as fine aggregate. The material satisfied grading requirements and w as free from deleterious substances.

2.1.3 CoarseAggregate

Crushed angular aggregates of nominal sizes 10 mm and 20 mm w ere utilized. These aggregates provided adequate strength and interlocking characteristics.

2.1.4 Fly Ash

Fly ash, a by- product of thermal pow er plants, w as used as a partial replacement for cement. It improves w orkability and contributes to long- term strength development.

2.1.5 UltrafineMaterials

Ultrafine materials w ere incorporated to enhance particle packing density and reduce porosity, thereby improving the mechanical and durability properties of concrete.

2.2 SieveAnaly sis

Particle size distribution of aggregates w as determinedthrough sieve analy sis as per IS 2386 (Part 1). Proper grading ensures improved w orkability and strength of concrete.

3. EXPERIMENTALPROGRAM

3.1 NominalMix Concrete

For comparison, M 20 grade concrete w ith a standard proportion of 1:1.5:3 (cement: fine aggregate: coarse aggregate) w as prepared.

3.2 Design Mix Concrete

M 40 grade concrete w as designed using the guidelines of IS 10262, considering parameters such as target mean strength, w ater- cement ratio, w orkability, and exposure conditions.

3.2.1 Design Parameters

Targetmeanstrength:48.25N/mm² W ater- cementratio:0.40 Cementitiouscontent:450kg/m³ Fly ashreplacement:upto30%

3.3 Preparation ofConcrete

Concretespecimensintheformofcubesmeasuring150mm× 150 mm × 150 mm w ere prepared. Procedure: Drymixingofcementandaggregates Addition ofw aterforw etmixing Propercompactionusingtampingrod Demouldingafter24hours W atercuringfor7and28days

Mixcalculation Themixcalculationperunitvolumeofconcreteshallbeas follow

1. Totalvolume=Im

Volume ofentrappedairinw etconcrete=0.01m ^3

2. VolumeofcementMassofcement/Specificgravity of cement x 1000

4. Volumeofw aterMassofw ater/Specificgravity ofw ater x 1000 = 0.157m3

=157/1×1000

5. Volume offly ashMassoffly ash/Specificgravity offly ash x 1000 = 0.053m^3 =123.78/2.32×1000

6. Volume of superplasticizer 1.1% of volume of cementitious material = mass of super plasticizer/ Specificgravity ofsuperplasticizerx 1000= (1.1/1000)*394 x (1.12 x 1000) = 0.00386m3

7. Volumeofallinaggregate

=l- (b+c+d+c+f)

=l-(0.01+0.117+0.157+0.053+0.00386)

=0.65883m

8. Massoffine aggregate

=Volumeofallaggregatex Volume offineaggregatex Specific gravity of fine aggregate x 1000

=0.65883x 0.382x 2.4x 1000

=603.98kg/m^3

9. Massofcoarseaggregate

Volumeofallaggregatex Volumeoffineaggregate x Specific gravity of coarse aggregate x 1000

=0.6588x 0.618x 2.73x 1000

=1099.27kg/m^3

3.4 TestingofSpecimens

3.4.1 W orkability Test

W orkability of fresh concrete w as evaluated using the slump test,w hich providesaquickindicationofconsistency andease of placement.

3.4.2 CompressiveStrengthTest

Hardenedconcretespecimensw eretestedusingacompression testing machine. The compressive strength values w ere recorded at specified curing intervals.

4. RESULTANDDISCUSSION

The compressive strength of concrete w as evaluated at different curing periods to study the effect of fly ash and ultrafine materials.

Key Findings:
Improvementinw orkability w asobservedw ithincreasing fly ash content.
Compressivestrengthincreaseduptoanoptimum replacement level (around 25%).
Furtherincreaseinreplacementpercentageresultedina gradual decrease in strength.
Ultrafinematerialscontributedtobetterpackingand enhanced strength characteristics.

Table1:CompressiveStrengthat7Days

Fly Ash(%)	Ultrafine(%)	Strength(N/mm²)
0	0	24.87
30	0	25.73
27.5	2.5	26.04
25	5	32.19

Table2:CompressiveStrengthat28days

Fly Ash(%)	Ultrafine(%)	Strength(N/mm²)
0	0	
30	0	36.43
27.5	2.5	
25	5	
22.5	7.5	
20	10	

5. CONCLUSIONS

1. Partialreplacementofcementw ithfly ashimprovesw orkability and contributes to sustainable construction.

2. Anoptimumreplacementlevel(approximately 25%) enhances compressive strength effectively.

3. Excessivereplacement leadstoreduction instrength dueto low er cementitious bonding.

4. Incorporationofultrafinematerialsimprovesparticle packing and overall performance of concrete.

5. Thestudy confirmsthatefficientmixdesigncanreduce cement usage w hile maintaining structural integrity

ACKNOWLEDGEMENT

The authors express their sincere gratitude to the institution and laboratory staff for their continuous support andassistance during the experimental w ork.

REFERENCES

1. Choudhary S., Bajaj R., Sharma R. K. (2014). Study of High Performance Concrete.
2. Ephraim M. E., Ode T. B. (2017). Mix Design for High Strength Concrete.
3. IS456:2000–PlainandReinforcedConcrete Code of Practice.
4. IS10262:2019–Con creteMix Proportioning Guidelines.
5. IS2386(Part1):M ethodsofTestforAggregates.