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# An Experimental Study on Strength Characteristics of Pervious Concrete by Partial Replacement of Cement with DifferentIndustrial wastes

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***Abstract: The main goal of this investigation is to develop a strong and durable pervious cement concrete (PCC) mix using different materials like Granite powder, Marble powder, Tile powder and Gypsum powder as a replacement of cement. In addition, it was aimed to compare the properties of these PCC mixes to lay concrete pavers.The properties such as compressive, flexural and Tensile strength tests were performed.***
**Keywords**: pervious, pavement, porosity, skid resistance.

## I. Introduction

No-Fines Concrete is made by eliminating the fines from conventional concrete. No-fines concrete is a type of concrete from which the fine aggregate fraction has been removed. This concrete is made up of only coarse aggregate, cement and water. Aggregates of size passing through 16 mm and retained on 12.5 mm, passing through 12.5mm and retained on 10mm is used in preparing the specimens. No-fines concrete is becoming popular because of some of the advantages it possesses over the conventional concrete.The advantages of this type of concrete are lower density (1600- 2000 kg/m3),lower cost due to replacement of cement with various industrial wastes such as granite powder, marble powder, Tile powder and gypsum powder increases the strength characteristics of pervious concrete.

## II. Material and Methodology

**Materials:**

**Cement:**

Ordinary Portland cement (OPC) of M53 grade conforming to IS:12269-1999 was used for casting.

**Aggregate:**

Aggregates of size passing through 16 mm and retained on 12.5 mm, passing through 12.5mm and retained on 10mm is used
.

**Water:**

Tap water that is suitable for making ordinary concrete should be used.

**Mix proportions:**

The cement: aggregate ratio by volume is in the range of 1:4 by volume. The water- cement ratio of 0.3 is used to make sure the cement paste coats the aggregates and does not run off.

to ensure the cement paste coats the aggregates and does not run off.

**Methodology:**

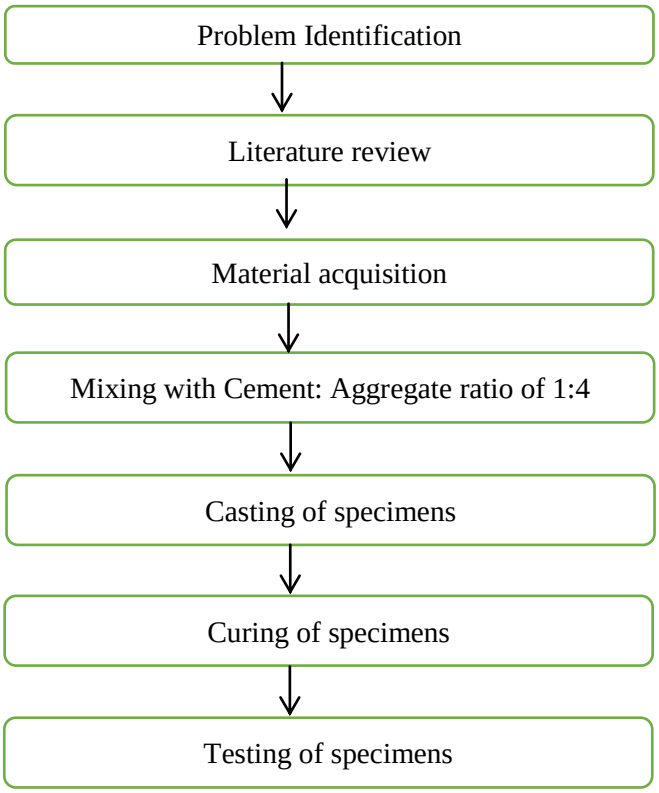


**Fig: Methodology**

Here the above figure shows the methodology adopted for the present experimental study.

**Preparation, casting and curing of the test specimens:**

The moulds are well cleaned and the internal faces are thoroughly coated with grease to avoid adhesion with the concrete after hardening. The casting was carried out in one layer without compaction. The specimens were demoulded after 24 hours. After demoulding, the specimens were totallysubmerged in curing tank with water attemperature of 24 ±1°c and a relative humidity of about 85% for a period of testing.

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## III. Results and Tables

### Compressive strength on Cubes without additives:

Table:3.1: compressive strength without additives

| Curing period ( days ) | Compressive strength (Mpa) |
|---|---|
| 7 | 7.78 |
| 14 | 11.22 |
| 28 | 17.1 |

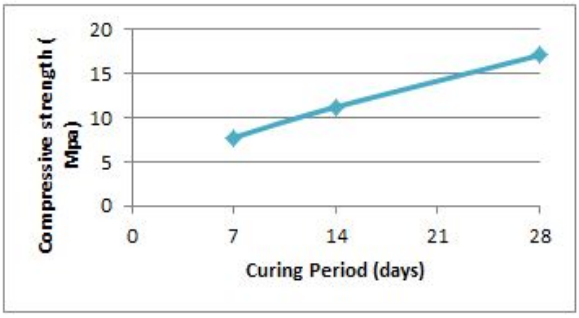


Figure:3.1: Compressive strength without additives

The graph shows the compressive strength of the cubes without adding materials for 7, 14 and 28 days

### Compressive Strength on Cubes with Granite powder:

Table:3.2: Compressive strength with Granite powder

| Curing period ( days ) | Compressive strength of GP 5 (Mpa) | Compressive strength of GP 10 (Mpa) | Compressive strength of GP 15 (Mpa) |
|---|---|---|---|
| 7 | 8.31 | 8.92 | 8.16 |
| 14 | 11.80 | 13.02 | 11.75 |
| 28 | 18.28 | 19.62 | 17.86 |

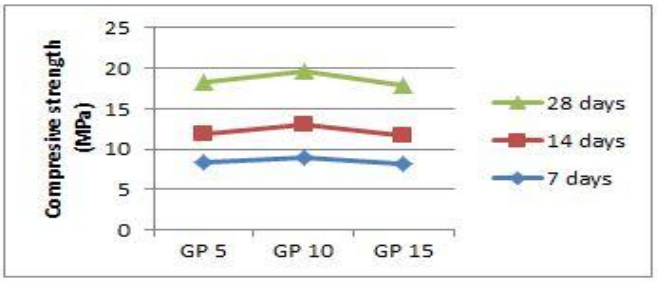


Figure:3.2: compressive strength with Granite powder

The graph shows the compressive strength of the cubes by replacing of cement withGranite powder for 7, 14 and 28 days respectively

### Compressive Strength on Cubes with Marble powder:

Table:3.3: compressive strength with Marble powder

| Curing period ( days ) | Compressive strength of MP 5 (Mpa) | Compressive strength of MP10 (Mpa) | Compressive strength of MP15 (Mpa) |
|---|---|---|---|
| 7 | 8.59 | 8.76 | 8.23 |
| 14 | 12.46 | 12.79 | 12.34 |
| 28 | 18.90 | 19.18 | 18.11 |

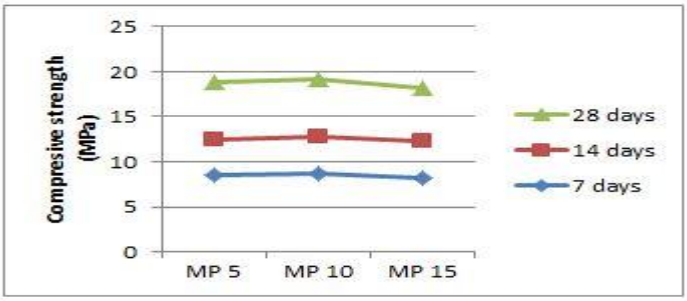


Figure:3.3: Compressive strength with Marble powder

The graph shows the compressive strength of the cubes by replacement of cement with Marble powder for 7, 14 and 28 days.

### Compressive Strength on Cubes with Tile powder:

Table:3.4: Compressive strength with Tile powder

| Curing period ( days ) | Compressive strength of TP 5 (Mpa) | Compressive strength of TP 10 (Mpa) | Compressive strength of TP 15 (Mpa) |
|---|---|---|---|
| 7 | 7.94 | 8.61 | 8.03 |
| 14 | 3.33 | 3.96 | 3.79 |
| 28 | 6.2 | 6.38 | 5.87 |

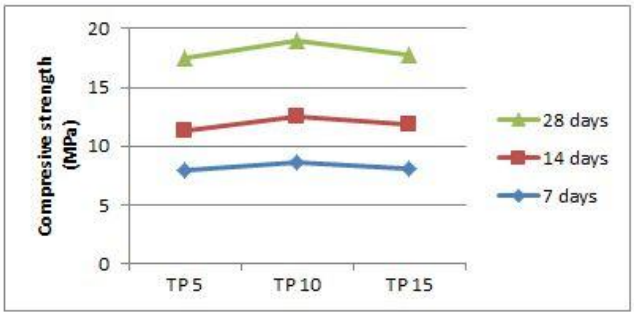


Figure:3.4: Compressive strength with Tile powder

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The graph shows the compressive strength of the cubes by replacement of cement with Tile powder for 7, 14 and 28 days respectively

**Compressive Strength on Cubes with Gypsum powder:**

Table: 3.5: Compressive strength with Gypsum powder

| Curing period ( days ) | Compressive strength of Gy.P 3 (Mpa) | Compressive strength of Gy.P 4 (Mpa) | Compressive strength of Gy.P 5 (Mpa) |
|---|---|---|---|
| 7 | 8.26 | 8.67 | 9.13 |
| 14 | 11.98 | 12.49 | 13.06 |
| 28 | 18.18 | 19.08 | 19.93 |

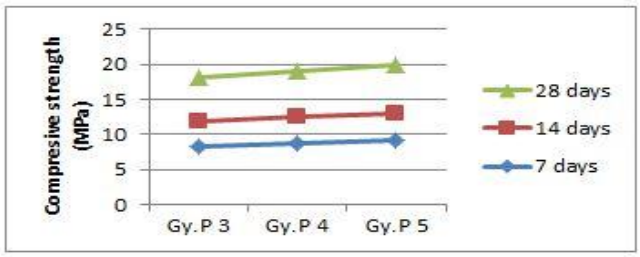


Figure: 3.5: Compressive strength with Gypsum powder

The graph shows the compressive strength of the cubes by partial replacement of cement with Gypsum powder for 7, 14 and 28 days respectively

**Flexural strength for control specimen:**

Table: 3.6: Flexural strength without industrial wastes

| Curing period ( days ) | Flexural strength (Mpa) |
|---|---|
| 7 | 0.8 |
| 14 | 1.05 |
| 28 | 1.35 |

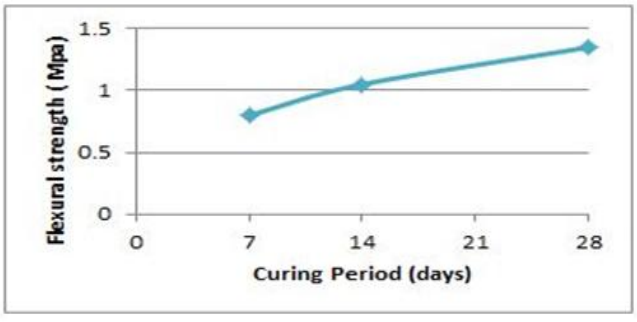


Figure: 3.6: Flexural strength without industrial wastes

The graph represents the Flexural strength of the Prisms without using industrial wastes for 7, 14 and 28 days respectively

**Flexural strength test with Granite powder:**

Table: 3.7: Flexural strength with Granite powder

| Curing period ( days ) | Flexural strength of GP 5 (MPa) | Flexural strength of GP 10 (MPa) | Flexural strength of GP 15 (MPa) |
|---|---|---|---|
| 7 | 0.81 | 0.84 | 0.75 |
| 14 | 1.08 | 1.10 | 0.98 |
| 28 | 1.38 | 1.43 | 1.28 |

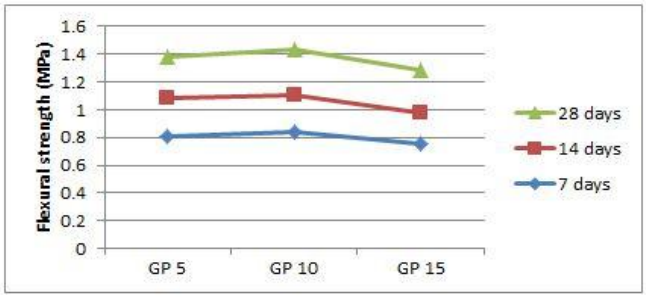


Figure: 3.7: Flexural strength with Granite powder

The graph shows the flexural strength of the prisms by partial replacement of cement with Granite powder for 7, 14 and 28 days respectively

**Flexural strength test with Marble powder:**

Table: 3.8: Flexural strength with Marble powder

| Curing period ( days ) | Flexural strength ofMP5 (Mpa) | Flexural strength of MP10 (Mpa) | Flexural strength of MP15 (Mpa) |
|---|---|---|---|
| 7 | 0.79 | 0.76 | 0.65 |
| 14 | 1.03 | 0.99 | 0.85 |
| 28 | 1.31 | 1.30 | 1.10 |

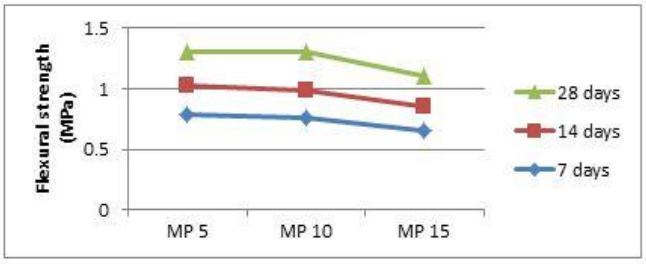


Figure: 3.8: Flexural strength with Marble powder

The graph shows the flexural strength of the prisms by partial replacement of cement with Marble powder for 7, 14 and 28 days respectively

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**Flexural strength test with Tile powder:**

Table: 3.9: Flexural strength with Tile powder

| Curing period ( days ) | Flexural strength of TP 5 (MPa) | Flexural strength of TP 10 (MPa) | Flexural strength of TP 15 (MPa) |
|---|---|---|---|
| 7 | 0.53 | 0.46 | 0.35 |
| 14 | 0.69 | 0.61 | 0.48 |
| 28 | 0.91 | 0.79 | 0.61 |

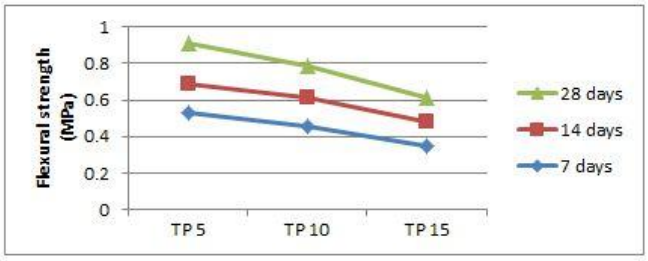


Figure: 3.9: Flexural strength with Tile powder

The graph shows the flexural strength of the prisms by partial replacement of cement with Tile powder for 7, 14 and 28 days respectively

**Flexural strength test with Gypsum powder:**

Table: 3.10: Flexural strength with Gypsum powder

| Curing period ( days ) | Flexural strength of Gy.P 3 (MPa) | Flexural strength of Gy.P 4 (MPa) | Flexural strength of Gy.P 5 (MPa) |
|---|---|---|---|
| 7 | 0.69 | 0.56 | 0.35 |
| 14 | 0.91 | 0.73 | 0.59 |
| 28 | 1.18 | 0.93 | 0.76 |

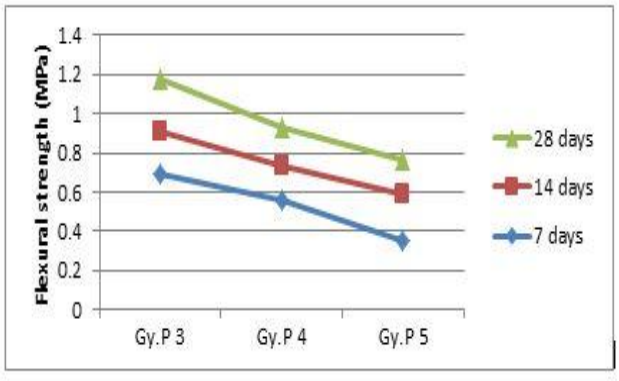


Figure: 3.10: Flexural strength with Gypsum powder

The graph shows the flexural strength of the prisms by partial replacement of cement with Gypsum powder for 7, 14 and 28 days respectively

**Tensile strength test for control specimen:**

Table: 3.11: Tensile strength without industrial wastes

| Curing period ( days ) | Tensile strength (Mpa) |
|---|---|
| 7 | 1.71 |
| 14 | 2.32 |
| 28 | 2.85 |

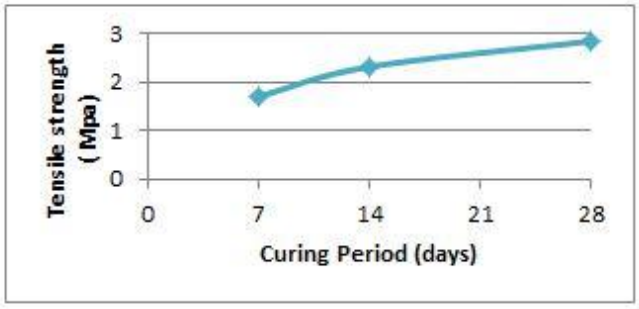


Figure: 3.11: Tensile strength without industrial wastes

The graph shows the tensile strength of the prisms without using industrial wastes for 7, 14 and 28 days respectively

**Tensile strength test with Granite powder:**

Table: 3.12: Tensile strength with Granite powder

| Curing period ( days ) | Tensile strength of GP5 (Mpa) | Tensile strength of GP10 (Mpa) | Tensile strength of GP15 (Mpa) |
|---|---|---|---|
| 7 | 1.73 | 1.85 | 1.69 |
| 14 | 2.38 | 2.50 | 2.28 |
| 28 | 2.94 | 3.14 | 2.88 |

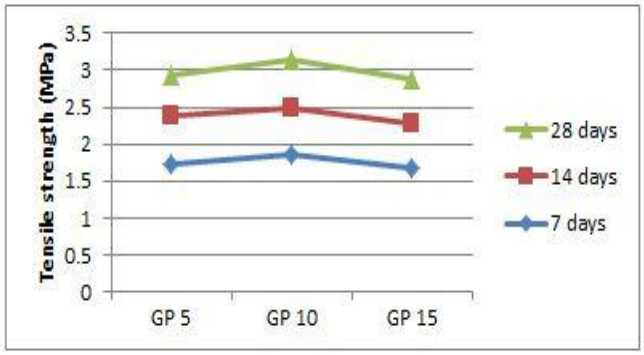


Figure: 3.12:Tensile strength with Granite powder

The graph shows the tensile strength of the prisms by partial replacement of cement with granite powder for 7, 14 and 28 days respectively

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**Tensile strength test with Marble powder:**

Table: 3.13: Tensile strength with Marble powder

| Curing period ( days ) | Tensile strength of MP 5 (Mpa) | Tensile strength of MP 10 (Mpa) | Tensile strength of MP 15 (Mpa) |
|---|---|---|---|
| 7 | 1.76 | 1.82 | 1.70 |
| 14 | 2.35 | 2.46 | 2.31 |
| 28 | 2.98 | 3.10 | 2.89 |

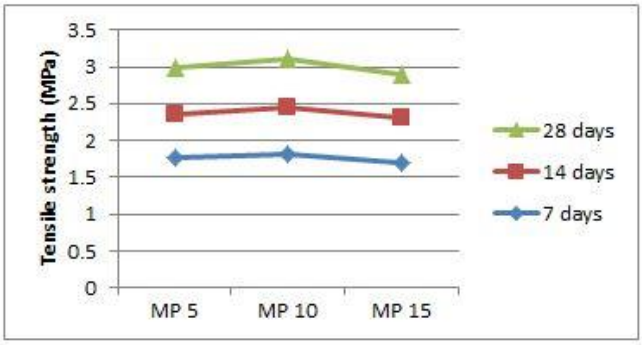


Figure:3.13: Tensile strength with Marble powder

The graph shows the tensile strength of the prisms by partial replacement of cement with marble powder for 7, 14 and 28 days respectively

**Tensile strength test with Tile powder:**

Table: 3.14: Tensile strength with Tile powder

| Curing period ( days ) | Tensile strength of TP5 (Mpa) | Tensile strength of TP10 (Mpa) | Tensile strength of TP15 (Mpa) |
|---|---|---|---|
| 7 | 1.68 | 1.46 | 1.23 |
| 14 | 2.27 | 1.98 | 1.67 |
| 28 | 2.81 | 2.49 | 2.09 |

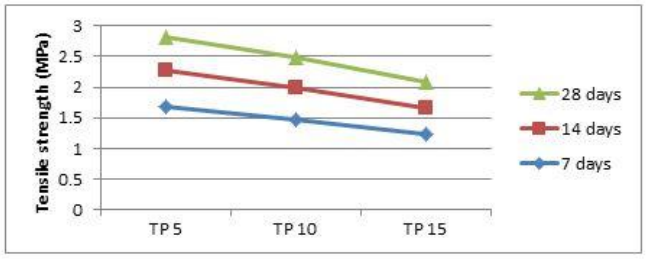


Figure:3.14: Tensile strength with Tile powder

The graph shows the tensile strength of the prisms by partial replacement of cement with tile powder for 7, 14 and 28 days respectively

**Tensile strength test with Gypsum powder:**

Table: 3.15: Tensile strength with Gypsum powder

| Curing period ( days ) | Tensile strength of Gy.P 3 (Mpa) | Tensile strength of Gy.P 4 (Mpa) | Tensile strength of Gy.P 5 (Mpa) |
|---|---|---|---|
| 7 | 1.59 | 1.52 | 1.36 |
| 14 | 2.15 | 2.06 | 1.84 |
| 28 | 2.71 | 2.54 | 2.24 |

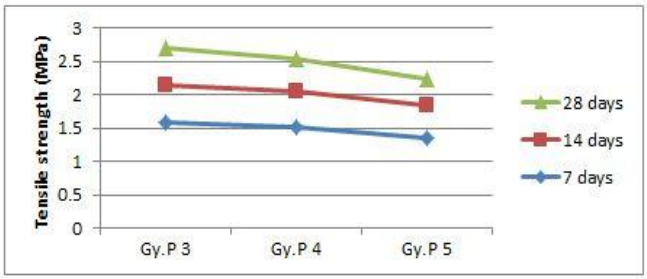


Figure:3.15: Tensile strength with Gypsum powder

The graph shows the tensile strength of the prisms by partial replacement of cement with gypsum powder for 7, 14 and 28 days respectively

**COMPARISION OF COMPRESSIVE STRENGTH OF CUBES AT OPTIMUM CONTENT OF REPLACEMENT OF CEMENT**

Table: 3.16: ComparisionofCompressivestrength

| Curing period ( days ) | Compressive strength of CS (Mpa) | Compressive strength of GP (Mpa) | Compressive strength of MP (Mpa) | Compressive strength of TP (Mpa) | Compressive strength of Gy.P (Mpa) |
|---|---|---|---|---|---|
| 7 | 7.78 | 8.92 | 8.76 | 8.61 | 9.13 |
| 14 | 11.22 | 13.02 | 12.79 | 12.57 | 13.06 |
| 28 | 17.1 | 19.62 | 19.18 | 18.95 | 19.93 |

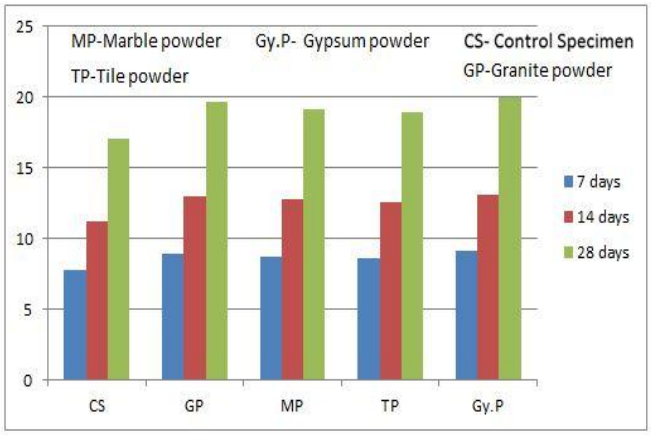


Figure: 3.16: Comparision of Compressive strength

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The above graph represents the comparision of Compressive strengths for control specimen, partial replacement of cement with granite powder, marble powder, tile powder and gypsum powder.

The graphindicates that the Compressive strength increases by the replacement of cement with various industrial wastes for 7, 14 and 28 days respectively. It also indicates that the strength of using gypsum powder is more when compared with the strength of remaining industrial waste materials.

**COMPARISION OFFLEXURAL STRENGTH OF CUBES AT OPTIMUM CONTENT OF REPLACEMENT OF CEMENT**

Table: 3.17: ComparisionofFlexuralstrength

| Curing period ( days ) | Flexural strength of CS (Mpa) | Flexural strength of GP (Mpa) | Flexural strength of MP (Mpa) | Flexural strength of TP (Mpa) | Flexural strength of Gy.P (Mpa) |
|---|---|---|---|---|---|
| 7 | 0.8 | 0.84 | 0.76 | 0.46 | 0.35 |
| 14 | 1.05 | 1.1 | 0.99 | 0.61 | 0.46 |
| 28 | 1.35 | 1.43 | 1.3 | 0.79 | 0.56 |

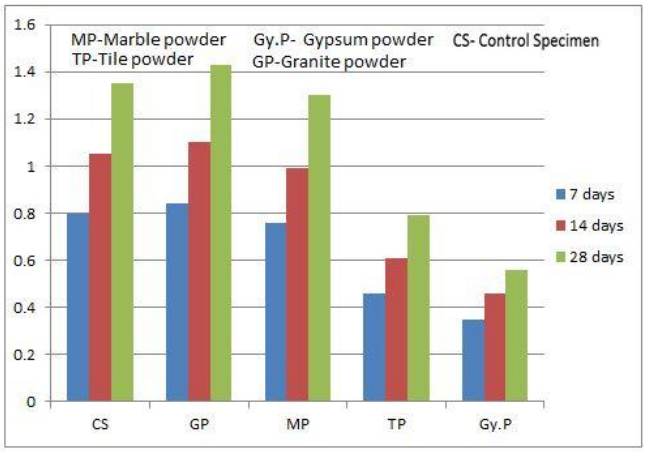


Figure: 3.17: Comparision of Flexural strength

The above graph represents the comparision of Flexural strengths for control specimen, partial replacement of cement with granite powder, marble powder, tile powder and gypsum powder.

The graphindicates that the Flexural strength increases by the replacement of cement with various industrial wastes for 7, 14 and 28 days respectively. It also indicates that the strength of usinggranite powder is more when compared with the strength of remaining industrial waste materials.

**COMPARISION OFTENSILE STRENGTH OF CUBES AT OPTIMUM CONTENT OF REPLACEMENT OF CEMENT**

Table: 3.18: ComparisionofTensilestrength

| Curing period (days) | Tensile strength of CS (Mpa) | Tensile strength of GP (Mpa) | Tensile strength of MP (Mpa) | Tensile strength of TP (Mpa) | Tensile strength of Gy.P (Mpa) |
|---|---|---|---|---|---|
| 7 | 1.71 | 1.85 | 1.82 | 1.46 | 1.36 |
| 14 | 2.32 | 2.5 | 2.46 | 1.98 | 1.84 |
| 28 | 2.85 | 3.14 | 3.1 | 2.49 | 2.24 |

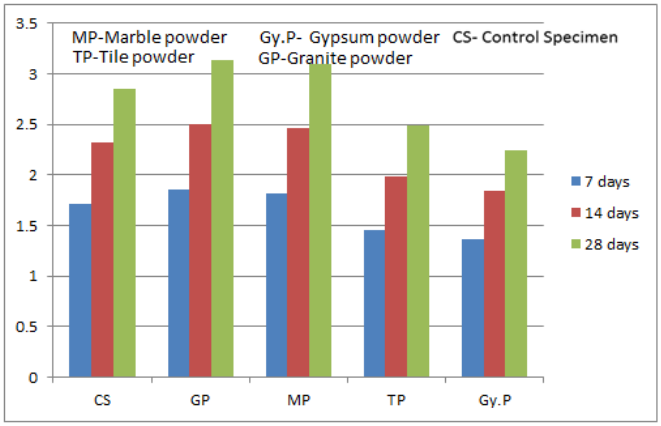


Figure: 3.18: Comparision of Tensile strength

The above graph represents the comparision of Tensile strengths for control specimen, partial replacement of cement with granite powder, marble powder, tile powder and gypsum powder.

The graphindicates that the Tensile strength increases by the replacement of cement with various industrial wastes for 7, 14 and 28 days respectively. It also indicates that the strength of using granite powder and marble powder is more when compared with the strength of tile powder and gypsum powder.

**Conclusions**

From the experimental study following conclusions were obtained:

1. From the above results, the optimum content of replacement of cement with granite powder is found to be 10%.
2. From the above results, the optimum content of replacement of cement with marble powder is found to be 10%.
3. From the above results, the optimum content of replacement of cement with tile powder is found to be 10%.
4. From the above results, the optimum content of replacement of cement with gypsum powder is found to be 5%.
5. From the above results, Compressive strength of specimens with granite powder, marble powder, tile powder and gypsum powder increased by 14.73%, 12.16%,10.81% &16.54% at 28 days when compared with control specimens.

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6. From the above results, Tensile strength of specimens with granite powder, marble powder increased by 10.17% &8.77% at 28 days when compared with control specimens.
7. From the above results, Tensile strength of specimens with Tile powder and gypsum powder decreased by 12.63% &21.40% at 28 days when compared with control specimens
8. From the above results, Flexural strength of specimens with granite powder increased by 5.92% at 28 days when compared with control specimens.
9. Flexural strength of specimens with Marble powder, tile powder and gypsum powder decreased by 3.72%,21.48% &23.70% at 28 days respectively when compared with control specimens

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