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Significance of Modern Concrete Use

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Abstract— **Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, highways, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Concrete is used in large quantities almost everywhere mankind has a need for infrastructure. The amount of concrete used worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. Concrete's use in the modern world is exceeded only by that of naturally occurring water. Concrete is also the basis of a large commercial industry. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is projected to exceed $100 billion in revenue by 2015. In the United States alone, concrete production is a $30-billion-per-year industry, considering only the value of the ready-mixed concrete sold each year. Given the size of the concrete industry, and the fundamental way concrete is used to shape the infrastructure of the modern world, it is difficult to overstate the role this material plays today. This paper reveals that in modern times, researchers have experimented with the addition of other materials, like water-based cross linking polymers, to create concrete with improved properties, such as higher strength, electrical conductivity, or resistance to damages through spillage.**

Key Words: Concrete, Cement, Fly ash, Aggregates .
Sub Area: Construction Technology
Broad Area: Transportation Engineering.

I. INTRODUCTION

A pavement is a multi-layered structural part of the road which is subjected to stresses imposed by vehicular loading applied, as well as to deterioration from the effects of weather and the abrasive action of moving traffic. A satisfactory pavement design is one that is able to withstand these effects for a required period of time. A pavement consists of a multi-layer system, which is formed of a number of layers of compacted unbound aggregates or bound materials. Pavements, in general, can be classified in two major categories: concrete pavements and bituminous pavements. Concrete pavements are generally called rigid pavements and bituminous pavements as flexible pavements. There could be some other types of pavements which are neither rigid, nor flexible, for example, block pavement, composite pavements etc.

There are three main components of a road pavement

1. Foundation
2. Base
3. Surfacing

The foundation comprises of sub grade soil (cut or fill), capping and sub-base. The foundation is designed to provide a certain standard quality of support for the higher layers.

The base is the main structural layer of the pavement. Meanwhile, an asphalt surfacing comprises of a surface course and a binder course. The function of the surfacing is to enable good ride quality to be combined with appropriate resistance to skidding and resistance to crack formation.

A concrete pavement, in general, consists of three layers, comprising of a sub-grade, base layer and the concrete slab. Generally bound base layers are used for concrete pavement construction. As per Indian specification, some example of such base layers are Dry Lean Concrete (DLC), Roller Compacted Concrete (RCC) (IRC:15-2002).The concrete slab is generally of M40 to M50 grade of concrete as per Indian specifications, and is called as paving quality concrete (PQC).

II. COMPONENTS OF CONCRETE PAVEMENT:

The main components of concrete pavement are discussed as below:

1) Sub grade
2) capping layer
3)drainage layer

1) Sub grade: Sub grade is not formally a pavement layer. However, its properties and function must be fully understood in order to design and construct a satisfactory pavement over it. Sub grade is the natural soil or made-up ground (fill) on which the pavement is built. The function of the sub grade is to support the load of the whole pavement.

The sub grade and sub base for lying of paving concrete slabs should comply with the following requirement: (IRC: 15-1991)

- No soft spots be present in the sub-grade or sub-base.
- The uniformly compacted sub-grade or sub- base should extend at least 300 mm on either of width to be concreted.
- It should be properly drained.
- The maximum modulus of sub-grade reaction obtained with a plate bearing test shall be 5.5 Kg/cm3.

2) Capping layer: Over a weak sub grade a capping may be provided to act as a sub grade improvement layer. It can also be used as a working platform and prevents deterioration of the sub grade. This layer usually uses a relatively low quality, cheap, locally available aggregate. Some recycled materials are also used as an alternative material to make a capping. Occasionally, a stabilizer such as cement or lime is incorporated into the upper part of the sub grade to improve the strength and bearing capacity of the sub grade soil.

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3) Geo-composite Drainage layer :Over a sub grade layer a geo-composite drainage layer is provided for improved pavement drainage.A geo-composite has many advantages over natural drainage materials in maintaining its flow capacity and compressive stiffness under construction and service, besides unequal support. It is a sand /graded gravel layer.

The concrete used in these pavements can be further classified as either DLC or PQC, which are briefly discussed as below:

i) Dry Lean Concrete (DLC): It is an important part of modern rigid pavement. It is a plain concrete with a large ratio of aggregate to cement than conventional concrete and is generally used as a base/sub base of rigid pavement (Central Road Research Institute,2010).

The IRC specification of materials used for Dry Lean Concrete are discussed as below (MORTH section 600)

a) ***Cement:*** Any of the cements, as mentioned in Table1.1 can be used for manufacturing dry lean concrete.

b) ***Fly ash*****:** Up to 20 percent by weight of Cement may be used in 53 Grade Cement. No fly ash shall be used in any other grade of Cement other than 53 Grade.

c) ***Aggregates****:* Aggregates for lean concrete shall be natural material complying with IS: 383. The aggregates shall not be alkali reactive. The limits of deleterious materials shall not exceed the requirements set out in IS: 383. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least72 hours before batching, or as directed by the Engineer.

Coarse aggregates**:** Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of the coarse aggregate shall be 31.5 mm.

Fine aggregates:The fine aggregates shall consist of clean, natural sand or crushed stone sand or a combination of the two and shall conform to IS:383 (Table 1.2). Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter

III. MARBLE DUST

Marble Dust (MD) is a very fine powder, obtained as a by-product of marble during the sawing and the shaping, and not recycling it due to environmental problems in the world. Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its color and appearance; it is white if the limestone is composed solely of calcite (100% $CaCO_3$). Marble is used for construction and decoration, is durable, has a noble appearance, and is consequently in great demand. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite minerals. The other mineral constituents vary from origin to origin. Quartz, muscovite, tremolite, actinolite, micro line, talc, garnet, osterite and biotite are the major mineral impurities whereas SiO_2, limonite, Fe_2O_3, manganese, $3H_2O$ and FeS_2 (pyrite) are the major chemical impurities associated with marble. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulfides.

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 into powder. 3,172 thousand tons of marble dust was produced in year 2009-10 thus leaving these waste materials to the environment directly can cause environmental problem.

IV. USE OF MARBLE DUST AS REPLACEMENT MATERIAL IN CONCRETE

In building industry, Marble has been commonly used as a building material since the ancient time. Today, 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. Therefore, utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Hence the reuse of waste material has been emphasized. 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. There are several reuse and recycling solutions for this industrial by-product.

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 to make blocks, building stones, floors and many other objects. Also the concrete production impact the environment with CO_2 emission which causes global warming during production of cement. Marble dust (MD) can be used to improve the mechanical and physical properties of the conventional concrete, the possibility of utilizing MD 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.

V. CHEMICAL COMPOSITION OF MARBLE DUST

Marble dust consist a high percentage of CaO and SiO_2 .it consists of mainly 40% amount of CaO and 28% SiO_2.

Table 1.1 chemical composition of marble dust

Oxide compound	Mass percentage
CaO	40.45
Al_2O_3	.42
SiO_2	28.35
Fe_2O_3	9.70
MgO	16.25

VI. OBJECTIVE AND SCOPE OF PRESENT WORK

The main objective of the proposed work is to be study the effect of use of marble dust as partial replacement of sand for the production of Rigid Pavement Quality Concrete. The effect of marble dust as a replacement of sand in concrete to be studied on the strength characteristics of Rigid Pavement Quality Concrete.

Demirel et al (2010) experimentally studied the effects of using waste marble dust (WMD) as a fine material on the mechanical properties of the concrete. For this purpose four different series of concrete-mixtures were prepared by replacing the fine sand (passing 0.25 mm sieve) with WMD at proportions of 0, 25, 50 and 100% by weight. In order to determine the effect of the WMD on the compressive strength with respect to the curing age, compressive strengths of the samples were recorded at the curing ages of 3, 7, 28 and 90 days. Water-cement ratio was adopted .50. It was seen from the observation that the compressive strength had increased with the increase WMD content. There was an increase of about 10% for the M100%, this may not be only due to the filling of the voids in the concrete mix but also due to the little cement properties of marble dust by providing an extra amount of cement in the mix.

Hebhoub et al (2010) demonstrated the possibility of using marble wastes as a substitute rather than natural aggregates in concrete production, experimental investigation was carried out on three series of concrete mixtures: sand substitution mixture, gravel substitution mixture and a mixture of both aggregates (sand and gravel). The concrete formulations were produced with a constant water/cement ratio of .5. The compressive strength for the all the mix in sand substitution increased except 100% replacement for sand. The 50% replacement of MD as sand had a highest increase of 20% to that of control mix and in case of coarse aggregate 75% MD replacement shows an increase of 25 %.

Brostowet al. (2011) carried out investigation on the properties of concrete paving blocks made with waste marble. In this research paper, they resulted that the cement type turns out to be an important factor. Mechanical strength decreases with increasing marble content while freeze- thaw durability and abrasive wear resistance increase. Waste marble is well usable instead of the usual aggregate in the concrete paving block production. Incorporation of marble waste provides concrete paving blocks of sufficient quality.

Rai et al.(2011) concluded the effect of using marble powder and granules as constituents of fines in mortar or concrete by partially reducing quantities of cement as well as other conventional fines has been studied in terms of the relative workability & compressive as well as flexural strengths. Partial replacement of cement and usual fine aggregates by varying percentage of marble powder and marble granules reveals that increased waste marble powder (WMP) or waste marble granule (WMG) ratio result in increased workability and compressive strengths of the mortar and concrete.

Rai et al (2011) studied the effect of use of marble dust as a granular material in concrete. In the study the sand was replaced up to 20% with marble granular and the mechanical strength was evaluated and compare with the control mix. By increasing the waste marble granules the compressive strength values of concrete tends to increase. 10% replacement had an 11% increase in strength at 28 days. This trend can be attributed to the fact that marble granules possess cementing properties. It is also as much effective in enhancing cohesiveness due to lower fineness modulus of the marble powder or granules both. In case of flexural strength there was an increase in the strength up to 15 % replacement.

Gupta et al. (2012) carried out investigation on the Partial replacement of cement with marble dust powder. In this research, they resulted that with the replacement of 10% of marble dust with cement, the compressive strength increases and further any replacement of marble dust with concrete the compressive strength decreases. Same case in the split tensile strength of cylinder, As 10% replacement of marble dust with cement the split tensile strength increases and further any replacement of marble dust the split tensile strength decreases. Thus they found that the optimum percentage for replacement of marble powder with cement and it is almost 10% cement for both cubes and cylinders.

Anil Kumar Patidar, Senthil Pandian M.(2012) aimed to focus on the possibilities of using waste materials from different manufacturing activities in the preparation of innovative mortar and concrete. The use of waste marble powder (dust) was proposed in partial replacement of cement, for the production of Mortar and Concrete Mix. In particular, tests were conducted on the mortars and concrete mix cured for different times in order to determine their workability, compressive strength. Partial replacement of cement by varying percentage of marble powder reveals that increased waste marble powder ratio result in increased workability and compressive strengths of the mortar and concrete at each curing age. The marble dust from marble processing is a waste utilized.

Aliabdo et al (2013) investigated the possibility of utilizing waste marble dust (MD) in cement and concrete production by discussing the properties of concrete contained marble dust as a cement replacement and as a sand replacement (cement addition). The replacement ratios which have been studied were 0.0%, 5.0%, 7.5%, 10.0% and 15% by weight. Water to cement ratio (w/c) were 0.50 and 0.40 in case of cement replacement and in case of sand replacement, respectively. It was observed that the higher values of marble dust decreases the C3A content compared to plain cement. For 15% marble dust, there was a decrease of 10% in the compressive strength of concrete. At w/c of 0.5, in all levels of marble dust as a cement replacement, the concrete compressive strength slightly decreases. Most likely this is due to the reduction in cementing material (C3A and C2S) which is mainly responsible for concrete strength. But at the w/c of 0.4 there was slightly increase up to the 10% MD.

Pathan and Pathan (2014) studied the feasibility of the substitution of marble dust for cement to achieve economy and environment saving. They reviewed different literature and concluded that in concrete production replacement of 5% cement by marble waste powder gives comparable compressive and flexural strength as of control concrete specimens; but increasing the replacement range beyond 5% results in strength reduction. In concrete production, replacing of sand up to 20% by marble waste powder gives similar strength as of concrete mixes with 100% sand both at early and latter ages.

Rakesh Gupta et al.(2014) studied on "Partial replacement of cement with marble powder" and concluded that for M 20 grade concrete the compressive strength of cubes are increased with addition of waste marble powder up to 10%

replace by weight of cement and further any addition of waste marble powder the compressive strength decreases. The split tensile strength of cylinders are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the split tensile strength decreases.

Abdullah Anwar et al.(2014) studied on “Study of compressive Strength of concrete by partial replacement of cement with marble dust powder” and concluded that marble dust powder has a potential to provide an alternative to cement and helps in maintaining the surroundings every bit well as economical balance. The compressive strength properties of concrete containing marble dust powder at 0%, 5%, 10%, 15%, 20% and 25% of Portland cement. The investigation was primarily to determine a resolution to the disposal problem of marble dust by making usage of it in concrete production for sustainable construction development. The result obtained for 28 day compressive strength confirms that the optimal percentage for replacement of cement with marble dust powder is about 10%. This will post less on the production of carbon dioxide and solving the environmental pollution by cement production, thereby enhances the urban surroundings.

Pooja J. Chavhan et al. (2014) studied on “To study the behaviour of marble powder as supplementary cementitious material in concrete” and concluded that compressive strength increases with increase of marble powder. The maximum 28 days spilt tensile strength was obtained with 45% marble powder replaced with fine aggregate where as in case of compressive strength the strength was gained by replacement of 30% along with replacement of sand by 45-50%. The marble slurry utilization in black cotton soil is one of the best ways to improve soil properties and to protect the environment up to some extent from the harmful effects of disposal of marble slurry in land and water.

Jashandeep singh et al.(2015) studied on “Partial replacement of cement with waste marble powder with M 25 grade” and concluded that up to 12% replacement of cement with waste marble there is an increase in all mechanical properties. The replacement of 12% of cement with waste marble powder attains maximum compressive and tensile strength. The optimum percentage for replacement of marble powder with cement is almost 12% cement for both cubes and cylinders. To minimize the costs for construction with usage of marble powder that is freely or cheaply available. To realm of saving the environmental pollution by cement production being our main objective.

VII. MATERIALS USED

The properties of material used for making concrete mix are determined in laboratory under controlled conditions as per relevant IS codes of practice. The material characterization was carried out for all the major ingredients of concrete which include cement, coarse aggregates, fine aggregates, super-plasticizer and water, in addition to marble dust and furnace slag. The purpose of the characterization is to check their acceptability as per relevant Indian standards so as to enable an engineer to design a concrete mix for a particular strength. The properties of the various materials, which were used in this study, are presented and discussed in the succeeding sub-sections:

Portland Cement

Cement is the most active component of concrete and usually has the greatest unit cost, thus, its selection and proper use are important in obtaining most economical balance of properties desired for any particular concrete mixture. It fills up voids existing in the fine aggregate and makes the concrete impermeable. It provides strength to concrete by binding the aggregate into a solid mass due to its setting and hardening properties when mixed with water. Although, it constitutes only about 20% of the total volume of concrete mix, its contribution to the compressive strength of concrete is the maximum. A good quality cement should satisfy all the requirements as per I.S. specifications. The amount of cement required for a given mix should be in a range of minimum and maximum amount for the given grade as per the IS code provision.

Portland cement, also referred to as Ordinary Portland Cement (OPC), is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. OPC is classified into 3 grades namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. The specification for the cement of any grade is given by the various IS codes. IS 8112: 2013 provides the specification of the OPC 43 Grade.

3.2.2 Aggregates

Aggregate occupy a large volume in concrete mixture and give dimensional stability to concrete. In the cement concrete, to provide good quality of concrete, aggregates are generally used in two size groups: coarse aggregates – Particle size more than 4.75mm and fine aggregate (sand) particle size less than 4.75mm. Coarse aggregates makes solid and hard mass of concrete with cement and sand and increase the crushing strength of concrete. It also reduce the cost of concrete, since it occupies major volume. Sand consists of small angular or rounded grains of silica and is commonly used as the fine aggregate in cement concrete. It fills the voids existing in the coarse aggregate and reduces shrinkage and cracking of concrete. It helps in hardening of cement by allowing the water through its voids. To form hard mass of silicates, as it is believed that, some chemical reaction takes place between silica of sand and constituents of cement. The fine aggregate assist the cement paste to hold the coarse particle in suspension this action promotes plasticity in the mixture and prevent the possible segregation of paste and coarse aggregate. The aggregates, which provide about 75% volume to concrete, should meet certain requirement if the concrete is to be workable, strong, durable and economical. The aggregate must be proper in shape, clean hard and well graded.

Coarse aggregates: The aggregates which are retained over IS sieve 4.75mm are termed as coarse aggregate. The coarse aggregate may be of following types: Crushed gravels or stone obtained by crushing of gravel or hard stone and partially crushed gravel or stone obtained as a product of blending of above two types. The normal maximum size is 10mm to 20mm, however, particle sizes up to 40mm are also used in dry lean concrete. Regarding the characteristics of different type of aggregates, crushed aggregates tend to improve the strength because of interlocking of angular particles, whereas, rounded aggregates improve the workability due to the lower internal friction. The coarse aggregate used in the present study were a mixture of two locally available crushed stones of 20mm and 10mm sizes. The aggregates were washed to remove dirt, dust and then dried to surface dry condition.

Fine aggregates: The aggregates, most of which pass through 4.75mm IS sieve are termed as fine aggregates. The fine aggregates may be of following types: Natural sand, i.e. the fine aggregate resulting from natural disintegration of rocks, Crushed stone sand, i.e. the fine aggregate produced by crushing hard stone, Crushed gravel sand, i.e. the fine aggregate produced by crushing natural gravel. Fineness of aggregates should be 2.2 to 2.8. Depending upon the particle size distribution IS 383

Marble dust

Marble dust may be collected from local marble vendors in the city. It should be white in colour and air dried and packed in bags in powder form. The fineness modulus of the marble dust should be 2.2 to 2.7 as in fine aggregate

Water

The water used in the concreting work was the potable water as supplied in the concrete lab of our college. Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000. Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable tap water was used for the preparation of all concrete specimens.

MIX DESIGN

The design of concrete mixes involves determination of the proportions of the given constituents namely cement, water, coarse aggregate, fine aggregates and admixtures , if any, which would produce concrete possessing specified properties both in the fresh and hardened states with the maximum overall economy. Workability is specified as the important property of concrete in fresh state; for hardened state compressive strength and durability are important. The mix design is therefore, generally carried out for a particular compressive strength of concrete with adequate workability so that fresh concrete can be properly placed and compacted, and achieves the required durability.

Mix Design by Indian Standard method IS: 10262-2009

Design of concrete mix was done for following basic data-

Characteristic strength of concrete at 28 days (f_{ck}) = 30N/mm^2

Maximum size of crushed aggregate = 20mm

Degree of workability (Compaction Factor) = 0.90

Value of Statistical Coefficient (K) = 1.65 (Refer IS: 456-2000 Clause 9.2.2)

Value of Standard Deviation (S) = 5.00 (Refer IS: 456-2000 Table 8)

Test data of materials:-

Cement used= OPC 43 grade

Specific Gravity of Cement = 3.0 to 3.2

Specific Gravity of coarse aggregates = 2.4 to 3.0

Specific Gravity of fine aggregates = 2.2 to 2.8

Specific gravity of marble dust = 2.2 to 2.7

TESTS FOR CONCRETE

The following tests should be done on various specimens:

Compressive strength test

Split tensile strength test

Flexure strength test

Water Absorption test

CONCLUSIONS

The use of this waste was proposed in different percentages both as an addition to and instead of cement, for the production of concrete mixtures. In the study, the use of marble dust collected during the shaping process of marble blocks has been investigated in the concrete mixtures as cementitious material. The study showed that marble wastes, which are in the dust form, could be used as cementitious material in concrete mixtures where they are available and the cost of construction is lower than ordinary concrete materials. The concrete and mortar is prepared containing 0, 10, 15 and 20% waste of marble dust with cement compared to the total quantity of normal concrete and mortar. The prepared mixtures were then studied in terms of their properties both in fresh and in hardened state.

BIOGRAPHIES

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