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COMPREHENSIVE STUDY ON SAND TESTING METHODS FOR QUALITY ASSESSMENT IN FOUNDRY APPLICATIONS

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ABSTRACT

This study looks into improving molding sand preparation in foundries by using data mining techniques to predict moisture content, which is crucial for casting quality. The study uses a number of studies to look into the impacts of fines concentration and void ratios on sand-silt mixtures, with an emphasis on liquefaction resistance, shear strength, and hydraulic conductivity. The interaction of additives with Portland Pozzolana Cement in self-compacting concrete is researched to determine its impacts on cement composition and admixture performance. Furthermore, bamboo is examined as a sustainable reinforcement alternative in concrete, with performance comparable to steel. The study also investigates the use of 3D sand printing for aluminum casting, showing the benefits in lead time and mold quality. Furthermore, the mechanical and hydraulic properties of concrete mixtures with fibers, tire chips, and fly ash are examined. The statistics show that coarser sands and higher cement content improve the mechanical and bond strength of brickwork, while finer sands have the reverse effect.

Keywords: Sand testing, Sand printing, sand moisture content prediction, , permeability of sand-bentonite mixes

1. INTRODUCTION

Quality assurance in foundry production is crucial for competitiveness and environmental sustainability. Controlling the moisture content in green moulding sand is crucial for sustaining casting quality since water influences its strength, flowability, and thermophysical properties. Predictive techniques can be utilized to improve molding sand preparation, hence enhancing process efficiency. This article looks at developments in moisture prediction and data-driven attempts to improve foundry processes. Soil liquefaction is a common occurrence in geotechnical earthquake engineering, resulting in catastrophic ground failures like settlements, tilting structures, and lateral spreading. The quantity of particles in natural sands influences liquefaction behavior, including shear resistance, pore water pressure, and soil stability. However, there are inconsistent results regarding the effect of fine content on liquefaction resistance, compression behavior, and hydraulic conductivity. This paper thoroughly investigates the engineering features of sand-silt mixtures, including void ratio, fines concentration, and stress conditions. The study's purpose is to provide insight into how these mixes react under different loading conditions, which will aid in soil stability assessments and geotechnical design recommendations[1]. Concrete's properties are improved by substituting ingredients or inserting additives. Compatibility issues between cement and additives have an effect on workability, strength, and setting time. Common concerns include slump loss, early stiffness, and increased water need. A survey in Kochi revealed popular cement brands, and trials with Auromix 300 Plus were conducted. The study aims to determine the optimal admixture dosages for various cements[2]. The rising cost of concrete production has spurred the search for alternative materials. Bamboo, with its high strength-to-weight ratio, is being studied as a sustainable alternative to steel reinforcement. This study examines bamboo-reinforced concrete (BRC) with fly ash and GGBS, evaluating its strength and structural qualities. There is little study on BRC with admixtures, therefore this finding is significant[3]. The rising cost of concrete production has spurred the search for alternative materials. Bamboo, known for its high strength-to-weight ratio and sustainability, is being investigated as an alternative to steel reinforcement. Although studies highlight bamboo's potential in construction, there is little research on bamboo-reinforced concrete (BRC) using admixtures such fly ash and GGBS. This study looks into the mechanical properties of BRC, such as strength, crack patterns, and load-deflection behavior, with the purpose of promoting sustainable construction. [4].

2. METHODOLOGY AND MATERIALS

The workability of Portland Pozzolana Cement (PPC) and Portland Slag Cement (PSC) with Sulfonated Naphthalene Formaldehyde (SNF) and Polycarboxylate Ether (PCE) superplasticizers is evaluated using the Marsh cone and micro slump tests. Concrete mixing required the use of both fine and coarse aggregates that satisfied traditional grading standards, as well as potable water. To assess mechanical qualities, concrete specimens were made and tested for compressive, tensile, and flexural strength [5]. This study looks at the permeability of sand-bentonite mixes (SBMs) treated with biopolymers as landfill liners. Guar and xanthan gums were added to sand-bentonite mixtures, and permeability experiments were performed utilizing typical geotechnical procedures and tools, such as a flexible wall permeameter, to determine their effectiveness in reducing permeability [6-7**]**.

To evaluate gas permeability under different conditions, the researchers utilized a bentonite-sand combination compacted at 12 MPa pressure. Permeability was determined using steady-state and pulse-test techniques at various relative humidity levels (75-98% and 7-12 MPa). Precise measurements were made with digital calipers, and the permeability was computed using Darcy's equation and mass conservation principles. This study looks into the mechanical and hydraulic properties of permeable concrete that contains fibers, tire chips, and fly ash as substitute components. Concrete mixtures were subjected to live-load intensities of 0%, 50%, and 75% to simulate mechanical distress, and their hydraulic properties were determined using an infiltrometer [8].

2.1MATERIALS

The study focuses on a clay-sand mixture composed of 20% Anzali sand and 80% Rasht clay from Iran's Guilan region. A variety of additives were tested, including rice husk ash (RHA) (2%, 5%, 8%), cement (2%, 4%, 5%, 8%, 10%, 16%), and polypropylene (PP) fibers (0, 6, 12 mm) at 0.2% weight. Clay-sand combinations were cured for 28 days, while clay samples were treated for 7, 28, and 90 days [9]. Binders employed in this experiment include Class F fly ash, Portland cement type-1, EPS beads (2-4 mm, density 0.008 g/cm³), and Chamkhaleh Beach sand. The mix proportions for fly ash, cement, and EPS vary; samples are taken at maximum dry density (MDD) and optimum moisture content (OMC) for optimal strength[10]. **11**

24 bulk soil samples with a clay concentration ranging from 1% to 50% were utilized in the study; They came from grassland and arable farming areas in the Netherlands. One sample was discarded, and the remaining seven were calcareous. There were six calcareous samples among the remaining 23. Acetic acid and gravimetric procedures were used to The thinness index assesses the presence of small particles, which influence mould permeability and determine the carbonate content of quartz sand, which served as a control. Fly ash from the Nghi Son thermal power plant (LOI 15.8%), natural sand with a fineness modulus of 2.97, and crushed stone as coarse aggregate were used in this study. The specific gravity of the fly ash was 2.16, while that of the cement was 3.12. The binder contained 1% superplasticizer. The design used water-to-binder ratios of 0.35 and 0.45.

Concrete mixes and fly ash were substituted for cement at percentages of 0%, 10%, 20%, and 30%, respectively. The mix proportions were consistent with ACI 211.91 [11-12]. Bentonite is a useful binder for molding sand because it improves its strength, cohesion, and permeability. It boosts the mould's green strength, resulting in higher durability during metal pouring. The clay's ability to retain moisture prevents the mould from drying out or splitting prematurely. Furthermore, bentonite promotes sand reusability, which reduces material waste and production costs. Its thermal stability improves mould integrity at high temperatures, eliminating casting faults. The proper amount of bentonite in sand ranges between 5% and 25%, depending on the casting needs. [13]. Fig.1 shows the effect of bentonite on permeability.

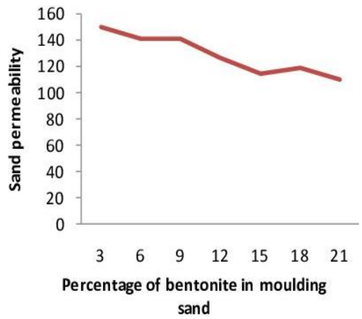

Fig.1 Permeability

Coal dust is a substantial additive to molding sand that improves casting surface quality by preventing metal penetration and decreasing defects. When heated to high temperatures, it produces glossy carbon, which forms a protective covering and increases the smoothness of the casting. Furthermore, coal dust reduces sand burn-on and veining issues, leading in better mould integrity. Its insulating properties help control the cooling rate of molten metal, hence reducing shrinkage defects. However, excessive use of coal dust may pose environmental risks due to volatile organic compound (VOC) emissions. To solve this, foundries are investigating ecologically friendly alternatives and emission-reduction measures [14]. Sand testing includes a number of analyses to determine its suitability for molding applications. Mechanical sieving is used to determine particle size distribution and ensure that the grain composition is suitable for casting.

strength. Acid demand experiments investigate the interaction between sand and binders, which is crucial for core production. Furthermore, measurements of black mineral content and oolitic content help determine sand aging and its effect on casting faults. Metal content study utilizing acid digestion revealed trace components that may impair mold performance [15].

2.2MATERIAL PROCESS:

Concrete mixtures were made by combining fly ash, cement, sand, crushed stone, and superplasticizer. Fly ash (0-30%) was utilized in place of cement, with water-to-binder ratios of 0.35 and 0.45. Cylindrical samples of fresh concrete were cured in sodium sulfate solution, and slump was measured. At various intervals, compressive strength and ultrasonic pulse velocity were measured[12]. To detect pollution and ensure compliance, precise emission reporting is critical. Emissions from Canadian oil sands plants are recorded in the National Pollutant Release Inventory (NPRI). Direct measurement of VOC emissions from these facilities is difficult. The TERRA technique and airplane measurements are utilized in a top-down strategy to confirm VOC emission claims, reducing ambiguity in environmental impact assessments and producing more precise estimates[16]. The study included Rasht clay (80%) and Anzali sand (20%) with cement (2%-16%), Rice Husk Ash (2%-8%), and polypropylene fibers (0.2% by weight, 6 mm and 12 mm). Samples were prepared at the optimal moisture content, compacted in molds, and cured for the specified periods. UCS tests were performed at a specific displacement rate, and the results were calibrated [9]. Dextrin is used as a binder in molding sand to improve green strength and grain cohesion. It improves sand flowability, resulting in better mold compaction and homogeneous hardness. During casting, dextrin decreases sand breakage and faults such erosion scabs and metal penetration. It improves surface finish by strengthening mold integrity and reducing gas defects. Furthermore, dextrin enhances collapsibility, making it easier to remove the casting from the mold. Its utilization is quite advantageous in green sand systems for producing high-quality casting[17].

3. RESULTS AND DISCUSSION

The researchers discovered that altering parameters increased permeability and hardness in green sand molds. Wall thickness and ramming were crucial in reducing casting flaws and increasing mold integrity. The Taguchi technique was used to fine-tune process parameters for improved quality. Proper regulation of these components resulted in increased mold performance and reduced defects. Overall, the data emphasize the importance of adjusting correct parameters in sand mold casting [18]. Bamboo and steel reinforcements were evaluated for their impact The M50% mixture demonstrated the best balance of strength and fatigue resistance, making it the most efficient composition. Microstructural studies, on concrete strength. Steel-reinforced concrete had higher compressive strength than bamboo. Bamboo reinforcement, while environmentally advantageous, has lower tensile and flexural strength. Synthetic sand outperformed traditional sand in terms of bonding and overall structural integrity [3]. The study examined aluminum castings, which demonstrated enhanced hardness and strength at 750°C while maintaining excellent sand permeability (80:20). MgFeSi inoculants enhanced fine-grained Al-Si eutectic phases, but higher temperatures (800°C) resulted in greater structural changes. Reduced porosity and enhanced phase distribution highlighted the need of accurate casting parameters[19]. The study looked at furan molding sand and discovered that resin increases green compression strength (GCS), whereas hardener decreases it. Optimizing the resin, hardener, and curing time improves mold quality and casting[20]. This study investigates how EPS, cement, and fly ash influence the mechanical properties of cement-stabilized sand. EPS lowers strength, but cement and fly ash boost it by encouraging cementitious reactions and pozzolanic activity[10]. Dextrin is used as a binder in molding sand to increase green strength and cohesiveness between sand grains. It promotes sand flowability, resulting in greater mold compaction and uniform hardness. During casting, dextrin reduces sand breakage and flaws such as erosion scabs and metal penetration. It improves surface finish by strengthening mold integrity and reducing gas defects. Furthermore, dextrin enhances collapsibility, making it easier to remove the casting from the mold. Its utilization is quite advantageous in green sand systems for producing high-quality casting [21]. The study's findings demonstrate that monitoring the power consumption of foundry moulding sand mixers might help optimize the mixing process. The comparison of paddle and Simpson-type mixers revealed significant differences in power demand, which were influenced by factors such as moisture content, mixer load, and mixing time. The results reveal that oscillations in power factor (cos φ) correspond to changes in technological parameters, indicating the possible use of power demand as a quality assessment factor. The system effectively collected real-time current and voltage measurements, allowing for precise control over energy consumption and operating efficiency. The statistics show that implementing this monitoring technique can improve process stability, reduce energy costs, and improve the overall quality of moulding sand preparation[22]. The Results and Discussion section looks at the mechanical and microstructural properties of Hot Mix Asphalt (HMA) mixtures. The study assesses durability and performance using indirect tensile strength (ITS), resilient modulus (MR), and moisture sensitivity (MLT).

including optical and scanning electron microscopy (SEM), proved the asphalt binder's homogeneity and effectiveness. The petrographic investigation of Waste

Foundry Sand (WFS) revealed that it had superior morphology when compared to standard aggregates. These findings back up the mechanical strength and durability of enhanced HMA blends for road applications[23]. The section evaluates the performance of asphalt concrete that includes Waste Foundry Sand (WFS) as a filler material. The bitumen tests demonstrated compliance with defined requirements, indicating suitability for asphalt manufacture. Marshall Stability and volumetric experiments showed that up to 60% WFS replacement resulted in good strength, density, and durability. The mix with 5.5% optimal bitumen percentage had excellent stability and flow properties. Microstructural analysis revealed a constant distribution of WFS, which increased the mechanical integrity of the asphalt. These findings highlight WFS's potential as a long-term and cost-effective option for flexible pavement construction [24].

4. CONCLUSION

Reinforcing clayey sand soil with waste plastic strips improves unconfined compressive strength and ductility, with corrugated strips showing more strength than plain ones. This paper provides a nonlocal peridynamic technique for addressing strain localization difficulties in metal cutting simulations while ensuring stable and objective results. The technique accurately replicates ductile failure and cutting chip patterns, with further extensions and research planned to address temperature impacts and semi-brittle materials. This paper emphasizes the significance of a balanced approach to instructional design, which combines unguided problem-solving with guided instruction to promote productive failure and success. By reevaluating assumptions in Cognitive Load Theory (CLT), it advocates for an educational technique that aligns with a variety of learning goals and employs scaffolding to build on learners' previous knowledge. The study concludes that coarser sands and higher cement content improve masonry's compressive strength, shear strength, and bond strength, while finer sands reduce performance. The conclusion should explain the research findings, emphasizing the ideal sand Mold composition (90% sand, 5% bentonite, and 5% water) that produced the fewest casting faults. It should demonstrate the usefulness of the ANOVA analysis in determining the ideal combination and indicate that proper composition greatly decreases defects such as blow holes and pinholes. It should also note the microstructural comparison, which demonstrates the enhanced quality of the optimized casting process. Finally, the result suggests further studies on further refining casting parameters for increased efficiency and sustainability.

The adjustment of green sand composition significantly improves sand casting quality by reducing defects like blowholes and porosity. The study identified the optimal combination of silica sand, bentonite, water, and coal dust, resulting in increased green compression strength. Statistical study indicated that bentonite and water are critical components in producing the appropriate mechanical characteristics. The high R-squared value suggests that the model accurately predicts outcomes. Implementing these results in the casting industry can increase product reliability while minimizing material waste. Future study can focus on further optimizing the component ratios for various casting applications.

REFERENCES

[1] D. H. Hsiao, V. T. A. Phan, Y. T. Hsieh, and H. Y. Kuo,(2015) "Engineering behavior and correlated parameters from obtained results of sand-silt mixtures," *Soil Dyn. Earthq. Eng.*, 77, 137–151, , doi: 10.1016/j.soildyn.2015.05.005.

[2] Tiji K James and Liji Anna Mathew, (2016)"Compatibility Study of an Admixture with Different Cement Brands of Varying Chemical Composition for SCC," *Int. J. Eng. Res.*, V5(09), 503–506., doi: 10.17577/ijertv5is090279.

[3] S. Karthik, P. R. M. Rao, and P. O. Awoyera, (2017)"Strength properties of bamboo and steel reinforced concrete containing manufactured sand and mineral admixtures," *J. King Saud Univ. - Eng. Sci.*, 29(4) 400–406, doi: 10.1016/j.jksues.2016.12.003.

[4] P. Hackney and R. Wooldridge, (2017)"Optimisation of Additive Manufactured Sand Printed Mould Material for Aluminium Castings," *Procedia Manuf.*, vol. 11, no. June, pp. 457–465, 2017, doi: 10.1016/j.promfg.2017.07.136.

[5] S. Shrihari, M. V. Seshagiri Rao, V. S. Reddy, and A. Manasa, (2020)"Compatibility Assessment of Commercial Cements with superplasticizers," *E3S Web Conf.*, 184(6)17–22, doi: 10.1051/e3sconf/202018401079.

[6] M. S. Biju and D. N. Arnepalli,(2020) "Effect of biopolymers on permeability of sand-bentonite mixtures," *J. Rock Mech. Geotech. Eng.*, 12(5)1093–1102, 2020, doi: 10.1016/j.jrmge.2020.02.004.

[7] J. F. Liu, F. Skoczylas, and J. Talandier,(2015) "Gas permeability of a compacted bentonite-sand mixture: Coupled effects of water content, dry density, and confining pressure," *Can. Geotech. J.*, 52(8)1159–1167, doi: 10.1139/cgj-2014-0371.

[8] Y. J. Kim, A. Gaddafi, and I. Yoshitake, (2016)"Permeable concrete mixed with various admixtures," *Mater. Des.*, 100,110–119, doi: 10.1016/j.matdes.2016.03.109.

[9] A. Ghorbani and M. Salimzadehshooiili, (2018)"Evaluation of Strength behaviour of Cement-RHA Stabilized and Polypropylene Fiber Reinforced Clay-Sand Mixtures," *Civ. Eng. J.*, 4(11) 2628, doi: 10.28991/cej-03091187.

[10] R. J. Chenari, B. Fatahi, A. Ghorbani, and M. N. Alamoti,(2018) "Evaluation of strength properties of cement stabilized sand mixed with EPS beads and fly ash," *Geomech. Eng.*, 14(6)533–544, doi: 10.12989/gae.2018.14.6.533.

[11] M. J. J. Hoogsteen, E. A. Lantinga, E. J. Bakker, and P. A. Tittonell, (2018)"An Evaluation of the Loss-on-Ignition Method for Determining the Soil Organic Matter Content of Calcareous Soils," *Commun. Soil Sci. Plant Anal.*, 49(13)1541–1552, doi: 10.1080/00103624.2018.1474475.

[12] S. H. Ngo, T. P. Huynh, T. T. Thi Le, and N. H. Thi Mai,(2018) "Effect of High Loss on Ignition-Fly Ash on Properties of Concrete Fully Immersed in Sulfate Solution," *IOP Conf. Ser. Mater. Sci. Eng.*, 371(1), 2018, doi: 10.1088/1757-899X/371/1/012007.

[13] K. K. Tripathi and B. V. S. Viswanadham,(2012) "Evaluation of the Permeability Behaviour of Sand-Bentonite Mixtures Through Laboratory Tests," *Indian Geotech. J.*,42(4) 267–277, doi: 10.1007/s40098-012-0020-8.

[14] K. Major-Gabryś, (2019)"Environmentally Friendly Foundry Molding and Core Sands," *J. Mater. Eng. Perform.*, 28(7) 3905–3911, doi: 10.1007/s11665-019-03947-x.

[15] M. C. Zanetti and S. Fiore,(2003) "Foundry processes: The recovery of green moulding sands for core operations," *Resour. Conserv. Recycl.*, 38(3) 243–254, doi: 10.1016/S0921-3449(02)00154-4.

[16] S. M. Li *et al.*,(2017) "Differences between measured and reported volatile organic compound emissions from oil sands facilities in Alberta, Canada," *Proc. Natl. Acad. Sci. U. S. A.*, 114(19)E3756–E3765, doi: 10.1073/pnas.1617862114.

[17] R. Khan, N. Mahadeva, and M. Seshadri, (1973)"Some Studies On Flowability Of Molding Sand," *J. Indian Inst. Sci.*, 54(4)194–210.