An Influence of Partial Replacement of Cement With Metakaolin And Marble Dust on Strength Enhancing Properties of Concrete

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Abstract- *Concrete is the most versatile construction material because it can be designed to withstand the harshest environments while taking on the most inspirational forms. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials. With the increase on demand of concrete, there is a huge emission of co2 from the concrete which leads environmental damage. To avoid this ecological imbalance investigations are motivated for the for the utilization of waste and bi products. To meet the requirements of globalization in the construction of building, concrete play major role. For one tone production of clinkers we are using 1.7 tones of lime stone and clay .Around 850 kg of co2 produced .Hence we need to focus on new substitute materials In this study partial replacement of cement has been done at 0%,3%,5%,9%,12%,13% with MK(Metakaolin) and 0%,10%(constant) with MP (Marble Powder). Compressive as well as tensile strength of concrete made with MK-MP has been compared with conventional concrete of grade M30. Durability of concrete was also analyzed with RCMT(Rapid chloride Migration Test). Result shows that there is a gain of strength with the addition of MK and MP. The optimized strength value of concrete was achieved for both compressive as well as split tensile strength at 9%MK and 10%MP. RCMT shows that with the increase of addition of Metakaolin and Marble powder, there is a decrease in rate of penetration of chloride ions, hence good durability as compared to standard concrete.*

I. INTRODUCTION

Concrete is a vital versatile construction material, used in large choice of things. Therefore it's vital to consider its sturdiness because it has indirect impact on economy, serviceability and maintenance. Concrete isn't absolutely resistance to acids. Most acid solutions can slowly or speedily disintegrate cement concrete relying upon the kind and concentration of acid. Sure acids, like ethanedioic acid and chemical element acids square measure harmless. The foremost vulnerable half of the cement hydrate is Ca (OH)2, however C-S-H gel also can be attacked. Siliceous aggregates square measure a lot of resistance than calcareous aggregates. Concrete may be attacked by liquids with Concrete will attack by liquids with pH scale price below 5, but the attacks square measure severe solely at a pH scale 4.5 the attack is incredibly severe. Because the attack takings, all the cement compounds square measure equally lessened and leached away, together with any carbonate mixture material. With the sulphuric acid attack, calcium sulfate may be proceed to react with metallic element aluminate introduce cement to create calcium sulpho aluminate, that on crystallization will cause extension and disturbance of cement On the off chance that acids or salt arrangements can achieve the strengthening steel through splits or porosity of solid, consumption will happen which can cause splitting. The sulfate assault means an ascent inside the volume of bond glue in cement or mortar inferable from the common activity between the relationship of concrete and determination containing sulfates. Once solidified cement is presented to soil or well water containing sulfate intensifies, the sulfates in determination square measure conceivable to respond with hydrous Tricalcium compound inside the solidified bond glue to make another substance known as Ettringite. This new compound causes extension and disturbance of the solid. Hence, it is important to restrict the penetrability of the solid to downsize the infiltration of sulfates in determination. Strong salts don't assault the solid seriously however once the chemicals square. Measure in arrangement, they see their entrance into permeable cement and respond with the hydrous bond stock Of All the sulfates, magnesium sulfate makes most damage concrete. A trademark whitish look is that the sign of sulfate assault Marble is one of the most common building materials used since ancient times. Marble is used for construction and decoration purposes and its mineralogical constituents vary depending on its place of origin. Marble is processed for different applications generating a huge amount of waste either at quarries or at processing plants. During its processing, 30% percent of marble becomes waste because of being irregular in shape or smaller in size. The amount of waste is 2–5% in the case of semi-processed slabs. Generally, there are two forms of processing waste from natural stones: solid and semi-liquid slurry. Water containing marble powder is termed as marble slurry. One ton of processed marble stone in vertical/horizontal cutter or gang-saw produces almost one ton of slurry with nearly 35–45% water content. Fig. 1 shows the percentage waste produced in the marble industry, mostly dumped as unused materials. This waste slurry especially after drying up causes risk to the environment such as dust pollution and occupies agricultural land and other nearby areas thus rendering them infertile. In addition, the waste on deposition creates destructive conditions for the surrounding areas, surface and underground water reserves are also contaminated. There is an expected increase in the amount of waste produced owing to the higher demand of marble in the construction industry USA, France, Belgium, India, Spain, Italy, Egypt, Turkey, Brazil, Portugal and Greece are among the countries with considerable marble reserves. In India, the marble reservoirs are located in the state of Rajasthan. More than 4000 marble mines and 1100 marble processing units are located over the 16 districts of Rajasthan. In Sardinia (Italy), even though granite is the main stone produced, marble is also produced in large quantity. The processing facilities are situated in the same area which has been designated both as an extractive district and industrial pole. This zone extends over 200 ha where 15 quarries and 15 processing plants operate. The processing plants handle 65% of the entire quarry production. There are also about 400 skilled workers employed in the district. It should be noted that just in Orosei Marble District (NE Sardinia, Italy) factories produce approximately 60,000 m^3/year of carbonate ultra-fine particle, currently disposed off in the council waste site for inert materials. These units generate almost five to six million tons of marble slurry annually. This slurry causes air pollution, water pollution, land infertility and chokes under water reservoirs. Recently, some researchers have shown keen interest in the use of this waste as substitutes or additives in the ceramic and construction industry . In the specific case of Orosei Marble district in NE Sardinia studied by Marras et al. the use of marble slurry along with the other traditional constituents has resulted in improvement of quality of bricks. The application of marble powder as a resource will not only reduce the environmental effects of the marble use but also lead to the reduction in the use of other natural resources leading to sustainable development. This is the primary motivation for this research Concrete is one of the most extensively used construction materials around the globe which is a mixture of cement, aggregate and water. Global production of concrete is about 12 billion tons a year corresponding to almost 1 m^3 per person per year, causing it to become one of the largest users of the natural resources in the world.It is predicted that concrete need will increase to more than 7.5 billion m^3 (about 18 billion tons) a year by 2050 .Such extensive consumption of concrete is the cause for higher use of natural aggregates and cement which eventually takes toll on the environment. It has a high carbon footprint Currently, global cement production is 4,100,000 thousand metric tons and this industry produces carbon dioxide which is nearly 5% of the total man made emissions. According to the IPCC ,11 of the last 12 years (1995–2006) are ranked as warmest years in instrumental record of global surface temperatures since 1850. Global average sea levels have risen since 1993 at the rate of 3.1 mm/year which has a considerable effect on future development .If immediate actions are not taken to reduce the emission of green house gases (GHG) then the overall costs and risks of climate change will be equivalent to losing more than 5% of global GDP per year from present time onwards. China alone contributes to 3% of the total 5% carbon dioxide production resulting from cement production because of its huge construction industry. The housing sector accounts for almost 67% of this demand. Infrastructural, commercial, and industrial constructions account for the remaining 33% demand. Already, a lot of architectural wonders and infrastructure systems have been built using cement but its environmental impacts are now being studied Natural fine aggregates in concrete; like sand, have direct impact on the environment causing erosion of soil and riverbeds. Sand mining has become an environmental issue in India, with the palpable cost of illegal mining in India being visible on the environment and ecology. Illegal mining activities have changed the river courses, diminished water tables and caused unimaginable impact on the organisms. For an emerging economy like India, there is focus on improvement of infrastructure such as power plants, roads & ports and this has created a huge requirement of cement and natural aggregates like sand. This research is focused to study the environmental and economical advantages of marble powder as an alternative to cement and sand for construction activities Impact assessment and economic analysis of concrete incorporated with marble powder is not available in the literature which imparts the paper its novelty. Current paper provides the review of literature on the studies of replacement of cement and sand in concrete, followed by the environmental and economic analyses of the replacement by marble powder in concrete. The life cycle assessment is performed to study the environmental impact of partial replacement of sand and cement with marble powder in normal concrete. Application of marble powder in concrete will provide economical and environmental advantages and will lead to sustainable development In construction Industry, consumption of cement is increasing day by day as well as cost is also increasing so to reduce the consumption of cement, partial replacement with Metakaolin and Marble powder was done in this study. Metakaolin is a calcinied clay and easily available in Gujarat, Maharashtra & Bombay etc. It is a Dehydroxylated form of the clay mineral Kaolinite. Stone having higher percentage of Kaolinite are known as china clay or kaolin, was traditionally used in the manufacture of porcelain i.e. ceramic material. The particle size of Metakaolin is smaller than cement particles Marble dust is obtained from cutting and manufacturing industries of marble. In India near about 3500 metric tons of marble dust slurry per day is generated. So, Marble So, it is advisory to use marble dust as partial replacement with cement as it has properties similar to cement and one of good pozzolanas. Similarly use of MK leads to Green concrete, because during production of MK there is no emission of carbon dioxide, also MK is good admixture for high early age strength, known as HPC etc Since there is large emission of carbon dioxide in manufacturing of cement and clinker, results in 3-5% increasein greenhouse gasses and global warming

II. REVIEW OF LITERATURE

Abdullah Anwar et.al (2014)[1]: In this paper the authorsrepresented that Marble Dust Powder has replaced the (OPC & PPC) cement of 0%, 5%, 10%, 15% 20%, & 25% by weight & M-20 grade concrete was used. Concrete is M30. mixtures were developed, tested and compared in terms of compressive strength to the conventional concrete. The purpose of the investigation is to analyze the behavior of concrete while replacing the Marble Dust Powder with Different proportions in concrete. The result obtained for 28-day compressive strength confirms that the optimal percentage for replacement of cement with marble dust powder is about 10% for (PPC) and (OPC). This will post less on the production of carbon dioxide and solving the environmental pollution by cement production there byenhances the urban surroundings

Sanjay N. Patil et,al(2014)[2]: The paper deals with the useof Metakaolin which is having good pozzolanic activity and is a good material for the production of high strength concrete. Use of MK is getting popularity because of its positive effect on various properties of concrete. Literature Review shows that optimal performance is achieved by replacing 7% to 15% of the cement with Metakaolin and when use of MK is less than 10% , then the benefits are not fully realized so at least 10% Metakaolin should be used. Values of compressive strength of concrete with Metakaolin after 28 days can be higher by 20%. Dosage of 15% of Metakaolin causes decrease of workability. So increasing amount of perceptual proportion of Metakaolin in concrete mix seems to require higher dosage of super plasticizer to ensure longer period of workability

J.M. Khatib et.al(2012)[3]: In the paper author studied the compressive strength, density and ultrasonic pulse velocity of mortar containing high volume of Metakaolin (MK) as partial substitution of cement. In this paper up to 50% of MK was used to replace cement in increment of 10. After De-molding, specimens were cured in water at 20°C for a total period of 28 days. The density seems to reduce with the increase of MK content especially at MK content above 30%.The strength increases as the MK content increases up to about 40% MK with a maximum strength occurring at 20% where the strength is 47% higher. At 50% the strength start reducing, 10% and the 30% MK mixes exhibit an Prof. P.A. Shirule et.al (2012)[4]: The paper described the feasibility of using the marble sludge dust in concrete production as partial replacement of cement. The Compressive strength of Cubes & Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% replaced by weight and it was also observed that 10% replacement gave optimum percentage of strength

B.B.Sabir et.al (2001)[5]: The paper described the partial replacement of cement with the Metakaolin in concrete and mortar, which causes great improvement in the pore structure and hence resistance of concrete to harmful solutions. The paper also demonstrated clearly that MK is very effective pozzolanas and result enhanced early strength with no detriment to, and some improvement in the long term strength. Mortar and concrete were observed as great improvement in resistance to the transportation of water and diffusion ions which lead to degradation of matrix

Jian Tong Ding (2002) investigated the MK or SK on the workability, strength, shrinkage and resistance to chloride penetration of concrete were investigated and compared in this study. For the given mixture proportions, MK offers better workability than does SF. As the replay\cement level was increased, the strength of the MK – modified concrete increased at all ages. The increase in the strength was similar to that of the SF – modified concrete. The incorporation of the both MK and SF in concrete can reduce the free drying the free drying shrinkage and restrained shrinkage cracking width. The initial cracking appeared earlier in the SF- and MK- in concrete can reduce the chloride diffusion rate significantly, with the SF concrete performing somewhat better

Nova John (2013) investigated the cement replacement levels were 5%,10%,15%,20% by weight for metakaolin. The strength of all metakaolin admixed concrete mixes over shoot the strength development of concrete. Mix with 15% metakaolin is superior to all other mixes. The increase in metakaolin content improves the compressive strength, split tensile strength and flexural strength upto 15% replacement. The result encourages the use of metakaolin, as pozzolanic material for partial cement replacement in producing high strength concrete. The inclusion of metakaolin results in faster early age strength development of concrete. The utilization of supplementary cementitious material like metakaolin concrete can compensate for environmental, technical and economic issues caused by cement production

Dhinakaran (2012) studied the strength increases by MK concrete is effective only at the early age of concrete and in the long term the strength increase is only marginal. The increase in compressive strength for MK concrete was greater especially at higher water cement ratios (i.e., 0.4 and 0.5) and hence more suitable for higher w/cm ratios. From the studies an optimum percentage of MK was found to be 10% for all w/cm ratios except for 0.32 and for 0.32 it was 15%. MK concrete higher increase in strength at early ages beyond 28 days it was found to be less than 10%. The maximum compressive strength of 59.25 N/mm2 was observed at 0.4 w/cm with 10% MK. Addition of MK reduced the pH values, but the reduction is insignificant, since the pH values are still above 11.5, which will be helpful for maintaining the steel in a passive state itself. The depth of penetration of chloride ions for MK concrete is much lesser than control concrete. The minimum rate of reduction of chloride penetration depth for MK admixed concrete were arrived as 78%, 38%, 25% and 25% for w/cm ratios 0.32, 0.35, 0.40 14.24 % and 22.90% due to addition of Metakaolin content of 4 %, 6 % and 8 % respectively in comparison with control concrete specimens of HGC The variation of RCPT values in HGC for different proportions of Metakaolin blended concrete. It has been observed that as the percentage of Metakaolin increase the permeability of concrete decreases. Also, it was observed that values of rapid chloride permeability of HGC decrease up to 1450 coulombs, 1548.67 coulombs and 1684.70 coulombs for 4% , 6% and 8% of metakaolin respectively in comparison to control concrete specimens. The percentage reduction in permeability values in coulombs was 48.57 %, 51.88 % and 56.43% for Metakaolin content of 4%, 6% and 8% respectively

Patil (2012) studied the compressive strength of concrete increases with increase in HRM content up to 7.5%. Thereafter there is slight decline in strength for 10%, 12% and 15% due excess amount of HRM which reduces the w/b ratio and delay pozzolanic activity. The higher strength in case of 7.5% addition is due to sufficient amount of HRM available to react with calcium hydroxide which accelerates hydration of cement and forms C-S-H gel. The 7.5% addition of high reactivity metakaolin in cement is the optimum percentage enhancing the compressive strength at 28 days by 7.73% when compared with the control mix specimen. The 7.5% addition of high reactivity metakaolin in cement is enhanced the resistance to chloride attack. The compressive strength of concrete incorporated with 7.5% HRM is reduced only by 3.85% as compared with the reduction of strength of control mix specimen is by 4.88%. The 7.5% addition of high reactivity metakaolin in cement is also enhanced the resistance to sulfate attack. The compressive strength of concrete incorporated with 7.5% HRM is reduced only by 6.01% as compared with the reduction of strength of control mix specimen by 9.29%. The present study deals with the compressive strength, split tensile strength and flexural strength for cement replacement by metakaolin based concrete

Mermerdas K [6] et al. (2012) in the paper "Strength development of concretes incorporated with metakaolin and different types of calcinedkaolins" investigated the effects of metakaolin and calcinedkaolins on the concrete. For this, non purified ground kaolins obtained from different sources were thermally treated at specified conditions. Commercially available metakaolin from Czech Republic was used for comparison. Replacement levels (5%, 10%, 15%, and 20%) of calcinedkaolins and metakaolin were assigned for concrete production. One plain mix without admixture was produced as reference. Compressive strength development of the concretes was carried out at 3, 7, 28, and 90 days. The strength development of concretes was evaluated by statistical technique named GLMANOVA. From gene expression programming a prediction model was derived to evaluate the parameters affecting the strength. SiO2, Al2O3, kaolinite, and alunite contents, fineness of mineral admixture, age of concrete, and replacement level were the parameters investigated. The experimental investigations showed that type of thermally treated kaolin, the replacement level, and age are very effective on the strength development of the concretes. The seven parameters in the prediction model was compared with the experimental results and proved to be a handful tool for estimating compressive strength of concrete incorporated with commercial metakaolin and calcinedkaolins

Ramezanianpour A.A[12] et al. (2012) in his paper "Influence of metakaolin as supplementary cementing material on strength and durability of concretes " investigates the performance of concrete mixtures containing local metakaolin in terms of compressive strength, water penetration, sorptivity, salt ponding, Rapid Chloride Permeability Test (RCPT) and electrical resistivity at 7, 28, 90 and 180 days. The microstructure of the cement pastes incorporating metakaolin was studied by XRD and SEM tests. The percentages of metakaolin that replace PC in this research are 0%, 10%, 12.5% and 15% by mass. The water/binder (w/b) ratios are 0.35, 0.4 and 0.5 having a constant total binder content of 400 kg/m3. Results show that concrete incorporating metakaolin had higher compressive strength and metakaolin enhanced the durability of concretes and reduced the chloride diffusion. There exhibit an exponential relationship between chloride permeability and compressive strength of concrete. A significant linear relationship was found between Rapid Chloride Permeability Test and salt ponding test results

Nova John [9] (2013) in her paper "Strength Properties of Metakaolin Admixed Concrete" studies the effect of Metakaolin as mineral admixture in the concrete on its performance. The replacement was done in a pattern of 0, 5, 10, 15 and 20% to cement by Metakaolin. Concrete mix of M30 grade was used for the experimental investigation. The cubes, cylinders and prisms were tested for compressive strength, split tensile strength and flexural strength respectively. The tests are performed after 7 days and 28 days curing of the specimens. The results indicate that the use of Metakaolin in concrete has improved the strength characteristics of concrete. From the results of considered parameters, it is observed that 15% replacement of cement with Metakaolin showed better performance in case of strength parameters such as compressive, flexural and split tensile strength

Arka Saha [1] et al. (2014) conducted a study on "Strength development characteristics of high strength concrete incorporating an Indian fly ash". The study generally focuses on the feasibility of using fly ash as a replacement material in the concrete production. In this paper the cement is replaced by fly ash and it ranges between 0 - 40 %. The investigation was done in such a way that the water cement ratio lies between 0.27 to 0.42 and the cement content varies from 430 to 550 kg/m3 . Compressive strength of the concrete was determined for 7, 28 and 90 days curing. From the studies they reached to the conclusion that increase of the fly ash upto a certain limit decreases the strength of the concrete and the optimum percentage found was 10

Guneyisi E [4] et al. (2014) in the paper "Combined effect of steel fiber and metakaolin incorporation on mechanical properties of concrete" reports the results of an experimental study on mechanical properties of plain and metakaolin (MK) concretes with and without steel fiber. To develop the metakaolin included steel fiber reinforced concrete mixtures, Portland cement was partially replaced with metakaolin as 10% by weight of the total binder content. Two types of hook ended steel fibers with length/aspect ratios of 60/80 and 30/40 were utilized to produce fiber reinforced concretes. Two series of concrete groups were designed with water to binder ratios (w/b) of 0.35 and 0.50. The effectiveness of MK and different types of steel reinforcement on the compressive, flexural, splitting, and bonding strength of the concretes were investigated. All tests were conducted at the end of 28 days of curing period. Analyses of variance on the experimental results were carried out and the levels of the significance of the variables on the mechanical characteristics of the concretes were determined. Moreover, correlation between the measured parameters was carried out to better understand the interaction between mechanical properties of the concretes. The results revealed that incorporation of MK and utilization of different types of steel fibers significantly affected the mechanical properties of the concretes, irrespective of w/b ratio

Barbhuiya S [2] et al. (2015) in the paper "Microstructure, hydration and nanomechanical properties of concrete containing metakaolin" presents the results of an experimental investigation carried out to evaluate the properties of concrete containing metakaolin. The properties of concrete containing metakaolin at 0%, 5%, 10% and 15% by mass of cement were studied for their compressive strength, sorptivity and carbonation resistance at two different water–binder ratios. It was found that 10% of the Portland cement could be beneficially replaced with the metakaolin to improve the sorptivity and carbonation resistance of concrete. To better understanding the properties various analytical techniques such as XRD, MIP and nanoindentation studies were carried on cement paste samples (with and without 10% MK). Test results showed that the incorporation of metakaolin modifies the cement paste in four different ways. Firstly, by transforming portlandite into C–S–H gel by means of pozzolanic reaction, secondly by reducing the porosity, thirdly by creating nucleation sites for hydration and finally, by modifying the relative proportions various phases of C–S–H gel

III. METHODOLOGY

3.1 Materials Used And Their Properties;- Concrete is a mixture of various materials. It is mainly consists of cement, fine aggregate, coarse aggregate and water. In this experimental study, we are replacing cement with Egg shell powder, fine aggregate with Foundary sand and coarse aggregate with palm kernel shells. The above mentioned materials are discussed below

Cement: Cement has different properties and characteristics which depend upon their chemical compositions. By changing in fineness of grinding, oxide compositions cement have exhibit different properties and different kind of cement. The use of additives, changing chemical composition, and use of different raw materials have resulted the availability of many types of cements OPC of 53 Grade confirming to IS:12269-1987 was used in the investigation. The specific gravity of cement was 3.10

FINEAGGREGATE: Aggregate whose sizes are lesser than 4.75 mm are fine aggregate which satisfied the required properties for experimental work and conforms as per the specification of IS: 383- 1970.Sand is a naturally and obviously occurring granular material collected of finely divided rock and mineral particles. The composition of sand is extremely variable, depending on the local rock sources and conditions, but the for the most part frequent constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz.

COARSE AGGREGATE: Construction aggregate, or simply "aggregate", is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geo synthetic aggregates. Aggregates are the majority mined materials in the world. Aggregates are a constituent of composite materials such as concrete and asphalt concrete; the aggregate serve as reinforcement to insert strength to the overall composite material

META KAOLIN:- Meta kaolin is not a by-product. I t is obtained by the calcinations of pure or refined Kaolinite clay at a temperature between 650^0 C and 850^0 C, followed by grinding to achieve a finesse of 700-900 m^2/kg. It is a high quality pozzolonic material, which is blended with cement in order to improve the durability of concrete. When used in concrete it will fill the void space between cement particles resulting in a more impermeable concrete Metakaolin, is a relatively new material in the concrete industry, is effective in increasing strength, reducing sulphate attack and improving air-void network. Pozzolanic reactions change the microstructure of concrete and chemistry of hydration products by consuming the released calcium hydroxide (CH) and production of additional calcium silicate hydrate (C-S-H), resulting in an increased strength and reduced porosity and therefore improved durability. The formation and properties of Meta kaolin are shown in below. The specimen kept immerse in water for 7 and 28days.The chemical content of meta kaolin presented in Table 1

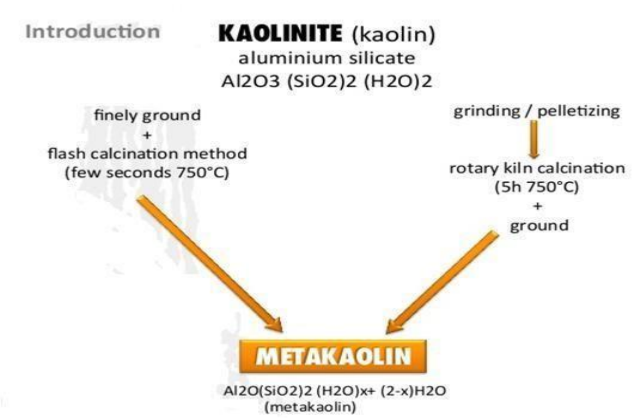


Fig. 3.2 Formation of Matakaolin

MARBLE POWDER:- Marble has been commonly used as a building material since the ancient times. Consequently, Marble waste as a by-product is a very important material which requires adequate environmental disposal effort. In addition, recycling waste without proper management can result in environmental problems greater than the waste itself. Marble dust is a waste product formed during the production of marble. A large quantity of powder is generated during the cutting process. The result is that about 25% of the original marble mass is lost in the form of dust. Leaving these waste materials to the environment directly can cause environmental problems such as increases the soil alkalinity, affects the plants, affects the human body etc. Marble powder can be used as an admixture in concrete, so that strength of the concrete can be increased. It is a solid waste material generated from the marble processing and can be used either as a filler material in cement or fine aggregates while preparing concrete. The production of cheaper and more durable concrete using this waste can solve to some extent the ecological and environmental problems. This paper highlights, the feasibility of the substitution of marble waste for cement to attain economy and environment saving

Fig. 3.4 Marble powder

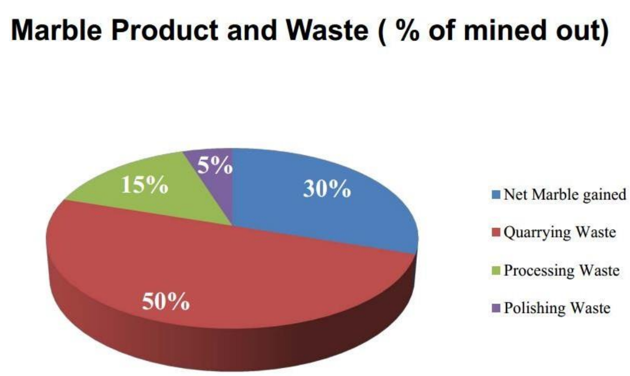


Fig. 3.5 Marble product and waste

Material Analysis

% Replacement of MK →	0%	3%	5%	9%	12.50%	13%
% Replacement of MP→	0%	10%				
Cement (kg)	9.24	8.04	6.99	6.08	5.29	4.61
Sand (kg)	9.96	9.96	9.96	9.96	9.96	9.96
Coarse aggregate(kg)	22.84	22.84	22.84	22.84	22.84	22.84
Metakaolin (kg)	0	0.00277	0.00402	0.00629	0.00761	0.00688
Marble powder (kg)	0	0.92	0.92	0.92	0.92	0.92
w/c Ratio	0.4	0.40	0.40	0.40	0.40	0.40

PREPARATION OF MATERIALS:

All materials shall be brought to room temperature preferably 27±3 before commencing thee test .the cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such manner as to ensure the greatest to avoid the instruction of foreign matter, the cement shall then be stored in a dry place, preferably in air- tight container. Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in air dried condition. In general, the aggregate shall be separated in to fine and coarse fractions and recommended for each concrete batch in such a manner as to produce the desired grading. IS sieve 480 shall be normally used for separated in to different sizes

PROPORTIONING :

The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work. Where the proportions of the ingredients of the concrete are as used on the proportions by weight used in the test cubes and the unit weights of the materials

SLUMP CONE TESTING:-

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch

MACHINE MIXING: Mixing of concrete was carried out by machine. Machine mixing is not only efficient but also economical. Before the materials are loaded in to drum about 25 percentage of the total quantity of water required for mixing is poured in to the mixer drum and to prevent any sticking of cement on the bodies or at the bottom of the drum. Then discharging all the materials i.e. coarse aggregate and cement in to the drum. Immediately after discharging the dry material in to the drum the remaining 75 percentage of water is added to the drum .The time is counted from the moment all the materials are placed particularly the complete quantity of water is fed in to the drum

IV. RESULTS OF THE EXPERIMENTAL INVESTIGATIONS

STRENGTH ANALYSIS: COMPRESSIVE & TENSILE STRENGTH: Compressive and split tensile strength of concrete is tested at different percentage of MK and MP from 0% to 13 % MK and 0% &10% MP (constant). For compressive strength of concrete, 72 cubes was casted with four samples of each percentage variation of MK & MP. The Compressive strength of concrete has been tested at 7 days, 14 days and 28 days of curing for Initial gain in strength of concrete, median gain of strength in concrete and final strength of concrete respectively. Compression testing machine is used for testing the compressive strength of concrete. At the time of testing the cube is taken out from water and dried and then tested keeping the smooth faces in upper position. Similarly, For Split tensile Strength 72 cylinder of 15cm and 20cm height was prepared at different percentage addition of MK&MP at 7,14 and 28 Days of curing. The strength of concrete is very much dependent up on curing i.e. the hydration reaction .The type and amount of cement used in concrete determines the hydration reaction. In this study Ultra Tech OPC 43 grade of concrete is used. The result analysis of compressive strength and split tensile strength with partial replacement of cement by MK & MP is shown in Table 1 for all different percentage of M

COMPRESSIVE STRENGTH TEST :

TABLE 4.1:- 7-Days compressive strength Analysis

S.NO	% of metakolin	% of marble powder	Compressive strength
1	0	0	24.5
2	3	10	25.1
3	5	10	27.2
4	9	10	33.8
5	12	10	33.1
6	13	10	30.1

TABLE 4.2: - 14-Days compressive strength Analysis

S.NO	% of metakolin	% of marble powder	Compressive strength
1	0	0	34.1
2	3	10	34.4
3	5	10	34.8
4	9	10	35.4
5	12	10	35.1
6	13	10	34.6

TABLE 4.3: - 28-Days compressive strength Analysis

S.NO	% of metakolin	% of marble powder	Compressive strength
1	0	0	38.2
2	3	10	38.4
3	5	10	38.6
4	9	10	38.8
5	12	10	38.5
6	13	10	37.5

SPLIT TENSILE STRENGTH:

Compressive and split tensile strength of concrete is tested at different percentage of MK and MP from 0% to 13 % MK and 0% &10% MP (constant). For compressive strength of concrete, 72 cubes was casted with four samples of each percentage variation of MK & MP. The Compressive strength of concrete has been tested at 7 days, 14 days and 28 days of curing for Initial gain in strength of concrete, median gain of strength in concrete and final strength of concrete respectively. Compression testing machine is used for testing the compressive strength of concrete. At the time of testing the cube is taken out from water and dried and then tested keeping the smooth faces in upper position. Similarly, For Split tensile Strength 72 cylinder of 15cm and 20cm height was prepared at different percentage addition of MK&MP at 7,14 and 28 Days of curing. The strength of concrete is very much dependent up on curing i.e. the hydration reaction .The type and amount of cement used in concrete determines the hydration reaction. In this study Ultra Tech OPC 43 grade of concrete is used. The result analysis of compressive strength and split tensile strength with partial replacement of cement by MK & MP is shown in Table 1 for all different percentage of MK-MP at 7,14 and 28 days of curing

TABLE 4.4: -
7- Days Split tensile strength Analysis

S.NO	% of metakolin	% of marble powder	Split tensile strength
1	0	0	2.12
2	3	10	2.28
3	5	10	2.39
4	9	10	2.53
5	12	10	2.51
6	13	10	2.49

TABLE 4.5: -
14- Days Split tensile strength Analysis

S.NO	% of metakolin	% of marble powder	Split tensile strength
1	0	0	2.42
2	3	10	2.51
3	5	10	2.86
4	9	10	3.01
5	12	10	2.95
6	13	10	2.90

TABLE 4.6: -
28-Days Split tensile strength Analysis

S.NO	% of metakolin	% of marble powder	Split tensile strength
1	0	0	3.83
2	3	10	3.89
3	5	10	3.92
4	9	10	4.03
5	12	10	3.98
6	13	10	3.84

FLEXURAL STRENGTH TEST:-

For each mix, totally twelve number of prism of size 100x100x500mm cast and tested in Flexural Testing Machine(FTM). The specimen of prism placed horizontallyon the platform of the FTM. The ultimate load noted and calculated the flexural strength of corresponding specimen.

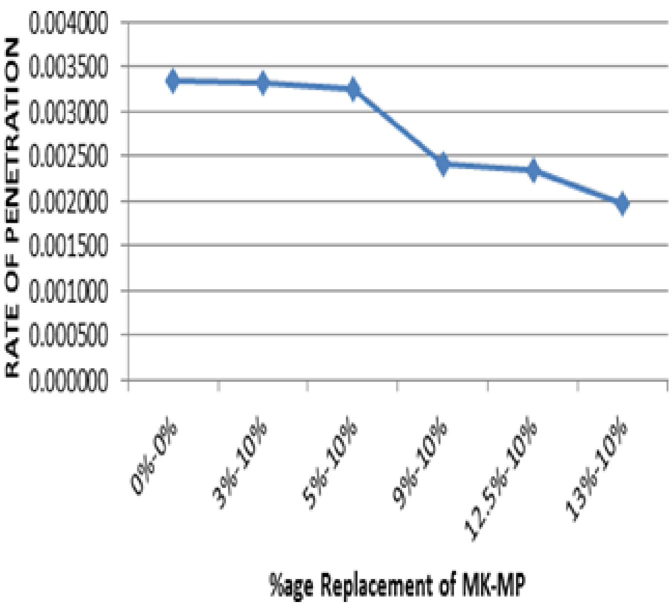
The Flexural strength compared to control specimen with various percentages of Metakaolin and Marble Dust

TABLE 4.7: -
28-Days Flexural strength Analysis

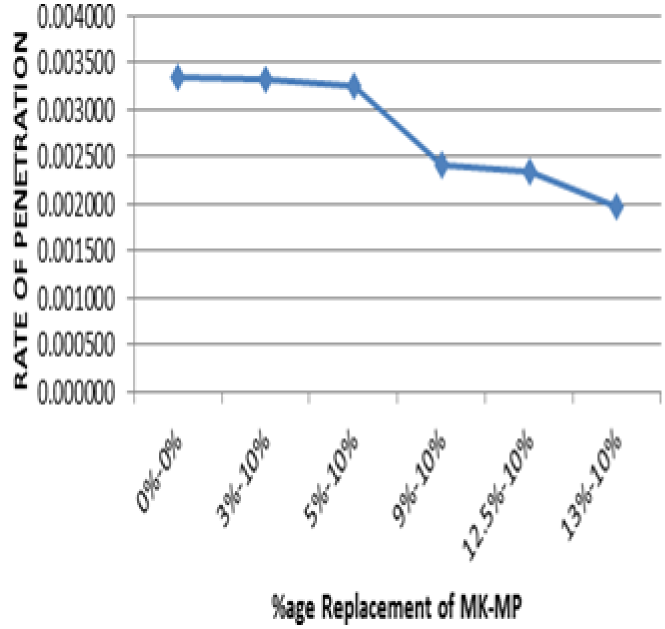
S.NO	% of metakolin	% of marble powder	Flexural strength
1	0	0	5.3
2	3	10	5.6
3	5	10	5.9
4	9	10	6.1
5	12	10	5.8
6	13	10	5.5

DURABILITY ANALYSIS RCMT:-

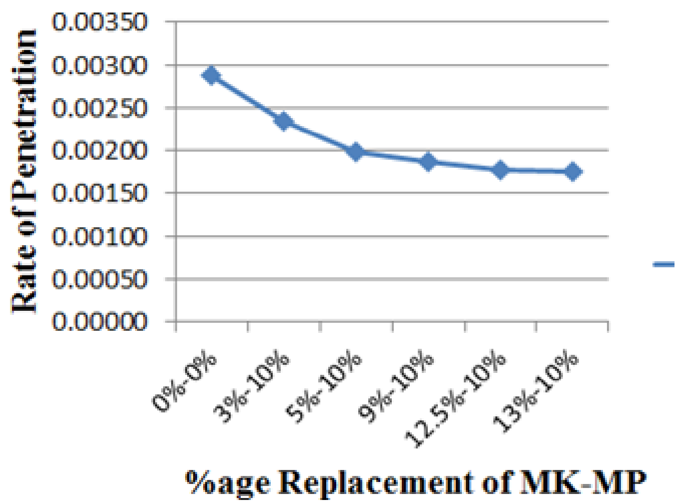
Durability of concrete is an important factor for the durability of concrete structures. Now Days, The properties of Metakaolin as high-quality pozzolanic materials are investigated by several researchers. Rapid Chloride Migration Test (RCMT) at 7 and 28 Days was performed on specimen for calculation of chloride ion penetration and kept at 60V of current for 18hrs, In addition, microstructure of the cement pastes incorporating Metakaolin and MP was studied by EDAX tests. The percentages of Metakaolin that replace PC in this research are 0%, 3%,5%,9%,12% and 13% by mass and MP as 0%(standard concrete) and 10 %



7-Days Analysis of Rate of Penetration



14-Days Analysis of Rate of Penetration



28-Days Analysis of Rate of Penetration

Hence from above result we can say durability of concretegoes on increase with addition of MK-MP

V. CONCLUSIONS

The Conclusions and Recommendations that could be drawn from the results of this project and experiments are summarized

1. The replacement of cement with 9%MK and 10% MP, give better results better for strength as shown in graphs 4.1 to 4.7
2. If the percentage of MK is increased above 9% keeping the percentage of MP as10%, there is reduction in strength of concrete

3. The permeability test shows that there is decrease in permeability of concrete with the increase in amountof Metakaolin and Marble powder addition
4. The optimum percentage for replacement of cement with Metakaolin and Marble powder was 9% and 10% respectively for both cubes and cylinders. After 9%MK & 10% MP, compressive strength as well as split tensile strength starts decreasing
5. Flexural strength of concrete was also increased for 9% MK and 10% MP as shown in graph 4.7
6. There is decrease in strength after 9% replacement of MK and 10% replacements of MP but durability properties go on increase with increase in percentage of MK-MP as shown in graphs 4.8 to 4.10
7. Use of Metakaolin and Marble powder give GREEN CONCRETE
8. Use of MK and MP save our environment, since during the production of MK and MP there is no emission of carbon dioxide.
9. RCMT results shows that concrete made of addition of MK-MP has very less rate of penetration of chloride ions. Hence Rate of penetration goes on decrease with increase of percentage of MK-MP in concrete as shown in fig. So we can say more durable concrete is obtained

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