# Influence of Limestone Dust on the Strengths of Pervious Concrete by using Recycled Aggregates

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**Abstract:- Pervious concrete pavement is a unique and effective way to capture storm water and allow it to seep into the ground thus recharging groundwater, reducing stormwater runoff, and meeting stormwater regulations. This system has been recommended by EPA (Environmental Protection Agency) and geotechnical engineers as a Best Management Practices (BMPs) for the management of stormwater runoff. This thesis presents experimental study on the potential use of limestone dust for producing a lightweight composite material that will add some of physical properties of concrete material having various levels of Limestone Powder Waste (LPW) in No-Fines concrete material. The obtained compressive strength, flexural strength, split tensile strength, unit weight satisfy the relevant Indian standards. The result shows the effect of high level replacement of Limestone Powder Waste (LPW).**

***Keywords**:- pervious concrete, stormwater, pavement technology, Infiltration, flexural strength, split tensile strength.*

## I. INTRODUCTION

Concrete is a composite material composed of aggregate bonded together with fluid cement which hardens over time. Most use of the term "concrete" refers to Portland cement concrete or to concretes made with other hydraulic cements, such as cement. However, road surfaces are also a type of concrete, "asphaltic concrete", where the cement material is bitumen.

In Portland cement concrete and other hydraulic cement concretes, when the aggregate is mixed together with the dry cement and water, they form a fluid mass that is easily molded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix which binds all the materials together into a durable stone-like material that has many uses. Often, additives such as pozzolana or super plasticizers are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials such as rebar embedded to provide tensile strength, yielding reinforced concrete. There are many types of concrete available, created by varying the proportions of main ingredients below. In this way substitution for the cementious and aggregate phases, the finished product can tailored to its application with varying strength, density, chemical and thermal resistance properties. Reinforcement is often included in concrete for increasing strength.

Limestone Powder Waste in No-Fines Concrete is used because No-Fines Concrete has porosity in it. It has no fine aggregate in it. It has 25% of voids which results in high porosity concrete block .The Limestone Powder Waste utilized in this research are available widely in large amounts. This research shows some physical and mechanical properties of brick having different percentages of Limestone Powder Waste .Most wastes used in this research are disposed and dumped in open areas.

The aim is to use industrial waste in building Materials. Limestone Powder Waste is used in No-Fines Concrete to use as a substitute for brick material. We are going to use No-Fines Concrete as per IS code 12727:1989. We are going to increase the Limestone Powder Waste by 5% in every variation of No-Fines concrete block and simultaneously decreasing the cement by 5% in variations of block. Using Limestone Powder Waste as a substitute for cement in No-Fines concrete block in its natural form has produced, economical, lighter and environment friendly new cement material. This research has studied the properties of this new concrete block material, which has different variations of Limestone Powder Waste percentages and cement as binder and water. The replacement of limestone powder in No-Fines Concrete cement in tested samples unit weight has reduced.

## II. SCOPE

The main objectives of the project is to manufacture and evaluate strength parameters of Pervious concrete by using aggregates of various sizes and different methods of mix design to achieve maximum percentage of voids and increase the load bearing capacity.

## III. ENVIRONMENTAL BENEFITS

As mentioned earlier, pervious concrete pavement systems provide a valuable stormwater management tool under the requirements of the EPA Storm Water Phase II Final Rule (EPA 2000).Phase II regulations provide programs and practices to help control the amount of contaminants in our waterways. Impervious pavements, particularly parking lots, collect oil, antifreeze, and other automobile fluids that can be washed into streams, lakes, and oceans when it rains.

EPA Storm Water regulations set limits on the levels of pollution in our streams and lakes. To meet these regulations, local officials have considered two basic approaches: 1) reduce the overall run-off from an area, and 2) reduce the level of pollution contained in runoff. Efforts to reduce runoff include zoning ordinances and regulations that reduce the amount of impervious surfaces in new developments (including parking and roof areas),increased green space requirements, and implementation of "stormwater utility districts" that levy an impact fee on a property owner based on the amount of impervious area. Efforts to reduce the level of pollution from stormwater include requirements for developers to provide systems that collect the "first flush" of rainfall, usually about 1 in. (25 mm), and "treat" the pollution prior to release. Pervious concrete pavement reduces or eliminates runoff and permits "treatment" of pollution: two studies conducted on the long-term pollutant removal in porous pavements suggest high pollutant removal rates.

## IV. MATERIALS USED

### *A. Cement*

Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988. The physical properties of the cement are listed in Table below.

| Sl No. | Properties | IS:169-1989 |
|---|---|---|
| 1. | Normal consistency | 0.32 |
| 2. | Initial setting time | Minimum of 30 min |
| 3. | Final setting time | Maximum of 600 min |
| 4. | Specific gravity | 3.14 |

### *B. Coarse Aggregate*

Crushed aggregates of less than 20mm size produced from local crushing plants were used. The aggregate exclusively passing through 20mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading. the particular gravity and water absorption of the mixture are given in table.

| | |
|---|---|
| Specific gravity of coarse aggregate | 2.6 |
| Water absorption | 1% |

### *C. Water*

Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9

### *D. Limestone Powder*

The water proportion in the mixes is taken 0.42as constant as per IS code to No-Fines Concrete but the cement proportion is decreasing by 5%in every variation In this mixing process of samples, Limestone Powder Waste, coarse aggregate and cement contents are placed in concrete mixer. The coarse aggregate used is (15-20mm) in the No-Fines Concrete. As per IS code 12727:1989.

## V. ENGINEERING PROPERTIES

### *A. Density And Porosity*

The density of pervious concrete depends on the properties and proportions of the materials used, and on the compaction procedures used in placement. In-place densities on the order of 100 lb/ft$^3$ to 125 lb/ft$^3$(1600 kg/m$^3$ to 2000 kg/m$^3$) are common, which is in the upper range of lightweight concretes.

### *B. Permeability*

The flow rate through pervious concrete depends on the materials and placing operations. Typical flow rates for water through pervious concrete are 3gal/ft$^2$/min (288 in./hr, 120 L /m$^2$/min, or 0.2 cm/s) to 8gal/ft$^2$/min (770 in./hr, 320 L /m$^2$/min, or 0.54 cm/s),with rates up to 17 gal/ft$^2$/min (1650 in./hr,700L/m$^2$/min,1.2 cm/s) and higher having been measured in the laboratory (Crouch 2004).

### *C. Compressive Strength*

Pervious concrete mixtures can develop compressive strengths in the range of 500 psi to4000 psi (3.5 MPa to 28 MPa), which is suitable for a wide range of applications. Typical values are about 2500 psi(17 MPa). As with any concrete, the properties and combinations of specific materials, as well as placement techniques and environmental conditions, will dictate the actual in-place strength. Drilled cores are the best measure of in-place strengths, as compaction differences make cast cylinders less representative of field concrete.

### *D. Flexural Strength*

| Mixes | Cement (kg) | Aggregate (kg) | Limestone dust (kg) | W/C ratio |
|---|---|---|---|---|
| Mix 1 | 0.675 | 5.4 | 0.00 | 0.40 |
| Mix 2 | 0.642 | 5.4 | 0.033 | 0.40 |

Flexural strength in pervious concretes generally ranges between about 150 psi (1 MPa) and 550 psi (3.8 MPa). Many factors influence the flexural strength, particularly degree of compaction, porosity, and the aggregate: cement (A/C) ratio. However, the typical application constructed with pervious concrete does not require the measurement of flexural strength for design.

*E. Shrinkage*

| Sl No. | Maximum size of stone ballast | Cement concrete mix by volume | Optimum W/C ratio | Expected compressive strength after 28 days (N/mm²) |
|---|---|---|---|---|
| 1 | 20mm | 1:8 | 0.4 | 5.5 |
| 2 | 20mm | 1:9 | 0.42 | 4.9 |
| 3 | 20mm | 1:10 | 0.45 | 3.5 |

Drying shrinkage of pervious concrete develops sooner, but is much less than conventional concrete. Specific values will depend on the mixtures and materials used, but values on the order of $200 \times 10^{-6}$ have been reported (Malhotra 1976), roughly half that of conventional concrete mixtures. The material's low paste and mortar content is a possible explanation. Roughly 50% to 80% of shrinkage occurs in the first 10 days, compared to 20% to 30% in the same period for conventional concrete. Because of this lower shrinkage and the surface texture, many pervious concretes are made without control joints and allowed to crack randomly.

## VI. MIX DESIGN

The mix design obtained for 20mm aggregates as per IS 12727:1989 is given below.

The ratio 1:8 for cement aggregate is taken for 1 part of cement and 8 parts of coarse aggregate is used. In the mining process of samples Limestone Powder Waste (LPW), cement contents and coarse aggregate are placed in a concrete mixing plate and hand mixed very well for 5-7 mixes. It is observed that as the limestone powder is added. The water absorption is more means heat of hydration is more compared to normal reaction of cement. Afterwards, the fresh mixes are fed into steel moulds. The total numbers of samples prepared are 6.

Note that the mix tabulated above is only for one mould (150x150x150mm).

Mix 1 is the required proportion for mix without adding limestone dust.
Mix 2 is the required proportion for mix by adding 5% of limestone dust.

Mix Proportion as per IS 12727:1989

## VII. SAMPLE PREPARATION

Six samples are prepared in a cubic mould of dimensions 150x150x150mm

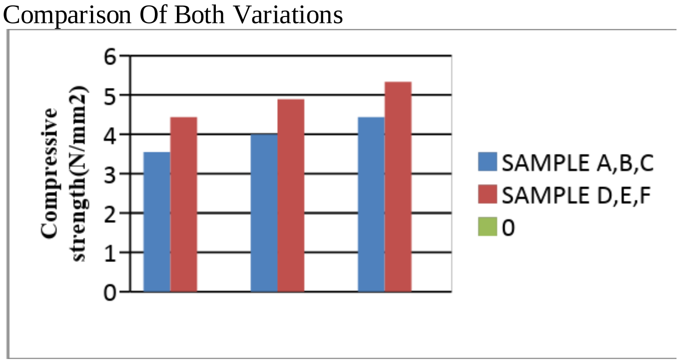
| Sl no | Sample | Cement (kg) | Aggregate (kg) | w/c ratio | Curing period (days) | Limestone dust (kg) |
|---|---|---|---|---|---|---|
| 1 | A | 0.675 | 5.4 | 0.4 | 7 | 0 |
| 2 | B | 0.675 | 5.4 | 0.4 | 14 | 0 |
| 3 | C | 0.675 | 5.4 | 0.4 | 28 | 0 |
| 4 | D | 0.642 | 5.4 | 0.4 | 7 | 0.033 |
| 5 | E | 0.642 | 5.4 | 0.4 | 14 | 0.033 |
| 6 | F | 0.642 | 5.4 | 0.4 | 28 | 0.033 |

## VIII. RESULTS

*A. Compressive Strength*

| Sl no | Sample | Weight (kg) | Load (kN) | Compressive strength (N/mm²) |
|---|---|---|---|---|
| 1 | A | 6.3 | 80 | 3.55 |
| 2 | B | 6.36 | 90 | 4 |
| 3 | C | 6.4 | 100 | 4.44 |
| 4 | D | 6.4 | 100 | 4.44 |
| 5 | E | 6.45 | 110 | 4.89 |
| 6 | F | 6.5 | 120 | 5.33 |

Comparison Of Both Variations




*B. Density*

The density of the concrete which are prepared is measured by weighing the concrete and dividing with the volume of the concrete.
Densities of concrete which are tested

| Sl no | Sample | Weight of the concrete (kg) | Volume of the concrete ($m^3$) | Density ($kg/m^3$) |
|---|---|---|---|---|
| 1 | A | 6.3 | $3.375 \times 10^{-3}$ | 1866.67 |
| 2 | B | 6.36 | $3.375 \times 10^{-3}$ | 1884.44 |
| 3 | C | 6.4 | $3.375 \times 10^{-3}$ | 1896.29 |
| 4 | D | 6.4 | $3.375 \times 10^{-3}$ | 1896.29 |
| 5 | E | 6.45 | $3.375 \times 10^{-3}$ | 1911.11 |
| 6 | F | 6.5 | $3.375 \times 10^{-3}$ | 1925.92 |

## IX. CONCLUSION

- The densities that are found in no fines concrete is less compared to conventional concrete.
- The influence of limestone powder showed good results than the other variation.
- The use of recycled aggregates tends to show a decline in terms of compressive strength compared to fresh concrete
- The compressive strength is slightly less compared to the data of IS:12727-1989
- The use of limestone dust is not disappointing as it showed good results in terms of compressive strength. Therefore it can be used in optimum quantity to attain cost efficiency.
- The optimum use of water gives the best result in terms of porosity.
- The aggregate cement ratio should be nearly accurate to give better porosity.
- The permeability is more compared to conventional concrete.
- The drying shrinkage is comparatively lower than conventional concrete
- Curing is done using gunny bags to prevent from cracks.
- Total omittion of fine aggregates gives better result in terms of porosity and permeability.

## X. MITIGATION MEASURES

- Mixing should be done thoroughly to attain better results.
- pH value of water should be between 6 and 9.
- Curing period should be adequate to give better results.
- CT machine should be checked to avoid mistakes.
- Permeameter should be checked to avoid mistakes.
- Cementitous material should be optimum to attain porosity.
- W/C ratio should be optimum.
- A/C ratio should be optimum.
- Proper care should be taken in final setting time.
- Proper care should be taken in apparatus handling

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