DOI: https://doi.org/10.29121/ijetmr.v5.i2.2018.170

IJETMR

International Journal of Engineering Technologies and Management Research

A Knowledge Repository

SIGNIFICANCE OF MARBLE AND PORTLAND CEMENT

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Abstract:

The aim of this current study is both to avoid the environmental. In this way, we will help to protect the environment by consuming the waste marble dust obtained as a by- product of marble sawing and shaping processes in the factories those operating in our region. Stone industry is an important factor in worldwide economy. Despite this, a large amount of residues is produced in ornamental stone industry with different dimension and particle size. The increasing rate at which raw material are continuously transformed into industrial products results in waste generation. Consequently, recycling of industrial wastes and byproducts is becoming a crucial demand by the environmental laws in agreement with the concept of sustainable development. The present study was therefore planned to explore the possibility of usage of waste marble powder (WMP) as partial replacement of sand for production of concrete This research work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing (OPC) cement via 0%, 10%, 12.5%, 15%, 17.5% and 20% of stone waste. Keeping all this view, the aim of the investigation is the behavior of concrete while replacing of waste with different proportions of stone waste in concrete by using tests like compression strength.

Keywords: *Marble; Cement; Concrete; Limestone; Portland Cement.*

Cite This Article: Dr. Arvind Dewangan, and Dr. D.P.Gupta. (2018). "SIGNIFICANCE OF MARBLE AND PORTLAND CEMENT." *International Journal of Engineering Technologies and Management Research,* 5(2), 255-265. DOI: 10.29121/ijetmr.v5.i2.2018.170.

1. Introduction

Marble as a building material especially in palaces and monuments has been in use for ages [7]. The marble has been commonly used as a building material since ancient times. Marble is a metamorphic rock resulting from the transformation of a pure limestone. Marble is a metamorphic rock produced from limestone by pressure and heat in the earth crust due to geological process [5] .Chemically, marble are crystalline rocks composed predominantly of calcite, dolomite or serpentine materials. The other mineral constituents vary from origin to origin. Physically, marble are re-crystallized hard, compact, fine to very fine grained metamorphosed rocks capable of taking shining polish. Marble dust is an industrial waste produced from cutting of marble stone. Marble is used for construction and decoration; marble is

ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

durable, has a noble appearance, and is consequently in great demand. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulfides. A large quantity of powder is generated during the cutting process. The result is that the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons [7]. Leaving these waste materials to the environment directly can cause environmental problem. The disposal of these materials constitutes an environmental problem because more of these materials are being generated yearly [1]. This put pressure on the limited number of landfill and suggests more sustainable use of such in construction development and in production of new products like concrete. A major component of concrete is cement, which similarly exerts environmental and social effects. The cement industry is one of the three primary producers of carbon dioxides, a major greenhouse gas 5-10%. The other two are the energy production and transportation industries. The use of marble dust as filler material in cement reduces the amount of natural resources required. This displaces some cement production, an energetically expensive and environmentally problematic process, while reducing both the need for land area for extracting resources and amount of industrial waste that must be disposed of. Marble powder can be used as filler in concrete and paving materials and helps to reduce total void content in concrete. Marble powder can be used as an admixture in concrete, so that strength of the concrete can be increased. Marble dust is mixed with concrete, cement or synthetic resins to make counters, building stones, sculptures, floors and many other objects [7].

The advancement of concrete technology can reduce the consumption of natural resources and energy sources which in turn further lessen the burden of pollutants on the environment. Presently, large amount of marble dust are generated in natural stone processing plants with an important impact on the environment and humans. In India, marble dust is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health [1]. Thus the utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. Test results show that this industrial bi product is capable of improving hardened concrete performance up to 10%, Enhancing fresh concrete behaviour. 30 cubes, 15 Beam and 15 cylinders have been casted. The compressive strength, Flexural strength and tensile strength of cubes and cylinders were measured for 7 and 28 days [1]. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. On the other hand, recycling waste without properly based scientific research and development can result in environmental problems greater than the waste itself. One of the logical means for reduction of the waste marble masses calls for utilizing them in building industry itself. Some attempts have been made to find and assess the possibilities of using waste marble powder in mortars and concretes and results about strength and workability were compared with control samples of conventional cements and mortar/ concrete. Marble powder is not available in all the places. Despite this fact, concrete production is one of the concerns worldwide that impact the environment with major impact being global warming due to CO2 emission during production of cement. In addition to this, due to fineness of the marble powder, it will easily mix with aggregates so that perfect bonding is possible [8]. Marble powder will fill the voids present in concrete and will give sufficient compressive

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

strength when compared with the ordinary concrete. India is among the top world exporters of marble stone. The Indian marble industry has been growing steadily at an annual rate of around 10% per year. Cutting of stones produces heat, slurry, rock fragments and dust. 20 to 30% of marble blocks are converted in to powder. 3,172 thousand tons of marble dust was produced in year 2009-10. Waste Marble dust (WMD) can be used to improve the mechanical and physical properties of the conventional concrete. The possibility of utilizing WMD as an alternative very fine aggregate in the production of concrete will also induce a relief on waste disposal issues. Now-a-days the cost of material is increasing so if we use the waste material in the production of the concrete so we decrease the price [7].

The other benefits to cement industry include lower cost of cement production and lower greenhouse gas emission per tonne of cement production. This may also enable cement industries to take benefits of carbon trading. The present scenario should deal with utilization of industrial wastes such as fly ash (from thermal power plants), marble sludge (from marble industry), blast furnace slag and steel slag (from iron & steel industries), phosphor gypsum (from fertilizer plants), red mud (from aluminum industries), lime sludge's (from sugar, paper, calcium carbide industries), lead-zinc slag (from zinc industries) and kimberlitic (from mining) for manufacture of cement and related building materials. From the results it is observed that all of the major components of ordinary Portland cement clinkers are present in the produced clinkers. Waste can be used to produce nee products or can be used as admixtures so that natural sources are used more efficiently and the environment is protected from waste deposits. The ordinary stone dust obtained from crushers does not comply with IS: 383-1979. The presence of flaky, badly graded and rough textured particles result in hash concrete for given design parameters. Use of marble dust as a fine aggregate in concrete draws serious attention of researchers and investigators. Marble powder has a very high Blaine fineness value of about 1.5 m^2/g with 90% of particles passing 50 μm sieves and 50% under 7 μm. The maximum compressive and flexural strengths were observed for specimens containing 6% waste sludge when compared with control and it was also found that waste sludge up to 9% could effectively be used as an additive material in cement [5]. To avoid the pollution and reuse the waste material, the present study has been carried out. As the Properties of marble powder are as good as the sand, the marble sludge powder and quarry dust has been used as fine aggregate in the cement concrete. Now strength and durability properties of concrete play an important role in concrete structures. In the past, only strength of concrete was considered in the concrete mix design procedure assuming strength of concrete is an all pervading factor for all other desirable properties of concrete including durability. Although compressive strength is a measure of durability to a great extent it is not true that the strong concrete is always durable concrete. It is now recognized that the strength of concrete alone is not sufficient, the degree of harshness of the environmental condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability have to be considered explicitly at the design stage.

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

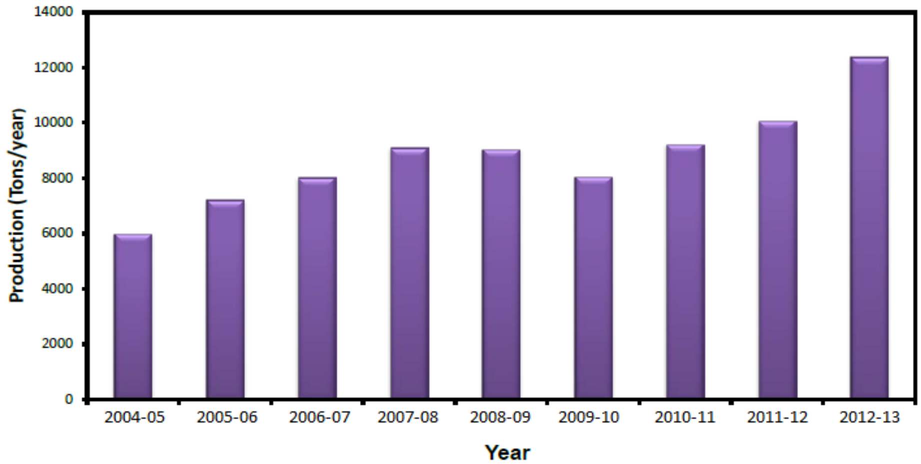

Figure 1.1: Marble Production in India

2. Effects of Marble Dust as Partial Replacement of Cement in Concrete

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on the environment. The cost of natural resources is also increased. They have forced to focus on recovery, reuse of natural resources and find other alternatives. Presently large amounts of Stone waste are generated in natural stone processing plants with an important impact on environment and humans [20]. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. Stone blocks are cut into smaller blocks in order to give them the desired shape and size. During the process of cutting, in that original Stone mass is lost by 25% in the form of dust. Every year 250-400 tons of Stone wastes are generated on site. The Stone cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the Stone waste quickly and use in the construction industry [20]. In INDIA, the marble and granite stone processing is one of the most thriving industry the effects if varying marble dust contents on the physical and mechanical properties of fresh and hardened concrete have been investigated This project describes the feasibility of using the marble sludge dust in concrete production as partial replacement of cement The compressive strength of concrete was measured f or 7 and 28 days. In order to evaluate the effects of marble dust on mechanical behavior, many different mortar mixes were tested [3].

3. Methodology

In order to achieve the objectives of the research and for the development of concepts, which are fundamental for the formation of the whole research work, a comprehensive literature review is made to understand the previous efforts which include the review of text books, periodicals and academic journals, seminars and research papers. The method followed to achieve the objectives of the research determines the required data, which intern is a ground to decide on type and method of data collection and their analysis. Different alternative data collection methods such as experiments, observations and archival records are examined and used when proved suitable.

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

Both primary data (collected personally) from the source itself and secondary data from different sources is collected and used for the analysis.

The test results were presented in tabular and graphical forms and the analysis and discussions were also made on the research findings both qualitatively and quantitatively. Finally based on the findings, conclusions and recommendations were forwarded.

Types of Portland Cement:

1) Ordinary Portland cement
2) Modified cement
3) Rapid-hardening Portland cement
4) Low heat Portland cement
5) Sulphate-resisting Portland cement
6) Portland blast furnace cement
7) Pozzolanic cement
8) Air-entrained cement
9) White Portland cement
10) Colored Portland cement

Properties of Portland Cement

- **Chemical properties** It is a Portland cement's chemical properties that determine most of its physical properties and how it cures. Therefore, a basic understanding of Portland cement chemistry can help one understand how and why it behaves as it does.
- **Chemical composition** The composition of Portland cement distinguishes one type of cement from another. The phase compositions in Portland cement are denoted as tricalcium silicate (C3S), dicalcium silicate (C2S), tricalcium aluminates (C3A), and tetra calcium aluminoferrite (C4AF). The actual components are often complex chemical crystalline and amorphous structures, denoted by cement chemists as "alite" (C3S), "belite" (C2S), and various forms of aluminates. The behavior of each type of cement depends on the content of these components [12]

Table 2.1: Chemical composition of cement

Chemical Name	**Chemical Formula**	**Shorthand Notation**	**Percent by Weight**
Tricalcium Silicate	3CaOSiO2	C3S	50
Dicalcium Silicate	2CaOSiO2	C2S	25
Tricalcium Aluminate	3CaOAl2O3	C3A	12
Tetracalcium Aluminoferrite	4CaOAl2O3Fe2O3	C4AF	8
Gypsum	CaSO4H2O	CSH2	3.5

Tricalcium silicate (C3S) hydrates and hardens rapidly and is largely responsible for initial set and early strength. Portland cements with higher percentages of C3S will exhibit higher early strength.

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Dicalcium silicate (C2S) hydrates and hardens slowly and is largely responsible for strength increases beyond one week.

Tricalcium aluminates (C3A) hydrates and hardens the quickest. It liberates a large amount of heat almost immediately and contributes somewhat to early strength. Gypsum is added to Portland cement to retard C3A hydration. Without gypsum, C3A hydration would cause Portland cement to set almost immediately after adding water.

Tetracalcium aluminoferrite (C4AF) hydrates rapidly but contributes very little to strength. Its presence allows lower kiln temperatures in Portland cement manufacturing. Most Portland cement color effects are due to C4AF

Comparison of the Characteristics of the Four Main Compounds in Portland Cement

	C_3S	C_2S	C_3A	C_4AF
Rate of hydration	Moderate	Slow	Fast	Moderate
Early Strength	High	Low	Low	Low
Ultimate Strength	High	High	Low	Low
Heat of Hydration	Medium	Low	High	Medium
Typical (cal/g)	120	60	320	100

Figure 2.1: Characteristics Comparison of Cement Compound

- **Physical properties**

Portland cements are commonly characterized by their physical properties for quality controlling purposes. Their physical properties can be used to classify and compare Portland cements [11]. Different standards have specified certain physical requirements for each type of cement .These properties include:

i. Fineness
ii. Specific Gravity
iii. Consistency
iv. Soundness
v. Setting time
vi. Compressive strength
vii. Heat of hydration
viii. Density
ix. Bulk density

i) Fineness

Fineness of cement is the total surface area of cement grains available for hydration. It determines the level of grinding of cement clinker in grinding mill of plant and affects the rate of hydration. Greater the fineness more is the surface available for hydration, resulting greater early strength and more rapid release of. Fineness of Portland cement has great effects on hydration

ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

rate and thus the setting time, and the rate of strength gain. As an example, the smaller is the particle size, the greater the surface area-to-volume ratio. This causes more area available for water-cement interaction. The finer particles mainly affect the early strength of the cement (2 days) while the larger particles dominate the strength after this time. The effects of greater fineness on strength are generally seen during the first seven or twenty eight days. There are, however, several disadvantages associated with high fineness. In fine cement, more gypsum is required for proper retardation because increased fineness makes more tricalcium aluminate available for early hydration. Grinding clinker to a high fineness requires more energy, increasing the production cost, and a higher early rate of hydration causes a higher early rate of heat liberation. If not properly dissipated, this heat may cause cracking especially in mass concrete construction [11]. The reaction of fine cement with alkali-reactive aggregate is stronger. Fineness, which has considerable effects on cement strength and hydration rate, is accepted as a vital parameter by European and American Standards The fineness of cement is measured by sieving it on standard sieves

ii) Specific gravity

Specific gravity is not a sign of the quality of the cement, but is required for calculations during concrete mix design. The specific gravity of Portland cement is approximately 3.15.

iii) Consistency of cement paste

Consistency indicates the degree of density or stiffness of cement. Therefore, it is necessary to determine the amount of water content for a given cement to get a mixture of required consistency. Consistency of cement is measured by vicat apparatus. The paste is said to be of standard consistency, when the penetration of plunger, attached to Vicat apparatus, is 33-35 mm. The moisture content of the standard paste is written as a percentage by weight of the powdered cement. The normal range is between 26-33%. This test precedes the test of cement for soundness, setting time, tensile strength or for compressive strength.

iv) Soundness

Soundness refers to the capability of the cement paste to maintain its volume after setting, and is associated with the existence of extreme amounts of free lime or magnesia in the cement or supplementary cementitious material. A cement paste should not undergo a large change in volume once it has been set. However, some expansion may occur due to gradual hydration or due to some other reactions of some compounds there in the hardened cement, namely free lime, magnesia and calcium sulfate. Free lime absorbs moisture and expands many times to its original volume and develops considerable heat and thus causes disintegration of concrete in which this cement is used. Expansion in OPC is limited to 10 mm or 0.5%.It is essential that cement concrete does not undergo large changes in volume after setting. This change in volume is known as unsoundness and may cause cracks, distortion and disintegration of concrete [11]. Bektas et al. (2008) investigated the effect of Portland cement fineness on the results of ASTM C1260 tests. He concluded that mortar-bar expansion was promoted with increased cement fineness regardless of clinker alkali, aggregate reactivity or soak solution normality.

v) Setting time

To enable the concrete to be laid in position properly the initial setting of cement should not start too quickly. Once the concrete has been laid it should harden rapidly so that the structure could

ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

be put to use early. Initial setting of cement is that step in the process of setting, after which if any cracks appear do not reunite. Final setting is that when it has occurred, sufficient strength and hardness is attained. As soon as water joins the cement, it forms gel that causes the paste to stiffen. However, this stiffening does not affect workability until initial set takes place. Thus, setting describes "The strength of the cement paste". Setting may also be understood as "setting refers to a transformation from a fluid to a hard state". During setting, the paste attains some strength. But it is different from hardening, which refers to the increase of strength of a set cement paste. The setting process is associated with temperature changes in the cement paste. Initial set is related to a quick increase in temperature and final set to the highest temperature. Setting time decreases with rise in temperature. Setting time of cement can be increased by adding some admixture, as sodium carbonate. The setting time of cement is measured using vicat apparatus with different penetrating attachments.

vi) Strength

Cement paste strength is typically defined in three ways: compressive, tensile and flexural. These strengths can be affected by a number of items including: water-cement ratio, cement-fine aggregate ratio, type and grading of fine aggregate, manner of mixing and molding specimens, curing conditions, size and shape of specimen, moisture content at time of test, loading conditions and age . Since cement gains strength over time, the time at which strength test is to be conducted must be specified [40]. Typically times are 1 day (for high early strength cement), 3 days, 7 days, 28 days and 90 days (for low heat of hydration cement).

- **Compressive strength**

The compressive strength of concrete is one of the most important mechanical properties. In most structural applications, concrete is employed primarily to resist the compressive forces. In those cases where other stresses (for e.g. tensile) are of primary importance, the compressive strength is still frequently used as a measure of the resistance because this strength is the most convenient to measure. For the same reason, the compressive strength is generally used as a measure of the overall quality of the concrete, when strength itself may be relatively unimportant.

- **Tensile strength**

The direct tension test does not provide any useful insight into the concrete-making properties of cements. It persists as a specified test because in the early years of cement manufacturing, it was the most common test since it was difficult to find machines that could compress a cement sample to failure.

- **Flexural strength**

Flexural strength (actually a measure of tensile strength in bending) is carried out on cement mortar beam that is loaded at its center point until failure.

vii) Heat of hydration

The heat of hydration is the heat generated when water and Portland cement react. Hydration begins at the surface of the cement particles. Therefore, the total surface area of cement represents the material available for hydration. That is, the early rate of hydration depends on the

ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

fineness of the cement particles. However, at later stages, the effect of surface area diminishes and, consequently, fineness exercise no influence on the total heat of hydration [40]. Heat of hydration is also influenced by the proportion of C3S and C3A in the cement, water-cement ratio, and fineness and curing temperature. As each one of these factors is increased, heat of hydration increases. In large mass concrete structures such as gravity dams, hydration heat is produced significantly faster than it can be dissipated (especially in the centre of large concrete masses), which can create high temperatures in the centre of these large concrete masses that, in turn, may cause undesirable stresses as the concrete cools to ambient temperature [11]. Conversely, the heat of hydration can help maintain favorable curing temperatures during winter

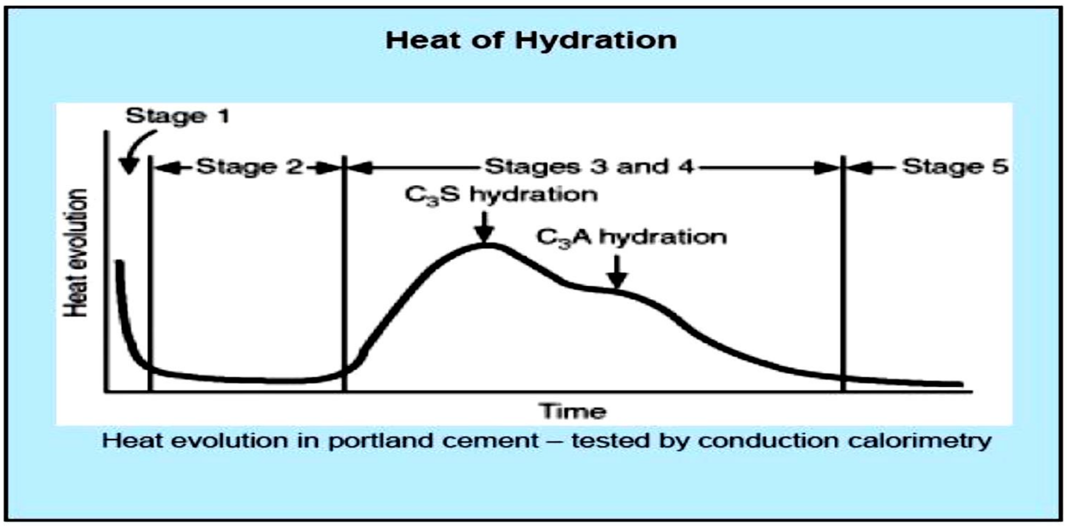

Figure 2.2: Heat of Hydration

Fineness Modulus

The fineness modulus (FM) of either fine or coarse aggregate according to ASTM C 125 is calculated by adding the cumulative percentages by mass retained on each of a specified series of sieves and dividing the sum by 100. The specified sieves for determining FM are: 150 μm (No. 100), 300 μm (No. 50), 600 μm (No. 30), 1.18 mm (No. 16), 2.36 mm (No. 8), 4.75 mm (No. 4), 9.5 mm (3⁄8 in.), 19.0 mm (3⁄4 in.), 37.5 mm (11⁄2 in.), 75 mm (3 in.) and, 150 mm (6 in.). FM is an index of the fineness of an aggregate the higher the FM, the coarser the aggregate. Different aggregate grading may have the same FM. FM of fine aggregate is useful in estimating proportions of fine and coarse aggregates in concrete mixtures[11]. Degradation of fine aggregate due to friction and abrasion will decrease the FM and increase the amount of materials finer than the 75 μm (No. 200) sieve.The usefulness of the fineness modulus lies in detecting slight variations in the aggregate from the same source, which could affect the workability of the fresh concrete

ISSN: 2454-1907
DOI: 10.5281/zenodo.1198999

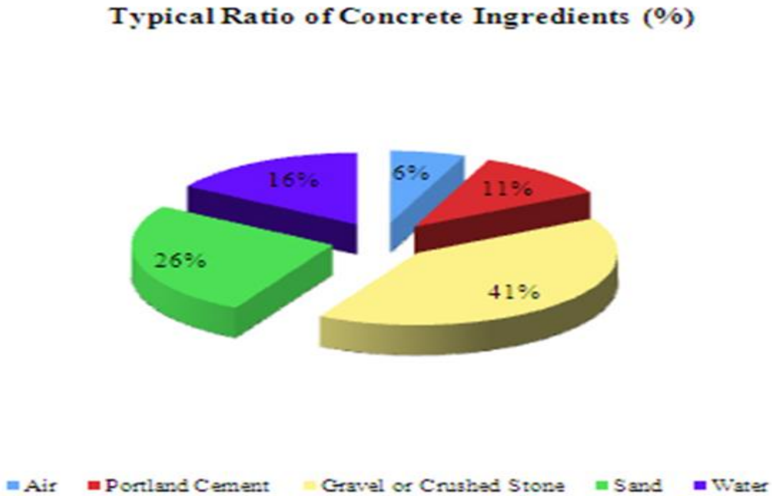

Figure 2.5: Concrete Ingredients

4. Conclusions

- The study indicates that the marble waste can be incorporated in Portland limestone production.
- Cost of cement production can be decreased by use of 10% WMD.
- The Compressive strength of Cubes are increased with addition of waste marble
- Powder up to 12.5 % replaces by weight of cement and further any addition of waste Marble powder the compressive strength decreases.
- The Tensile strength of Cylinders are increased with addition of waste marble
- powder up to 12.5 % replace by weight of cement and further any addition of waste
- Marble powder the Tensile strength decreases.
- Thus we found out the optimum percentage for replacement of marble powder with
- Cement and it is almost 12.5 % cement for both cubes and cylinders.
- We have put a simple step to minimize the costs for construction with usage of
- Marble powder which is freely or cheaply available more importantly.

We have also stepped into a realm of s the environmental pollution by cement production being our main objective as Civil Engineers.

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