

# Cost analysis of Concrete made with Composite Cement and Ordinary Portland Cement

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**Abstract:** Composite Cement is made by uniformly and intimately blending of ordinary Portland cement, Granulated Slag and Fly Ash together. Two industrial by-products are simultaneously utilized in composite cement. In our study we have compared the cost occurring in concrete made with composite cement and same concrete made with Ordinary Portland Cement. Firstly Low grade Concrete (M20 and M25) and high grade concrete (M30 and M35) were made with OPC cement as controlled samples. Thereafter same concrete was casted with composite cement. Based on the investigations and results it is evident that concrete made with composite cement has substantially lower cost when compared to concrete made with OPC cement only. Moreover, Low grade concrete (M20 and M25) and high grade concrete (M30 and M35) both made with composite cements shows compressive strength achieved more than their respective target strengths when compared to concrete made with controlled OPC cement.

**Index Terms:** composite cement, granulated blast furnace slag, fly ash, OPC, concrete mix, save environment, reduce cost of concrete.

Low grade, high grade concrete.

## 1. INTRODUCTION

Concrete is most widely used in the world. The cost of concrete per metre cube is rising day by day due to increasing demands and growth in infrastructure. In this study we are finding optimum percentage of ash based waste materials that can replace OPC without compromising concrete strength at 28 days to reduce the cost of concrete. Therefore it is expected at the end of this study two ash based waste materials i.e. fly ash and granulated slag in a fixed percentage are simultaneously utilized with OPC cement in concrete manufacturing resulting in cost reduction of concrete as compared to concrete made with only OPC cement.

## 2. RAW MATERIAL PROPORTIONS TO BE USED IN COMPOSITE CEMENT AS PER IS CODE 16415:2015

TABLE-1

Sr.no	Material	Proportion (percent by weight)
1	Ordinary Portland Cement	35-65
2	Fly Ash	15-35
3	Granulated Slag	20-50

### 2.1 Raw materials and their sources

- Ordinary Portland Cement **OPC** was collected from Ultratech Cement plant. Jhajjar.
- **Fly ash** is an industrial by-product made from combustion of coal in thermal power plants. Fly Ash was collected from Goindwal Sahib Thermal Power Plant, Tarn Taran District, Punjab.
- **Granulated blast furnace slag (GBFS)** is an industrial by-product of steel/iron manufacturing industry. Granulated Slag was collected from Jindal Steels Hissar.

**2.2 combination of different raw materials intended to be formulated to be give all the desired objectives shall be as under:**

TABLE-2

SETS	OPC A %	FLY ASH B %	GBFS C %	BLENDED MIX A+B+C
SET 1	65	15	20	100
SET 2	60	15	25	100
SET 3	60	20	20	100

### 3. RESULTS AND DISCUSSION

#### 3.1. PHYSICAL PARAMETERS RESULTS

The following results were obtained after testing 3 possible sets of composite cement for physical properties:

TABLE-3

SET NO	CONSISTENCY %	FINENSS BY BLAINE AIR PERMEABILITY M <sup>2</sup> /KG	SOUNDNESS %	INITIAL SETTING TIME Minutes	FINAL SETTING TIME Minutes	DENSITY
CONTROLLED SAMPLE	29.50	297.54	1.5	155	260	3.15
SET 1	29.00	332.84	1.0	150	240	2.84
SET 2	29.00	332.12	1.5	155	245	2.87
SET 3	29.00	345.12	1.0	150	255	2.83

#### 3.1.1. COMPRESSIVE STRENGTH RESULTS:

TABLE-4

SET NO	1 DAY COMPRESSIVE STRENGTH N/mm <sup>2</sup>	3 DAY COMPRESSIVE STRENGTH N/mm <sup>2</sup>	7 DAY COMPRESSIVE STRENGTH N/mm <sup>2</sup>	28 DAY COMPRESSIVE STRENGTH N/mm <sup>2</sup>	90 DAY COMPRESSIVE STRENGTH N/mm <sup>2</sup>
CONTROLLED SAMPLE	15.37	24.9	35.09	46.55	59.57
SET 1	13.23	18.24	24.11	34.99	46.99
SET 2	10.94	17.56	23.10	33.49	43.54
SET 3	10.58	17.39	22.46	33.15	42.15

#### 3.2. CHEMICAL PARAMETERS RESULTS:

The following results were obtained after testing 25 sets of composite cement for chemical properties:

TABLE-5

SET NO	LOSS ON IGNITION %	INSOLUBLE RESIDUE %	MAGNESIA %	TOTAL SULPHUR %	CALCIUM OXIDE %
CONTROLLED SAMPLE	2.98	1.18	2.72	1.96	32.15
SET 1	3.68	32.68	5.35	2.11	43.34
SET 2	3.17	32.54	5.25	2.45	39.45
SET 3	3.25	33.56	4.15	1.99	41.20

Based on the above results achieved after physical and chemical testing the following interpretations are concluded:

- The 3 sets of composite cement conforms to IS 16415:2015 requirements for all chemical parameters tested.
- The 3 sets of composite cement conforms to IS 16415:2015 requirements for all physical parameters.
- Therefore up to 40% OPC cement can be replaced with a mixture of Fly Ash (Max 20%) + Granulated Slag (Max 20%) or Mixture of Fly Ash ( Max 15%) and granulated Slag (Max 25%), Without compromising its Physical and Chemical Standard IS requirements.
- Controlled sample here means only OPC cement.

### 4. USE OF COMPOSITE CEMENTS IN CONCRETE MIXES

5.1 Now, for low grade (M20 and M25) as well as high grade (M30 and M35) concrete mixes, we will use composite cement SET 1, SET 2 and SET 3 and compare its target strength with controlled concrete made with only OPC cement.

TABLE-8

Grade of concrete	Target strength required	Controlled Sample made with only OPC cement		Concrete made with Composite cement SET 1		Concrete made with Composite cement SET 2		Concrete made with composite cement SET 3	
		7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day
M20	26.6	31.58	45.84	22.15	32.10	19.85	28.90	19.41	27.72
M25	31.6	36.10	51.78	27.47	40.25	24.05	34.15	21.19	32.49
M30	38.25	41.55	60.64	31.02	45.23	27.58	40.10	25.0	39.08
M35	43.25	46.57	66.14	34.99	50.74	30.65	44.58	28.45	43.99

## 5. DIFFERENCE OF COST BETWEEN COMPOSITE CEMENT CONCRETE AND OPC CEMENT CONCRETE:

### Cost Analysis for M20 Concrete

Cost of ingredients per kg as per market rate in Chandigarh

Cement - 8.00 Rs/Kg

Fly Ash - 2.00 Rs./Kg

Granulated Slag - 2.5 Rs/Kg

Controlled Concrete made with only cement OPC

For 1m<sup>3</sup> concrete with normal cement OPC 43 grade

Cement content 325.00Kg/m <sup>3</sup>	325x8= 2600
Fine Aggregate 552.5Kg/m <sup>3</sup>	552.5x1.32= 729.3
Coarse Aggregate 1105.00kg/m <sup>3</sup>	1105x1.11= 1226.55
Total cost for 1 m <sup>3</sup> Concrete	4555.85

Concrete made with composite cement (65% OPC, 15% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 325.00Kg/m <sup>3</sup>	
• OPC 65% - 211.25 Kg/m <sup>3</sup>	211.25x8=1690
• Fly Ash 15% - 48.75Kg/m <sup>3</sup>	48.75x2=97.5
• Granulated Slag 20% - 65.00 Kg/m <sup>3</sup>	65x2.5=162.5
Fine Aggregate 552.5Kg/m <sup>3</sup>	552.5x1.32= 729.3
Coarse Aggregate 1105.00kg/m <sup>3</sup>	1105x1.11= 1226.55
Total cost for 1 m <sup>3</sup> Concrete	3905.85

Concrete made with composite cement (60% OPC, 15% Fly Ash, 25% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 325Kg/m <sup>3</sup>	
• OPC 60% - 195.00 Kg/m <sup>3</sup>	195x8=1560
• Fly Ash 15% - 48.75 Kg/m <sup>3</sup>	48.75x2=97.5
• Granulated Slag 25% - 81.25 Kg/m <sup>3</sup>	81.25x2.5=203.13
Fine Aggregate 552.5Kg/m <sup>3</sup>	552.5x1.32= 729.3
Coarse Aggregate 1105.00kg/m <sup>3</sup>	1105x1.11= 1226.55
Total cost for 1 m <sup>3</sup> Concrete	3816.48

Concrete made with composite cement (60% OPC, 20% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 325Kg/m <sup>3</sup>	
• OPC 60% - 195.00 Kg/m <sup>3</sup>	195x8=1560
• Fly Ash 20% - 65 Kg/m <sup>3</sup>	65x2=130.00
• Granulated Slag 20% - 65 Kg/m <sup>3</sup>	65x2.5=162.5
Fine Aggregate 552.5Kg/m <sup>3</sup>	552.5x1.32= 729.3
Coarse Aggregate 1105.00kg/m <sup>3</sup>	1105x1.11= 1226.55
Total cost for 1 m <sup>3</sup> Concrete	3808.35

### Cost Analysis for M25 Concrete

Cost of ingredients per kg as per market rate in Chandigarh

Cement - 8.00 Rs/Kg

Fly Ash - 2.00 Rs./Kg

Granulated Slag - 2.5 Rs/Kg

Controlled Concrete made with only cement OPC

For 1m<sup>3</sup> concrete with normal cement OPC 43 grade

Cement content 383.16Kg/m <sup>3</sup>	383.16x8= 3065.28
Fine Aggregate 622.6Kg/m <sup>3</sup>	622.6x1.32= 821.832
Coarse Aggregate 1211.76kg/m <sup>3</sup>	1211.76x1.11= 1345.05
Total cost for 1 m <sup>3</sup> Concrete	5232.13

Concrete made with composite cement (65% OPC, 15% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 383.16Kg/m <sup>3</sup>	
• OPC 65% - 248.95 Kg/m <sup>3</sup>	249.05x8=1992.4
• Fly Ash 15% - 57.47 Kg/m <sup>3</sup>	57.45x2=114.94
• Granulated Slag 20% - 76.63 Kg/m <sup>3</sup>	76.63x2.5=191.58

Fine Aggregate 622.6Kg/m <sup>3</sup>	622.6x1.32= 821.832
Coarse Aggregate 1211.76kg/m <sup>3</sup>	1211.76x1.11= 1345.05
Total cost for 1 m <sup>3</sup> Concrete	4465.80

Concrete made with composite cement (60% OPC, 15% Fly Ash, 25% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 383.16Kg/m<sup>3</sup>

- OPC 60% - 229.90 Kg/m<sup>3</sup> 229.9x8=1839.2
- Fly Ash 15% - 57.47 Kg/m<sup>3</sup> 57.45x2=114.94
- Granulated Slag 25% - 95.79 Kg/m<sup>3</sup> 95.79x2.5=239.48

Fine Aggregate 622.6Kg/m<sup>3</sup> 622.6x1.32= 821.832

Coarse Aggregate 1211.76kg/m<sup>3</sup> 1211.76x1.11= 1345.05

Total cost for 1 m<sup>3</sup> Concrete 4360.50

Concrete made with composite cement (60% OPC, 20% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 383.16Kg/m<sup>3</sup>

- OPC 60% - 229.90 Kg/m<sup>3</sup> 229.9x8=1839.2
- Fly Ash 20% - 76.63 Kg/m<sup>3</sup> 76.63x2=153.26
- Granulated Slag 20% - 76.63 Kg/m<sup>3</sup> 76.63x2.5=191.58

Fine Aggregate 622.6Kg/m<sup>3</sup> 622.6x1.32= 821.832

Coarse Aggregate 1211.76kg/m<sup>3</sup> 1211.76x1.11= 1345.05

Total cost for 1 m<sup>3</sup> Concrete 4350.92

### Cost Analysis for M30 Concrete

Cost of ingredients per kg as per market rate in Chandigarh

Cement - 8.00 Rs/Kg

Fly Ash - 2.00 Rs./Kg

Granulated Slag - 2.5 Rs/Kg

Controlled Concrete made with only cement OPC

For 1m<sup>3</sup> concrete with normal cement OPC 43 grade

Cement content 425Kg/m<sup>3</sup> 425x8= 3400.00

Fine Aggregate 631.3Kg/m<sup>3</sup> 631.3x1.32= 833.32

Coarse Aggregate 1186.10kg/m<sup>3</sup> 1186.10x1.11= 1316.57

Total cost for 1 m<sup>3</sup> Concrete 5549.89

Concrete made with composite cement (65% OPC, 15% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 425Kg/m<sup>3</sup>

- OPC 65% - 276.25 Kg/m<sup>3</sup> 276.25x8=2210.00
- Fly Ash 15% - 63.75 Kg/m<sup>3</sup> 63.75x2=127.5
- Granulated Slag 20% - 85.00 Kg/m<sup>3</sup> 85.00x2.5=212.5

Fine Aggregate 631.3Kg/m<sup>3</sup> 631.3x1.32= 833.32

Coarse Aggregate 1186.10kg/m<sup>3</sup> 1186.10x1.11= 1316.57

Total cost for 1 m<sup>3</sup> Concrete 4699.89

Concrete made with composite cement (60% OPC, 15% Fly Ash, 25% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 425Kg/m<sup>3</sup>

- OPC 60% - 255 Kg/m<sup>3</sup> 255x8=2040
- Fly Ash 15% - 63.75 Kg/m<sup>3</sup> 63.75x2=127.5
- Granulated Slag 25% - 106.25 Kg/m<sup>3</sup> 106.25x2.5=265.63

Fine Aggregate 631.3Kg/m<sup>3</sup> 631.3x1.32= 833.32

Coarse Aggregate 1186.10kg/m<sup>3</sup> 1186.10x1.11= 1316.57

Total cost for 1 m<sup>3</sup> Concrete 4583.02

Concrete made with composite cement (60% OPC, 20% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 425Kg/m<sup>3</sup>

- OPC 60% - 255 Kg/m<sup>3</sup> 255=2040.00
- Fly Ash 20% - 85 Kg/m<sup>3</sup> 85x2=170.00
- Granulated Slag 20% - 85 Kg/m<sup>3</sup> 85x2.5=212.5

Fine Aggregate 631.3Kg/m<sup>3</sup> 631.3x1.32= 833.32

Coarse Aggregate 1186.10kg/m<sup>3</sup> 1186.10x1.11= 1316.57

Total cost for 1 m<sup>3</sup> Concrete 4572.39

**Cost Analysis for M35 Concrete**

Cost of ingredients per kg as per market rate in Chandigarh

Cement - 8.00 Rs/Kg

Fly Ash - 2.00 Rs./Kg

Granulated Slag - 2.5 Rs/Kg

Controlled Concrete made with only cement OPC

For 1m<sup>3</sup> concrete with normal cement OPC 43 grade

Cement content 450Kg/m <sup>3</sup>	450x8= 3600.00
Fine Aggregate 586.3Kg/m <sup>3</sup>	586.3x1.32= 773.92
Coarse Aggregate 1190.32kg/m <sup>3</sup>	1190.32x1.11= 1321.26
Total cost for 1 m <sup>3</sup> Concrete	5695.18

Concrete made with composite cement (65% OPC, 15% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 450Kg/m <sup>3</sup>	
• OPC 65% - 292.5 Kg/m <sup>3</sup>	292.5x8=2340.00
• Fly Ash 15% - 67.5 Kg/m <sup>3</sup>	67.5x2=135.0
• Granulated Slag 20% - 90.00 Kg/m <sup>3</sup>	90.00x2.5=225.00
Fine Aggregate 586.3Kg/m <sup>3</sup>	586.3x1.32= 773.92
Coarse Aggregate 1190.32kg/m <sup>3</sup>	1190.32x1.11= 1321.26
Total cost for 1 m <sup>3</sup> Concrete	4795.18

Concrete made with composite cement (60% OPC, 15% Fly Ash, 25% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 450Kg/m <sup>3</sup>	
• OPC 60% - 270 Kg/m <sup>3</sup>	270x8=2160
• Fly Ash 15% - 67.5 Kg/m <sup>3</sup>	67.5x2=135.0
• Granulated Slag 25% - 112.5 Kg/m <sup>3</sup>	112.5x2.5=281.25
Fine Aggregate 586.3Kg/m <sup>3</sup>	586.3x1.32= 773.92
Coarse Aggregate 1190.32kg/m <sup>3</sup>	1190.32x1.11= 1321.26
Total cost for 1 m <sup>3</sup> Concrete	4671.43

Concrete made with composite cement (60% OPC, 20% Fly Ash, 20% GS)

For 1m<sup>3</sup> concrete with normal composite cement

Cement content 450Kg/m <sup>3</sup>	
• OPC 60% - 270 Kg/m <sup>3</sup>	270x8=2160.00
• Fly Ash 20% - 90.00 Kg/m <sup>3</sup>	90x2=180.00
• Granulated Slag 20% - 90 Kg/m <sup>3</sup>	90x2.5=225.0
Fine Aggregate 586.3Kg/m <sup>3</sup>	586.3x1.32= 773.92
Coarse Aggregate 1190.32kg/m <sup>3</sup>	1190.32x1.11= 1321.26
Total cost for 1 m <sup>3</sup> Concrete	4660.18

**6. CONCLUSIONS:**

- The best possible combination of OPC, Granulated Slag and Fly Ash to produce composite cement without compromising its codal requirements i.e. IS 16415:2015 is identified as SET 1, SET 2 and SET 3.
- Lower Cement/Clinker Ratio by utilizing second waste material granulated slag, first being fly ash is achieved.
- The combination will reduce the cost compared to OPC, besides consuming waste by-product.
- The use of GBFS and Fly Ash is cheaper than cement and eco-friendly than conventional, raw material for cement manufacturing.
- Results of Concrete mixes validates that we can successfully use Combination of OPC, Fly ash and Granulated Slag in ratios of Set 1, Set 2 and Set 3 without compromising the compressive strength.
- Effective cost of concrete made with composite cement shows considerable cost effectiveness when compared to cost of concrete made with OPC cement concrete.
- Both low and high grade concrete made with composite cement shows cost saving, therefore more usability of composite cement concrete can be achieved if correct awareness is maintained.
- It is a win-win situation for society by using composite cement concrete instead of OPC cement concrete as not only two waste materials are utilized, cost is also reduced.

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