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An Experimental Study on Mechanical Properties of Concrete Paver Block with Partial Replacement of Cement with Metakaolin and Fine Aggregate with Red Soil

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Abstract; **Even though it is the second most extensively used material in the world, after water, concrete is prone to a broad variety of damages due to its low tensile strength. This is despite the fact that concrete is the second-most widely used material in the world. There are a few characteristics that are connected to concrete that is produced by employing Portland cement as the primary construction material. In terms of compression, it is fairly robust, but when it comes to tension, it is insufficient, and it has a propensity to be brittle. Because of both of these shortcomings, its use has been limited. There has been a significant increase in the demand for concrete as a material for construction. This is due to the fact that concrete is a material that is both long-lasting and inexpensive, as well as the rapid growth of the building industry and the expansion of the world's population. The use of concrete leads to a rise in the use of Portland cement, which in turn leads to an increase in the amount of energy and emissions that are created. This cycle continues until the quantity of energy and emissions increase. We came to the realization that metakaolin and red soil may be replaced in a partial amount of up to 15-20% and 20%, respectively, in order to generate the same strength as traditional concrete. This was the conclusion that we came to. Because of the considerable study that we conducted on the relevant literature, we were able to arrive at this conclusion. During the course of our inquiry, we want to ascertain the suitable ratio of metakaolin to red soil that ought to be used in the production of concrete in order to achieve the maximum possible degree of strength. In order to identify the suitable amount of metakaolin and red soil that may be partially replaced in the manufacture of concrete, we conducted a compressive test, a flexural strength test, and a split tensile strength test. These kinds of tests were carried out in order to find the appropriate quantity. It has been determined that the best possible result can be accomplished by partly substituting cement with metakaolin and red soil at a proportion ranging from 20–5%. This is the conclusion that has been reached.**

***Keywords**:* **Flexural strength test, Spilt Tensile strength test, Metakaolin, Red soil**

1. INTRODUCTION

Cement, in its broadest definition, may be defined as a substance that has adhesive and cohesive characteristics, which enable it to possess the potential to unite mineral particles into a compact mass. Such qualities allow cement to be used in a variety of applications. Due to the fact that it contains these characteristics, cement is able to do this. Cement is a cohesive substance that is utilized in conjunction with stones, bricks, blocks, and other materials that are similar in nature. When used in the context of building, the word "cement" refers to this substance. Two types of cement that are used throughout the numerous phases of the construction process are concrete block and concrete. Both of these types of cement are used. Because it may be utilized in both forms, cement is the material that is the most significant in structural construction. Additional applications for cement include the building of a variety of different kinds of infrastructure. In the process of bringing together a variety of various components, one of the things that takes place is the formation of a solid mass. Over the course of time, the cement will construct a solid matrix that will bind the other components together to produce a construction that is both robust and long-lasting. An effort was made in this chapter to use metakaolin and red mud as a partial substitute for cement. The goal of this chapter was to make an attempt. The scope of this chapter was the confines under which this endeavor was done. Aluminum output has been steadily increasing by around one percentage point throughout the course of the last ten years, while experiencing periods of stagnation and setbacks at different times in time. This trend has been seen during the whole period. At this point, it is generally known that the manufacturing of aluminum results in a wide range of environmental issues that are harmful to the environment. The waste gases that are produced by rolling mills and aluminum electrolysis facilities pose a threat to the contamination of the air and surface water, as well as the pollution of the water that is located below the surface. This is possible because these waste gases are released into the atmosphere. The calculation of the mix percentage for self-compacting concrete (SCC) considers several factors, including the structural conditions, such as the form, size, and density of reinforcement, as well as the surrounding environment of the structure. The primary need for self-consolidating concrete (SCC) is the ability to perform compaction without relying on external vibration. The strength and durability of the material should be equivalent to those of traditional concrete. Dumne (2014) asserts that the use of superplasticizers and air-entraining admixtures is essential for achieving the requisite performance in both the fresh and hardened phases of self-compacting concrete (SCC). Self-compacting concrete (SCC) may be classified into three separate categories: powder type, viscosity type, and powder-cum-viscosity type SCC.

1.1 Paver Blocks

A technique of constructing a pavement or hard standing that is occasionally utilized for ornamental purposes is known as brick paving, which is another synonym for block paving. Brick paving is also known as block paving. Brick pavement is another name that is sometimes used to refer to block paving. One of the most significant advantages of bricks, in comparison to other materials, is that individual bricks may be removed and replaced at a later time.

1.2 Use Of Metakaolin And Red Soil In Concrete

At the same time as it allows for a reduction in the amount of cement that is employed, the utilization of pozzolanic in the production of concrete is regarded as a beneficial technique. This is due to the fact that it concurrently enhances the concrete's strength and durability properties. The properties of concrete hardened concrete containing metakaolin are:

i) Strength development of concrete made with highly reactive metakaolin.

ii) Drying shrinkage of metakaolin concrete.

Table 1- Chemical composition of metakaolin

Chemical composition	Percentage (%)
Sio2	54.3
Al2o3	38.3
Fe2o3	4.28
Cao	0.39
Mg0	0.08
Na2o	0.12
K_2O	0.50

1.3 Scope

1. To utilize metakaolin in an effective environment friendly manner.
2. There is a scope for further research to develop self-compacting concrete using industrial wastes and by products and high-volume ultrafine flash with super pozzolona.
3. Study on china clay (porcelain) waste can open new horizons in use of use of blendedcement.
4. The increasing concern of the environment is a promising factor for a highly activity in thefield and a re-evaluation of the economical aspect.

2.PROPERTIES OF MATERIALS

2.1 Cement

It is possible to transform cement into a paste by adding water to it, and when it is poured or molded, it will solidify into a mass. This process may be repeated as many times as necessary. Cement is a substance that is often in the form of powder. Cement is widely used in construction. Fineness When you are working with the cement sample, you will need to make use of your fingers in order to break up any air-set lumps that may be present. Taking a precise measurement of one hundred grams of cement and then placing it on an IS standard that is ninety microns in thickness is the next step that has to be done.

Standard consistency A temperature of 27 degrees Celsius plus 20 degrees Celsius is necessary for this test to be carried out, and the relative humidity of the laboratory should be 65 percent plus five percent.

Table 2: Properties of cement

TEST	VALUES	STANDARD VALUES
Specific gravity	3.11	3.15
Initial setting time	45 mins	Not less than 30 mins
Final setting time	10 hrs	Not greater than 600 mins

Table 3: Fine Aggregate Test

TEST	VALUES	STANDARD VALUES
Specific gravity	2.60	2.73
Fineness modulus	3.37	4.66
Water absorption	1.2%	1.6%

Table 4: Test conducted for Coarse Aggregates are listed in table as per IS code of IS: 383-1970

TEST	VALUES	STANDARD VALUES
Specific gravity	2.72	2.5 - 2.9
Fineness modulus	5.6	6.5 - 8
Water absorption	0.5%	0.1- 2%

2.2 Metakaolin

It is referred to as metakaolin, and it is one of the forms of the clay mineral kaolinite that is considered to be anhydrous. The terms "china clay" and "kaolin" refer to the minerals that are present in kaolinite in significant amounts. Both of these phrases are used interchangeably. For a long time, the production of porcelain has been accomplished by the use of these minerals in the manufacturing process.

Table 5: Properties of Metakaolin

SL NO	CHARACTERISTICS	VALUE
1	Specific Gravity	2.7
2	Water absorption	3.06%

2.3 Red Soil

The color of red soil also serves as a identifier. The manufacture of alumina, which is the primary raw material used in the production of aluminum metal, is a component of the industrial process that ultimately ends in the synthesis of this substance large portion of the total output, the waste product is considered to be a very important one.

Table 6 Properties Of Red Soil

S.NO	CHARACTERISTICS	VALUE
1	Specific Gravity	2.5
2	Fineness modulus	2.76

4.RESULTS & DISCUSSION

4.1 Compressive strength test

In this test, the values of compressive strength for different replacement levels of metakaolinand red soil at the end of different curing periods (7 Days and 15 days)

Table 7: Compressive strength of paver blocks

MIXES	PARTIAL REPLACEMENT		NO. OF PAVER BLOCK CASTED		COMPRESSIVE STRENGTH OBTAINED (N/mm²)	
	METAKAOLIN %	RED SOIL %	CURING PERIOD		CURING PERIOD	
			7 DAY	15 DAY	7 DAY	15 DAY
CC	0%	0%	3	3	29	35
M1	5%	5%	3	3	34.65	38.5
M2	5%	10%	3	3	31.4	38.07
M3	5%	15%	3	3	30.5	37.35
M4	5%	20%	3	3	27.4	33.31
M5	5%	25%	3	3	25.9	31.40
M6	5%	30%	3	3	24.5	29.74
M7	10%	5%	3	3	30.42	36.88
M8	10%	10%	3	3	29.61	35.91
M9	10%	15%	3	3	28.06	34.02
M10	10%	20%	3	3	26.81	32.51
M11	10%	25%	3	3	25.71	31.17
M12	10%	30%	3	3	24.73	29.98

MIXES	PARTIAL REPLACEMENT		NO. OF PAVER BLOCK CASTED		COMPRESSIVE STRENGTH OBTAINED (N/mm²)	
	METAKAOLIN %	RED SOIL %	CURING PERIOD		CURING PERIOD	
			7 DAY	15 DAY	7 DAY	15 DAY
CC	0%	0%	3	3	29	35
M13	15%	5%	3	3	32.34	39.2
M14	15%	10%	3	3	31.51	38.2
M15	15%	15%	3	3	31.01	37.59
M16	15%	20%	3	3	31.40	38.07
M17	15%	25%	3	3	30.91	37.5
M18	15%	30%	3	3	30.81	37.35
M19	20%	5%	3	3	32.64	39.57
M20	20%	10%	3	3	31.60	38.31
M21	20%	15%	3	3	31.51	38.2
M22	20%	20%	3	3	31.2	37.83
M23	20%	25%	3	3	31.01	37.59
M24	20%	30%	3	3	30.62	37.20

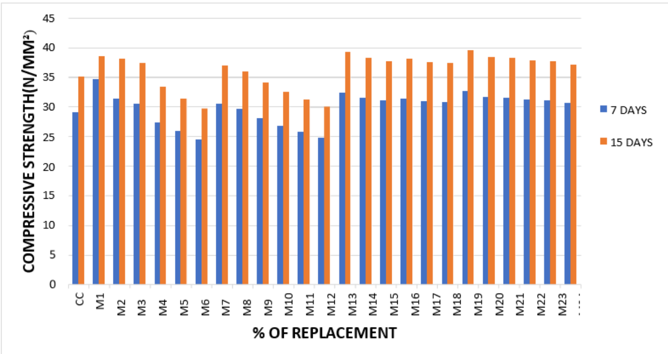

Figure 1: Compressive strength of paver blocks

clear that the compressivestrength increases at

20 % replacement of metakaolin and 5% of Red soil where then it goes on decreases. Where the minimum value of compressive strength is 29.74 N/mm^2. The compressive strength of the concrete decreases with increase in metakaolin and red soil content after 15% of replacement. Therefore, the optimum replacement of metakaolin and red soil concrete is found to be 20% and 5%.

4.2 Flexural Strength

In this test, the values of flexural strength for different replacement levels of Metakaolin andred soil at the end of specified curing period (15Days)

Table 8: Flexural Strength of Paver Blocks

MIXES	PARTIAL REPLACEMENT		NO. OF PAVER BLOCKS CASTED	COMPRESSIVE STRENGTH OBTAINED (N/mm²)
	METAKAOLIN %	RED SOIL %	CURING PERIOD 15 DAYS	CURING PERIOD 15 DAYS
CC	0%	0%	3	4.06
M1	5%	5%	3	4.34
M2	5%	10%	3	4.31
M3	5%	15%	3	4.27
M4	5%	20%	3	4.03
M5	5%	25%	3	4.0
M6	5%	30%	3	3.98
M7	10%	5%	3	4.24
M8	10%	10%	3	4.2
M9	10%	15%	3	4.08
M10	10%	20%	3	4.0
M11	10%	25%	3	3.9
M12	10%	30%	3	3.82

MIXES	PARTIAL REPLACEMENT		NO. OF PAVER BLOCKS CASTED	COMPRESSIVE STRENGTH OBTAINED (N/mm²)
	METAKAOLIN %	RED SOIL %	CURING PERIOD 15 DAYS	CURING PERIOD 15 DAYS
CC	0%	0%	3	4.06
M13	15%	5%	3	4.38
M14	15%	10%	3	4.32
M15	15%	15%	3	4.29
M16	15%	20%	3	4.31
M17	15%	25%	3	4.28
M18	15%	30%	3	4.27
M19	20%	5%	3	4.40
M20	20%	10%	3	4.42
M21	20%	15%	3	4.32
M22	20%	20%	3	4.31
M23	20%	25%	3	4.32
M24	20%	30%	3	4.26

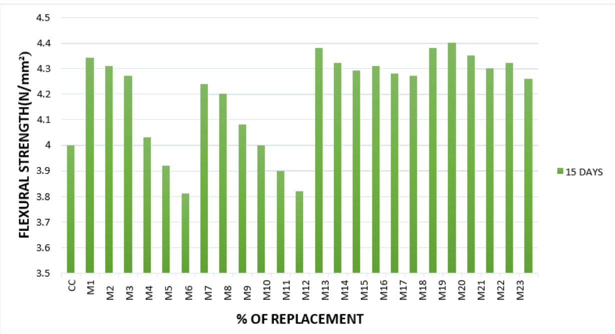

Figure 2: Flexural Strength of Paver Blocks

clear that the flexural strength increases at 20% replacement of metakaolin & 10% of red soil and then it goes on decreases. Where the minimum value of flexural strength is 3.82 N/mm^2. The flexural strength of the concrete decreaseswith increase in metakaolin and red soil after 20% of replacement. Therefore, the optimum replacement of metakaolin & red soil in concrete for flexure is found to be 15 - 20%.

4.3 Split Tensile Strength

In this test, the values of split tensile strength for different replacement levels of metakaolinand red soil at the end of specified curing period (15Days)

Table 9: Split Tensile Strength of Paver Blocks

MIXES	PARTIAL REPLACEMENT		NO. OF PAVER BLOCKS CASTED	SPLIT TENSILE STRENGTH (N/mm²)
	METAKAOLIN %	RED SOIL %	CURING PERIOD 15 DAYS	CURING PERIOD 15 DAYS
CC	0%	0%	3	3.4
M1	5%	5%	3	3.86
M2	5%	10%	3	3.78
M3	5%	15%	3	3.4
M4	5%	20%	3	3.39
M5	5%	25%	3	3.38
M6	5%	30%	3	3.37
M7	10%	5%	3	3.74
M8	10%	10%	3	3.64
M9	10%	15%	3	3.54
M10	10%	20%	3	3.40
M11	10%	25%	3	3.33
M12	10%	30%	3	3.24
M13	15%	5%	3	3.91
M14	15%	10%	3	3.84
M15	15%	15%	3	3.79
jM16	15%	20%	3	3.78
M17	15%	25%	3	3.93
M18	15%	30%	3	3.33
M19	20%	5%	3	3.84
M20	20%	10%	3	3.20
M21	20%	15%	3	3.84
M22	20%	20%	3	3.81
M23	20%	25%	3	3.79
M24	20%	30%	3	3.76

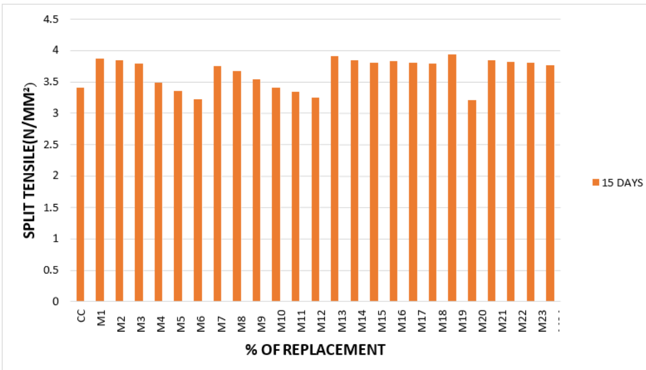

Figure 3: Split tensile test of paver blocks at 15 days

increase and decrease of split tensile strength with gradual increase in percentage of Metakaolin and red soil as a replacement for fine aggregate. From the abovetable, it is clear the split tensile strength increases at 20% replacement of metakaolin & 5% of Red soil and then it goes on decreases. Where the minimum value of split tensile strength is 3.20 N/mm^2.The split tensile strength of the concrete decreases with increase in metakaolin content after 20% of replacement. Therefore, the optimum replacement of metakaolin and red soil in concrete for split tensile is found to be 20%and 5%.

4. CONCLUSION

- When we raise the amount of metakaolin to a level of twenty percent, there is a clear and consistent gain in strength, but when we increase the percentage of red soil, there is a decrease in strength.
- The use of metakaolin as an alternative to red soil results in an increase in compressive strength that is anywhere from twenty percent to five percent greater than the material that was first used. The M35 grade of concrete reaches its maximum strength of 39.57 N/mm2 fifteen days after being exposed to the material. This is the highest strength that it is capable of achieving.
- From the M14 to the M19, there has been a noticeable increase in the split tensile strength. When 20% metakaolin and 5% red soil are combined, the maximum strength is found to be achieved. This combination yields a value of 3.93 n/mm2 when the immersion procedure is carried out. This particular combination has the ability to provide the maximum amount of strength.
- The combination of these two components results in a concrete that is stronger than the conventional kind. This is clear when comparing the strength that is achieved by combining 20% of metakaolin with 5%, 15%, 20%, 25%, and 30% of red soil. The strength that is produced is visible when comparing the strength that is obtained.
- According to the findings of a study, the combination of twenty percent metakaolin and ten percent red soil results in the highest flexural strength, which is 4.42 tons per square millimetre. This was determined by the use of the study.
- The results show that the compressive, flexural, and split tensile strengths go down when more metakaolin is used instead of cement and more fine aggregates are replaced with red soil than a certain level. This is the case because such an increase has caused the strength of the material to decrease. This reduction is a direct result of the substitution of metakaolin and red soil for cement in the construction industry.
- As a result of the research, we have come to the conclusion that paver blocks that are made with 20% metakaolin and 5% red soil exhibit an improvement in the performance of compressive, flexural, and split tensile strength when compared to the conventional mix as well as other mixes. This is the conclusion that we have arrived at. In conclusion, this is the conclusion that we have arrived at.
- Not only is the usage of metakolain and red soil replacement in concrete paver blocks something that is both practical and something that has the ability to be proposed for utilization in the future, but it is also something that has the potential to be used in the future.
- An entirely new and cutting-edge additional building material has been produced as a direct consequence of the findings of this investigation.
- A recent analysis that was carried out led to the conclusion that metakaolin and red soil have the capacity to adequately replace fine aggregate at a rate that varies from twenty percent to five percent. This conclusion was reached as a result of the inquiry that was carried out very recently.

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