ISSN No:-2456-2165

Comparative Study on Green and Conventional Concrete

A Thesis Submitted
In Partial Fulfillment of the Requirement for the Degree Of
MASTEROF TECHNOLOGY

IN
STRUCTURAL ENGINEERING AND CONSTRUCTION

By
Ashutosh Kumar
(Enrolment No.-210240714003)

Under the Supervision of
Prof. Amrendra Kumar
Roorkee Institute of Technology

To the
ROORKEE INSTITUTE OF TECHNOLOGY ROORKEE
JANUARY, 2024

ISSN No:-2456-2165

CERTIFICATE

"This is to certify that Ashutosh Kumar (210240714003) conducted the research presented in the thesis titled "A Comparative Study on Green Concrete and Conventional Concrete" towards the attainment of a Master of Technology in Structural Engineering and Construction at Roorkee Institute of Technology. The research was undertaken under my supervision and guidance, as part of the curriculum affiliated with Uttarakhand Technical University.

The content included in the thesis solely represents the original work of the student and has not been previously submitted for the conferment of any other academic degree or diploma."

Signature
Prof. Amrendra Kumar
Department of Civil Engineering Roorkee Institute of Technology

Signature and name
External Examiner

ACKNOWLEDGMENT

I am immensely privileged and delighted to extend my heartfelt gratitude to my supervisor, Ajay Singh, whose unwavering guidance, continuous support, and encouragement have been invaluable throughout this endeavor. His consistent supervision and insightful suggestions have been instrumental in navigating and resolving challenges encountered during this research journey.

I extend my sincere appreciation to the entire staff of the Computation Laboratory and Computer Service Centre for their collaborative assistance during the analysis phase. Their cooperation has been pivotal in conducting the necessary analyses.

My gratitude equally extends to my classmates, friends, and family, whose unwavering encouragement, support, and assistance have been a source of strength throughout this academic pursuit. Their support has been invaluable in shaping the completion of this work.

(Ashutosh Kumar) (210240714003**)**

ABSTRACT

"Green Concrete, renowned for its resource-efficient nature, plays a pivotal role in curbing environmental impact, reducing carbon dioxide emissions, and minimizing wastewater production. This study involves a comparative assessment of the strength and durability characteristics between conventional concrete and green concrete, which incorporates recycled coarse aggregates and fly ash.

In the laboratory setting, three sets of concrete mixtures were meticulously prepared, adhering to the concrete mix design specified by IS 10262:1982 and IS 456 standards. The findings indicate a marginal decrease in compressive strength (approximately 10 to 12%) and tensile strength in green concrete. This reduction might be attributed to the reduced angularity index of the recycled aggregates utilized. Additionally, there was a notable decrease in the tensile strength, up to 25%, observed in recycled aggregate concrete compared to conventional concrete, possibly due to reduced binding of aggregates in the former.

However, the performance of green concrete closely mirrors that of conventional concrete, which can be attributed to the pozzolanic action facilitated by the presence of fly ash in green concrete. Moreover, the study reveals a moderate rate of chloride ion permeability in green concrete with water/cement (W/C) ratios of 0.3 and 0.4. At a slightly higher W/C ratio of 0.5, there is a slightly elevated rate of chloride ion permeability observed in green concrete."

ISSN No:-2456-2165

TABLE OF CONTENTS

- *Replacement of 5% Cement with Fly Ash*
- *Replacement of 10% Cement with Fly Ash*
- *Replacement of 15% Cement with Fly Ash*
- *Replacement of 20% Cement with Fly Ash*
- *Replacement of 25% Cement with Fly Ash*
- *Replacement of 30% Cement with Fly Ash*
- *Replacement of 40% Cement with Fly Ash*
- *Replacement of 50% Cement with Fly Ash*

C. Cost Analysis for 1m3 Conventional Concrete
- *Materials*
- *Machinery*
- *Total Cost for 1m3 Conventional Concrete*

D. Cost Analysis for 1m3 Green Concrete
- *Replacement of 5 % Cement with fly ash*
- *Replacement of 10 % Cement with flyash*
- *Replacement of 15 % Cement with flyash*
- *Replacement of 20 % Cement with flyash*
- *Replacement of 25 % Cement with flyash*
- *Replacement of 30 % Cement with flyash*
- *Replacement of 40 % Cement with flyash*
- *Replacement of 50 % Cement with flyash*

E. Cost Comparison

CHAPTER 7: CONCLUSION

CHAPTER 8: REFERENCES

ISSN No:-2456-2165

LIST OF TABLES

LIST OF FIGURE

CHAPTER ONE

INTRODUCTION

A. GREEN CONCRETE

"Green concrete stands as a progressive concept, marking a significant milestone in the evolution of the concrete industry. Its inception dates back to 1998 in Denmark, signifying a paradigm shift towards environmentally conscious concrete solutions. Despite its name, 'green concrete' doesn't denote a specific color or appearance; rather, it embodies an innovative approach that integrates environmental considerations across various stages, from raw material procurement and manufacturing processes to mixture design, structural implementation, and its entire lifecycle.

Notably, green concrete offers cost-effectiveness in its production. By utilizing waste materials as partial substitutes for cement, it curtails waste disposal expenses, minimizes energy consumption during manufacturing, and concurrently enhances durability. This form of concrete mirrors conventional concrete in appearance but significantly reduces heat energy requirements during manufacturing, thereby minimizing environmental impact and damage.

The emergence of green concrete presents a sustainable alternative within the realm of concrete types, prioritizing minimal energy consumption and reduced environmental footprint throughout its production and application."

B. C02 EMISSIONS

The direct association between concrete manufacturing, particularly cement production, and CO2 emissions falls within the range of 0.1 to 0.2 tonnes per tonne of concrete manufactured. Despite this seemingly modest figure, the sheer volume of concrete production significantly amplifies the environmental impact due to the substantial quantities of cement and concrete produced. Remarkably, concrete ranks as the second most utilized material globally, trailing only water, and contributes to approximately 5% of the world's total CO2 emissions.

Addressing this environmental challenge doesn't entail replacing concrete with alternative materials but rather mitigating the environmental footprint of concrete and cement constituents. The potential societal advantages of adopting green concrete for construction are substantial. There's a realistic prospect of developing technology capable of halving CO2 emissions associated with concrete production, presenting an opportunity to potentially reduce the world's total CO2 emissions by 1.5-2% considering the extensive usage of concrete. Moreover, this approach could offer solutions to numerous environmental issues beyond direct CO2 emissions.

Exploring the utilization of residual products from other industries in concrete production without compromising concrete quality emerges as a feasible avenue. In recent decades, society has heightened its awareness of deposition issues concerning residual products, resulting in increased demands, regulatory restrictions, and various levied taxes.

C. GREEN CONCRETE'S POTENTIAL

There exists significant potential in exploring the utilization of residual products in the manufacturing of concrete. Residual items like silica fume and fly ash present promising prospects. Within the concrete industry, there's a growing realization that proactively addressing environmental concerns and improving the surrounding environment is more advantageous than reacting to regulatory demands, customer preferences, and economic repercussions, such as imposed taxes.

Over time, certain companies within the concrete industry have come to acknowledge a correlation between reductions in manufacturing expenses and diminished environmental impacts. Consequently, environmental considerations are not solely subjects for ideological debates but also hold relevance in terms of economic viability.

D. ADVANTAGES

- Green concrete presents numerous advantages when compared to conventional concrete mixtures.
- Through the utilization of recycled aggregates and materials, green concrete not only alleviates the strain on landfills but also reduces aggregate wastage, resulting in a net reduction in CO_2 emissions.
- The reuse of materials significantly contributes to the economy.
- It can be readily employed for applications requiring low-strength concrete at a cost-effective manufacturing price.
- Utilizing waste materials like aggregates sourced locally and fly ash from nearby power plants minimizes expenses, considering their affordability and minimal transport costs.
- Green concrete plays a pivotal role in sustainable development due to its eco-friendly nature.
- The widespread adoption of green concrete in green building practices aids in achieving LEED and Golden Globe certifications for environmentally sustainable constructions.
- Incorporating fly ash in concrete enhances its workability and various properties, notably durability.
- Several methods employed for producing green concrete focus on reducing the percentage of cement in the mixture composition, effectively cutting down the overall cement consumption.
- Major issue of disposing the excessive amount of concrete industry waste also get helped out due to the its use in green concrete.
- Use of Green Concrete will result in lower CO_2emissions.
- Low manufacturing cost.
- It helps in saving energy.
- Gives another motivation for the recycling of wastes from the industries.
- Workability properties as superior.
- As the tests suggests Compressive strength is comparatively equal to the normal concrete

CHAPTER TWO

LITERATURE REVIEW

A. Materials To Be Taken In Use For The Preperation Of Green Concrete

- *CEMENT*

The prevailing type of cement utilized is Portland Pozzolana Cement, adhering to the IS CODE 1489 (PART-1) 1991 standards.

- *AGGREGATE*

For aggregates, crushed coarse particles within the range of 12.5-20mm sieve size, and conforming to regular continuous grading are employed. The specific gravity stands at 2.4.

- *WATER*

Potable water is used for manufacturing of Green concrete. In general considerations tap water will work.

- *FLY ASH*

Burning of coal is a simple phenomenon, after the burning the left over contains 80% fly ash.

The introduction of fly ash concrete into the concrete industry not only facilitates a substantial reduction in cement usage and energy consumption but also presents numerous advantages.

Laboratory research suggests the possibility of replacing 100% of Portland cement with fly ash. However, studies have revealed that maintaining an optimal replacement level of around 30% ensures maximum quality-based output.

Furthermore, incorporating fly ash can enhance various concrete properties such as durability and slump. Its lower heat of hydration makes it particularly suitable for mass concrete production.

Optimally proportioned use of fly ash in concrete offers several technical benefits, improving concrete performance in both its fresh and hardened states. Typically, fly ash contributes to concrete by reducing the need for mixing water and enhancing paste flow behavior.

CHAPTER 3

ORIGIN OF GREEN CONCRETE

A. General

Concrete is being used now for a very long period of time. Over the time the tyopes incorporated have changed yet the basic idea of concrete remains the same as years before.

Considering the concrete's age or presence "Green Concrete" is a very young topic and alot has still to be known and improved upon.

B. First Contact

The concept and initial development surfaced in Denmark back in 1998. The growing consciousness regarding environmental conservation and the recognition of concrete manufacturing's substantial CO2 emissions were the primary driving forces behind the rapid emergence of Green Concrete.

C. The Kyoto Conference And The Guidelines

The Kyoto Conference of 1997 was a pivotal event where multiple countries deliberated on prevailing environmental conditions. From these discussions emerged the Kyoto Protocol, a set of guidelines serving as directives for participating nations' environmental practices.

The Kyoto Protocol outlined specific targets for countries to reduce their CO2 emissions by a designated degree. Initially set to be achieved by 2012, progress toward this goal has been ongoing, yet remains incomplete.

Following the Kyoto Protocol, numerous countries explored various options. Denmark specifically directed attention toward cement and concrete manufacturing, recognizing that approximately 2% of Denmark's overall CO2 emissions stem from this sector. Given the extensive use of concrete globally, addressing this sector could potentially reduce the world's total CO2 emissions by 1.5-2%. Additionally, it could serve as a remedy for several environmental issues beyond those directly associated with CO2 emissions.

D. The Denmark's Obligation

The Danish government proposed a plan in compliance with the International and Europen Convention and Protocols, aligning with national agreed goal. Central to this proposal is Denmark's commitment to curbing CO2 emissions, addressing various environmental aspects:

- Researching and mitigating the Greenhouse effect.
- Identifying causes and countermeasures for ozone layer depletion.
- Addressing issues related to photochemical oxidation.
- Tackling eutrophication, a process fostering excessive plant growth due to chemicals from rainfall.
- Addressing the effects of acidification and developing countermeasures.
- Managing materials that pose environmental and health risks, particularly concerning water and other resources.

➢ *Five Priority Environmental Impacts*

Additionally, priority areas have been established for participating countries like Grece, Italy, and The Netherland, as well as for Europe and the international community. Despite political differences in environmental priorities, there's unanimous agreement on prioritizing five environmental impacts:

- CO2 emissions
- Energy consumption

- Water management
- Waste management
- Control of pollutants

The convergence of these factors, alongside cost-minimization advantages, has motivated concrete producers to integrate green concrete into their operational strategies. Cement and concrete manufacturing collectively contribute to approximately 5% of the world's total CO2 emissions.

The potential societal and environmental advantages of utilizing green concrete in construction are substantial. Developing technology to reduce CO2 emissions related to concrete manufacturing could potentially lower Denmark's total CO2 emissions by 0.5%. The moderately lenient environmental obligations imply specific technical requirements for various industries, including the concrete sector.

➢ *Technical Specifications*

These technical prerequisites encompass:

- Experimentation with upcoming concrete mix designs
- Exploration of new raw materials
- Application of practical experience and technical models regarding their properties

The increasing global interest in sustainable development has motivated engineers to opt for more sustainable concrete options. However, this decision involves comparing materials based on specific criteria to select those with a lesser impact on environmental performance.

Life Cycle Assessment (LCA) encompasses an extensive array of environmental impact indicators, which encompass embodied energy, air and water pollution, greenhouse gas emissions, water usage, waste generation, recycled content, and various other factors.

E. Environmental Objectives

As per significant global seminars and construction hubs, Green Concrete holds the potential to fulfill several environmental commitments:

- Reducing CO2 emissions by 21%, aligning with the Kyoto Protocol of 1997.
  b. Augmenting the utilization of inorganic residual products from industries other than concrete by around 20%.
- Reducing dependence on fossil fuels by advocating for the incorporation of waste-derived combustible materials in the cement industry.
- Sustaining the recyclability aspect of green concrete when compared to current concrete variants.
- Ensuring the manufacturing of green concrete doesn't disrupt the working environment and maintains a balance with nature.

CHAPTER FOUR

METHODOLOGY

A. Use of Inorganic Waste in Green Concrete

Various materials have been identified as suitable for concrete manufacturing and have been chosen for further development. The selection was made after extensive comparisons and evaluations concerning concrete technology and environmental considerations.

➢ *Stone Dust*

Stone dust, a residual substance generated from the crushing, breaking, and grinding of aggregates, is a non-reactive material with particle sizes falling between those of cement and sand. It is foreseen to be utilized as a partial substitute for sand in the production of concrete.

➢ *Concrete Slurry*

An aftermath material from concrete manufacturing processes, originates from the cleansing of equipment such as mixers. This residue can exist in dry or wet forms, depending on its origin, and is recyclable in both states—either as dry powder or in a water-based form. Processing the dry material into powder is necessary for recycling purposes. Its observed pozzolanic effect renders it suitable for partial replacement of cement.

➢ *Combustion Ash/ Fly Ash*

Fly ash, originates from water-purification plants and factories. This type of ash bears similar characteristics in terms of particle size and shape to fly ash, and its heavy metal content is roughly comparable. Moreover, it exhibits a certain level of pozzolanic activity.

➢ *Smoke Waste*

Smoke waste emerges from waste combustion processes. This waste exhibits some pozzolanic-like effects. Notably, its metal content surpasses that of locally available fly ash. Its impact on chloride, fluoride, and sulfate presence can influence factors like reinforcement corrosion, retardation, and the formation of thaumasite (a calcium sulfate carbonate silicate hydrate formed under cold wet conditions). Further refinement and comprehensive analysis are essential before considering its utilization in concrete production.

B. Different Methodology for Green Concrete's Manufacturing

- To amplify the proportionate use of residual products for the concrete industry, Reducing the content of clinker, for instance by substituting a partial amount of cement with micro silica, fly ash
- Replacement of cement portion with that of Fly ash at different levels as per the required strength requirements.
- Use of waste or by products of construction industries for temporary structures with lower requirements of durability.
- By developing various varieties of green cements and binding materials
- Finding different raw materials with low carbon values that have basic similar properties to the constituents of concrete.

C. Selection Of Method To Produce Green Concrete

Considering the ease and availability of Fly Ash, Replacement of cement portion with that of Fly ash at different levels for the experimental study of Green Concrete is selected.

CHAPTER FIVE

EXPERIMENTAL STUDY – M25

Now, the investigation will be under two flags Strength Analysis & Cost Analysis.

A. Strength Analysis

➢ *Conventional Concrete Ingredients:*
Cement + Aggregates (Fine + Coarse) + Water

➢ *M25 Green Concrete Mix I.*

- Cement:
  50% substitution with Fly Ash II.

- Aggregates:
  ✓ Fine Aggregates portion remains identical to that in Conventional Concrete Mix.
  ✓ Coarse Aggregates portion remains identical to that in Conventional Concrete Mix. III.

- Water:
  Equivalent amount of water to be employed as specified in the conventional concrete mix. (Water/Cement Ratio Used: 0.5)

B. MIX DESIGN FOR M25

Calculation of quantities of:

- Cement
- Sand
- Aggregate for 1m³ concrete

M25 grade (Ratio: 1:1:2)

Total volume considering a safety factor for shrinkage = 1.57m³

Then

The Volume of Concrete – 1.57 m³

➢ *Determining the Volume Of Cement*

Volume of Cement = Cement × 1.57 / (Cement + Sand + Aggregate)
= 1 × 1.57 / (1 + 1 + 2)
= 0.3925 m³

1m³ of Cement = 1440 kgs
For 1m³, Cement = 565.92 kg
Number of Bags = 565.92 / 50 ≈ 12 Bags (Rounded to the nearest whole number)

➢ *Determining the Volume Of Sand*

Volume of Sand = Sand × 1.57 / (Cement + Sand + Aggregate)

ISSN No:-2456-2165

$= 1 \times 1.57 / (1 + 1 + 2)$
$= 0.393 \text{ m}^3$

1m^3 of Sand = 1600 kgs (assumed)
For 1m^3, Sand = 628.8 kgs or approximately 629 kgs

- *Determining the volume of coarse aggregates.*

Volume of Aggregates = Aggregate × 1.57 / (Cement + Sand + Aggregate)
$= 1 \times 1.57 / (1 + 1 + 2)$
$= 0.785 \text{ m}^3$

Now,
1m^3 of Aggregate = 1560 kgs (assumed)
For 1m^3, Coarse Aggregate = 1224.6 kgs or approximately 1225 kgs for 20mm size.

- *Water Requirements*

Cement Requirement = 12 bags = 600 kg
Water-Cement Ratio (W/C) = 0.5
Water required = 600 × 0.5 = 300 kgs
or 300 Liters

Table 1: Required Quantities of Materials for 1 m^3 of Concrete

Material	**Quantity**
Cement	12.0 Bag or 0.416 m^3
Sand	0.393m^3
Aggregates	0.785m^3
Water	300.00Liters

CHAPTER SIX

RESULTS

A. Experiment And Result Comparisions

Comparison of Compressive Strength Test Findings (Cube Test) between Conventional Concrete and Green Concrete.-

Strength observations were made at 7 days and 28 days, respectively.

Table 2: Comparison of Cube Test Results between Conventional Concrete and Green Concrete with 50% Replacement

	7 days Strength	28days Strength
Conventional Concrete Sample		
Sample 1	21.94	28.02
Sample 2	21.20	28.96
Sample 3	23.02	29.22
Average Strength	22.05	28.73
Green Concrete(50%flyash in place of cement)		
Sample 1	19.26	22.51
Sample 2	18.69	23.20
Sample 3	18.89	23.95
Avg Strength	18.94	23.22

B. Further-More Progress While Replacing Cement With Flyash (Percent-Wise)

- *Replacement of 5% Cement With Fly Ash*

Table 3: Comparison between Conventional Concrete and Green Concrete with 5% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.56	26.87
Sample 2	21.21	29.12
Sample 3	23.11	29.48
Average Strength	21.99	28.52
Green Concrete (5%flyash)		
Sample 1	21.83	26.68
Sample 2	21.44	27.46
Sample 3	21.24	27.56
Avg Strength	21.51	27.23

➢ *Replacement of 10% Cement with Fly Ash*

Table 4: Comparison between Conventional Concrete and Green Concrete with 10% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.97
Sample 2	21.91	29.12
Sample 3	22.11	29.48
Avg Strength	21.96	28.32
Green Concrete (10%flyash)		
Sample 1	21.10	26.24
Sample 2	20.83	27.12
Sample 3	20.16	25.62
Avg Strength	20.70	26.33

➢ *Replacement of 15% Cement With Fly Ash*

Table 5: Comparison between Conventional Concrete and Green Concrete with 15% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.97
Sample 2	21.21	29.72
Sample 3	22.11	29.38
Avg Strength	21.96	28.52
Green Concrete (15%flyash)		
Sample 1	20.89	26.02
Sample 2	20.13	26.51
Sample 3	20.54	25.98
Avg Strength	20.52	26.17

➢ *Replacement of 20% Cement With Fly Ash*

Table 6: Comparison between Conventional Concrete and Green Concrete with 20% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.97
Sample 2	21.91	29.12
Sample 3	22.21	29.38
Avg Strength	21.99	28.53
Green Concrete (20%flyash)		
Sample 1	20.34	25.81
Sample 2	19.92	26.29
Sample 3	19.87	25.83
Avg Strength	20.04	25.98

- *Replacement of 25% Cement with Fly Ash*

Table 7: Comparison between Conventional Concrete and Green Concrete with 25% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.87
Sample 2	21.91	29.72
Sample 3	22.21	29.38
Avg Strength	21.96	28.32
Green Concrete (25%flyash)		
Sample 1	19.56	24.21
Sample 2	20.00	24.46
Sample 3	19.79	24.11
Avg Strength	19.78	24.26

- *Replacement of 30% Cement With Fly Ash*

Table 8: Comparison between Conventional Concrete and Green Concrete with 30% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.87
Sample 2	21.21	29.12
Sample 3	22.21	29.48
Average Strength	21.96	28.52
Green Concrete (30%flyash)		
Sample 1	19.18	23.48
Sample 2	18.98	23.15
Sample 3	19.44	23.59
Avg Strength	19.20	23.40

- *Replacement of 40% Cement With Fly Ash*

Table 9: Comparison between Conventional Concrete and Green Concrete with 40% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.98
Sample 2	21.91	29.17
Sample 3	22.21	29.43
Avg Strength	21.96	28.52
Green Concrete (40%flyash)		
Sample 1	18.85	22.31
Sample 2	18.46	22.57
Sample 3	18.15	22.32
Avg Strength	18.42	22.83

➢ *Replacement of 50% Cement with Fly Ash*

Table 10: Comparison between Conventional Concrete and Green Concrete with 50% Replacement

	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	22.15	27.97
Sample 2	22.02	28.12
Sample 3	20.21	28.48
Average Strength	22.99	27.82
Green Concrete (50%flyash)		
Sample 1	19.11	22.08
Sample 2	17.96	21.26
Sample 3	18.58	21.75
Avg Strength	18.55	21.70

C. Cost Analysis For 1m3 Conventional Conrete

The cost analysis for 1m³ of Conventional Concrete:

➢ *Materials*

- *Cement: 12 Bags*
- ✓ Cost = Rs 316.40/ Bag
- ✓ Total Cost = 12 x Rs 316.40 = Rs 3796.80

- *Sand = 0.393m³*
- ✓ Cost = Rs 577.80/m³ (Quarry price)
- ✓ Total Cost = 0.393 x Rs 577.80 = Rs 227.08

- *Aggregates (20mm Nominal Size) = 0.785m³*
- ✓ Cost = Rs 1207.76/m³
- ✓ Total Cost = 0.785 x Rs 1207.76 = Rs 948.09

- *Water Quantity = 300 Liters*
- ✓ Rate = Rs 40 Per K.L. (1000 Liters)
- ✓ Total Cost = Rs (40 x 300) / 1000 = Rs 12

➢ *Machinery*

- Concrete Mixer (1m³ capacity)
- ✓ Output of Machine = 7.5 Cum/Hour
- ✓ Required Output = 1 Cum
- ✓ Rate = Rs 247/hour
- ✓ Calculated Cost = (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

➢ *Total Cost Of Conventional Concrete per m³*

- CEMENT = Rs 3796.80
- SAND = Rs 227.08
- AGGREGATES = Rs 948.09
- WATER = Rs 12
- CONCRETE MIXER = Rs 49
- TOTAL COST = Rs 5032.97 per m³

ISSN No:-2456-2165

D. Cost Analysis Of 1m^3 Green Concrete

➢ *Replacement of 5% Cement with Fly Ash*

- Materials

✓ *Cement: - 11.4 Bags*

Cost= Rs 316.40/ Bag
= 11.4 x 316.40
= Rs 3606.96

✓ *Fly Ash :- Quantity of cement*
0.6 bags of cement = 0.035 m^{3}x 0.6 = 0.021m^3
Cost of 1 metric ton Fly Ash = Rs 720

1 cubic meter = 2.41 metric ton
0.021 cubic meter = (2.41/1) x 0.021
= 0.0506 metric ton

Cost = Rs 720 x 0.0506
= Rs 36.432

✓ *Sand:*
Volume: 0.393 cubic meters
Cost: Rs 577.80 per cubic meter (from SoneQuary)
Calculation: 0.393 * 577.80 = Rs 227.08

✓ *Aggregates (20mm Nominal Size):*
Volume: 0.785 cubic meters
Cost: Rs 1207.76 per cubic meter
Calculation: 0.785 * 1207.76 = Rs 948.0

✓ *Water:*
Quantity: 300 Liters
Rate: Rs 40 per kiloliter (K.L.)
Calculation: (40 * 300) / 1000 = Rs 12

✓ *Machinery*
Concrete Mixer (1 cubic meter)
Machine Output: 7.5 cubic meters per hour
Required Output: 1 cubic meter.
Rate: Rs 247 per hour
Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- TOTAL COST OF GREEN CONCRETE REPLACING 5% CEMENT WITH FLY ASH

CEMENT	= Rs 3606.69
FLY ASH	= Rs 36.432
SAND	= Rs 227.08
AGGREGATES	= Rs 948.09
WATER	= Rs 12
CONCRETE MIXER	= Rs49
TOTAL COST	= Rs4879.29/m^3

➢ *Replacement of 10% Cement with Fly Ash*

- Materials

✓ Cement :- 10.8 Bags
✓ Cost = Rs316.40/ Bag
= 10.8 x 316.40
= Rs 3417.12

✓ Fly Ash :- Quantity of cement

1.2 bags of cement = 0.042 m^3
Cost of 1 metric ton Fly Ash = Rs 720
1 cubic meter = 2.41 metric ton
0.083 cubic meter = (2.41/1) x 0.042
= 0.101 metric ton
Cost = Rs 720 x 0.101
= Rs 72.72

✓ Sand:
Volume: 0.393 cubic meters
Cost: Rs 577.80 per cubic meter (from SoneQuary)
Calculation: 0.393 * 577.80 = Rs 227.08

✓ Aggregates (20mm Nominal Size):
Volume: 0.785 cubic meters
Cost: Rs 1207.76 per cubic meter
Calculation: 0.785 * 1207.76 = Rs 948.0

✓ Water:
Quantity: 300 Liters
Rate: Rs 40 per kiloliter (K.L.)
Calculation: (40 * 300) / 1000 = Rs 12

- Machinery
Concrete Mixer (1 cubic meter)
Machine Output: 7.5 cubic meters per hour
Required Output: 1 cubic meter.
Rate: Rs 247 per hour
Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- TOTAL COST OF GREEN CONCRETE REPLACING 10% CEMENT WITH FLY ASH

CEMENT	= Rs 3417.12
FLY ASH	= Rs 72.72
SAND	= Rs 227.08
AGGREGATES	= Rs 948.09
WATER	= Rs 12
CONCRETE MIXER	= Rs49
TOTAL COST	= Rs4726.01/m^3

➢ *Replacement of 15% Cement with Fly Ash*

- *Materials*

✓ Cement :- 10.2 Bags
Cost= Rs316.40/ Bag
= 10.2 x 316.40
= Rs 3227.28

✓ *Fly Ash :- Quantity of cement*

1.8 bags of cement	= 0.063 m^3
Cost of 1 metric ton Fly Ash	= Rs 720
1 cubic meter	= 2.41 metric ton
0.083 cubic meter	= (2.41/1) x 0.063
	= 0.101 metric ton
Cost	= Rs 720 x 0.152
	= Rs 109.44

✓ *Sand:*
Volume: 0.393 cubic meters
Cost: Rs 577.80 per cubic meter (from SoneQuary)
Calculation: 0.393 * 577.80 = Rs 227.08

✓ *Aggregates (20mm Nominal Size):*
Volume: 0.785 cubic meters
Cost: Rs 1207.76 per cubic meter
Calculation: 0.785 * 1207.76 = Rs 948.0

✓ *Water:*
Quantity: 300 Liters
Rate: Rs 40 per kiloliter (K.L.)
Calculation: (40 * 300) / 1000 = Rs 12

- *Machinery*
Concrete Mixer (1 cubic meter)
Machine Output: 7.5 cubic meters per hour
Required Output: 1 cubic meter.
Rate: Rs 247 per hour
Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- *TOTAL COST OF GREEN CONCRETE REPLACING 15% CEMENT WITH FLY ASH*
  CEMENT = Rs 3227.28
  FLY ASH = Rs 109.44
  SAND = Rs 227.08
  AGGREGATES = Rs 948.09
  WATER = Rs 12
  CONCRETE MIXER = Rs49
  TOTAL COST = Rs4572.89/m^3

➢ *Replacement of 20% Cement with Fly Ash*

- *Materials*

✓ Cement :- 9.6 Bags (for cost analysis)
Cost= Rs 258.70/ Bag
= 9.6 x 316.40
= Rs 3037.44

✓ Fly Ash :- Quantity of cement
2.4 bags of cement = 0.083 m^3
Cost of 1 metric ton Fly Ash = Rs 720
1 cubic meter = 2.41 metric ton
0.083 cubic meter = (2.41/1) x 0.083
= 0.200 metric ton
Cost = Rs 720 x 0.200
= Rs 144.02

✓ Sand:
Volume: 0.393 cubic meters
Cost: Rs 577.80 per cubic meter (from SoneQuary)
Calculation: 0.393 * 577.80 = Rs 227.08

✓ Aggregates (20mm Nominal Size):
Volume: 0.785 cubic meters
Cost: Rs 1207.76 per cubic meter
Calculation: 0.785 * 1207.76 = Rs 948.0

✓ Water:
Quantity: 300 Liters
Rate: Rs 40 per kiloliter (K.L.)
Calculation: (40 * 300) / 1000 = Rs 12

- *Machinery*
  Concrete Mixer (1 cubic meter)
  Machine Output: 7.5 cubic meters per hour
  Required Output: 1 cubic meter.
  Rate: Rs 247 per hour
  Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- *TOTAL COST OF GREEN CONCRETE REPLACING 20% CEMENT WITH FLY ASH*

  CEMENT = Rs 3037.44
  FLY ASH = Rs 144.02
  SAND = Rs 227.08
  AGGREGATES = Rs 948.09
  WATER = Rs 12
  CONCRETE MIXER = Rs49
  TOTAL COST = Rs4417.63/m^3

➢ *Replacement of 25% Cement with Fly Ash*

- *Materials*

✓ Cement :- 9.0 Bags (for cost analysis)
Cost = Rs316.40/ Bag
= 9 x 316.40
= Rs 2847.60

✓ *Fly Ash :- Quantity of cement*
3 bags of cement = 0.105 m^3
Cost of 1 metric ton Fly Ash = Rs 720
1 cubic meter = 2.41 metric ton
0.083 cubic meter = (2.41/1) x 0.105
= 0.253 metric ton
Cost = Rs 720 x 0.253
= Rs 182.16

✓ Sand:
Volume: 0.393 cubic meters
Cost: Rs 577.80 per cubic meter (from SoneQuary)
Calculation: 0.393 * 577.80 = Rs 227.08

✓ Aggregates (20mm Nominal Size):
Volume: 0.785 cubic meters
Cost: Rs 1207.76 per cubic meter
Calculation: 0.785 * 1207.76 = Rs 948.0

✓ Water:
Quantity: 300 Liters
Rate: Rs 40 per kiloliter (K.L.)
Calculation: (40 * 300) / 1000 = Rs 12

- *Machinery*

  Concrete Mixer (1 cubic meter)
  Machine Output: 7.5 cubic meters per hour
  Required Output: 1 cubic meter.
  Rate: Rs 247 per hour
  Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- *TOTAL COST OF GREEN CONCRETE REPLACING 25% CEMENT WITH FLY ASH*

  CEMENT = Rs 2847.60
  FLY ASH = Rs 182.16
  SAND = Rs 227.08
  AGGREGATES = Rs 948.09
  WATER = Rs 12
  CONCRETE MIXER = Rs49
  TOTAL COST = Rs4265.93/m^3

➢ *Replacement of 30% Cement with Fly Ash*

- *Materials*

✓ Cement :- 8.4 Bags (for cost analysis)
Cost = Rs316.40/ Bag
= 8.4 x 316.40
= Rs 2657.76

✓ Fly Ash :- Quantity of cement
3.6 bags of cement = 0.126 m^3
Cost of 1 metric ton Fly Ash = Rs 720
1 cubic meter = 2.41 metric ton
0.083 cubic meter = (2.41/1) x 0.126
= 0.307 metric ton
Cost = Rs 720 x 0.307
= Rs 221.04

✓ Sand:
Volume: 0.393 cubic meters
Cost: Rs 577.80 per cubic meter (from SoneQuary)
Calculation: 0.393 * 577.80 = Rs 227.08

✓ Aggregates (20mm Nominal Size):
Volume: 0.785 cubic meters
Cost: Rs 1207.76 per cubic meter
Calculation: 0.785 * 1207.76 = Rs 948.0

✓ Water:
Quantity: 300 Liters
Rate: Rs 40 per kiloliter (K.L.)
Calculation: (40 * 300) / 1000 = Rs 12

- *Machinery*

  Concrete Mixer (1 cubic meter)
  Machine Output: 7.5 cubic meters per hour
  Required Output: 1 cubic meter.
  Rate: Rs 247 per hour
  Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- *TOTAL COST OF GREEN CONCRETE REPLACING 30% CEMENT WITH FLY ASH*

CEMENT	= Rs 2657.76
FLY ASH	= Rs 221.04
SAND	= Rs 227.08
AGGREGATES	= Rs 948.09
WATER	= Rs 12
CONCRETE MIXER	= Rs49
TOTAL COST	= Rs4114.97/m^3

➢ *Replacement of 40% Cement with Fly Ash*

- *Materials*

✓ Cement :- 7.2 Bags (for cost analysis)
Cost = Rs316.40/ Bag
= 7.2 x 316.40
= Rs 2278.08

✓ Fly Ash :- Quantity of cement

4.8 bags of cement	= 0.168 m^3
Cost of 1 metric ton Fly Ash	= Rs 720
1 cubic meter	= 2.41 metric ton
0.083 cubic meter	= (2.41/1) x 0.168
	= 0.405 metric ton
Cost	= Rs 720 x 0.405
	= Rs 291.6

✓ Sand:
Volume: 0.393 cubic meters
Cost: Rs 577.80 per cubic meter (from SoneQuary)
Calculation: 0.393 * 577.80 = Rs 227.08

✓ Aggregates (20mm Nominal Size):
Volume: 0.785 cubic meters
Cost: Rs 1207.76 per cubic meter
Calculation: 0.785 * 1207.76 = Rs 948.0

✓ Water:
Quantity: 300 Liters
Rate: Rs 40 per kiloliter (K.L.)
Calculation: (40 * 300) / 1000 = Rs 12

- *Machinery*

Concrete Mixer (1 cubic meter)
Machine Output: 7.5 cubic meters per hour
Required Output: 1 cubic meter.
Rate: Rs 247 per hour
Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- *TOTAL COST OF GREEN CONCRETE REPLACING 40% CEMENT WITH FLY ASH*

  CEMENT = Rs 2278.08
  FLY ASH = Rs 291.6
  SAND = Rs 227.08
  AGGREGATES = Rs 948.09
  WATER = Rs 12
  CONCRETE MIXER = Rs49
  TOTAL COST = Rs3805.85/m^3

➢ *Replacement of 50% Cement with Fly Ash*

- *Materials*

✓ Cement :- 6 Bags
  Cost = Rs316.40/ Bag
  = 6x 316.40
  = Rs 1898.40

✓ Fly Ash :- Quantity of cement
  6 bags of cement = 0.208 m^3
  Cost of 1 metric ton Fly Ash = Rs 720
  1 cubic meter = 2.41 metric ton
  0.208 cubic meter = (2.41/1) x 0.208
  = 0.501 metric ton
  Cost = Rs 720 x 0.501
  = Rs 360.72

✓ Sand:
  Volume: 0.393 cubic meters
  Cost: Rs 577.80 per cubic meter (from SoneQuary)
  Calculation: 0.393 * 577.80 = Rs 227.08

✓ Aggregates (20mm Nominal Size):
  Volume: 0.785 cubic meters
  Cost: Rs 1207.76 per cubic meter
  Calculation: 0.785 * 1207.76 = Rs 948.0

✓ Water:
  Quantity: 300 Liters
  Rate: Rs 40 per kiloliter (K.L.)
  Calculation: (40 * 300) / 1000 = Rs 12

- Machinery
  Concrete Mixer (1 cubic meter)
  Machine Output: 7.5 cubic meters per hour
  Required Output: 1 cubic meter.
  Rate: Rs 247 per hour
  Calculated Cost: (1/7.5) x 365 = Rs 48.67 (rounded to Rs 49.00)

- TOTAL COST OF GREEN CONCRETE REPLACING 50% CEMENT WITH FLY ASH

  CEMENT = Rs 1898.40
  FLY ASH = Rs 360.72
  SAND = Rs 227.08
  AGGREGATES = Rs 948.09
  WATER = Rs 12
  CONCRETE MIXER = Rs49
  TOTAL COST = Rs3495.29/m^3

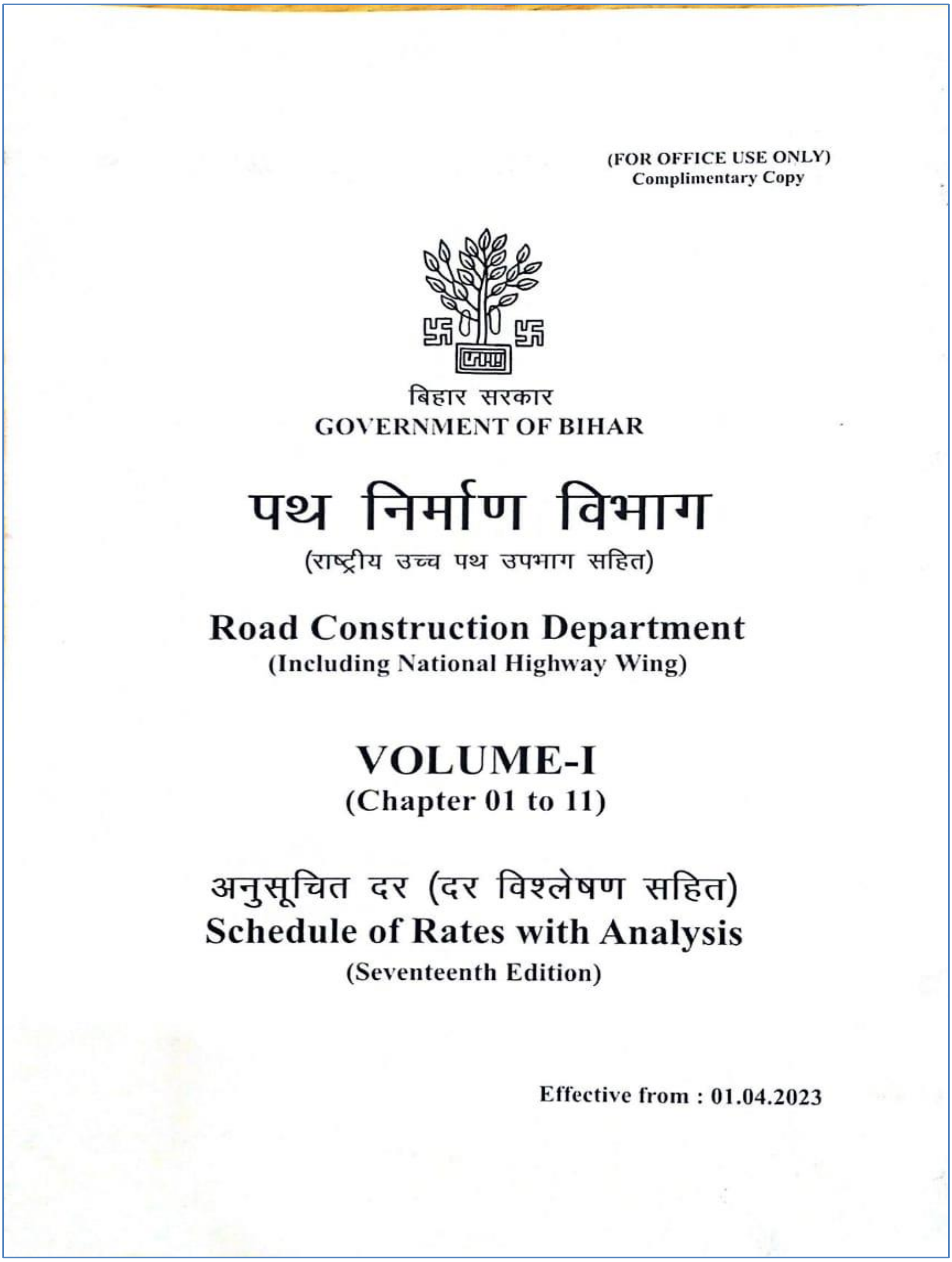
E. Cost Comparision

Now comparing the different Fly ash content based Green concrete on the basis of their costing**.**

Table 11: the Cost Comparison of Green Concrete based on Percentage-wise Replacement

Concrete type	**Cost per cum**
Conventional Concrete	Rs5032.97/m^3
Green Concrete with a 5% Replacement Ratio	Rs4879.29/m^3
Green Concrete with a 10% Replacement Ratio	Rs4726.01/m^3
Green Concrete with a 15% Replacement Ratio	Rs4572.89/m^3
Green Concrete with a 20% Replacement Ratio	Rs4417.63/m^3
Green Concrete with a 25% Replacement Ratio	Rs4265.93m^3
Green Concrete with a 30% Replacement Ratio	Rs4114.97/m^3
Green Concrete with a 40% Replacement Ratio	Rs3805.85/m^3
Green Concrete with a 5 0% Replacement Ratio	Rs3495.29/m^3

RATE SHEET USED IN THE COST ESTIMATION



(FOR OFFICE USE ONLY)
Complimentary Copy

बिहार सरकार
GOVERNMENT OF BIHAR

पथ निर्माण विभाग
(राष्ट्रीय उच्च पथ उपभाग सहित)

Road Construction Department
(Including National Highway Wing)

VOLUME-I
(Chapter 01 to 11)

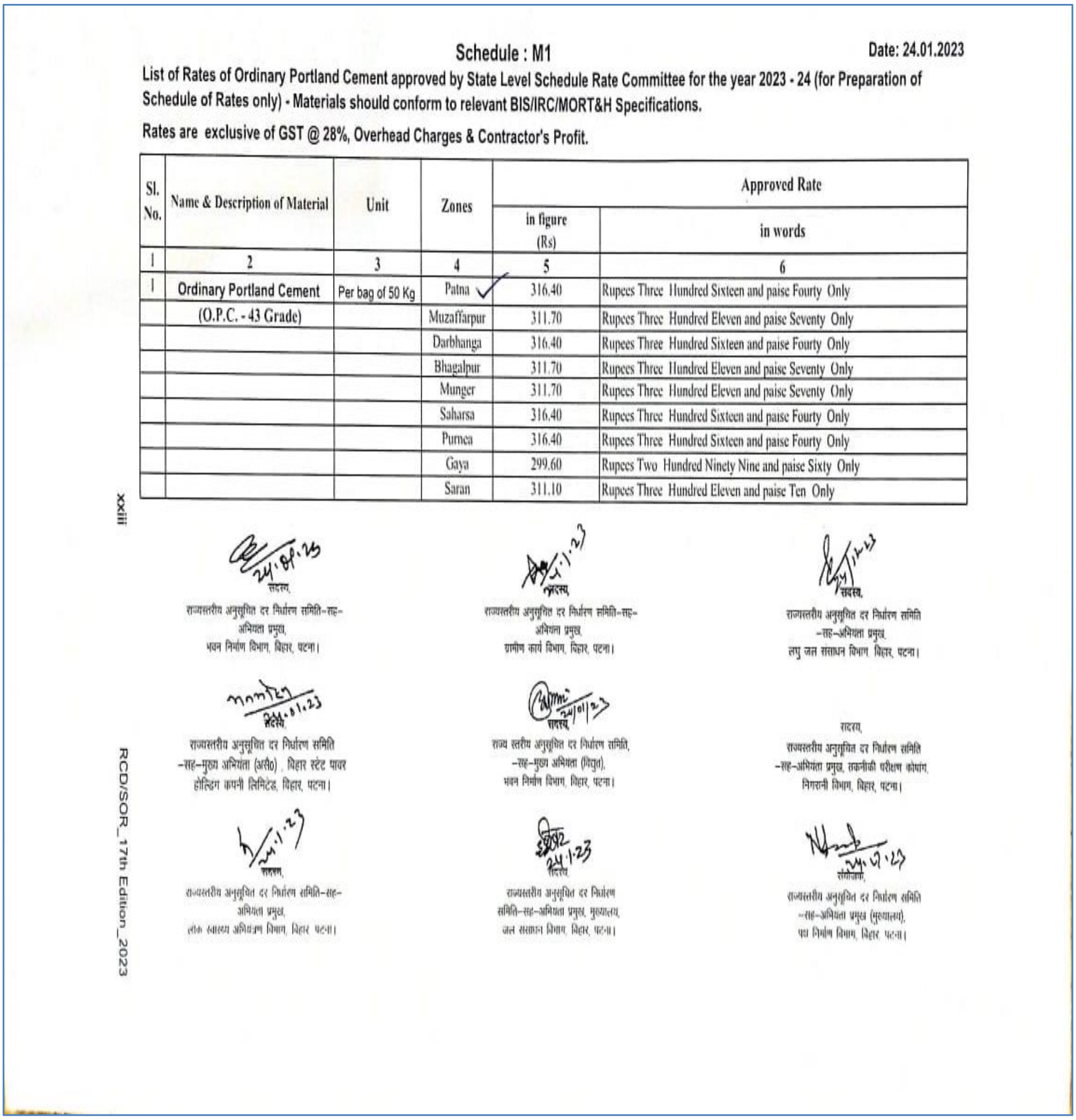
अनुसूचित दर (दर विश्लेषण सहित)
Schedule of Rates with Analysis
(Seventeenth Edition)

Effective from : 01.04.2023

Fig. 1: Rate Sheet Used in the Cost Estimation

ISSN No:-2456-2165

CEMENT RATES



Schedule : M1

Date: 24.01.2023

List of Rates of Ordinary Portland Cement approved by State Level Schedule Rate Committee for the year 2023 - 24 (for Preparation of Schedule of Rates only) - Materials should conform to relevant BIS/IRC/MORT&H Specifications.

Rates are exclusive of GST @ 28%, Overhead Charges & Contractor's Profit.

Sl. No.	Name & Description of Material	Unit	Zones	Approved Rate	
				in figure (Rs)	in words
1	2	3	4	5	6
1	Ordinary Portland Cement	Per bag of 50 Kg	Patna	316.40	Rupees Three Hundred Sixteen and paise Fourty Only
	(O.P.C. - 43 Grade)		Muzaffarpur	311.70	Rupees Three Hundred Eleven and paise Seventy Only
			Darbhanga	316.40	Rupees Three Hundred Sixteen and paise Fourty Only
			Bhagalpur	311.70	Rupees Three Hundred Eleven and paise Seventy Only
			Munger	311.70	Rupees Three Hundred Eleven and paise Seventy Only
			Saharsa	316.40	Rupees Three Hundred Sixteen and paise Fourty Only
			Purnea	316.40	Rupees Three Hundred Sixteen and paise Fourty Only
			Gaya	299.60	Rupees Two Hundred Ninety Nine and paise Sixty Only
			Saran	311.10	Rupees Three Hundred Eleven and paise Ten Only

xxiii

24.01.23
सदस्य,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति–सह–अभियंता प्रमुख,
भवन निर्माण विभाग, बिहार, पटना।

24.1.23
सदस्य,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति–सह–अभियंता प्रमुख,
ग्रामीण कार्य विभाग, बिहार, पटना।

24.1.23
सदस्य,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति –सह–अभियंता प्रमुख,
लघु जल संसाधन विभाग, बिहार, पटना।

24.01.23
सदस्य,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति –सह–मुख्य अभियंता (असै0), बिहार स्टेट पावर होल्डिंग कपनी लिमिटेड, बिहार, पटना।

24/01/23
सदस्य,
राज्य स्तरीय अनुसूचित दर निर्धारण समिति, –सह–मुख्य अभियंता (विद्युत),
भवन निर्माण विभाग, बिहार, पटना।

सदस्य,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति –सह–अभियंता प्रमुख, तकनीकी परीक्षण कोषांग,
निगरानी विभाग, बिहार, पटना।

24.1.23
सदस्य,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति–सह–अभियंता प्रमुख,
लोक स्वास्थ्य अभियंत्रण विभाग, बिहार, पटना।

24.1.23
सदस्य,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति–सह–अभियंता प्रमुख, मुख्यालय,
जल संसाधन विभाग, बिहार, पटना।

24.01.23
संयोजक,
राज्यस्तरीय अनुसूचित दर निर्धारण समिति –सह–अभियंता प्रमुख (मुख्यालय),
पथ निर्माण विभाग, बिहार, पटना।

RCD/SOR_17th Edition_2023

Fig. 2: Cement Rates

ISSN No:-2456-2165

MACHINERY RATES

Schedule- P & M / MORTH - 1A Date :- 18.11.2022

Approved Usages rate of Plants & Machinery for preparation of Schedule of rate including all charges ,cost of repair,maintenance,tyre- replacement,running and operating charges such as fuel, lubricant, labour etc but excluding GST,Overhead and Contractor's profit.

Sl.No.	Code	Description	Unit	Approved Rate	Remarks
1	PM1001	Dozer - 240 HP	Hour	5,610.00	
2	PM1002	Dozer - 175 HP	Hour	4,326.00	
3	PM1003	Dozer - 90 HP	Hour	2,997.00	
4	PM2001	Motor Grader 4.3 metre blade	Hour	5,518.00	
5	PM2002	Motor Grader 3.7 metre blade	Hour	5,051.00	
6	PM2003	Motor Grader 3.35 metre blade	Hour	4,463.00	
7	PM3003	Hydraulic Excavator of 1.2 cum bucket	Hour	2,778.00	
8	PM3004	Hydraulic Excavator of 1.1 cum bucket	Hour	2,504.00	
9	PM3005	Hydraulic Excavator of 0.9 cum bucket	Hour	2,272.00	
10	PM4001	Jack Hammer (attachment of Hydraulic Excavator)	Hour	206.00	
11	PM5001	Front End loader 3.1 cum bucket capacity	Hour	3,506.00	
12	PM5002	Front End loader 2.1 cum bucket capacity	Hour	2,095.00	
13	PM5003	Backhoe-loader 1 cum bucket capacity	Hour	1,419.00	
14	PM6001	Tipper-18 Cum	Hour	2,310.00	
15	PM6002	Tipper-14 Cum	Hour	2,065.00	
16	PM6003	Tipper-10 Cum	Hour	1,847.00	
17	PM6004	Tipper-5.5 Cum	Hour	1,426.00	
18	PM7001	Vibratory Soil Compactor (10 tonne)	Hour	2,063.00	
19	PM8001	Smooth Wheeled Roller 8 tonne	Hour	1,593.00	
20	PM9001	Tandem Roller	Hour	2,053.00	Vibratory road Roller
21	PM9002	Mini Tandem Roller	hour	1,115.00	Do
22	PM10001	Pneumatic Road Roller	Hour	2,062.00	Do
23	PM11001	Water Tanker (16 KL)	Hour	1,171.00	
24	PM11002	Water Tanker (12 KL)	Hour	997.00	
25	PM11003	Water Tanker (6 KL)	Hour	752.00	
26	PM12001	Tractor-Trolly	Hour	676.00	
27	PM13001	Rotavator	Hour	17.00	
28	PM14001	Ripper	Hour	21.00	
29	PM15001	Air Compressor -250 cfm	Hour	440.00	
30	PM15002	Air Compressor -500 cfm	Hour	1,920.00	
31	PM16001	Integrated Stone Crusher Stone (3 Stage) 250 TPH	Hour	13,721.00	
32	PM17001	Wet Mix Plant - 250 TPH Capacity	Hour	680.00	
33	PM17002	Wet Mix Plant - 200 TPH Capacity	Hour	385.00	
34	PM17003	Wet Mix Plant - 100 TPH Capacity	Hour	360.00	
35	PM18001	Hotmix Plant - 200 TPH Capacity	Hour	86,273.00	
36	PM18002	Hotmix Plant - 160 TPH Capacity	Hour	67,878.00	
37	PM18003	Hotmix Plant - 120 TPH capacity	Hour	51,299.00	
38	PM19001	Batching and Mixing Plant - 240 cum Capacity	Hour	5,733.00	
39	PM19002	Batching and Mixing Plant - 120 cum Capacity	Hour	3,672.00	
40	PM20001	Mobile Concrete Batching / Mixing Plant	Hour	655.00	
41	PM21001	Concrete Mixer - 0.4/0.28 cum	Hour	334.00	
42	PM21002	Concrete Mixer - 1 cum	Hour	365.00	
43	PM22001	Generator 725 KVA	Hour	7,988.00	
44	PM22002	Generator 500 KVA	Hour	5,521.00	
45	PM22003	Generator 400 KVA	Hour	4,455.00	
46	PM22004	Generator 250 KVA	Hour	3,130.00	
47	PM22005	Generator 125 KVA	Hour	1,642.00	
48	PM22006	Generator 100 KVA	Hour	1,407.00	

RCD/SOR_17th Edition_2023

Fig. 3: Machinery Rates

ISSN No:-2456-2165

MATERIAL RATES

Schedule -M / MORTH-1 Date:-24.01.2023.

List for Approved Rates of Construction Materials for the Preparation of Schedule of Rates for year 2023-24 only by the State Level Schedule Rate Committee (Materials Should conform to relevant B.I.S., MoRD and MoRT&H Specifications). The rates are inclusive of royalty but exclusive of all taxes, G.S.T,Overhead,Seigniorage fee and Contractor's profit. "Rates are at source"Quarry/ Crusher Plant.

Sl. No.	Description of Materials	Unit	Approved Rates inclusive of Royalty for SOR 2023 (Rs)	Royalty included in col.4 (Rs)
1	2	3	4	5
M-001	Stone Boulder of size 150 mm and below at Source Quarry	Cum	686.03	150.00
M-002	Supply of quarried Stone 150-200 mm size for Hand Broken at source Quarry	Cum	686.03	150.00
M-003	Boulder with minimum size of 300 mm for Pitching at source Quarry	Cum	686.03	150.00
M-004*	Coarse sand/ Sand at source Quarry from five rivers- Sone / Kiul / Falgoo / Chanan and Morhar river.	Cum	577.80	150.00
M-005	Coarse sand / Sand at Source ,Quarry from other river.	Cum	502.80	75.00
M-006	Fine sand at Source	Cum	144.75	75.00
M-007	Moorum at Source Quarry	Cum	161.62	83.00
M-008	Gravel/Quarry spall at Source Quarry	Cum	360.11	150.00
M-009	Granular Material or hard murum for GSB works at source Quarry	Cum	167.03	83.00
M-010	Fly ash conforming to IS:3812 (Part II & I) at HMP Plant/Batching Plant/Crushing Plant	Cum	Nil	Nil
M-011	Filter media/Filter Material as per Table 300-3 (MoRT&H Specification) at Crusher.	Cum	689.23	150.00
M-012	Close graded Granular sub-base Material 53 mm to 9.5 mm/4.75mm at Crusher.	Cum	931.75	150.00
M-013	Close graded Granular sub-base Material 37.5 mm to 9.5 mm at Crusher.	Cum	931.75	150.00
M-014	Close graded Granular sub-base Material 26.5 mm to 9.5 mm at Crusher.	Cum	901.46	150.00
M-015	Close graded Granular sub-base Material 9.5 mm to 4.75 mm at Crusher.	Cum	595.16	150.00
M-016	Close graded Granular sub-base Material 9.5 mm to 2.36mm at Crusher.	Cum	429.97	150.00
M-017	Close graded Granular sub-base Material 4.75mm to 2.36mm At Crusher.	Cum	264.78	150.00
M-018	Close graded Granular sub-base Material 4.75mm to 75 micron at Crusher.	Cum	264.78	150.00
M-019	Close graded Granular sub-base Material 2.36 mm & below at Crusher.	Cum	264.78	150.00
M-020	Stone crusher dust finer than 3 mm with not more than 10% passing 0.075 sieve at Crusher.	Cum	264.78	150.00
M-021	Coarse graded Granular sub-base Material 2.36 mm & below At Crusher.	Cum	264.78	150.00
M-022	Coarse graded Granular sub-base Material 4.75 mm to 75 micron at Crusher.	Cum	264.78	150.00
M-023	Coarse graded Granular sub-base Material 4.75mm to 2.36 mm at Crusher.	Cum	264.78	150.00
M-024	Coarse graded Granular sub-base Material 9.5mm to 4.75 mm at Crusher.	Cum	595.16	150.00
M-025	Coarse graded Granular sub-base Material 26.5mm to 4.75 mm at Crusher.	Cum	901.46	150.00
M-026	Coarse graded Granular sub-base Material 26.5 mm to 9.5 mm at Crusher.	Cum	901.46	150.00
M-027	Coarse graded Granular sub-base Material 37.5 mm to 9.5 mm at Crusher.	Cum	931.75	150.00
M-028	Coarse graded Granular sub-base Material 53 mm to 26.5 mm at Crusher.	Cum	1100.04	150.00
M-029	Aggregates below 5.6 mm at Crusher.	Cum	429.97	150.00
M-030	Aggregates 22.4 mm to 2.36 mm at Crusher.	Cum	689.23	150.00
M-031	Aggregates 22.4 mm to 5.6 mm at Crusher.	Cum	901.46	150.00
M-032	Aggregates 45 mm to 2.8 mm at Crusher.	Cum	765.01	150.00
M-033	Aggregates 45 mm to 22.4 mm at Crusher.	Cum	1100.04	150.00
M-034	Aggregates 53 mm to 2.8 mm at Crusher.	Cum	765.01	150.00
M-035	Aggregates 53 mm to 22.4 mm(Grade -III) at Crusher.	Cum	1100.04	150.00
M-036	Aggregates 63 mm to 2.8 mm at Crusher.	Cum	765.01	150.00

xxxv RCD/SOR_17th Edition_2023

Fig. 4: Material Rates

ISSN No:-2456-2165

Sl. No.	Description of Materials	Unit	Approved Rates inclusive of Royalty for SOR 2023 (Rs)	Royalty included in col.4 (Rs)
1	2	3	4	5
M-037	Aggregates 63 mm to 45 mm (Grade- II)at Crusher.	Cum	992.33	150.00
M-038	Aggregates 90 mm to 45mm(Grade-I) at Crusher.	Cum	992.33	150.00
M-039	Aggregates 10 mm to 5 mm at Crusher.	Cum	595.16	150.00
M-040	Aggregates 11.2 mm to 0.09 mm (Key aggregate Type B) at Crusher.	Cum	429.97	150.00
M-041	Aggregates 13.2 mm to 0.09 mm (Key aggregate Type A) at Crusher.	Cum	429.97	150.00
M-042	Aggregates 13.2 mm to 5.6 mm at Crusher.	Cum	595.16	150.00
M-043	Aggregates 13.2 mm to 10 mm at Crusher.	Cum	595.16	150.00
M-044	Aggregates 20 mm to 10 mm at Crusher.	Cum	901.46	150.00
M-045	Aggregates 25 mm to10 mm at Crusher.	Cum	901.46	150.00
M-046	Aggregates 19 mm to 6 mm at Crusher.	Cum	901.46	150.00
M-047	Aggregates 37.5 mm to 19 mm at Crusher.	Cum	1100.04	150.00
M-048	Aggregates 37.5 mm to 25 mm at Crusher.	Cum	1100.04	150.00
M-049	Aggregates 6 mm nominal size at Crusher.	Cum	429.97	150.00
M-050	Aggregates 10 mm nominal size at Crusher plant.	Cum	595.16	150.00
M-051	Aggregates 13.2/12.5 mm nominal size at Crusher plant.	Cum	595.16	150.00
M-052	Aggregates 20 mm nominal size at Crusher plant.	Cum	1207.76	150.00
M-053	Aggregates 25 mm nominal size at Crusher.	Cum	1207.76	150.00
M-054	Aggregates 40 mm nominal size at Crusher.	Cum	992.33	150.00
M-055	Crushing of Stone aggregates (GSB Crusher Run)	Cum	727.91	150.00

24.01.23
सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह–अभियंता
प्रमुख भवन निर्माण विभाग,
बिहार, पटना।

24.1.23
सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह–अभियंता
प्रमुख ग्रामीण कार्य विभाग,
बिहार, पटना।

24.1.23
सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह– अभियंता
प्रमुख लघु जल संसाधन विभग
बिहार पटना।

24.01.23
सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह–मुख्य अभियंता
(असै) बिहार स्टेट पावर होल्डिंग
कम्पनी लि. बिहार, पटना।

24/01/23
सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह–मुख्य अभियंता
(विद्युत) भवन निर्माण विभाग,
बिहार, पटना।

सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह– अभियंता
प्रमुख तकनीकी परीक्षक कोषांग निगरानी
विभाग ,बिहार पटना।

24.1.23
सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह–अभियंता
प्रमुख लोक स्वास्थ्य अभियंत्रण,
विभाग, बिहार, पटना।
बिहार, पटना।

24.1.23
सदस्य,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह–अभियंता प्रमुख,
(मुख्यालय), जल संसाधन विभाग,
बिहार, पटना।

24.01.23
संयोजक,
राज्य स्तरीय अनुसूचित दर
निर्धारण समिति –सह– अभियता
प्रमुख (मुख्यालय) पथ निर्माण
विभाग बिहार, पटना।

RCD/SOR_17th Edition_2023 xxxvi

Fig. 5

CHAPTER SEVEN

CONCLUSION

Based on the cube test results comparing conventional concrete with green concrete, it is evident that substituting up to 25% of cement with fly ash marginally decreases the compressive strength. However, this minor decrease can be viewed positively as it enables the use of this green concrete mix in constructing temporary structures and low-traffic roads.

Moreover, a cost analysis indicates that the reduction in cost is significant. With proper monitoring of quality control, the outcomes align well with the primary objective of engineering: achieving efficient quality while ensuring cost-effectiveness.

A. LIMITATIONS OF GREEN CONCRETE

Limitations of green concrete, despite its appeal for environmentally friendly sustainable development, primarily revolve around its durability.

There are concerns about the longevity of structures made with green concrete. Additionally, the split tension of green concrete has been observed to be significantly lower than that of conventional concrete.

In today's market, green concrete faces stiff competition. Its growth prospects remain limited until its properties match those of conventional concrete.

Some researchers suggest that the durability of green concrete can be enhanced by incorporating stainless steel reinforcements. However, this solution poses a predicament due to the considerable increase in construction costs associated with the use of stainless steel.

The limitations of green concrete can be summarized as follows:

- Increased reinforcement costs when using stainless steel.
- Reduced lifespan compared to conventional concrete for structures made with green concrete.
- Lower split tension compared to conventional concrete.
- Inferior durability compared to conventional concrete.
- Demands skilled labor and continuous supervision throughout production and construction stages.

ISSN No:-2456-2165

REFRENCES

[1]. Vardhan Nagarkar , Sanket Padalkar, Samruddhi Bamre , Akshay Tupe " Experimental Study On Green Concrete Using Silica Fumes" Volume 5 Issue IV, April 2017 IC Value: 45.98 ISSN: 2321-9653.
[2]. Nihar Khalatkar "Study on Green Concrete" Volume -4 Issue-2 April 2017 ISSN: 2394-2827.
[3]. A. Mujahid and A. Zaidi " Assessment of Recycled Aggregate Concrete" Modern Applied Science, Vol-3 no.10 PP-.47-54,2009.
[4]. M.S Shetty "Concrete Technology" 3rd Edition, S. chand & Company Limited. Delhi 1992.
[5]. IS 383-1970 : Specification for Coarse & Fine Aggregate from Natural Source for Concrete, Bureau Of Indian Standards, New Delhi, India.
[6]. IS 516- 1959 Method of test for strength of Concrete, Bureau Of Indian Standards, New Delhi, India.
[7]. IS 456 – 2000 Plain & Reinforced Concrete Code of Practice, Bureau Of Indian Standards, New Delhi, India.
[8]. Kyoto Protocol.