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Experimental Investigation on Strength and Longevity of High-Performance Concrete Treated with Natural Rubber Latex

Ashok Kumar Suluguru[1], Dasari Guru Swami[2], C. Balasai[3]

[1]*Associate Professor, Civil Engineering Department, Malla Reddy Engineering College, Maisammaguda, Hyderabad, Telangana State, 500100, India*

[2]*Research Scholar, Civil Engineering Department, Malla Reddy Engineering College, Maisammaguda, Hyderabad, Telangana State, 500100, India*

[3]*Assistant Professor, Civil Engineering Department, G. Pulla Reddy Engineering College, Kurnool, 518007, India*

Abstract: **-** High-performance concrete, which meets modern standards for compressive strength, durability, and toughness, has gained attention. Researchers recognize that beyond strength, it can be engineered to align with cost and service life requirements. To address the needs of highrise buildings and pavements, mineral admixtures like fly ash, GGBS, and metakaolin are being explored to replace a portion of cement. These admixtures enhance durability, fatigue strength, and toughness. Polymer latexes, such as natural rubber latex, are also being investigated as modifiers for cement concrete to improve its properties. To fulfill current demands, a new type of concrete called Natural Rubber Latex Metakaolin Modified High Performance Concrete (NRLMKHPC) is proposed.

In this study, NRLMKHPC is developed using naturally sourced rubber latex from Hevea trees, locally available aggregates, and locally produced metakaolin. Various percentages of metakaolin (ranging from 0% to 30%) and natural latex (ranging from 0% to 1.5%) are incorporated. Workability of NRLMKHPC mixes is evaluated through Vee-Bee tests and compaction factor tests. Concrete cubes (150mm x 150mm x 150mm), beam specimens (100mm x 100mm x 500mm), and cylindrical specimens (150mm diameter, 300mm height) are cast for each mix percentage. Compressive strength, flexural strength, and split tensile strength are determined. Durability tests such as rapid chloride ion permeability test are conducted, and acid immersion tests with hydrochloric acid and sulfuric acid are planned to assess NRLMKHPC durability under different water-to-binder ratios. Experimental results are used to develop statistical models linking key parameters to concrete strength and durability.

Keywords*: Concrete, Natural Latex, Metakaolin, High-performance concrete, Compressive Strength*

1. Introduction

Concrete is a composite building material. Concrete is made up of three main components: water, aggregate, and cement. Concrete is said to be one of the most important manufactured goods in the world. Concrete is becoming the second most important resource for new infrastructure developments after water. As of now, the attributes of cement might be changed by adding various parts to it as per needs. The substantial's mechanical and sturdiness characteristics have been depicted top to bottom in this examination, which included altering the substantial's properties to create Superior Execution concrete using regular elastic plastic and metakaolin (NRLMKHPC).

High Performance Concrete (HPC)

The highest objective compressive, 45 N/mm2, can be obtained from regular cement. Except if its properties are adjusted, high and extremely high strength concrete can't be gotten past 45 N/mm2. Consequently, actually there is a great deal of essential for the significant which have high mechanical properties as well as strength

characteristics. This can only be done by making a type of concrete with the right amount of compaction, the right paste characteristics, the right bondage, and the right strength and durability. This can be achieved by the production of First class Execution Concrete. The elite exhibition cement may have a high start-up cost, but designs made with HPC last longer, which reduces the cost of maintaining properties. In this assessment the significant properties have been changed by the improvement of Unrivaled Execution concrete, using Normal flexible plastic, metakaolin (NRLMKHPC) and its mechanical and strength properties has been presented comprehensively.

1. Literature review

This audit centers principally around the utilization of metakaolin instead of concrete and the creation of cements in light of polymers. The continuous assessment centers around figuring out where metakaolin-cemented Prevalent Execution concrete (NRLMKHPC's) persuading use regarding standard adaptable plastic changed the creation. In recent years, experts and planners have increasingly recognized the significance and benefits of HPC in the development of dams, streets, ranges, air terminals, thermal energy stations, and multistory plans. Because of its solidarity and fortitude properties, for example, protection from ice, chloride assault, impermeability, and warm breaking, the making of HPC has acquired conspicuousness. Concrete with amazing execution is essential for such progressions. The commonplace critical has a compressive strength of under 40 MPa, so it isn't reasonable for improving raised structures. The use of unrivaled execution concrete has emerged as essential because world-class concrete is preferred in such circumstances. High-performance concrete (HPC) delivered for modern use is likely to change in a variety of ways, so its defining characteristics will vary in terms of weight, strength, and durability. In contrast with plain a-list execution concrete, predominant execution concrete with mineral admixtures and polymers has high strength.

2. Methodology and Materials used

A down to business exploratory evaluation on standard flexible plastic Metakaoline cemented Unparalleled execution concrete (NRLMKHPC) has been expected to accomplish the targets sorted out partially 1. The polymer ordinary versatile plastic is used to sustain the bond. Metakaoline is a mineral admixture, is utilized to manage the mechanical properties by superseding the significant. Concrete the super plasticizers are typically utilized to a lesser water-folio extent in order to further enhance the stream properties of the top presentation. The ongoing system stores the actual properties of every material. The various tests that were carried out on each material—concrete, fine total, coarse total, Metakaoline, regular elastic plastic, and water—in order to determine whether or not they were appropriate have been listed.

3.1 Cement:

53 grade traditional Portland concrete conforming to IS: 12269, 1987[83] has been obtained, and the following tests were conducted in accordance with IS: 8112-1989[82].

a) Cement's usual consistency

b) The cement's initial setting time

c) The season of final setting for concrete

d) Cement's specific gravity

e) Cement's compressive strength

f) The fineness of the concrete (Blain's air penetration test)

3.2 Fine aggregate

The sand confirming zone II in table 4 of IS 383-1970 [77] was utilized in this investigation. The sand is gathered from a nearby stream that is easily accessible to the general public. The significance of the fine total is assumed to be 40% of the firm total, a constant throughout the evaluation process. The following tests were carried out in accordance with the plan outlined in IS 383-1970 [77], and the outcomes are presented in tables 3.2(a), 3.2(b), and 3.2(c).

a) Sifter Examination and Fineness Modulus

b) Mass in grams

c) Thickness of mass

TABLE NO. 3.1 SIEVE ANALYSES:

IS sieve size	*Weight retired gm*	*Cumulative weight retired gm*	*Cumulative percent age weight retired (%)*	*Cumulative percent age weight retired passing*	*IS code requirements*
2.46 mm	76	75	25	85	75-100
1.28 mm	99	180	44	66	55-90
650 mm	94	290	62	48	35-59
350 mm	120	360	88	22	8-30
100 mm	78	435	93	7	0-10
70 mm	35	500	--	--	--
Total	500		272		

Fineness modules $= \frac{272}{100} = 2.72$

Medium sand, confirming to zone –II

3.3 Coarse aggregate

Crushed stone, which can be found locally, was used for the coarse all out in this evaluation. The coarse absolute was split in half and hung on a 10 mm sifter, while the coarse absolute was split in half and hung on a 12.5 mm sifter. Compared to the total, the coarse total weighed 60% more. The starting tests have been completed, and the results are coordinated in tables 3.3 (a) to 3.3 (c) in accordance with the system described in IS 383-1970 [77] page 2. a) Mass in grams b) Digestion of water c) Thickness of mass d) The order of coarse sums e) The perfection list f) An extended document g) The overall impression of h) Disrespect crushing

3.4 Natural rubber latex

In the ongoing assessment the typical flexible plastic is obtained from Calicut, from Related Plastic India Limited. Table 3.5 provides an overview of the organization's properties and organization. The Ordinary versatile plastic is pursued for suitability by the supplier as per ACI 548.03.

TABLE 3.2 PROPERTIES AND COMPOSITION OF NATURAL RUBBER LATEX

SL.NO	***PROPERTY***	***RESULT***
1	Color	White milky fluid
2	Specific gravity	0.96
3	Particle size of rubber	0.212µm
4	Iron content as ppm	8.22
5	Copper content as ppm	5.4
6	Ammonia content	0.8% maximum
7	Total solid content	61.75% maximum by weight
8	Dry Rubber content	65% minimum by weight
9	Non Rubber solid content	1.6% maximum
10	Particle size of rubber latex	0.272 µm

3. Results and discussions

An important aspect of concrete that requires investigation is its durability. Strong cement is a substantial that is safe to freeze and defrost, resists compound activity, and has low porosity. When compared to the majority of the samples that did not contain NRLMKHPC, the trial findings of this study indicate that NRLMKHPC provided unparalleled protection against penetration and corrosive assault. Additionally, acid immersion durability tests and studies on the permeability of concrete were carried out.

Behavior of NRL & MKHPC when immersed in acid solution.

i)Sulphuric Acid Immersion:

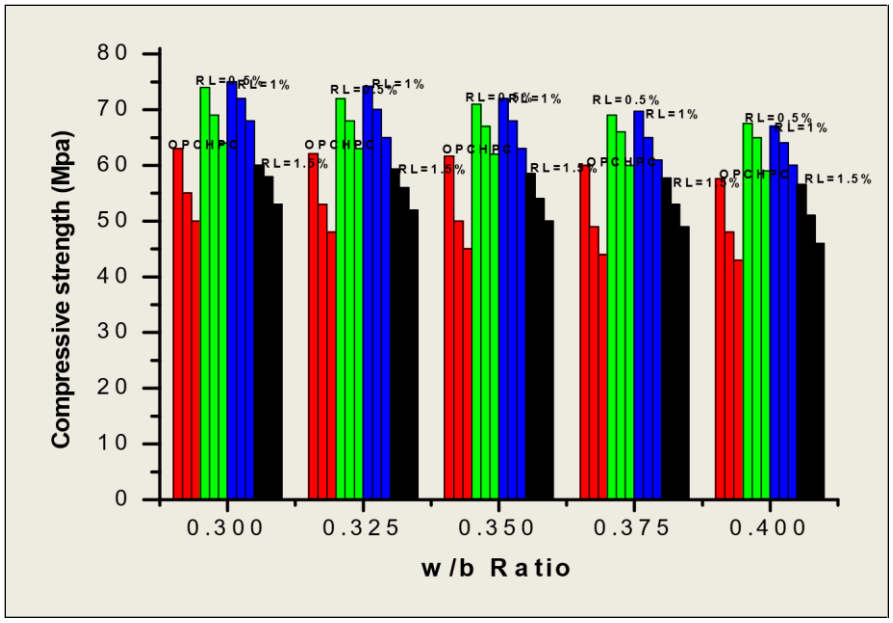

Fig :4.1 Compressive Strength of OPCHPC,0.5% ,1% & 1.5%NRL at 30days and 90 days of Sulphuric acid immersion.

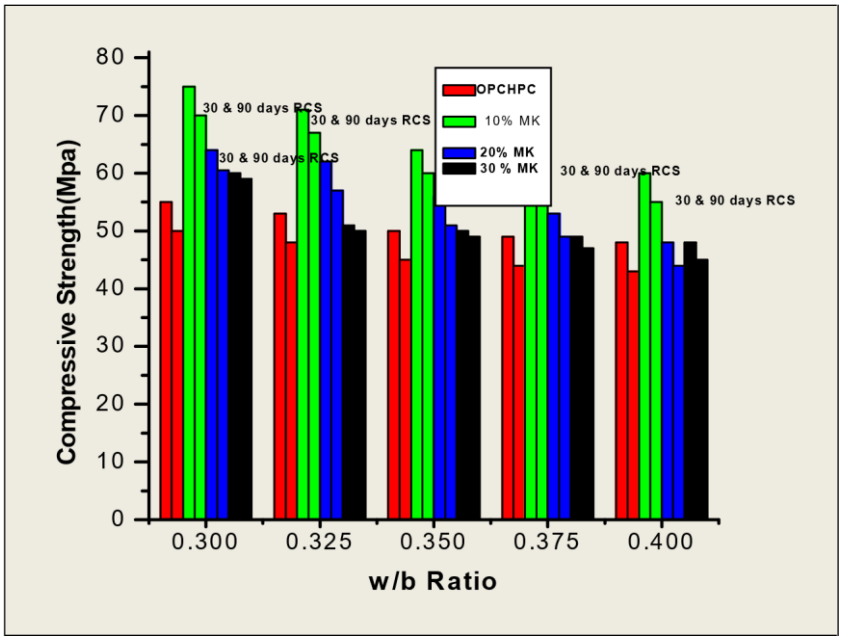

Fig :.4.2 Compressive Strength of OPCHPC,10% ,20% & 30% MKHPC at 30days and 90 days of Sulphuric Acid immersion.

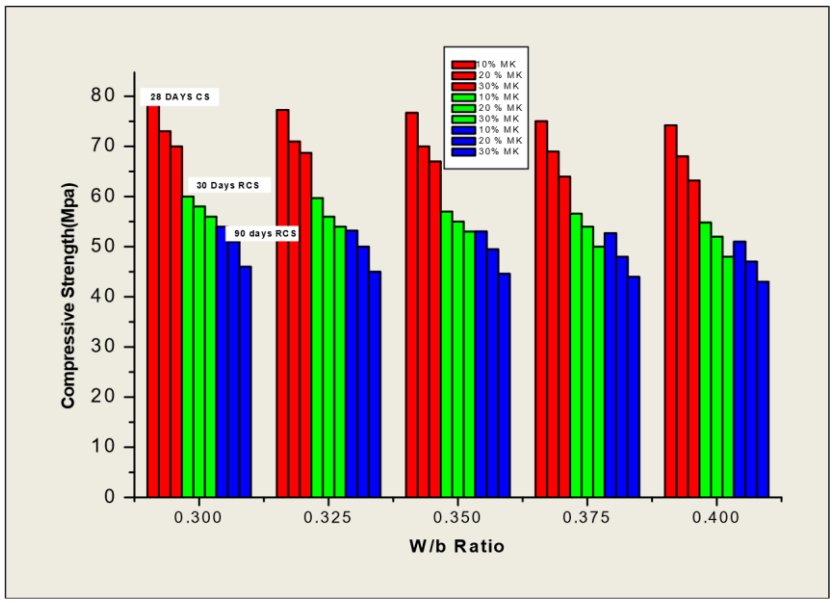

Fig :4.3 Compressive Strength of ,10% ,20% & 30% MKHPC & 0.5% NRL at 30days and 90 days of Sulphuric acid immersion.

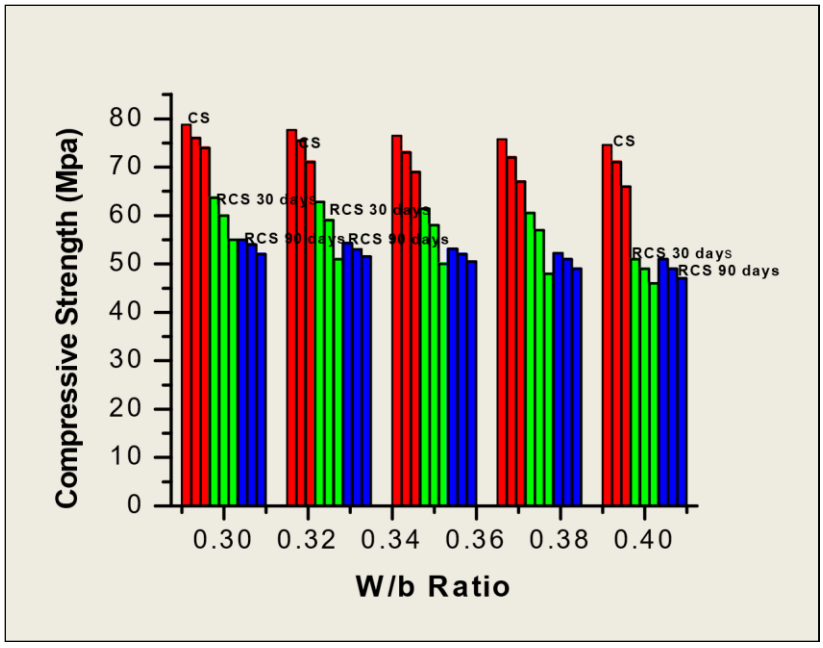

Fig :4.4 Compressive Strength of ,10% ,20% & 30% MKHPC & 1.0% NRL at 30days and 90 days of Sulphuric acid immersion

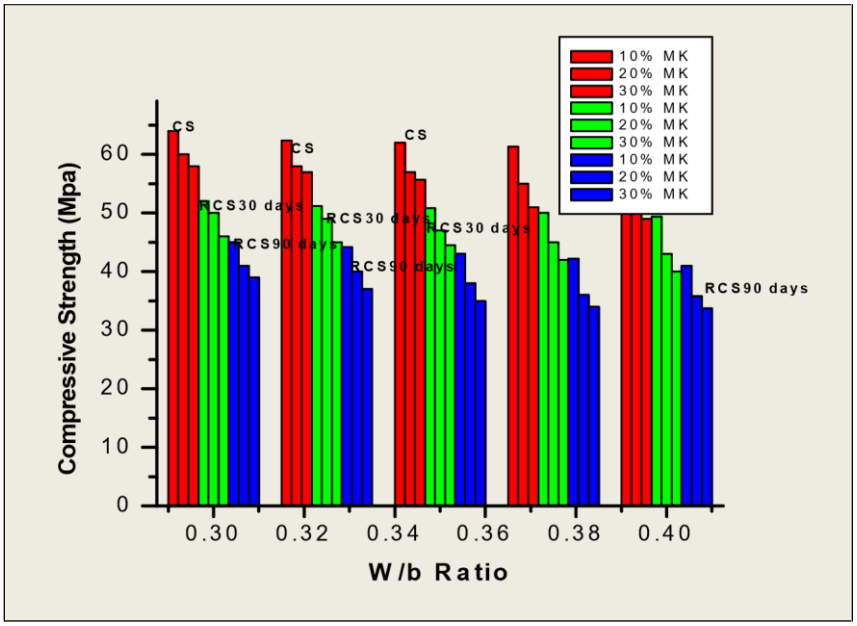

Fig :4.5 Compressive Strength of ,10% ,20% & 30% MKHPC & 1.5% NRL at 30days and 90 days of Sulphuric acid immersion.

ii)Hydrochloric Acid Immersion:

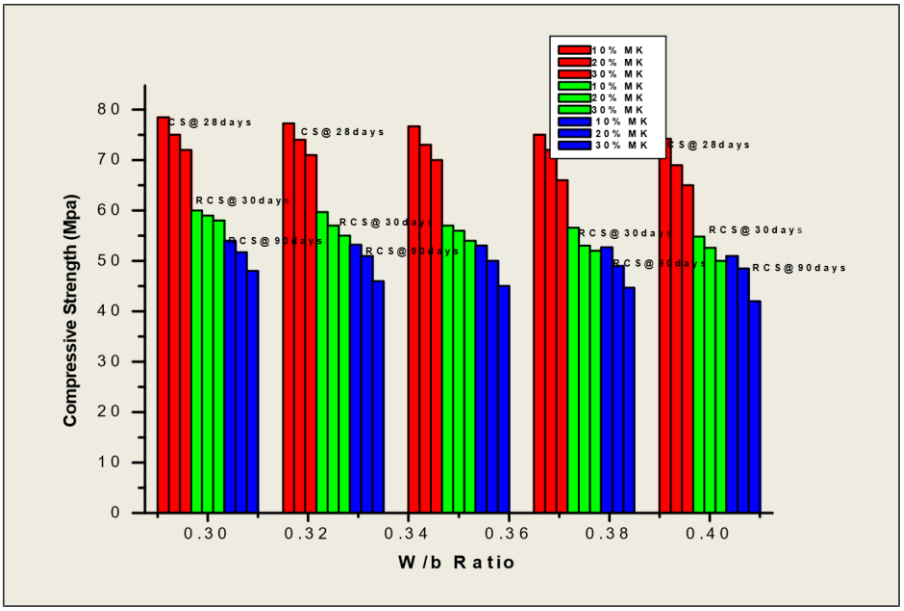

Fig: 4.6 Compressive Strength of, 10%, 20% & 30% MKHPC & 0.5% NRL at 30days and 90 days of Hydrochloric acid immersion.

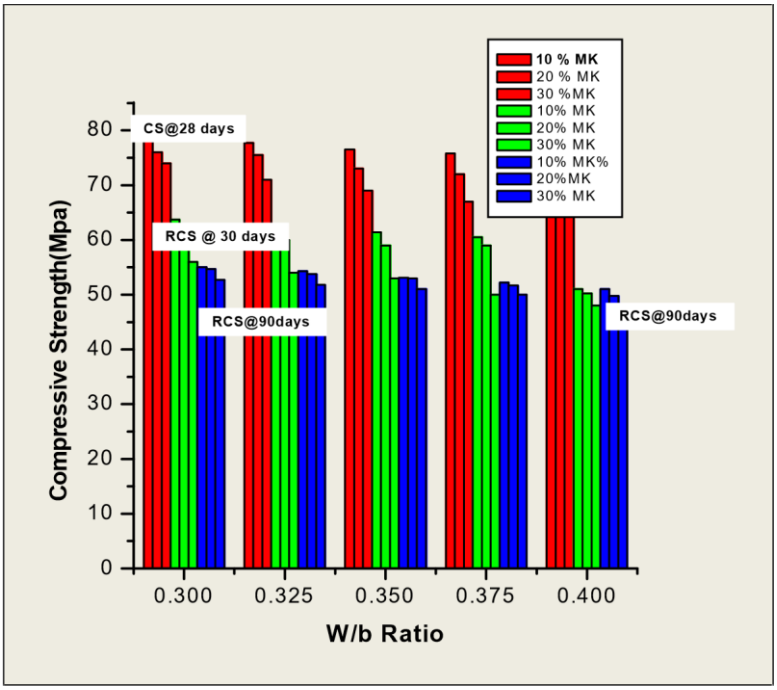

Fig :4.7 Compressive Strength of ,10% ,20% & 30% MKHPC & 1.0% NRL at 30days and 90 days of Hydrochloric acid immersion.

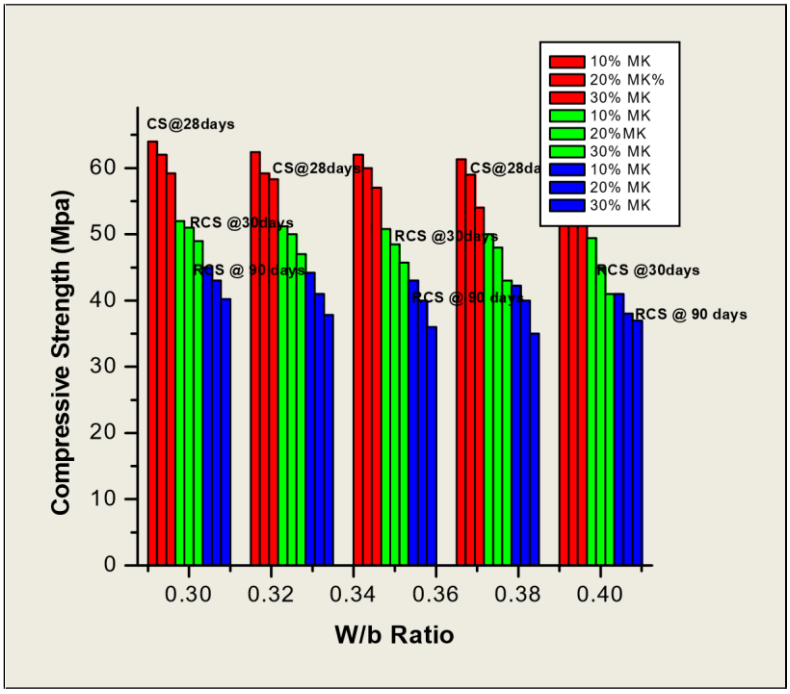

Fig :4.8 Compressive Strength of ,10% ,20% & 30% MKHPC & 1.5% NRL at 30days and 90 days of Hydrochloric acid immersion.

iii) Effect of Acids on natural rubber latex modified metakaoline high performance concrete:

The significance of the huge shapes are diminished by 2% to 4% for HCl submersion when showed up contrastingly corresponding to the 3D squares without damaging inundation. With sulphuric damaging drenching,

further lessening in weight and compressive strength is observed. The weight loss is approximately 6.04 percent for a 0.3 w/b proportion, and 10.5% for a 0.4 w/b proportion. In case of sulphuric destructive submersion, the compressive strength additionally diminishes. Table The effects of sulphuric destructive and hydrochloric destructive on NRLMKHPC are shown in Figures 5.9, 5.4(a) to 5.4(e), and 5.5(a) to 5.5(c). 5.10 5.10 For Hcl drenching, the compressive rate decreases by 3.17 percent after 30 days of corrosive submersion, and for w/b=0.3, it decreases by 7.93 percent after 90 days. Additionally, when compared to the strength at 28 days for w/b=0.3, the rate of decrease in compressive strength for H2So4 soaking is 12.69% for 30 days and 20.63% for 90 days. NRLHPC and MKHPC, on the other hand, have lower compressive strengths. NRL and MK concrete suffer less from a decrease in compressive strength. Hcl inundation has a compressive strength of 1% NRL and 10% MK that is lower than that of H 2So4 drenching.

5. Conclusions

The accompanying targets are gotten from the consequences of different exploration place tests: • Since customary adaptable plastic contains water rate, the test information of compaction factor and Vee honey bee tests exhibit that the helpfulness of plastic changed most excellent execution huge augmentations with expansion in part of ordinary adaptable plastic.

• The making examination out of specialists revealed that the need to organize the assessment concerning getting standard adaptable plastic changed five star execution huge utilizing metakaolin with locally open materials.

• It has been seen that acceptable convenientce can be accomplished at 1% standard adaptable plastic and 10% concrete metakaoline substitution weight. The value results will stay impeccable for extra NRL and MK blend speeds. The convenience arrangement is essentially irrelevant.

• The Vee Bumble bee time will increment in seconds as how much metakaolin increments. This is on the grounds that metakaolin can assimilate water and has bigger particles.

• With the increase in degree of ordinary versatile plastic the Vee-Bumble bee time in seconds decreases in view of the water present in the standard versatile plastic and as such achieving headway in convenience with the development of standard adaptable plastic.

• The 7-days and 28 days compressive strength of traditional versatile plastic metakaolin HPC mixes headways in with the development of conventional adaptable plastic and huge replacement by metakaolin. • Typical adaptable plastic shows a compressive strength expansion of up to 1% by weight, while metakaolin shows a 10% augmentation. • Further improvement in NRL and MK, the compressive strength diminishes. The compressive strength decrease for seven days with w/b=0.3 is approximately -1.81% lower than that of OPCHPC (0%NRL,0%MK). The most noteworthy compressive strength was recorded at 67.0 MPa for 10% MK and 1% NRL following seven days of reclamation. As the degree of NRL rises, the material's compressive strength diminishes, which thusly makes the degree of water rise.

• The ordinary adaptable plastic metakaolin changed (NRLMKHPC) HPC compressive strength for 28 days consolidates advancements notwithstanding the development of NRL and MK regarding OPCHPC. The rate keeps on increasing, arriving at one percent NRL and 10% MK. The additional increase in NRL from 1% to 1.5% has resulted in a decrease in the compressive strength of the NRLMKHPC mix. At 1% NRL and 10% cement by weight, the 28-day compressive strength had a generally outrageous value of 79.0 MPa. As a result, it is argued that the ideal dose for MK is 10% by weight of concrete and the ideal dose for NRL is 1%. With lower water folio proportions, the strength rises. At a lower water clasp extent of 0.3, ordinary versatile plastic changed metakaolin significant arrives at its most noteworthy separated unbending nature. The split inflexibility is most noteworthy at a metakaolin level of 10% and a NRL level of one percent. A split strength of 7.2 MPa is accomplished by using 10% MK.mix and 1% NRL. Part adaptability of NRLMKHPC blends seems, by all accounts, to be diminishing past 10% MK and 1% NRL

. • In testing with M20 grade concrete and OPCHPC, the 28-day flexural strength of standard adaptable plastic changed fundamentally in contrast with metakaolin's augmentations. For 0.5% NRL, a flexural strength of 10.5

Mpa was observed. In any case, it is around 3.1 MPa for M20 grades that are critical. Subsequently, the NRLMKHPC blend has a scope of roughly 183.87% and 19.88% when contrasted with the M20 grade and OPCHPC.

• The flexural strength moves from 10.55 MPa to 12 MPa when the level of NRL is stretched out from 0.5 percent to 1% for w/b=0.3. There is a rate range of 248.33 percent to 287.09 percent when compared to M20 grade concrete. With OPCHPC (0%NRL,0%MK), the rate increases from 19.88 percent to 36.36 percent for w/b=0.3. The estimated increase in flexural strength of NRLMKHPC ranges from one percent to one percent. The slight increment is from 287.09% to 287.42% for M20 grade concrete.

• At the point when showed up distinctively corresponding to the flexural strength of OPCHPC at w/b=0.3, the rate combination in flexural strength for an improvement in NRL (for 1%, 1.5%) spaces from 36.36 percent to 38.63 percent. Thus, it is currently sensible to accept that when NRL is thought about, NRLHPC's flexural strength fundamentally increments.

• With the development of metakaolin, the flexural strength of MKHPC increases when stood separated from OPCHPC and M20 grade concrete. The rate assortment in flexural strength of MKHPC goes from 187.09 for 5% MK (w/b=0.3-0.4) to 154.84%. For expansion in MK from 5% to 10% the flexural strength shifts from 187.09% to 216.13% for (w/b=0.3) with M20 grade concrete. For extra improvement in MK from 15% to 30%, there is a downtrend fall in flexural strength. As a result, it is possible that the optimal amount of metakaolin to be added is 10% by weight of concrete.

• One of the strength properties, for instance, quick chloride molecule assault starter of NRLMKHPC has been surveyed. At the point when showed up contrastingly according to M20 grade concrete and OPCHPC, the robustness of NRLMKHPC is really commonplace. The primer outcomes show that the chloride porousness of NRLMKHPC blends expansions in with the expansion in w/b degree.

• Because it was thought to be made of typical flexible plastic, the NRLMKHPC is more solid. Better protection against chloride entry has been demonstrated by the RCIPT's potential increases of NRLHPC and MKHPC.

• Considering the exploratory revelations, a piece of one percent standard adaptable plastic and 10% metakaolin by weight of concrete from the worth and strength parts of typical adaptable plastic and metakaoline changed most excellent execution concrete is recommended.

• At 28 days, OPCHPC has a compressive strength of 63 MPa and a w/b ratio of 0.33. For 30 days of destructive submersion, the pace of diminishing in compressive for Hcl soaking is 3.17 percent, and for 90 days, it is 7.93 percent. After 30 days of drenching, H2So4's compressive strength decreased by 12.69 percent, while after 90 days, its strength decreased by 20.63 percent, compared to 28 days. On the other hand, NRLHPC and MKHPC have lower compressive strengths. NRL and MK concrete experience the ill effects of a reduction in compressive strength. At 1% NRL and 10% MK, Hcl immersion appeared to have a different compressive strength than H 2So4 submersion.

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