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A Study on Effect of Mustard Husk Ash on Properties of Porous Concrete

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Abstract: Mustard Husk Ash (MHA), a by-product of the mustard oil extraction process, has gained attention as a potential supplementary cementitious material in the construction industry. The incorporation of MHA in porous concrete offers the dual benefits of waste management and sustainable construction practices. The environmental advantages of utilizing MHA, such as reducing landfill waste and conserving natural resources. The review paper synthesizes the findings from various research studies that have investigated the influence of RHA on the properties of porous concrete. The impact of different percentages of Rice Husk Ash (RHA) as a partial replacement for cement is analysed. The fresh and hardened properties of porous concrete, including workability, compressive strength, water absorption, and porosity, are examined in light of the incorporation of RHA. The review paper identifies key trends and observations from the existing literature. It discusses the influence of water content and size of coarse aggregates on the performance of RHA-based porous concrete. It also addresses the challenges and limitations associated with the use of RHA, such as its effect on the water demand and workability of concrete mixes. By synthesizing the collective findings, the review paper provides valuable insights into the effectiveness and feasibility of RHA as a sustainable alternative in porous concrete production. It identifies knowledge gaps and areas for further research, emphasizing the need for long-term durability studies and performance assessments on MHA based on porous concrete under different environmental conditions. In conclusion, this review paper contributes to the understanding of the effect of mustard husk ash on the properties of porous concrete. It underscores the potential of MHA as a viable option for enhancing the sustainability and performance of porous concrete. The comprehensive analysis serves as a valuable resource for researchers, engineers, and practitioners seeking to explore the application of MHA in porous concrete and promote environmentally friendly construction practices.

Keywords: Mustard Husk Ash (MHA); Rice Husk Ash (RHA); Ordinary Portland Cement (OPC); Porous Concrete; Workability; Compressive Strength; Porosity

I. INTRODUCTION

Porous concrete, also known as permeable or pervious concrete, has gained significant attention in recent years due to its unique properties and environmental benefits. It is a specialized type of concrete that allows water to pass through its interconnected voids, promoting natural drainage and reducing stormwater runoff. Porous concrete finds applications in various infrastructure projects, such as parking lots, sidewalks, and low-traffic roadways, where effective stormwater management is essential.

However, the production of traditional concrete involves a significant amount of cement, which is known to have a high carbon footprint and contribute to environmental concerns. Therefore, researchers and engineers have been exploring alternative materials and techniques to enhance the sustainability and performance of concrete. One such material under investigation is mustard husk ash.

MHA is a by-product generated from the mustard oil extraction process, which is widely practiced in several regions around the world. It is an abundant agricultural waste material that poses challenges in terms of waste management and disposal. However, MHA possesses certain characteristics that make it a potential candidate for use in construction materials, particularly in concrete.

The incorporation of MHA in concrete has the potential to address both environmental and engineering aspects. By utilizing this agricultural waste product, the industry can reduce its reliance on cement, thereby mitigating the carbon emissions associated with cement production. Additionally, the use of MHA in concrete can offer improved material properties, such as enhanced strength, reduced water absorption, and increased durability.

The effects of several wastes, including fly ash, RHA and silica fume, on the characteristics of concrete have been the subject of numerous research. The impact of mustard husk ash on porous concrete, however, has only received a small amount of study attention.

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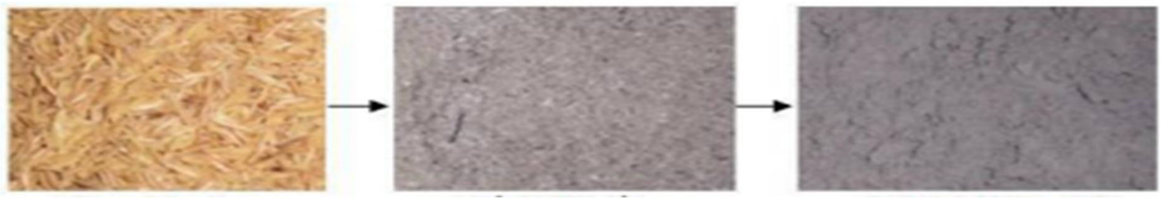
By examining the effects of mustard husk ash on the properties of porous concrete, this study seeks to close this research gap.



Mustard Husk　　Mustard Husk after burning　　Mustard Husk Ash after grinding

Fig. 1: Steps for obtaining MHA

II. NEED AND SCOPE OF STUDY

Understanding how mustard husk ash affects the fresh and hardened properties of porous concrete is crucial for optimizing its utilization in practical applications. This research will investigate the workability, compressive strength, water absorption, and porosity of porous concrete with varying percentages of MHA as a partial replacement for cement. The findings of this study will provide valuable insights into the feasibility and effectiveness of incorporating MHA in porous concrete, offering a sustainable solution for waste management and contributing to the development of eco-friendly construction materials.

The need to explore the "Effect of Mustard Husk Ash on properties of porous concrete" arises from the demand for sustainable construction practices and the limited research available in this specific area. The scope of this study encompasses evaluating the workability, mechanical properties, durability, and environmental impact of MHA-based porous concrete, with the aim of providing practical insights for its effective utilization in construction projects.

III. OBJECTIVES OF STUDY

The following are the objectives of the study:

1) To design porous concrete using conventional material.
2) To add MHA replacing cement for developing porous concrete.
3) To compare the properties of both concretes and suggest implementation.

IV. LITERATURE REVIEW

A lot of work in the field of porous concrete using different types of replacement material has been done. The work done by various researchers is presented here.

Siddharth Talsania et al., (2015) study aimed to evaluate the impact of RHA as a partial replacement for OPC in pervious concrete. The researchers investigated the behaviour of pervious concrete by replacing OPC with RHA at different proportions (10% and 20% by weight of cement) and using w/c ratios of 0.30, 0.35, and 0.40. To assess the concrete's performance, the researchers conducted compressive strength tests and flexural strength tests at 7, 14, and 28 days. These tests were carried out to measure the concrete's ability to withstand compressive forces and bending stresses, respectively. The findings indicated that substituting up to 10% of cement with RHA yielded optimal results without compromising the fresh and cured concrete's qualities. The compressive strength values met the desired standards, suggesting that the concrete remained structurally sound. The flexural strength tests provided additional insights into the concrete's ability to withstand bending forces. By incorporating RHA as a partial replacement of cement, the researchers explored the potential of enhancing the properties of pervious concrete. The results provided valuable information regarding the feasibility of using RHA in sustainable construction practices without negatively impacting the concrete's strength and durability [1].

Rambabu et al., (2015) the results of a study on RHA in concrete showed that 10% of the cement's weight is the ideal replacement level for RHA. The goal of the study was to identify the greatest ideal value within this 10% range to get higher compressive strength and durability. Due to its high silica content, RHA was shown to have excellent pozzolanic properties and demonstrate good pozzolanic behaviour. 90% of the material that makes up RHA is amorphous silica, with minor amounts of carbon (5%), and K_2O (2%). By weight of cement, various RHA replacement percentages (0%, 5%, 6%, 7%, 8%, 9%, and 10%) were utilised, and the concrete mixtures underwent various curing times (28 days, 60 days, and 90 days).

But the 6% RHA replacement in the concrete demonstrated good resistance to sulfuric acid assault. This study emphasizes the possibility of using RHA to supplement cement in concrete and enhance performance.

The results imply that a 6% replacement level of RHA can improve compressive strength and offer resistance to sulfuric acid, making it a suitable choice for environmentally friendly building techniques [2].

Egbe, (2018) there has been research into the use of RHA as a pozzolan additive in cement for construction applications. Amorphous silica (SiO2) was created by carefully burning RHA at a temperature of 500 degrees Celsius to create RHA. In concrete mixes, RHA was added in various amounts (0%, 5%, 10%, 20%, and 30%) in place of cement. The curing times for the concrete samples ranged from 7 days to 14 days to 21 days to 28 days. The results showed that a 20% replacement of RHA in the concrete mix produced the strongest results. The mixture with a particle size of 75 microns offered the best strength performance, according to a comparison of mixtures with different particle sizes (ranges from 600 μ to 75 μ). The chemical oxide content of RHA was ascertained by X-ray fluorescence (XRF) analysis. Numerous oxides were found, including Mg, Si, P, K, Ca, Mn, Fe Zn, and Ru, according to the analysis. Additionally, X-ray diffraction (XRD) investigation supported the samples' low crystallinity, with a peak value found at 26.66, which is consistent with primary quartz. The experiment showed that employing RHA as a pozzolan additive in cement for building applications has some promise. The results indicated that a 20% replacement of RHA and a particle size of 75 microns led to optimal concrete strength. The chemical composition analysis provided valuable insights into the oxide content of RHA, while XRD analysis confirmed its low crystallinity [3].

Bheel et al., (2018) exploring the potential of waste materials as substitutes for conventional concrete constituents in order to promote sustainable development. The finite availability of natural resources used in concrete production necessitates the search for alternative materials. This study focuses on the effectiveness of using waste RHA in place of certain cement and how it affects the strength of concrete. When RHA is utilised as a 10% replacement for cement, the research also looks into how the water-cement ratio affects the strength of the concrete. Rice husk is burned at a certain temperature to produce RHA, a mineral admixture. Previous research indicates that RHA possesses reactive pozzolanic properties and binding capabilities, making it a suitable cement supplement. The laboratory experimental work involved casting and testing a total of 144 cubic and 72 cylindrical concrete specimens. The concrete mix had a ratio of 1:2:4, and various w/c ratios (0.45, 0.50, and 0.60) were used. A UTM was used to measure the compressive and splitting tensile strengths. The concrete's physical characteristics were assessed after 7, 14, 28, and 56 days of cure. According to the experimental findings, using 10% RHA increased compressive strength by up to 14.51 percent and tensile split strength by up to 10.71 percent at a water-cement ratio of 0.45. At all w/c ratios, ordinary fresh concrete had a slightly higher workability than concrete that had been blended with 10% RHA. As a result, integrating RHA in a specified percentage can improve concrete qualities, potentially lowering building costs and decreasing environmental concerns [4].

Kulkarni et al., (2014) has many benefits, including as increased strength, improved durability, and environmental benefits by lowering carbon dioxide emissions and waste disposal. The use of RHA as an additional material in the production of concrete as well as cement in Vietnam has received little attention, nevertheless. The main goal of this study is to determine whether RHA can replace cement as a pozzolanic ingredient in concrete. The research aims to assess how the incorporation of RHA in concrete can enhance its strength properties. The study also focuses on developing concrete by partially replacing cement with RHA, ensuring that the resulting concrete meets various structural requirements, particularly compressive strength. After conducting extensive experimental work and analysis, the findings conclude that the concrete mix denoted as M2 (M0 + 20% RHA) yields the best results among all the mixes. This particular mix exhibits superior tensile, flexural, and compressive strength compared to normal concrete, highlighting the positive impact of incorporating RHA as a replacement of cement. Overall, the study suggests that the use of RHA in concrete has the potential to improve its strength properties. The optimized mix with 20% RHA content demonstrates the most favorable combination, showcasing enhanced tensile, flexural, and compressive strength compared to normal concrete [5].

Singh Aulakh et al., (2018) Carbon dioxide (CO_2) emissions from the construction industry are substantial, with the production of OPC alone accounting for about 10 quintals of CO_2 emissions for every 10 quintals of cement produced, or about 7% of all CO_2 emissions worldwide. Due to their pozzolanic qualities, additional cementitious materials such RHA, fly ash, blast-furnace slag, metakaolin, and silica fume can be used to alleviate this environmental hazard. Due to its poor nutritional value, a by-product called rice husk cannot used as animal feed, and its disposal in landfills or burning creates environmental problems. However, due to its high silica concentration, rice husk can be transformed into RHA, which is a potential option for replacing some of the cement in concrete. The usage of RHA as a partial cement substitute and its effects on various concrete qualities, such as workability, permeability, compressive strength, and tensile strength, are reviewed in this research. The outcomes demonstrate the potential advantages of adding RHA to concrete by demonstrating improvements in certain properties [6].

Prof Shiram h mature et al., (2014) the research showed It possessed the necessary compressive strength, flexural strength, split tensile strength, flow capacity, and self-compatibility. The slump flow value was beyond what was permissible. Therefore, the addition of 20% RHA can be permitted in accordance with the requirements of fresh state properties of SCC [7].

Sameer et al., (2009) study on use of RHA in concrete, Compressive strength gradually increases from 3 days to 7 days for all RHA replacement cement levels. The compressive strength does, however, significantly increase from 7 days to 28 days, and then gradually increases from 28 days to 56 days. The flexural strength of concrete made with rice husk ash is initially observed to steadily decline with an increase in the percentage replacement of both RHA until 7.5% replacement. The flexural strength of RHA Concrete, however, significantly decreases with age [8].

Kamau et al., (2017) RHA is used in this study as an additional cementitious material in concrete to improve its sustainability and characteristics. In the study, the effect of RHA density is examined in relation to the workability and compressive strength of both freshly-poured and hardened concrete. Between 0% and 30% of RHA is substituted with cement, both by weight (RHA-W) and by volume (RHA-V). According to the findings, RHA dramatically lowers the workability of wet concrete and the rate at which compressive strength increases during curing, in contrast to other well-established pozzolans. This is because the greater volume of replacement concrete as a result of RHA's low density results in a high water demand. Workability for both RHA-W and RHA-V declines as replacement rates rise. Due to the high water demand, replacements above 15% are not possible for RHA-W, however replacements up to 30% are possible for RHA-V. During the 28 to 91-day curing period, RHA-W specimens show lower compressive strengths and slower strength development than RHA-V specimens. This can be due to the lack of water necessary for the pozzolanic reaction that follows cement hydration and contributes to the strength and performance of concrete through SCMs. However, both RHA-W and RHA-V's compressive strengths at 91 days exceed the desired concrete strength of class C32/40, which is regarded as appropriate for structural applications. The results lead to the conclusion that RHA should be utilised as a volumetric substitute for cement rather than just a weight replacement [9].

Ologunagba et al., (2015) used in the investigation on the mechanical properties of concrete at varied percentages ranging from 0% to 20% by the weight of cement. The concrete cubes used in this experiment were created using a 1:2:4 concrete mix ratio with a water-cement ratio of 0.44 and were allowed to cure for 7, 14, 21 and 28 days. After 28 days, it was found that utilising 10% RHA in concrete as a partial replacement of cement resulted in a compressive strength measurement of 24 N/mm^2 [10].

Mehnaza Akhter, (2017) conducted an experimental investigation on the properties and strength of concrete combined with RHA at different cement weight percentages ranging from 0% to 20%. Concrete samples for this study project were prepared and allowed to cure for 7 and 28 days. It was discovered that utilising 10% RHA as a partial replacement for cement boosted the concrete's compressive strength by 15.74% at 28 days [11].

Ramadhansyah et al., (2020) use of nanoparticles made from Black Rice Husk Ash (BRHA) as a substitute material in porous concrete pavement mixtures has, however, received relatively little attention. The purpose of this study is to evaluate the compressive strength, porosity, and correlation of the performance of porous concrete pavement using nano Black Rice Husk Ash. In the tests, nano BRHA was added at concentrations of 10%, 20%, 30%, and 40% by weight of the binder. Examining four distinct grindings of BRHA, it was found that the ground BRHA included nanoparticles with sizes ranging from 64 nm to 85 nm. The findings point to an ideal replacement of 10% nano BRHA, which results in a notable rise in compressive strength and porosity [12].

Mohd Ibrahim et al., (2018) experimental analysis of the impacts of nano black rice husk ash on the characteristics of porous concrete pavement is the study's main objective. Based on the pavement mixtures' compressive strength, flexural strength, and splitting tensile strength, performance was assessed. The results show that using black rice husk ash nanoparticles as a material enhances the mechanical characteristics of porous concrete pavement. The findings also show that longer curing times enhance the pavement's compressive, flexural, and breaking tensile strengths. The porous concrete pavement with a 10% replacement level among the tested replacement levels displays exceptional performance and superior strength in comparison to the other combinations [13].

Sathawane et al., (2013) according to the research presented in this paper, the behaviour of concrete made from cement with a combination of FA and RHA at varying proportions has an impact on the mechanical properties of concrete, such as compressive strength, flexural strength, and split tensile strength. According to the study's findings, at a ratio of 22.5% FA to 7.5% RHA, compressive strength increased by 30.15% in comparison to the targeted strength and decreased by 8.73% at 28 days compared with control concrete, flexural strength increased by 4.57% at 28 days compared with control concrete, and split tensile strength decreased by 9.58% at 28 days compared with control concrete. Cost-effective, ecologically friendly concrete is produced as a result of reduced environmental impact from partial FA and RHA substitution [14].

Pandey et al., (2021) we have carried out significant experimental studies on the partial replacement of cement by RHA (20% by the weight of cement) with super plasticizers (0.15% & 0.25%) and varied sized aggregates. A slump test is used to determine if pervious concrete is workable.

The maximum aggregate size utilised in this test is 38 mm, and the tests were conducted in accordance with IS: 516 - 1959 for the compressive strength on a cube for size at 7, 28, and 56 days of curing, the flexural strength on a beam at 28 days of curing, and the split tensile strength on a cylinder at 28 days of curing [15].

Ayyappan et al., (2018) study demonstrates how the angularity number affects the characteristics and behaviour of pervious concrete containing coarse aggregates. Maximum compressive strength and the ideal infiltration rate are expected from the ideal pervious concrete mix. Roadway pervious concrete, in particular, must be able to handle a variety of traffic loads while enabling sufficient infiltration to lower surface runoffs. It is advised to use the Control Mix based on the analysis's findings. The control design mix had a coefficient of permeability ranging from 57.8 to 299.5 in/hr and a maximum compressive strength of 31N/mm^2. The best approach for preparing the pervious concrete seems to be the traditional Proctor Hammer compaction process. In actual applications, the water would have entirely dissolved the cement, sending it into the sub foundation and leaving little cement for bonding the aggregate. Despite the fact that a wide range of compressive strengths could be obtained, none of the combinations could match the strength of regular concrete [16].

Liu et al., (2018) The use of permeable concrete has quickly advanced in sophistication. Cement, silica fume, and superplasticizer are used to create high-performance pervious concrete. Controlling factors and evaluating the corrosion resistance and abrasion resistance of pervious concrete allow one to determine the effects of SF, SP, aggregate size, w/c ratio, and aggregate-cement ratio on permeability coefficient, compressive strength, and flexural strength. The findings imply that adding a tiny quantity of aggregate and 0.5% SP to 5% SF can result in a large increase in strength. In order to increase the strength and porosity coefficient, the water-cement ratio should be employed at its ideal level. This pervious concrete has a much higher corrosion and resistance to abrasion than standard pervious concrete [17].

Dulawat & Ahmad, (2021) porous concrete, also known as dry concrete other than shattered concrete, no fines concrete, and porous concrete, may be an incredibly strong building used in the advancement industry. A noteworthy component is water. Concrete, coarse aggregates, water, and, where needed, admixtures and special cementing chemicals are all used to create penetrable concrete, a rare type of strong. The strong cross section uses more void material, which let the water to pass through its body, as there are no fine aggregates employed in this section. Solid, water, and, if necessary, coarse masses, admixtures, and unmistakable cementation components are combined to create permeable concrete. There is a tonne of research being done in the area of porous concrete. Due to its porosity and voids, porous concrete has less desirable qualities and structural characteristics when compared to normal concrete. In spite of the fact that porous concrete has a certain amount of favourable conditions, its use is nonetheless required. If the porous concrete's ability to compress and bend is increased, it may then be put to a variety of logical uses. For the time being, penetrable concrete usage is primarily restricted to "light traffic lanes". If the qualities are improved, at that point it can also be utilised for inflexible pavements with medium and heavy traffic. Nearby, permeable concrete allows for the effective utilisation of open space while removing storm water runoff from the surface and restoring groundwater. This project's overarching goal is on the relationship between the flexural, compressive, and porosity properties of concrete between porous concrete with no fine masses and cement replacement and structure of permeable concrete. However, it will typically be observed that the permeability of a penetrable strong will decrease with an increase in quality [18].

Sah et al., (2018) using four criteria: compressive strength test, split tensile strength test, flexural strength test, and permeability test, the effects of aggregate size (20 mm and 10 mm), w/c ratio (0.32 & 0.28), super plasticizers (Auramix 400 & Conplast SP 430), and different percentages of fibre (i.e. 1% & 2%) on the behaviour of pervious concrete were compared. The findings demonstrate that super plasticizer (Conplast SP 430) and w/c ratio reduction from 0.32 to 0.28 both produce a moderate improvement in strength. The inclusion of fibre, or 1% of the cement by weight, made a significant contribution to the increase in strength [19].

Saini et al., (2018) in this experiment, cement that contains 5%, 10%, 15%, 20%, and 25% of RHA is utilised as a partial substitute. For concrete grades M35, M40, and M45, a total of 18 mixes were created. This study tests the concrete's slump and compressive strength after 3 days, 17 days, 14 days, and 28 days. A total of 54 cube specimens were made for the examination of the effects of RHA on concrete. Based on the findings that RHA concrete performs nearly as well as regular concrete and costs less than regular concrete, its usage should be encouraged for low-cost infrastructure and improved performance [20].

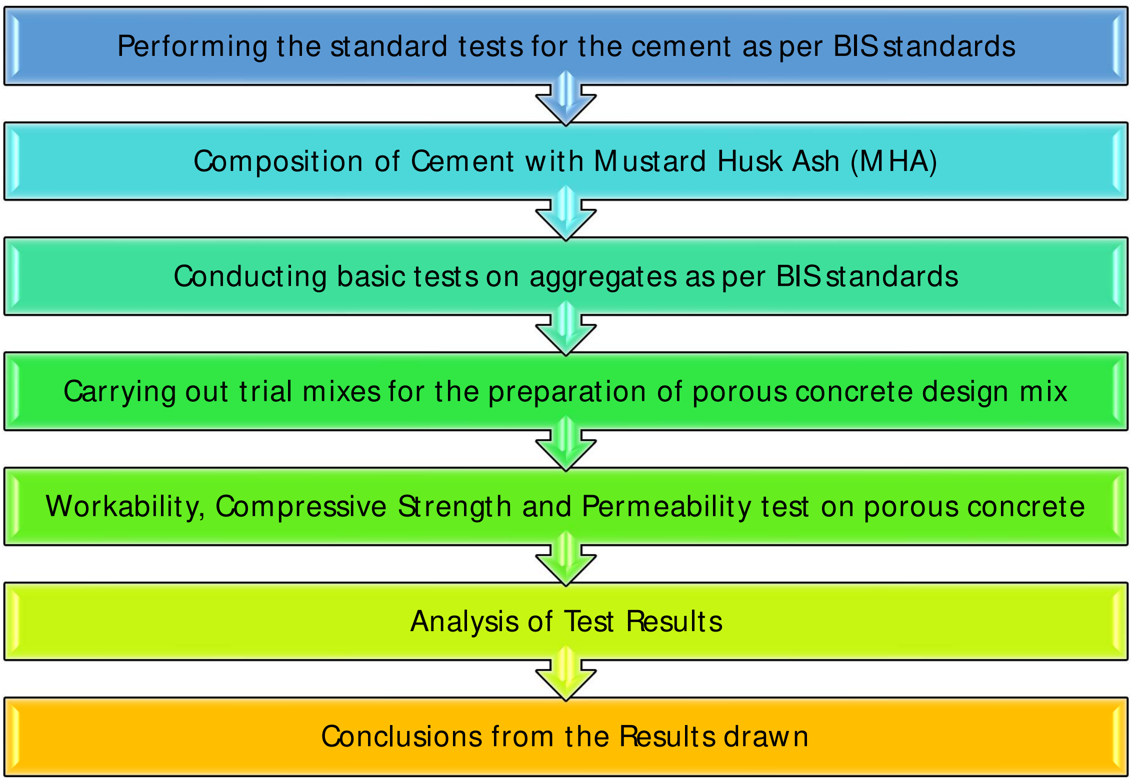
V. GAPS IN LITERATURE REVIEW

These gaps represent areas where limited or insufficient information is available:

1) *Limited Studies*: The literature review revealed a scarcity of studies specifically focused on the effect of mustard husk ash (MHA) on porous concrete. Most of the existing research primarily focuses on other supplementary cementitious materials like rice husk ash or fly ash.

2) *Optimum Dosage*: The literature lacks consensus on the optimum dosage of mustard husk ash in porous concrete mixtures. The studies available for rice husk ash employ varying dosages, making it challenging to establish a standardized recommendation.
3) *Mechanical Properties*: The existing literature provides limited information on the influence of MHA on the mechanical properties of porous concrete. Specifically, studies on compressive strength, tensile strength, and flexural strength are relatively scarce.
4) *Durability Aspects*: The literature review indicates a dearth of information on the durability aspects of porous concrete containing MHA. Factors such as porosity, water absorption, carbonation resistance, and resistance to chemical attack have not been extensively explored.
5) *Microstructural analysis*: Detailed studies investigating the microstructure and pore characteristics of porous concrete incorporating MHA are lacking. Understanding the changes in the microstructure and pore size distribution due to MHA inclusion is essential for comprehending the mechanisms behind the observed property enhancements or limitations.
6) *Environmental Assessment*: The environmental impact and sustainability aspects of porous concrete with MHA have not been adequately addressed in the literature. Comprehensive life cycle assessments, including carbon footprint analysis and embodied energy evaluation, are essential to assess the environmental benefits and drawbacks associated with the use of MHA in porous concrete.

VI. RESEARCH METHODOLOGY



VII. EXPECTED OUTCOMES

The expected outcomes from this study are as follows:
1) Normal Consistency, initial and final setting time of cement will be achieved as per with OPC cements.
2) After the trial mixes, the ideal design mix for cement will be obtained by changing the composition with MHA from 0% to 15%.
3) Workability results of porous concrete will correspond to the requirements of IRC:44-2017.
4) Higher compressive strength at 28 days curing of porous concrete made with composition of MHA will be achieved with reduced cost.

VIII. CONCLUSION

Following conclusions has been derived after reviewing various research works:

1) The literature review highlights the potential benefits of incorporating Mustard Husk Ash in porous concrete. The use of MHA can improve the mechanical properties, durability, and environmental sustainability of porous concrete. However, further research is required to optimize the dosage and understand the long-term performance of MHA-based porous concrete under different environmental conditions.
2) In majority of the literatures, the cementitious material is replaced partially. The main purpose of partial replacement of cementitious material is to cut down the expenses incurred during the procurement of cement at the time of construction.
3) Rice Husk Ash (RHA) when partially substitute with cement, it performs nearly as well as regular concrete and encouraged low-cost infrastructure.
4) Black Rice Husk Ash (BRHA) is partially replaced with cement in porous concrete within certain limit, the compressive strength and porosity appear higher at optimal level.

IX. FUTURE SCOPE

From the reviewed study it has been derived those following investigations also be conducted in future:

1) Further research is required to determine the optimum dosage of MHA in porous concrete mixtures. By conducting systematic studies on varying MHA content, the optimal proportion can be identified to achieve the desired properties while maintaining cost-effectiveness.
2) Investigating the performance of MHA-based porous concrete in different environmental conditions, such as varying temperatures, humidity levels, and exposure to aggressive chemicals, is crucial. This research can provide insights into the long-term durability and resistance of MHA-incorporated concrete in diverse settings.
3) Exploring the synergistic effects of combining MHA with other supplementary cementitious materials, such as fly ash or silica fume, can offer enhanced properties. These combinations can potentially further improve the strength, durability, and sustainability of porous concrete.
4) Future studies can delve deeper into the influence of MHA on both fresh and hardened properties of porous concrete. This includes investigating the workability, setting time, shrinkage, creep behavior, and crack resistance of MHA-incorporated concrete to comprehensively understand its impact on the overall performance.
5) Detailed analysis of the microstructure and pore characteristics of MHA-based porous concrete can provide valuable insights. Techniques such as scanning electron microscopy (SEM) and X-ray diffraction (XRD) can be employed to study the formation and distribution of hydration products, as well as the pore structure evolution.
6) Developing performance-based design guidelines for MHA-incorporated porous concrete can facilitate its wider adoption in the construction industry. These guidelines can encompass recommendations for MHA dosage, mix proportions, and testing methods to ensure consistent and reliable performance.
7) Conducting life cycle assessment (LCA) studies to evaluate the environmental impact of MHA-based porous concrete compared to conventional concrete is an important area for future research. This holistic approach can provide a comprehensive understanding of the sustainability benefits and potential carbon footprint reduction associated with the use of MHA.
8) Real-world field applications of MHA-based porous concrete, along with monitoring and evaluation, can provide valuable insights into its performance under actual construction scenarios. Case studies and practical implementations can help validate the laboratory findings and further refine the utilization of MHA in porous concrete.

REFERENCES

[1] Siddharth Talsania, E., Mukeshkumar Vyas, C., Talsania, S., Pitroda, J., & Vyas, C. M. (2015). EFFECT OF RICE HUSK ASH ON PROPERTIES OF PERVIOUS CONCRETE Translucent Concrete Using Optical Fibers: A Review View project Feasibility Report on Recycle and Reuse of Wind Turbine Blade Waste View project EFFECT OF RICE HUSK ASH ON PROPERTIES OF PERVIOUS CONCRETE. In International Journal of Advanced Engineering Research and Studies. https://www.researchgate.net/publication/281639934

[2] Rambabu, P. V, Chanakya Varma, V., & Ramarao, G. V. (2015). Experimental Study on Rice Husk Ash for Optimum Level of Replacement of Cement in Concrete. www.ijert.org

[3] Egbe, J. (2018). Investigation of Rice Husk Ash (RHA) as a Supplement in Cement for Building Applications. Civil Engineering Research Journal, 6(2). https://doi.org/10.19080/cerj.2018.06.555681

[4] Bheel, N., Meghwar, S. L., Abbasi, S. A., Marwari, L. C., Mugeri, J. A., & Abbasi, R. A. (2018). Effect of Rice Husk Ash and Water-Cement Ratio on Strength of Concrete. Civil Engineering Journal, 4(10), 2373. https://doi.org/10.28991/cej-03091166

[5] Kulkarni, M. S., Govind Mirgal, P., Prakash Bodhale, P., Tande, S. N., & Students, M. T. (2014). Effect of Rice Husk Ash on Properties of Concrete. 1(1), 26–29. http://www.krishisanskriti.org/jceet.html
[6] Singh Aulakh, D., Singh, J., & Kumar, S. (2018). The Effect of Utilizing Rice Husk Ash on Some Properties of Concrete - A Review. Current World Environment, 13(2), 224–231. https://doi.org/10.12944/cwe.13.2.07
[7] Prof shiram h mature Dr V.M Monilker, "Effects of RHS on fresh and hardened properties of self compacting concrete", Journal of Civil Engineering and Environmental Technology Print ISSN: 2349- 8404; Online ISSN: 2349-879X; Volume 1, Number 1; August, 2014.
[8] Sameer, M. B. G., Santosh, K. D., Prasad, P. P. R. D., Bipin, K., Phani, C., Ramu, G., Chandan, S. P., & Tech, K. M. (2009). A STUDY ON USE OF RICE HUSK ASH IN CONCRETE A PROJECT REPORT SUBMITTED IN THE PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING IN CIVIL ENGINEERING SUBMITTED BY Under the Esteemed Guidance of.
[9] Kamau, J., Ahmed, A., Hyndman, F., Hirst, P., & Kangwa, J. (2017). Influence of Rice Husk Ash Density on the Workability and Strength of Structural Concrete. European Journal of Engineering Research and Science, 2(3), 36. https://doi.org/10.24018/ejers.2017.2.3.292
[10] I.B. Ologunagba1, A.S. Daramola, A.O. Aliu. "Feasibility of using Rice Husk Ash as Partial Replacement for Concrete". International journal of engineering Trends and technology, 30(5) (2015): 267-269. doi: 10.1016/j.tics.2006.07.005.
[11] Mehnaza Akhter. "Experimental Study on Effect of Rice Husk Ash on Strength of Concrete". Volume 04, Issue 7, (July– 2017): 2349–9745. doi: 10.21884/IJMTER.2017.4218.505GF.
[12] Ramadhansyah, P. J., Masri, K. A., Mangi, S. A., Mohd Yusak, M. I., Mashros, N., Mohd Warid, M. N., Satar, M. K. I. M., & Mohd Haziman, W. I. (2020). Strength and Porosity of Porous Concrete Pavement Containing Nano Black Rice Husk Ash. IOP Conference Series: Materials Science and Engineering, 712(1). https://doi.org/10.1088/1757-899X/712/1/012037
[13] Mohd Ibrahim, M. Y., Ramadhansyah, P. J., Mohd Rosli, H., & Wan Ibrahim, M. H. (2018). Mechanical performance of porous concrete pavement containing nano black rice husk ash. IOP Conference Series: Materials Science and Engineering, 290(1). https://doi.org/10.1088/1757-899X/290/1/012050
[14] Sathawane, S. H., Vairagade, V. S., & Kene, K. S. (2013). Combine effect of rice husk ash and fly ash on concrete by 30% cement replacement. Procedia Engineering, 51, 35–44. https://doi.org/10.1016/j.proeng.2013.01.009
[15] Pandey, A. K., Pal, S., & Singh, A. (2021). Effect of Addition of Rice Husk Ash and Super Plasticizer on Pervious Concrete. International Research Journal of Engineering and Technology. www.irjet.net
[16] Ayyappan, A., Dinesh Kumar, D., Sangeetha, G., Roshini, S., Sivasangari, M., & Students, U. G. (2018). EXPERIMENTAL STUDY OF PERVIOUS CONCRETE. International Journal of Scientific Development and Research, 3(3). www.ijsdr.org
[17] Liu, H., Liu, R., Yang, H., Ma, C., & Zhou, H. (2018). Experimental study on the performance of pervious concrete. IOP Conference Series: Earth and Environmental Science, 113(1). https://doi.org/10.1088/1755-1315/113/1/012126
[18] Dulawat, S., & Ahmad, E. (2021). Experimental Investigation of Porous Concrete for Concrete Pavement. In Article in International Journal of Engineering and Technical Research. www.ijert.org
[19] Sah, S. K., Guntakal, S. N., & Selvan, S. S. (2018). Experimental Study on behavior of Pervious Concrete in Strength and Permeability by Changing Different Parameters. In International Journal of Applied Engineering Research (Vol. 13, Issue 6). http://www.ripublication.com
[20] Saini, R. K., Kumar Saini, M., & Meena, S. (2018). An Experimental Investigation on Behavior of Concrete on Partial Replacement of Cement by Rice Husk Ash.
[21] Koti Marg, K., & Puram, R. (2017). GUIDELINES FOR CEMENT CONCRETE MIX DESIGN FOR PAVEMENTS INDIAN ROADS CONGRESS.
[22] Bureau of Indian Standards Specification for Ordinary Portland Cement, BIS: 269 – 2015.
[23] Bureau of Indian Standards Specification for Methods of test for Aggregates for Concrete, BIS: 2386 – 1963.
[24] Bureau of Indian Standards Specification for Specification for Coarse and Fine Aggregates from Natural sources for Concrete, BIS: 383 – 1970