iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 10 **Issue:** XI **Month of publication:** November 2022

**DOI:** https://doi.org/10.22214/ijraset.2022.47668

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

# A Study on the Use of Foundry Sand as a Sustainable Construction Material: A Review

Vinay Patel[1], Mahesh Ram Patel[2]
[1]M.Tech Scholars (Structural Engineering), SSTC, SSGI, BHILAI, C.G., India
[2]Assitant Professor, Department of Civil Engineering, SSTC, SSGI, BHILAI, C.G., India

***Abstract: Foundry sand is used as a substitute of a fine aggregate for green concrete for the sustainable development of construction industry. Foundry sand may also used to develop a design mix for the concrete, and to check the properties of green cement used in concrete, the following properties of concrete were determine, Compressive strength of the concrete, Split tensile strength of the concrete and Flexural Strength of the concrete..***

***Keywords: Foundry Sand, Compressive strength of the concrete, Split tensile strength of the concrete and Flexural Strength of the concrete.***

## I. INTRODUCTION

Shear walls have been long used as lateral load resisting systems. The main function of steel plate shear wall is to resist horizontal story shear and overturning moment due to lateral loads. Steel plate shear walls (SPSW) can be used as lateral load resisting system for buildings. A typical SPSW (Fig.1) consists of stiff horizontal and vertical boundary elements (HBE and VBE) and infill plates.[1] Recent researches have demonstrated that steel plate shear walls, SPSWs, can act as effective and economic seismic load resisting systems in the high risk zones. SPSWs have high elastic stiffness, large displacement ductility, and stable hysteretic behavior and high energy dissipating capacity.[2] There are two types of SPSW system,(1) Standard system used sole lateral load resisting system and pin type beam to column connection.(2) Dual system is a part of a lateral load resisting system and installed in a moment resisting frame. Force are resisted by frame and SPSW.

## II. LITERATURE REVIEW

1) *Sheikh MayesserMushtaqet.al.:* The workability, compressive strength, split tensile strength, and drying shrinkage of such concretes are all examined in this study. WFS wasutilized to replace some of the fine aggregate, with replacement levels ranging from 0 to 50% in constant 10% increments. As the proportion of WFS in concrete increased, the workability decreased, increasing the surface area and necessitating the use of additional water to obtain the necessary workability.With the addition of WFS, it was shown that the compressive strength and split tensile strength of concrete dropped. The lowering of the water-cement gel caused by the addition of WFS to concrete lowers the compressive strength. However, WFS particles can also fill the pores and create denser concrete since they are finer and more uniform in size. Only a 3.5% drop in strength (in comparison to control concrete) was noted at the age of 28 days in WFS3.However, the strength of the mix WFS3 (30% WFS) was strikingly similar to that of the control concrete. The magnitude of drying shrinkage increased significantly by 16.7%, 23.44%, 29.05%, 36.35%, and 45.18% compared to control concrete at the age of 28 days when the amount of WFS in the concrete was adjusted from 10 to 50%.With an increase in WFS addition, it was observed that concrete drying shrinkage had increased. All of the mixes' shrinkage, however, was discovered to fall within the normal range of 200-800 x 10^6 mm/mm.Indicating its success in predicting the drying shrinkage of concrete containing WFS as fine aggregate, a multi-regression shrinkage prediction model provided a high value of the coefficient of regression (R2) between the actual and projected values of drying shrinkage strain.
2) *RafatSiddique et.al.:* Waste foundry sand (WFS) is an industrial by-product that can be used in a variety of products, including concrete and controlled low-strength materials (CLSM). Hazardous chemicals may be present in the leachate produced by such materials, which could potentially have an adverse effect on the environment. It is crucial to comprehend the leachate properties of WFS in order to dispose of it, reduce its environmental impact, and possibly develop a useful application for solid waste management. This essay discusses the physical and chemical features of waste foundry sand (WFS), various leachate test procedures, and research that have been done on the leachate properties of WFS.Compared to conventional sand, waste foundry sand has a lower unit weight, a higher water absorption rate, and a higher percentage of voids.As foundry sand content rises, so do the strength attributes of concrete mixtures.Various leaching techniques, such as TCLP, SPLP, shaking extraction (ASTM

D3987), NEN 7343, NORD TEST, 1995, and NEN 7341, can be used to examine leachate. Results showed that substantial amounts of copper, lead, and zinc were present in TCLP extracts of old foundry sand without any additions, exceeding the statutory limitations for hazardous waste of 5 mg/L.It was discovered that PAH (poly aromatic hydrocarbon) chemicals are present in all spent/waste foundry sands. Even though phenolic/ester sands have greater levels of PAHs than furan/acid and silicate sands, the PAHs in green sands are significantly higher than those in chemical binder wasted sands.It also came to the conclusion that WFS had little organics. Spended foundry sand met all ES parameters, although it exceeds the PAL for lead and chromium. Clean foundry sand met both the WDNR preventive action limits and the enforcement standards of Ground Water Quality Standards (GWQS).

3) *An Deng, Paul J. Tikalsky:* WFS samples for this study were collected from 17 separate metal casting factories using various casting techniques, providing a good representation of WFS attributes. In the laboratory experiments, flowable fillings made of WFS, cement, and fly ash mixed with various amounts of water are examined for their physical, geotechnical, and leaching qualities.Gradation, grain forms, and fines for WFS samples, flowability, hydraulic conductivity, setting time, and PR, bleeding, UC strength, pollutants in bleed water, and TCLP leachates for WFS flowable fills were all examined and addressed. Both technically and environmentally, the inclusion of these WFS samples into flowable fills was verified.Cement (25 to 94), fly ash (334 to 463), WFS (818 to 1264), and water (291 to 504) were suggested as a starting or scouting mixing formula. The test findings show that the majority of the data, in terms of physical attributes, fall within small ranges, though data from the copper/aluminum-based WFS samples may go outside the ranges. Geotechnical characteristics of WFS flowable fills were confirmed to be in accordance with the characteristics of the required flowable fills in both the fresh and hardened phases. According to material leaching analyses, the toxicity of WFS flowable fills is less than what is allowed.This study's mix formulation range is suggested for the development of WFS produced flowable fill.
4) *Yucel Guney et.al.:* This study looked into the possibility of using leftover foundry sand to make high-strength concrete. Waste foundry sand is used in place of natural fine sand to varying degrees (0, 5, 10, and 15%). Several tests were conducted, including the Slump test and standard tests for physical values. Results from a number of test programs have revealed that the addition of waste foundry materials in concrete directly affects compressive and tensile strengths as well as the elasticity modulus.In terms of the strength criteria, utilizing leftover foundry sand in a ratio of less than 5% may not be sufficient,Water absorption and vacancy ratios were reduced in the concrete that contained waste foundry sand in concentrations more than 5%, while using more than 10% will be excessive. However, the 10% waste foundry sand-concrete reveals findings that are nearly identical to the control.As the ratio of discarded foundry sand increases, the slump and workability of fresh concrete decrease. Although the mechanical and physical qualities of the concrete are severely diminished by freezing and thawing. The results obtained are within the permitted ranges established by the American Concrete Institute (ACI).It is important to note that the effects of freezing and thawing were roughly the same for the control and specimens with used foundry sand added. The findings shown that foundry sand can be utilized successfully in high-strength concrete applications if the particle-size distribution is carefully adjusted, delivering qualities similar to those of high-strength concrete containing ordinary fine sand.
5) *H. Merve Basar, Nuran Deveci Aksoy:* The creation of ready-mixed concrete (RMC) could potentially utilize waste foundry sand (WFS), which is presented in this paper. All concrete mixtures underwent the solidification/stabilization (S/S) process and five weight percentages of WFS (0%, 10%, 20%, 30%, and 40%) in place of regular sand. For the WFS-based-certification, RMC's three factors—the mechanical, leaching, and microstructural properties—were examined. The findings showed that using WFS as a partial replacement for sand decreased the strength performance and density of the concrete mixtures and also increased the water absorption ratio.All concrete mixtures have increasing strength characteristics with time, and the strength performance measured at 56 days is roughly comparable to that shown in the case of 90 days.However, the concrete containing 20% WFS showed findings that were remarkably similar to those of the control. Utilizing XRD, XRF, SEM, and EDS techniques, micro-structural analyses of both the control mix and the concrete mix containing 20% WFS were also carried out. The S/S technique can immobilize the Ni, Zn, Cr, F, TDS, DOC, and TOC components of WFS in the matrix. It has been found that the eluate concentrations at various pH settings are consistent with the EULFD limitations.The research's findings indicate that WFS can be used to produce high-quality RMC as a partial replacement for fine aggregates without having a negative impact on mechanical, environmental, or microstructural properties; however, the partial replacement shouldn't exceed 20%.
6) *Tarun R. Naik et.al.:* This study looked into how well newly-poured, hardened concrete performed when foundry sands were used in place of fine aggregate. The proportions of a control concrete mixture were set at a 28-day compressive strength of 38 MPa (5,500 psi). Other concrete mixtures were proportioned to substitute clean/new foundry sand and used foundry sand for 25% and 35%, respectively, of the ordinary concrete sand. Compressive strength, tensile strength, and elastic modulus were

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 10 Issue XI Nov 2022- Available at www.ijraset.com*

used to evaluate the performance of concrete. Comparatively to concrete with no replacement, the compressive strength values for concrete with 25% and 35% substitutions of ordinary sand with used foundry sand are lower. However, concrete that replaced 25% and 35% of the fine aggregate with clean, new foundry sand had compressive strength that was comparable to the control mix. The average compressive strength of concrete that substituted foundry sand for normal sand up to 35% was greater than 30 MPa.Based on the findings, it can be said that discarded foundry sands can serve as a partial substitute for conventional concrete sand in the production of structural-grade concrete. According to test results, the mixture comprising 25% wasted foundry sand had a compressive strength that was 10% higher at 28 days than the mixture containing 35% discarded foundry sand. However, compared to the mixes including abandoned foundry sands, the compressive strength of the control mix was roughly 20–30% higher. At 28 days old, the modulus of elasticity changes amongst mixtures by 2 to 4%. Mixed 20-F2 and 20-F3 produced much lower entrapped air content readings. The density of freshly laid concrete and hardened concrete did not significantly differ for any of the mixes.

7) *Rafat Siddique, Gurpreet Singh:* An overview of some of the studies on the utilization of waste foundry sand (WFS) in concrete is provided in this publication. It is discussed how WFS affects concrete qualities like compressive strength, splitting tensile strength, elastic modulus, freezing-thawing resistance, and shrinkage.When compared to conventional concrete sand, waste foundry sand has a lower unit weight, a higher water absorption rate, and a higher % void.The slump of the concrete is negatively impacted by the partial replacement of fine particles with waste foundry sand.As the WFS content rises, the concrete's ability to absorb water declines.As concrete mixtures age and their foundry sand contents rise, so do their strength qualities.Findings on strength qualities show that leftover foundry sand can be used very conveniently to produce high-quality concrete and building materials.
8) *RecepBakis, HakanKoyuncu and Ayhan:* An experiment was conducted in the lab to see whether waste foundry sand (WFS) might be used in place of some of the aggregate for making asphalt concrete. The findings indicated that the most acceptable aggregate replacement for asphalt concrete mixtures was determined to be 10% waste foundry sand. Additionally, waste foundry sand's chemical and physical characteristics were examined in a lab to ascertain any potential environmental effects. According to the findings, the ecosystem near the deposition region was not severely impacted by the analyzed waste foundry sand.According to the findings of the experiments presented, which were conducted on samples of asphalt concrete, the Marshall stability dramatically falls with the addition of WFS in amounts more than 10%, going from 12.1 kN with 0% WFS added to 10.9 kN with 10% WFS added. Therefore, for practical purposes, only 10% or less of WFS should be used as an additional material in asphalt concrete.In comparison to the Turkish Solid Wastes Standards, which set limitations on heavy metals to prevent soil pollution, the concentrations (g kg-1) of heavy metals discovered in WFS were relatively low, according to the chemical analysis. According to measurements of the flow characteristics of WFS-asphalt cement mixtures, the flow reduced as the quantity of WFS added rose. The findings of the indirect tensile strength test show that the strength of the mixtures fell almost linearly as more WFS was added to the asphalt concrete, with values ranging from 13.9 kPa for 0% WFS addition to 11.8 kPa for 10% WFS addition.The use of WFS as a partial replacement for fine aggregate in asphalt concrete should be kept to a maximum of roughly 10% in practical applications, according to all of the experimental results of this study.
9) *Rafat Siddique et.al.:* In this study, used-foundry sand (UFS) is employed as a partial replacement for fine aggregates in concrete mix designs. Different mechanical characteristics are assessed (compressive strength, and split tensile strength). The concrete's durability in terms of resistance to carbonation and chloride penetration is also assessed. At 28, 90, and 365 days, compressive strength, split-tensile strength, and resistance to carbonation and fast chloride penetration were all measured.It was found that cylinder and cube compressive strengths and split tensile strengths grew stronger with age. Indicating that the strength difference between foundry sand concrete specimens and control concrete specimens became less noticeable after 28 days, the various strengths were initially found to be slightly lower than the control mix at 28 days. These differences increased with age and, at 365 days, were either higher or equal to the control mix. For mixes containing foundry sand, the maximum carbonation depth in a natural environment has never exceeded 2.5 mm at 90 days and 5 mm at 365 days. According to ASTM C 1202-97, the RCPT values fell into the extremely low category when they were less than 750 coulombs at 90 days and 500 coulombs at 365 days. Also the concrete containing foundry sand F mixes demonstrated good carbonation resistance and quick chloride penetration resistance. This shows that foundry sand can be used effectively as an alternative material to replace some of the fine particles in concrete. Utilizing XRD and SEM methods, micro-structural analyses of control mixes and mixes containing different amounts of foundry sand were also carried out. A replacement rate of foundry sand for fine aggregate of 30% was discovered to be ideal and shouldn't go higher than that. At 90 days, the rate of gain for all the mixes containing foundry sand was higher than the CM mix, and at 365 days, it was more similar to the rate of increase for the control mix.C2S,

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

C3S, and C4AF peaks were not discernible in any of the blends, indicating that they have all been consumed. It was proven that calcium hydroxide was consumed in the hydration reaction because calcium hydroxide was not found in any of the mixtures.When compared to control mix, the microstructure of concretes made with foundry sand had less voids and less evenly distributed C-S-H gel paste.

10) *BavitaBhardwaj, Pardeep:* In the current research, a number of attributes have been analyzed. The findings from the numerous investigations show that replacing foundry sand can improve the concrete's toughness and endurance to some extent, while also lowering slump values as replacement levels of waste foundry sand increase.The presence of impurities like clay, sawdust, and other dust particles lowers the material's specific density and also lowers the density of the concrete by causing air spaces in the concrete. Concrete's unit weight is reduced when WFS replacement increases.The majority of waste foundry sands have demonstrated good durability and are classified as nonhazardous waste because they are not corrosive, ignitable, reactive, or poisonous.The presence of finer sand and additive particles generally causes concrete's workability to deteriorate as substitution increases. Beyond 50% replacement, the pattern remained the same for specific concretes like SCC and GPC.This essay reviews several papers that discuss the usage of WFS in place of natural sand in concrete.Numerous research on the use of WFS in concrete have been conducted; the best replacement amount was found to be 30% for the majority of properties.
11) *G. Ganesh Prabhu et. al.:* The findings of experiments done to assess the use of foundry sand (FS) as a replacement material for fine aggregate in concrete production are presented in this research. The FS's physical and chemical properties were also discussed. Five alternative substitution rates (10%, 20%, 30%, 40%, and 50%) for fine aggregate were tested using FS sourced from the aluminium casting industry. To comprehend the impacts of FS on the behavior of concrete, a number of experiments were conducted, including density, slump cone, split tensile strength, flexural strength, ultrasonic pulse velocity (UPV), and compressive strength tests. According to an analysis of the grain size distribution of FS, 8% of FS had a grain size of less than 75 lm, and 1.13% of FS absorbed water.The workability of the concrete is decreased by the FS's fineness and high water absorption qualities, and it also declines as the FS substitution rate rises. The strength characteristics of the concrete mixtures containing FS up to 20% were generally near to the strength value of the CM in all ages of concrete, and the average strength decline was just 2.1%. When compared to the CM at the age of 28 days, the concrete mixtures FS 20% and FS 30% showed a loss in compressive strength of just 1.6% and 5.7%, respectively.At the age of 28 days, the flexural strength of the control mixture was 4.087 N/mm2, but the FS 10%, FS 20%, and FS 30% mixes each obtained strengths of 3.986, 3.988, and 3.879 N/mm2, respectively, which are only 2.47%, 2.42%, and 5.08% lower than the strength of CM, respectively. Due to the fineness of the FS and the presence of clay, sawdust, and wood flour in the FS, concrete compositions that exceeded a replacement rate of 20% exhibited worse behavior when compared to the CM. The findings indicate that FS can be utilized successfully as a fine aggregate in the manufacturing of high-quality concrete with a substitution rate of up to 20% without compromising the concrete requirements.
12) *RafatSiddique, Albert Noumowe:* This document provides a summary of some of the available research on the use of spent foundry sand (SFS) in concrete and controlled low-strength materials. We describe the impact of SFS on concrete qualities such as compressive strength, splitting tensile strength, elastic modulus, freezing-thawing resistance, and shrinkage as well as Controlled Low-Strength Material (CLSM) features such as plastic properties, compressive strength, permeability, and leachate analysis.When compared to conventional concrete sand, used foundry sand has a lower unit weight, higher water absorption, and higher % void.Foundry sand adds to the increased bleeding because it causes more gaps in the mixture because its particles are coarser than fly ash particles.Due to the clay content's ability to absorb water, clay-bonded foundry sand weakens stabilized mixes more than resin-bonded sands do.As concrete mixtures age and their foundry sand contents rise, so do their strength qualities. Making high-quality concrete and other building materials from used foundry sand is quite convenient.
13) *N. Gurumoorthy, K. Arunachalam:* This study's findings were used to evaluate the microstructural and mechanical characteristics of concrete mixtures in which treated used foundry sand was used to replace some of the fine aggregate (river sand) (TUFS). When used foundry sand is treated with 5% HCl, the silica content is roughly 80%.Depending on the TUFS percentage at 28 days, the increase in compressive strength varies between 4% and 11%, and at 90 days, it varies between 9% and 17%.Depending of the TUFS percentage, the increase in splitting tensile strength varies between 4% and 11% at 28 days, and between 5% and 14% at 90 days.Depending on the TUFS percentage at 28 days, the increase in flexural strength varies between 5% and 13%, and between 8% and 17% at 90 days.SEM analysis by TUFS reveals that the void has been decreased, and C-S-H gel paste has been applied evenly and firmly throughout the sample, reducing porosity and enhancing strength as a result. From 10% to 40% TUFS mix, C-S-H gel distributed more effectively, and nodule formation increased, reaching its peak

at 30% TUFS mix.According to test results, adding TUFS as a replacement for some of the fine aggregate resulted in a little improvement in the strength qualities and good microstructural properties of plain concrete (sand).

14) *Thiruvenkitam Manoharan at.al.:* In this study, used foundry sand largely replaced river sand (UFS). The percentage replacements were, respectively, 0, 5, 10, 15, 20 and 25 wt%. The mechanical, durability, and microstructural characteristics of M20 concrete were assessed experimentally at ages 7, 28, and 91 days. To find different chemicals and tiny cracks in the concrete with UFS, X-ray diffraction, energy dispersive X-ray and optical-microscopic imaging analyses were used.Compression strength, flexural strength, and elastic modulus were discovered to be roughly constant up to 20 weight percent UFS and to decline with additional addition. However, the addition of 20 weight percent boosted the split tensile strength at the expense of other concrete qualities.The durability characteristics of concrete mixes with UFS above 20 wt% were superior to those of concrete mixes without the substitution, including ultrasonic pulse velocity, quick chloride penetration, water absorption, and abrasion resistance. The durability test findings revealed that the concrete mixture containing up to 20 wt% UFS had nearly identical values to the control mix in terms of abrasion resistance and fast chloride permeability. With a 20 weight percent replacement of UFS, test results for mechanical, durability, and microstructural qualities were comparatively better than those of the other blends.The results imply that UFS can successfully replace river sand. However, it is advised that the replacement not go over 20% weight.
15) *Gurpreet Singh, Rafat Siddique:* Investigations were made into the abrasion resistance and strength characteristics of concrete using waste foundry sand (WFS). By mass, WFS was substituted for sand (fine aggregate) in amounts of 0%, 5%, 10%, 15%, and 20%. At 0.40 and 85 5 mm, respectively, the water-to-cement ratio and the workability of mixes were kept constant. Compressive strength, splitting tensile strength, elastic modulus, and abrasion resistance expressed as depth of wear were the properties analyzed.Depending on the WFS concentration, the concrete's compressive strength increased by 8.25-17%, splitting tensile strength by 3.55- 10.40%, and modulus of elasticity by 1.67-6.35% at 28 days. All of these parameters continued to improve when the curing time was extended.Regardless of the age of curing, WFS replacement for fine aggregate increased the abrasion resistance of concrete mixtures. For instance, the depth of wear at 28 days for concrete containing 0%, 5%, 10%, 15%, and 20% WFS was 2.84 mm, 2.6 mm, 2.5 mm, and 2.28 mm, respectively.According to the results, concrete containing up to 15% WFS could be used to create structural concrete as well as in other situations where abrasion is a crucial factor.
16) *Muhammad FarjadIqbal at. al.:* In this study, a cutting-edge artificial intelligence method called The split tensile strength (ST) and modulus of elasticity (E) of concrete containing waste foundry sand are modeled using Multi-Expression Programming (MEP) (CWFS). The provided formulae connect compressive strength, foundry sand content, superplasticizer content, and w/c to mechanical characteristics. The accuracy of the model is validated by statistical analysis, as shown by the low values of the objective function (0.033 for E and 0.052 for ST). Additionally, for the ST and E models, respectively, the average error in the projected values is extremely low at 0.287 MPa and 1.75 GPa.The models' outputs perform equally well on unobserved data and exhibit good agreement with experimental findings. The created models' accuracy and dependability were evaluated using a variety of performance measures, including R, MAE, RMSE, RSE, and RRMSE. Additionally, the results of the evaluation of and OF showed that the constructed models are very broad, and the problem of overfitting has been successfully resolved. The mean uncertainties in the anticipated values range from 0.28 to 0.32 MPa and 1.7 to 2.0 GPa for the ST and E models, respectively, while the R value is in the range of 0.89 to 0.96.
17) *Bernhard J. Stauder, Hubert Kerber, Peter Schumacher:* The current work shows that it is possible to assess the mechanical and functional characteristics of sand cores using data from carefully obtained 3-point bending test load curves utilizing typical bending test geometries. Investigations have been done on four organic binder systems. A load curve pre-treatment to remove sample settling effects was used for a corrected deflection and stiffness analysis, in addition to bending strength and the elastic modulus, which may be directly calculated from the load curves.Based on curve and work parameters, dimensionless indicators to measure core brittleness have been established. In general, visco-plastic effects must be taken into account when evaluating the mechanical properties of resin-bonded sand cores since, for partially hardened binder systems, decreased strength, deflection, and work of fracture were seen at lower load rates. The benchmark findings demonstrate that the load curve evaluation idea is a useful tool for more sensitively analyzing the properties of foundry sand cores. The work that is being described here has shown that it is possible to greatly improve the assessment of typical foundry sand core bending tests. Testing of Coldbox, Hotbox, and Warmbox bonded sand cores demonstrated the usefulness of this idea. – Straightforward measurements of bending strength and elastic modulus can be made from non-treated load data. – In particular for soft bonded granular materials like sand cores, a load curve pre-treatment is necessary to remove initial settling effects of the samples towards the testing supports before to further studies. – Pre-treated load curves can be used to estimate the mechanical work and

deflection that are elastic and plastic. – Both a work-based and a modulus-based approach have been used to express brittleness.Both produce similar relationships. - For materials with a higher degree of flexibility, a work-based approach should be used. Due to the effects of visco-plasticity, strength and deformability may be compromised at low load rates. The overcritical sample fracture of samples at bending test settings in accordance with foundry standards, which encourages instable crack propagation, provides limitations to the concept. Consequently, it is suggested to explore the particular work of fracture, such as by wedge split tests as produced by (Harmuth and Tschegg, 1997). Due to an enhanced ratio of fracture surface to sample volume, this has been demonstrated to be a useful approach for characterising heterogeneous materials like refractory bricks or concrete samples. Future studies should focus on the characteristics of the sand core during casting, including the effects of heat exposure and the high temperature features that result. Inorganically bound cores should also be given attention. These provide benefits for the environment and job hazards while requiring a more advanced process control.

18) *Ali Behnood, Emadaldin Mohammadi Golafshani:* In this study, the M5P method was employed to simulate the compressive strength, elastic modulus, flexural strength, and splitting tensile strength of concretes made from waste foundry sand (WFS). An extensive dataset containing data on the mixture proportions and the values of the mechanical characteristics at various ages was compiled for this purpose from publications that were published internationally. The outcomes showed that the suggested models are capable of making accurate predictions of the desired mechanical properties.In this study, waste foundry sand was used as a partial or full replacement for fine aggregate in concrete, and the M5P algorithm was used to develop predictive models for the concretes' compressive strength (CS), modulus of elasticity (MoE), flexural strength (FS), and splitting tensile strength (SPT). The input parameters were age, the ratio of waste foundry sand to fine aggregate (WFS/FA), the ratio of water to cement (W/C), the ratio of coarse aggregate to cement (CA/C), the ratio of fine aggregate to total aggregate (FA/TA), and the ratio of waste foundry sand to coarse aggregate (WFS/FA).The output parameters were the cube's CS, MoE, FS, and SPT. To create the models, the dataset was separated into training and testing subsets. The effectiveness of the models was assessed using a variety of error metrics, including root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), coefficient of determination (R2), and correlation coefficient (R). The results of this study showed that the M5P algorithm could generate valid simple predictive models for a variety of parameters of concretes containing WFS.
19) *Saveria Monosi et. al.:* In the current study, the characteristics of fresh and hardened mortars and concretes containing various dosages of used foundry sand (UFS) as a partial replacement of sand were examined. Particularly, addition percentages were regarded to be larger in mortars than in concretes, but lower if referred to the entire aggregate (fine and coarse). Regarding uniformity of the fresh mixture and compressive strength of the hardened material, mortars and concretes were both assessed. Concretes were used to determine the hardened material's elastic modulus. Used foundry sand, in small amounts (10%), has little effect on the mortar's performance. The obtained test findings lead to the conclusion that UFS can be used in the construction of structural mortar and concrete as a partial replacement for natural sand. It might be proposed to recycle the leftover foundry sand properly for use in construction. According to the new solid data, all UFS-containing mixes need high superplasticizer dosages to retain good workability. Significantly, UFS addition results in low slump (or slump flow), which is mostly caused by the presence of very fine binders. When it comes to mechanical performance, mortars containing UFS at a water-cement ratio of 0.5 exhibits compressive strengths that are 20–30% lower than those of the reference mix. Concrete could achieve the same % with the same water-to-cement ratio.The elastic modulus doesn't change much that much; in the case with the largest penalty, it is roughly 94% of the control mix's elastic modulus. Drying shrinkage increases as mechanical properties deteriorate.

## III. CONCLUSION

They made a review on utilization of ceramic waste and foundry sand in civil engineering practice. In the world, there are large amounts of calcined-clay wastes and waste foundrysand produce from the industry each year. So, these wastes are use in landfills. Reusing these wastes in concrete can be very beneficial situation for society. Therefore, at one side, we can solve the problems of industries and at the other side, they can make more sustainable concrete by reducing nonrenewable resources like cement, aggregates and also solve the environmental problems related to land fill wastes

## REFERENCES

[1] Sheikh MayesserMushtaq, RafatSiddique, ShwetaGoyal, KulwinderKaur, “Experimental studies and drying shrinkage prediction model for concrete containing waste foundry sand” Received 10 December 2020; Received in revised form 24 February 2021; Accepted 17 March 2021, Contents lists available at ScienceDirectCleaner Engineering and Technologyjournal homepage: www.journals.elsevier.com/cleaner-engineering-and-technology, https://doi.org/10.1016/j.clet.2021.100071Published by Elsevier Ltd. All rights reserved.

[2] RafatSiddique, GurdeepKaur, Anita Rajor, "Waste foundry sand and its leachate characteristics" Received 25 January 2010; Received in revised form 21 April 2010; Accepted 21 April 2010, Contents lists available at ScienceDirect Resources, Conservation and Recycling, journal homepage: www.elsevier.com/locate/resconrec , doi:10.1016/j.resconrec.2010.04.006 ,Elsevier B.V. All rights reserved.

[3] An Deng, Paul J. Tikalsky"Geotechnical and leaching properties of flowable fill incorporating waste foundry sand", Accepted 10 September 2007, Available online 21 December 2007, Available online at www.sciencedirect.com , www.elsevier.com/locate/wasman , doi:10.1016/j.wasman.2007.09.018 Published by Elsevier Ltd.

[4] YucelGuney, YasinDursun Sari, MuhsinYalcin, AhmetTuncan, SenayiDonmez "Re-usage of waste foundry sand in high-strength concrete" Received 28 June 2009 Accepted 9 February 2010, Available online 9 March 2010, Contents lists available at ScienceDirect, Waste Management ,journal homepage: www.elsevier.com/locate/wasman, doi:10.1016/j.wasman.2010.02.018 Elsevier Ltd. All rights reserved.

[5] H. MerveBasar, NuranDeveciAksoy"The effect of waste foundry sand (WFS) as partial replacement of sand on the mechanical, leaching and micro-structural characteristics of ready-mixed concrete" Received 10 February 2012, Received in revised form 8 April 2012, Accepted 25 April 2012, Contents lists available at SciVerseScienceDirect, Construction and Building Materials, journal homepage: www.elsevier.com/locate/conbuildmat , http://dx.doi.org/10.1016/j.conbuildmat.2012.04.078Published by Elsevier Ltd. All rights reserved.

[6] Tarun R. Naik, Viral M. Patel, Dhaval M. Parikh and Mathew P. Tharaniyii "UTILIZATION OF USED FOUNDRY SAND IN CONCRETE" Downloaded from ascelibrary.org by Government College Of Engineering - Karad. Copyright ASCE, all rights reserved.

[7] RafatSiddique, Gurpreet Singh "Utilization of waste foundry sand (WFS) in concrete manufacturing" Received 28 January 2011, Received in revised form 1 May 2011, Accepted 1 May 2011, Contents lists available at ScienceDirect, Resources, Conservation and Recycling Journal home page: www.elsevier.com/locate/resconrec , doi:10.1016/j.resconrec.2011.05.001 Elsevier B.V. All rights reserved.

[8] RecepBakis, HakanKoyuncu and AyhanDemirbas "An investigation of waste foundry sand in asphalt concrete mixtures" Received 27 October 2004; Accepted in revised form 13 February 2006, This article can be found at:http://wmr.sagepub.com/content/24/3/269 , Published by: http://www.sagepublications.com , DOI: 10.1177/0734242X06064822, Copyright © ISWA 2006 Waste Management & Research ISSN 0734–242X

[9] RafatSiddique, YogeshAggarwal, ParatibhaAggarwal, El-HadjKadri, RachidBennacer "Strength, durability, and micro-structural properties of concrete made with used-foundry sand (UFS)" Received 21 August 2010, Received in revised form 21 October 2010, Accepted 13 November 2010, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , doi:10.1016/j.conbuildmat.2010.11.065 ,Elsevier Ltd. All rights reserved.

[10] BavitaBhardwaj, Pardeep Kumar "Waste foundry sand in concrete: A review" , Received 7 May 2017, Received in revised form 28 August 2017, Accepted 1 September 2017, Contents lists available at ScienceDirect, Construction and Building Materials , Journal homepage: www.elsevier.com/locate/conbuildmat , http://dx.doi.org/10.1016/j.conbuildmat.2017.09.010 Elsevier Ltd. All rights reserved.

[11] G. Ganesh Prabhu, Jung Hwan Hyun, Yun Yong Kim "Effects of foundry sand as a fine aggregate in concrete production", Received 14 April 2014, Received in revised form 11 July 2014, Accepted 23 July 2014, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , http://dx.doi.org/10.1016/j.conbuildmat.2014.07.070Elsevier Ltd. All rights reserved.

[12] RafatSiddique, Albert Noumowe "Utilization of spent foundry sand in controlled low-strengthmaterials and concrete" Received 14 May 2008, Received in revised form 19 August 2008, Accepted 16 September 2008, Contents lists available at ScienceDirect, Resources, Conservation and Recycling, Journal homepage: www.elsevier.com/locate/resconrec , doi:10.1016/j.resconrec.2008.09.007, Elsevier B.V. All rights reserved.

[13] N. Gurumoorthya,⇑, K. Arunachalam "Micro and mechanical behaviour of Treated Used Foundry Sand concrete" Received 20 January 2016, Received in revised form 15 June 2016, Accepted 29 June 2016, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , http://dx.doi.org/10.1016/j.conbuildmat.2016.06.143Elsevier Ltd. All rights reserved.

[14] ThiruvenkitamManoharan, DhamothiranLaksmanan, KaliyannanMylsamy, PandianSivakumar,AnirbidSircar "Engineering properties of concrete with partial utilization of used foundry sand" Received 19 February 2017, Revised 6 October 2017, Accepted 19 October 2017, Contents lists available at ScienceDirect, Waste Management, Journal homepage: www.elsevier.com/locate/wasman , https://doi.org/10.1016/j.wasman.2017.10.022Published by Elsevier Ltd.

[15] Gurpreet Singh, RafatSiddique "Abrasion resistance and strength properties of concrete containing wastefoundry sand (WFS)" Received 27 June 2011, Received in revised form 30 August 2011, Accepted 30 August 2011, Contents lists available at SciVerseScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , doi:10.1016/j.conbuildmat.2011.08.087 Elsevier Ltd. All rights reserved.

[16] Muhammad FarjadIqbal, Muhammad Faisal Javed, MominaRauf, IftikharAzim, Muhammad Ashraf, Jian Yang, Qing-feng Liu "Sustainable utilization of foundry waste: Forecasting mechanicalproperties of foundry sand based concrete usingmulti-expression programming" Received 27 October 2020, Received in revised form 12 March 2021, Accepted 12 March 2021, Contents lists available at ScienceDirect, Science of the Total Environment Journal homepage: www.elsevier.com/locate/scitotenv , https://doi.org/10.1016/j.scitotenv.2021.146524Elsevier B.V. All rights reserved.

[17] Bernhard J. Stauder, Hubert Kerber, Peter Schumacher "Foundry sand core property assessment by 3-point bending testevaluation" Received 25 September 2015, Received in revised form 1 June 2016, Accepted 4 June 2016, Contents lists available at ScienceDirect, Journal of Materials Processing Technology journal home page: www.elsevier.com/locate/jmatprotec , http://dx.doi.org/10.1016/j.jmatprotec.2016.06.0100 , Elsevier B.V. All rights reserved.

[18] Ali Behnood, EmadaldinMohammadiGolafshani "Machine learning study of the mechanical properties of concretescontaining waste foundry sand" Received 7 November 2019, Received in revised form 2 January 2020,Accepted 9 January 2020, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , https://doi.org/10.1016/j.conbuildmat.2020.118152 , Elsevier Ltd. All rights reserved.

[19] EhsanYaghoubi, Arul Arulrajah, MohammadjavadYaghoubi, SuksunHorpibulsuk "Shear strength properties and stress–strain behavior of waste foundry Sand" Received 24 December 2019, Received in revised form 10 March 2020, Accepted 14 March 2020, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , https://doi.org/10.1016/j.conbuildmat.2020.118761Elsevier Ltd. All rights reserved.

[20] RafatSiddique, El-HadjKadri "Effect of metakaolin and foundry sand on the near surface characteristics of concrete" Received 8 December 2010, Received in revised form 5 February 2011, Accepted 1 March 2011, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , doi:10.1016/j.conbuildmat.2011.03.012 Elsevier Ltd. All rights reserved.

[21] Paulo Ricardo de Matos, Matheus Felipe Marcon, RudieleAparecidaSchankoski, Luiz Roberto Prudencio Jr. "Novel applications of waste foundry sand in conventional and dry-mix Concretes" Received 2 February 2019; Received in revised form 28 March 2019; Accepted 15 April 2019, Contents lists available at

ScienceDirect, Journal of Environmental ManagementJournal homepage: www.elsevier.com/locate/jenvman , https://doi.org/10.1016/j.jenvman.2019.04.048 , Elsevier Ltd. All rights reserved.

[22] AnujParashar, ParatibhaAggarwal, BabitaSaini, YogeshAggarwal, ShashankBishnoi "Study on performance enhancement of self-compacting concrete incorporating waste foundry sand" Received 15 April 2019, Received in revised form 22 January 2020, Accepted 23 March 2020, Contents lists available at ScienceDirect, Construction and Building Materials Journal homepage: www.elsevier.com/locate/conbuildmat , https://doi.org/10.1016/j.conbuildmat.2020.118875Elsevier Ltd. All rights reserved.

[23] GurdeepKaur, RafatSiddique, Anita Rajor "Properties of concrete containing fungal treated waste foundry sand" Received 20 July 2011, Received in revised form 16 August 2011, Accepted 16 August 2011, Contents lists available at SciVerseScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , doi:10.1016/j.conbuildmat.2011.08.091 Elsevier Ltd. All rights reserved.

[24] YogeshAggarwal, RafatSiddique "Microstructure and properties of concrete using bottom ash and wastefoundry sand as partial replacement of fine aggregates" Received 19 September 2013, Received in revised form 6 December 2013, Accepted 16 December 2013, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , http://dx.doi.org/10.1016/j.conbuildmat.2013.12.051Elsevier Ltd. All rights reserved.

[25] Kevin J. Hodder, Richard J. Chalaturnyk "Bridging Additive Manufacturing and Sand Casting:Utilizing Foundry Sand" Received date: 3 April 2019, Revised date: 13 May 2019, Accepted date: 9 June 2019, https://doi.org/10.1016/j.addma.2019.06.008, Reference: ADDMA 756, Elsevier Ltd. All rights reserved.

[26] SaveriaMonosi, Daniela Sani and Francesca Tittarelli "Used Foundry Sand in Cement Mortars and Concrete Production", Received: March 27, 2010 Revised: April 22, 2010 Accepted: May 3, 2010, The Open Waste Management Journal, 2010, Volume3, Monosiet al.; Licensee Bentham Open.

[27] RavinderKaurSandhu, RafatSiddique "Strength properties and microstructural analysis of self-compactingconcrete incorporating waste foundry sand" Received 13 February 2019, Received in revised form 26 June 2019, Accepted 19 July 2019, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , https://doi.org/10.1016/j.conbuildmat.2019.07.216 Elsevier Ltd. All rights reserved.

[28] Paulo P.O.L. Dyer, MaryangelaGeimba de Lima, Luis Miguel G. Klinsky, Silvelene A. Silva, Gustavo J.L. Coppio "Environmental characterization of Foundry Waste Sand (WFS) in hot mixasphalt (HMA) mixtures" Received 29 November 2017, Received in revised form 18 March 2018, Accepted 20 March 2018, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , https://doi.org/10.1016/j.conbuildmat.2018.03.151 Elsevier Ltd. All rights reserved.

[29] Arul Arulrajah, EhsanYaghoubi, MonzurImteaz, SuksunHorpibulsuk "Recycled waste foundry sand as a sustainable subgrade fill and pipe-bedding construction material: engineering and environmental evaluation" Received date: 15-6-2016, Revised date: 17-10-2016, Accepted date: 19-10-2016, http://dx.doi.org/10.1016/j.scs.2016.10.009 , Elsevier Ltd. All rights reserved.

[30] Maria Auxiliadora de Barros Martins, Regina Mambeli Barros, Gilbert Silva, Ivan Felipe Silva Santos "Study on waste foundry exhaust sand, WFES, as a partial substitute of fine aggregates in conventional concrete" Received date: 24 June 2018, Revised date: 10 November 2018, Accepted date: 11 November 2018, https://doi.org/10.1016/j.scs.2018.11.017 , Elsevier Ltd. All rights reserved.

[31] RafatSiddique, Geert de Schutter, Albert Noumowe "Effect of used-foundry sand on the mechanical properties of concrete" Received 12 December 2007, Received in revised form 19 March 2008, Accepted 6 May 2008, Contents lists available at ScienceDirect, Construction and Building Materials, Journal homepage: www.elsevier.com/locate/conbuildmat , doi:10.1016/j.conbuildmat.2008.05.005, Elsevier Ltd. All rights reserved.