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Sustainable Concrete with Pigeon Pea Stalk Ash and Recycled Aggregates: A Review

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Abstract: ***Due to the rapid growth of construction activities and increasing concerns regarding environmental sustainability, the demand for eco-friendly and resource-efficient construction materials is increasing day by day. The extensive use of cement and natural aggregates in concrete production leads to depletion of natural resources and higher carbon emissions. To overcome these issues, various waste and agricultural by-products are being utilized as partial replacement materials in concrete. Among them, Pigeon Pea Stalk Ash (PPSA) is used as a partial replacement of cement, while Recycled Coarse Aggregate (RCA) is used as a replacement of natural coarse aggregate. In addition, M-Sand is adopted as an alternative to natural river sand to promote sustainable construction practices. In this study, various papers related to this topic are reviewed in which significant work has already been carried out by researchers. The review focuses on the comparative strength characteristics and performance of sustainable concrete incorporating PPSA, RCA, and M-Sand. With the help of the review of research papers, the effects of these replacement materials on the mechanical properties of concrete are identified, and the conclusive outcomes obtained form the research objectives for further study.***

Keywords: Sustainable Concrete; Pigeon Pea Stalk Ash (PPSA); Recycled Coarse Aggregate (RCA); Manufactured Sand (M-Sand); Compressive Strength; Cement Replacement; Aggregate Replacement; Literature Review; Green Concrete; Construction Waste Recycling.

I. INTRODUCTION

The rapid growth of the construction industry has resulted in increased consumption of natural resources and significant environmental impacts associated with the production of conventional concrete. Cement manufacturing contributes substantially to global carbon dioxide emissions, while excessive extraction of natural aggregates leads to resource depletion and ecological imbalance. To address these challenges, researchers have focused on developing sustainable concrete by incorporating waste and recycled materials as partial replacements for conventional ingredients. Pigeon Pea Stalk Ash (PPSA), an agricultural waste by-product, has emerged as a potential supplementary cementitious material, whereas Recycled Coarse Aggregate (RCA) obtained from construction and demolition waste serves as an alternative to natural coarse aggregate. In addition, Manufactured Sand (M-Sand) is increasingly being adopted as a replacement for river sand due to its availability and consistent quality. Numerous studies have investigated the influence of PPSA, RCA, and M-Sand on the mechanical and durability properties of concrete. This paper presents a comprehensive review of the available literature to evaluate the comparative strength performance of sustainable concrete incorporating these materials and to identify the optimum replacement levels reported by various researchers.

II. REVIEW OF LITERATURE

Anitha Krishnan, Senthil Selvan Subramanian (2025), In this paper the researcher investigated the utilization of pigeon pea stalk ash in concrete by substituting cement content up to 8 percent. A total replacement range from 4 to 12 percent was evaluated through experimental testing for mechanical and durability characteristics. An increase of 6.96 percent in compressive strength was recorded at 8 percent PPSA substitution, while values dropped beyond this limit. Split tensile strength remained equal to control concrete at 8 percent, but surpassed other replacement levels. Flexural strength was observed to be higher in PPSA8 concrete compared to the control mix. Permeability reduction and enhanced acid resistance were also exhibited by PPSA concrete. A significant environmental benefit was achieved by reusing agricultural residue, minimizing cement consumption. Improved strength, durability and sustainability in PPSA concrete were their conclusive outcomes.

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Table: Compressive Strength Mix Design with Pigeon Pea Stalk Ash (PPSA) Replacement

Specimen Type	Material Replacement (%)	Cement (kg)	PPSA (kg)	Fine Aggregate (FA) (kg)	Coarse Aggregate (CA) (kg)	Water (liters)
C	0	390.0	0.0	867	989	176
PPSA2	2	382.2	7.8	867	989	176
PPSA4	4	374.4	15.6	867	989	176
PPSA6	6	366.6	23.4	867	989	176
PPSA8	8	358.8	31.2	867	989	176
PPSA10	10	351.0	39.0	867	989	176

Fig 1: Mix design with PPSA by Anitha Krishnan, 2025

Compressive test results for 28days curing period

S.No	Specimen Type	PPSA %	Compressive strength for 28 days in N/mm²			
			Sample 1	Sample 2	Sample 3	Average
1	CC	0	32.30	33.20	34.10	33.20
2	PPSA2	2	33.46	33.61	32.57	33.21
3	PPSA4	4	30.01	28.06	30.66	29.58
4	PPSA6	6	34.45	33.75	33.18	33.78
5	PPSA8	8	35.15	36.25	35.14	35.51
6	PPSA10	10	26.13	26.29	26.05	26.16

Fig 2: Compressive Strength Results with PPSA by Anitha Krishnan, 2025

Steiner, S., Proske, T., Winnefeld, F., & Lothenbach, B. (2022), In this paper the researcher was focused on the partial replacement of Portland cement clinker with limestone powder, through which economic and ecological benefits were identified while carbonation resistance was examined. The effective CO_2 diffusion coefficient (DCO_2) and water vapour diffusion coefficient (DH_2O) were determined by a developed testing method and detailed analytical evaluation. An increase in both DCO_2 and DH_2O was observed with increasing water to cement ratios from 0.5 to 1.25. At identical water to cement ratios, reductions in DCO_2 and DH_2O together with improvements in compressive strength were achieved through higher limestone contents. A linear correlation between DCO_2 and DH_2O was established for specimens with water to cement ratios ≥ 0.6, whereas a non linear relationship was identified for dense concrete with water to cement ratios ≤ 0.5. DCO_2 values were measured within the ranges of 2.6×10^{-9} to 9×10^{-9} m²/s and 1.9×10^{-7} to 7×10^{-7} m²/s for water to cement ratios of 0.5 and 1.25, respectively. DH_2O values were recorded between 2.8×10^{-8} and 8×10^{-8} m²/s and between 4.5×10^{-7} and 7×10^{-7} m²/s. A predictive model for estimating DCO_2 in concrete containing high limestone contents was derived from correlations among mix design, compressive strength and CO_2 diffusion, which were their conclusive outcomes.

Usman, K. R., Hainin, M. R., Satar, M. K. I. M., Warid, M. N. M., Usman, A., Al-Saffar, Z. H., & Bilema, M. A. (2021), In this paper the researcher was engaged in evaluating the suitability of spent garnet as a fine aggregate replacement in cold mix asphalt, where improvements in sustainability, waste utilization and asphalt surface treatment performance were investigated. Microstructural, crystallinity and compositional analyses were performed through FTIR spectroscopy, XRD and XRF techniques to establish material compatibility and performance potential. The contamination of spent garnet by toxic heavy metals commonly associated with landfill disposal and abrasive blasting activities was also examined. High sand equivalent values of 98% and 89% together with low water absorption values of 0.14% and 0.23% were recorded for AG and MG spent garnets, respectively. The obtained physical properties indicated that both spent garnet grades could effectively replace natural sand in cold mix asphalt applications. Nevertheless, limitations for use in chemically sensitive materials were identified for MG spent garnet because of its compositional characteristics. AG spent garnet was classified as Pyrope while MG spent garnet was predominantly identified as Almandine, the strongest garnet form, with traces of other garnet phases, which were their conclusive outcomes.

Sahoo, S. S., Vijay, V. K., Chandra, R., & Kumar, H. (2021), In this paper the researcher examined the influence of pyrolysis temperature on the physicochemical characteristics of biochar derived from bamboo and pigeon pea stalk residues. Temperatures of 400, 500 and 600 degrees Celsius were applied for 1 hour, producing yields of 32.20 to 27.00 percent for bamboo and 29.80 to 21.70 percent for pigeon pea stalk. Carbon content in biochar ranged between 76.17 and 88.43 percent, with the highest recorded at 600 degrees Celsius. Fixed carbon values spanned from 81.85 to 85.68 percent, confirming significant carbon retention. H to C and O to C atomic ratios between 0.03 to 0.06 and 0.09 to 0.25, respectively, indicated enhanced aromatic and hydrophobic properties. BET surface areas ranged from 16.90 to 307.10 square meters per gram, highest at 600 degrees Celsius. Alkalinity increased with temperature, ranging from 7.25 to 10.14. Functional groups were eliminated and mineral enrichment was achieved at higher temperatures, were their conclusive outcomes.

Zerihun, B., Yehualaw, M. D., & Duy-Hai Vo. (2022), In this paper the researcher reviewed the chemical and physical properties, all containing aluminosiliceous compounds suitable for pozzolanic action. Finer particle size and larger surface area compared to cement were identified, influencing fresh concrete properties. Workability was reduced when BLA, CCA, RHA and SCBA were introduced due to their finer particles. Mechanical performance improved with BLA, RHA and SCBA, supported by secondary reactions of amorphous silica. Denser tetrahedral gel structures and improved microstructure were revealed through SEM and XRD analysis. Durability also improved as denser morphology reduced permeability and enhanced resistance. Replacement up to 10 percent was found effective without quality loss, were their conclusive outcomes.

Abedom, F., Sakthivel, S., Asfaw, D., Melese, B., Solomon, E., & Kumar, S. S. (2021), In this paper the researcher explored the experimental development of hybrid composites using sugarcane bagasse fiber and bamboo charcoal for technical applications. Five composite ratios ranging from 100 percent bagasse to 100 percent charcoal were reinforced with 65 percent polyurethane foam and processed through compression molding. Mechanical testing following ASTM standards revealed a maximum tensile strength of 255.80 megapascals, nearly equal to 260.10 megapascals of artificial fiber composites. The 30 to 70 ratio composite showed superior thermal insulation and the highest impact and flexural strengths among all variants. Morphological analysis confirmed effective fiber alignment and internal bonding. The thermal insulation coefficient increased significantly in bamboo-rich composites. The integration of natural materials enabled promising performance in structural and insulating aspects. Potential for automotive interior applications using eco-based composites were their conclusive outcomes.

Priyanka Luthra, Ram Singh, GS Kapur, (2019), In this paper the researcher investigated the effectiveness of Laccase enzyme treatment, sodium hydroxide treatment and potassium permanganate. The treatment were performed and analyzed through SEM, XRD, FTIR, TGA and XPS techniques. Significant reduction in lignin and hemicellulose content was confirmed post-treatment. An increase in percent crystallinity and improved thermal stability were recorded in the modified fibers. Morphological observations indicated enhanced surface area and roughness following treatment. These surface modifications improved the bonding potential with polymer matrices. The role of each chemical agent in structural transformation was identified. Stronger interfacial adhesion and composite performance were their conclusive outcomes.

Sathvik S, Suchith. S, Edwin. A, Jemimahcarmicheal. M, Sheela. V, (2019), In this paper the researcher evaluated the use of biomedical waste ash as a partial replacement for cement in concrete up to a level of 15 percent. A slight reduction in concrete density was observed with increasing replacement levels and workability was found to be lower than that of conventional concrete. Compressive strength decreased overall, yet 5 and 10 percent replacements delivered favorable results, while 15 percent led to significant reduction. Split tensile strength at 5 and 10 percent replacement nearly matched that of conventional concrete and showed excellent performance. Strength loss was noted at 15 percent replacement for both compressive and tensile properties. A consistent trend of mechanical decline beyond 10 percent was confirmed through experimental data. Hence, 10 percent BMW ash was identified as optimal for structural applications, were their conclusive outcomes.

Yadav, A. K., Chandel, V. S., Rai, A. K., Dwivedi, A., Kumar, V., & Raj, J. (2024), In this paper the researcher conducted a comparative investigation of pigeon pea and santa maria feverfew fiber-based lime concretes using both destructive and non-destructive testing methods. A compressive strength increase of 33.3 percent was recorded in concrete blocks containing 3.45 percent SMF fiber compared to those with equal PP fiber content. Ultrasonic pulse velocity testing revealed the lowest wave transmission in PP fiber-based concrete and the highest in plain lime control blocks. Concrete blocks were cast and evaluated for structural and thermal responses using standard instruments. Lightweight nature and improved insulation performance were confirmed for agro-waste based compositions. Suitability for non-load bearing and insulation purposes in construction systems were their conclusive outcomes.

Manikanta, C., Manikandan, P., Duraimurugan, S., Elavenil, S., & Vasugi, V. (2020), The pozzolanic activity of agro-waste ashes like rice husk ash, cocoa fruit shell ash, corncob ash, bamboo leaves ash, sugarcane bagasse ash have been tested and compared using the strength activity test, the saturated lime test and the Frattini test with the implementation of Artificial Intelligence using Neural Network was carried out. It is observed that Rice husk ash, corncob ash, bamboo leaf ash, sugar cane bagasse ash have the potential to be replaced for Cement while cocoa fruit shell ash does not have the expected pozzolanic activity. The predicted pozzolanic strength property of the different agro-waste ashes with the utilization of Artificial Neural Network was observed to correspond with experimental values.

Zalegowski, K. (2021), In this paper the researcher was concerned with evaluating the influence of polymer concrete sample geometry and dimensions on ultrasonic wave propagation characteristics through an extensive experimental investigation. The compositions of fly ash based polymer concretes were determined using a material optimization approach and specimens were prepared in three distinct shapes, namely cubes, beams and plates. Ultrasonic measurements were conducted by the direct transmission method using a digital ultrasonic flaw detector equipped with piezoelectric transducers operating at a central frequency of 100 kHz. Fourier transform and Fourier based synchrosqueezing transform techniques were employed. The time frequency domain analysis demonstrated greater sensitivity to geometric variations than conventional frequency spectrum evaluation and proved effective for assessing particulate composite properties when pulse velocity changes were less distinguishable, which were their conclusive outcomes.

Ayenan, M. a. T., Danquah, A., Ahoton, L. E., & Ofori, K. (2017), In this paper the researcher examined the socio-cultural drivers and varietal diversity of pigeonpea cultivation among 302 farmers across Benin using structured surveys, field visits and focus group discussions. Medicinal applications for stems and leaves were identified for conditions such as malaria, dizziness, measles and eye infections. Statistical analysis revealed a significant link (P less than 0.01) between medicinal use and farmers' ethnic group and residence, while no association (P greater than 0.05) was found with age, gender or household size. White seed coat varieties were most cultivated, whereas black, red and mottled seeds faced neglect. Farmers classified pigeonpea varieties by seed color, size, plant height, maturity and cooking time. Gender showed no significant effect in the number of varieties held, confirmed through the Mann-Whitney test. Vertical transmission of medicinal knowledge and need for targeted conservation were their conclusive outcomes.

Subramanian, A., Selvaraj, S. K., Mani, R., Chandrasekaran, P., Kunjuraman, S., Guru, R., & Santhanam, S, (2024), In this paper the researcher examined the socio-cultural drivers and varietal diversity of pigeonpea cultivation among 302 farmers across Benin using structured surveys, field visits and focus group discussions. Medicinal applications for stems and leaves were identified for conditions such as malaria, dizziness, measles and eye infections. Statistical analysis revealed a significant link (P less than 0.01) between medicinal use and farmers' ethnic group and residence, while no association (P greater than 0.05) was found with age, gender or household size. White seed coat varieties were most cultivated, whereas black, red and mottled seeds faced neglect. Farmers classified pigeonpea varieties by seed color, size, plant height, maturity and cooking time. Gender showed no significant effect in the number of varieties held, confirmed through the Mann-Whitney test. Vertical transmission of medicinal knowledge and need for targeted conservation were their conclusive outcomes.

Sokolova, L. N. S., Ermakova, E. V., & Rynkovskaya, M. (2018), In this paper the researcher identified several research limitations regarding agro-waste-based concrete materials, particularly in their mechanical, chemical and durability evaluations. Tensile and flexural strengths were not sufficiently explored, despite their relevance for structural use in rural construction. Chemical compositions of OPS, CNS and WNL were not provided and their heterogeneous nature demands homogenization through further experimentation. The impact of technological processing on mixture behavior, along with cost, machinery and time requirements, was not detailed. Resistance to fire, wear and elution under tropical conditions was not addressed in final element design. Long-term strength behavior was insufficiently studied, with most results limited to 28-day curing. Later strength reductions observed at 360 and 540 days confirmed the need for durability testing. Extended performance validation under environmental stressors were their conclusive outcomes.

Nimitha Vijayaraghavan and A S Wayal, (2013), In this paper the researcher analyzed the influence of manufactured sand as a complete and partial replacement for natural river sand in concrete mixes. All replacement levels demonstrated increased compressive strength when compared to the reference mix with 0 percent replacement. A 50 percent replacement combined with admixture led to a compressive strength rise of 5.7 percent. The maximum increase of 7.03 percent was recorded at 100 percent replacement with crushed sand. However, a noticeable harshness in mix texture was observed as manufactured sand proportion increased. Workability challenges emerged alongside strength improvements. Full replacement of river sand by manufactured sand

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was validated through experimental results. Structural performance and material sustainability enhancement were their conclusive outcomes.

Begam, S. U., R Raja, M., M Rahim, M. I., Gurunathan, S., & Vani, G. (2018), In this paper the researcher investigated the impact of manufactured sand from multiple sources on the workability of concrete across varying water to cement ratios of 0.3, 0.35, 0.4, 0.45 and 0.5. Slump cone and compaction factor tests were performed to evaluate consistency and compaction behavior. Significant variations in workability were observed depending on the water-cement ratio and origin of M-Sand. Admixtures were introduced at lower water-cement ratios to enhance workability without compromising mix quality. Despite M-Sand requiring higher water content and exhibiting reduced air content, improved workability was achieved. The type of parent rock was found to influence M-Sand behavior. Optimized concrete mixes with better performance using varied M-Sand sources were their conclusive outcomes.

Padmanaban, R., & Ahamed, A., M. Tech (CEM). (2020), In this paper the researcher explored the role of manufactured sand as a fine aggregate alternative to natural river sand in concrete production. Physical and mineralogical differences between M-Sand and natural sand were found to significantly affect workability, strength and durability. Higher compressive and flexural strengths were achieved using M-Sand compared to natural sand. However, strict quality control during the M-Sand manufacturing process was emphasized as essential. Economic advantages of M-Sand usage in concrete applications were also identified. Mix design procedures tailored for M-Sand-based concrete were detailed for construction standards. Expectations from the user industry regarding consistency and performance were outlined. Enhanced mechanical performance with cost-effectiveness were their conclusive outcomes.

Roushan Kumar, Mithun Kumar Rana, Pushpendra kumar kushwaha, (2024), In this paper the researcher reviewed experimental studies published between 2010 and 2017 to assess the performance of crushed sand as a replacement for natural sand in concrete. Enhanced compressive and flexural strength was reported with crushed sand, especially in higher-grade mixes. A reduction in workability was consistently observed due to the angular shape and rough texture of M-Sand particles. Natural sand, being round and smooth, showed better workability through reduced internal friction. M-Sand, free from sulphates, chlorides and organic impurities, improved durability and strength with no adverse environmental effects. Pre-sieved particle size below 4.75 millimeters prevented material loss. Overall, M-Sand proved to be a more economical and effective alternative, were their conclusive outcomes.

Tharshigan, T., Kajaharan, T., & Baskaran, K. (2019), In this paper the researcher investigated the application of manufactured sand as a full replacement for natural river sand in concrete, along with partial cement replacement using fly ash. A total of 72 concrete cubes were cast in three sets: one with 100 percent river sand, one with 100 percent manufactured sand and one combining 100 percent manufactured sand with 25 percent fly ash. Compressive strength was measured at 7, 28 and 56 days to assess mechanical performance. Durability was examined through water absorption, water permeability and sorptivity tests. Higher strength and improved durability were consistently observed in mixes with manufactured sand. The mix with fly ash also performed effectively under long-term exposure conditions. Enhanced material efficiency and sustainability through alternative aggregates were their conclusive outcomes.

Tejaswini Nandipati, Eswar Venkata Sai Akula, Issac Galinki, Rahul Billa, (2024), In this paper the researcher critically assessed the performance of manufactured sand in concrete with respect to workability, strength and durability parameters. M-Sand produced by crushing granite or basalt was evaluated as a replacement for natural sand under specific grading and shape conditions. Studies confirmed that M-Sand can maintain or improve concrete quality when appropriately processed. Environmental impact was reduced and construction cost lowered due to decreased reliance on river sand sources. Strength and durability properties were found to be acceptable across varying mix designs. Economic and ecological benefits were supported by experimental evidence. Concerns regarding quality variation and long-term performance were acknowledged. Sustainable use of M-Sand in concrete applications were their conclusive outcomes.

Tushar R Sonawane, Prof. Dr. Sunil S. Pimplikar, (2024), In this paper the researcher was focused on the mechanical and fresh state properties of recycled aggregate concrete, including compressive strength, flexural strength and workability, were assessed for different combinations of recycled and natural aggregates. The increasing adoption of recycled aggregates in numerous construction projects across European, American, Russian and Asian countries was reviewed together with the infrastructural policy relaxations introduced to promote their utilization. Codal provisions and guidelines governing recycled aggregate concrete in various countries were analyzed to understand their implications for practical concreting applications. The current status of recycled aggregate usage in India, along with future requirements and opportunities for wider implementation, was critically evaluated. The findings indicated that recycled aggregates can effectively contribute to sustainable construction practices while maintaining acceptable concrete performance, which were their conclusive outcomes.

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Table 2: Compressive strength

Compressive Strength	Replacement Of Natural Aggregate			
	0%	10%	20%	30%
M30-3Days	20.63 N/mm^2	16.38 N/mm^2	19.05 N/mm^2	18.46 N/mm^2
M30-7 Days	33.13 N/mm^2	23.83 N/mm^2	31.93 N/mm^2	28.05 N/mm^2
M30-28 Days	47.53 N/mm^2	42.28 N/mm^2	43.92 N/mm^2	40.27 N/mm^2
M40-3 Days	31.59 N/mm^2	28.44 N/mm^2	27.56 N/mm^2	25.78 N/mm^2
M40-7 Days	56.67 N/mm^2	53.69 N/mm^2	51.69 N/mm^2	49.78 N/mm^2
M40-28 Days	64.42 N/mm^2	60.44 N/mm^2	56.22 N/mm^2	54.22 N/mm^2

Fig. 3: Compressive Strength results by Tushar R Sonawane, 2024

Md. Sabbrojjaman, Ruman Mia,Tafsirojjaman, (2019), Recycled coarse aggregate (RCA) is produced by crushing the demolition waste from concrete structures. To determine the strength properties of RCA concrete depending on the various content of RCA and to compare them to the strength properties of concrete made with conventional coarse aggregates (CCA). The fine aggregates of high FM of 3.0 was used for recycled and conventional concrete. After performing the compressive strength test, it was found that concrete made with full replaced RCA have less strength than concrete made with CCA but not much. But partial replaced RCA concretes are showing comparable strength with CCA concrete whereas it is cheaper than CCA aggregate concrete. So, RCA can be used as a partially replacement of CCA in concrete production. In addition, full replacement of RCA can be used in structures of less importance such temporary walls, base of roads etc.

Anusuri Uma Maheswari, B. Naidu Babu, K. Jagan, (2021), In this paper the researcher was engaged in assessing the physical properties of recycled aggregates and natural aggregates were determined and compared to evaluate their suitability for concrete production. Recycled concrete aggregate was incorporated as a partial replacement of natural aggregate by weight at levels of 0%, 10%, 20%, 30% and 40% in the concrete mixtures. Concrete cube specimens were prepared, cured and tested under laboratory conditions to determine workability and compressive strength characteristics. Experimental observations indicated that the mechanical performance of concrete was influenced by the percentage of recycled aggregate replacement. A slight reduction in compressive strength was recorded for mixtures containing recycled aggregate replacements up to 30% when compared with conventional concrete. The effective utilization of site generated concrete waste for producing economical, resource efficient and environmentally sustainable concrete mixtures was demonstrated, which were their conclusive outcomes.

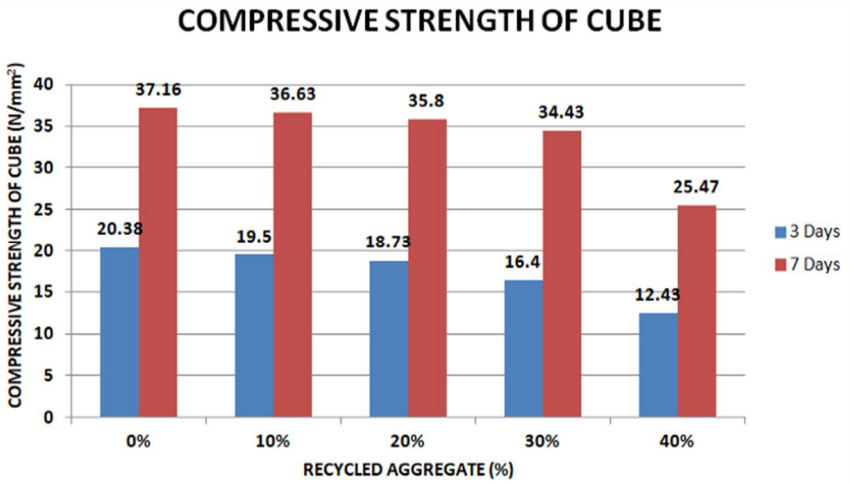

Fig. 4: Compressive Strength results by Anusuri Uma Maheswari, 2021

Pranto Saha, Md. Wahid Hassan Shihab, (2022), In this paper the researcher was concerned with the applicability of RCA as a partial as well as full replacement for virgin coarse aggregate in concrete mixtures was investigated. Increasing interest within the construction industry toward the adoption of recycled concrete aggregate for economical and environmentally responsible construction practices was identified. Reductions in waste generation, disposal charges and transportation costs were achieved through the reuse of recycled aggregates near demolition and construction locations. The suitability of recycled concrete aggregate for non-structural concrete applications, as reported by numerous researchers, was reviewed and assessed which were their conclusive outcomes.

Vinay Kumar, Er. Rohit Kumar, Dr. Gurvinder Singh, (2024), In this paper the researcher was directed toward addressing the diversion of substantial quantities of concrete waste from landfills through the utilization of recycled coarse aggregates was evaluated for its contribution to sustainable waste management practices. The replacement of natural aggregates with recycled coarse aggregates was analyzed to determine its environmental, technical and economic advantages in concrete production. Significant reductions in the demand for virgin aggregate resources were achieved through the incorporation of recycled coarse aggregates, thereby promoting resource conservation. Lower energy consumption, reduced transportation requirements and decreased greenhouse gas emissions throughout the construction lifecycle were identified as major benefits of recycled aggregate utilization. The adoption of recycled coarse aggregates was established as an effective strategy for sustainable concrete production and environmental protection, which were their conclusive outcomes.

Dr. K. Ramadevi, Dr. R. Chitra, (2017), In this paper the researcher was motivated by the global generation of approximately 1.3 billion tonnes of solid waste annually, of which nearly 50% was attributed to building materials and construction related activities. RCA were produced from concrete debris collected from a waste yard, after segregation, crushing through a jaw crusher, sieving, washing and processing for concrete production. M25 grade concrete mixtures were prepared with recycled coarse aggregate replacement levels of 0%, 30%, 60% and 100% in place of natural coarse aggregates. The RCA were characterized by greater angularity, higher water absorption and higher specific gravity than natural coarse aggregates, resulting in enhanced strength and improved load carrying capacity. The feasibility of utilizing RCA for effective Construction and Demolition waste management and sustainable concrete production was demonstrated, while further investigations on durability and workability enhancement were recommended, which were their conclusive outcomes.

Nayanasree Kadarla, Rakesh Siempu, B. Murali Krishna, (2024), In this paper the researcher was focused to enhance aggregate quality. Acid treatment using HCl, base treatment using NaOH and mechanical treatment methods were applied to recycled coarse aggregates prior to their incorporation into concrete mixtures. The aggregate characteristics including water absorption, specific gravity, bulk density, abrasion resistance, impact resistance and crushing values were systematically determined and evaluated. Significant improvements in the physical and mechanical properties of RCA were achieved after treatment when compared with untreated recycled aggregates and natural aggregate benchmarks. The treated RCA were utilized as a 100% replacement for natural coarse aggregates in M30 standard strength concrete and M65 high strength concrete mixtures. Enhanced hardened concrete properties together with improved aggregate performance demonstrated the viability of treated recycled aggregates for sustainable and high performance concrete applications, which were their conclusive outcomes.

Abbas Haghollahi, Mohsen Besharat Ferdous, Mehdi Kasiri, in this paper studies are carried out in 2 steel framed high rise building 20 & 25 storied high braced by outrigger and belt truss system. This investigation is done by response spectrum and non- linear time history analysis by SAP software. The aim of this study is to find the optimum location of outrigger beams against lateral load within the building. The result of the study shows that stories drift ratio is kept away from the outcomes of response spectrum analysis. On the contrary the procedures trend is reversed for time history analysis. Outrigger beam location critically influences the structure's lateral behavior under seismic load. Outrigger and belt truss optimum location is at 10th and 14th story for 20 and 25 storied model respectively by response spectrum method on the other hand optimum location is 14th and 16th storey for 20 and 25 storied model respectively by time history analysis. Still the study claims that the optimum location is preferably upper levels for each specific case as per site condition.

Shivacharan K, Chandrakala S, Karthik N M, in this paper an effort is made to explore the effect of belt truss and outrigger location in a building when subjected to both the cases of seismic and wind load one by one. Assumption made for wind load calculations is based on IS 875 (Part III) and similarly earthquake load by IS 1893 (Part I):2002. To analyze the response of above study a 30 storied vertically irregular multistory building model is proposed providing belt truss and outriggers at different levels are analyzed against various parameters. Drift and displacement of the structure under compression is studied. Linear static analysis is conducted for evaluation of outrigger and belt truss performance by E tabs software. The result of the study shows that our assumption of using outrigger and belt truss is proved efficient against lateral load and stiffness is increases in high rise structure. More precisely it can be stated that outrigger optimum location is 0.5 times of its height.

Mohd Abdus Sattar et. al. ,this paper involve the comparative study limited to RC high rise building of 15, 20 and 25 stories with shear core, outrigger and belt truss. The plan area of the building is bay frame in the spread area of 40mX40m having columns placed at 5m apart from center to center. But the study is carried out for L shaped plan for floor rigidity with several models built without and outrigger and belt truss and 4 more cases with shear wall core and stringer beam with variable location of both one at a time each so as to understand the effect of each system effectively. The study is conducted by E tabs software for both wind loads and earthquake loads against various factors. The conclusions of the research shows presence of combination of double core shear

wall, stringer beam and floor rigidity increases the stiffness of the structure. Floor rigidity is not necessarily increased for dead load and live load on floors. Combination of double core and stringer beams show a minimum of column forces and moments and also the drift and displacement is relatively less. Also corner columns have lesser moment as compared to outer one.

J.C.D. Hoenderkamp, in this paper optimum location of outriggers on shear wall with basement fin extensions was found by graphical means for preliminary design of multistory high rise building against horizontal loading. In this method we need seven parameters comprises of shear wall bending stiffness, fin-walls and outrigger, outrigger racking shear stiffness, bending stiffness by exterior column, shear wall's rotational stiffness and foundation of column. Clubbing all the parameters provide a base for optimization for optimum level of outrigger and displayed in graphical form. All the study is carried out in form of characteristics equations to find the optimum location of outriggers. The assumption of basement fin wall reduce the translational stiffness of the piles to zero value and so providing an infinite value for characteristics non dimensional parameter. The mishmash of shear wall braced with outrigger and additionally providing basement fin wall facilitates optimum location of outrigger and maximum horizontal displacement.

P.M.B. Raj Kiran Nanduri et. al., focuses their study on analyzing the behavior of outrigger system, optimization of its location and its efficiency while using three outriggers in a structure. Various models are framed for a 30storied high rise building with belt truss and outrigger placed in structure against both wing and seismic loadings for lateral displacement reduction. The analysis is done for Reinforced concrete high rise building of 90m height with a plan area of 38.5mX38.5m with column to column spacing of 5.5m by E tabs software. A total of seven different models are framed with or without outriggers placed at various locations. The result of the study shows that stiffness is increased by the use of aforesaid system also structural efficiency is improved. It is also found that placing of outrigger at the top is not so effectual but the use of second outrigger with cap truss at middle height of the structure is more efficacious.

A. Rutenberg, D. Tal, presents a numerical study and results of the study to investigate the drift reduction with rigid outriggers against various lateral load distributions in uniform and non -uniform belted structure. The assumption of the analysis are axial rigidity of periphery column and flexural rigidity of core, belts arm are infinitely rigid, neglecting shear deformations and frame action is precluded by pinning floor girders. On the basis of above analysis author makes an effort to study to investigate the influence caused by location of outrigger perimeter column to core stiffness ratio and variation of stiffness. The result of the study shows that outrigger efficiency is fully achieved by use of two outriggers for full mobilization of perimeter columns. Also the outriggers are not placed very proximate to the base of the structure.

J.C.D. Hoenderkamp, has made an attempt to analyze horizontally loaded tall building performances laterally supported by vertical trusses and horizontal offset riggers that are placed in the front face of the structure along the direction of lateral loading. The analyses is performed against various structural parameters viz. trussed frames, façade rigger and perimeter frame. Several structural properties are discussed like location of façade rigger, horizontal deflection reduction, bending moment of trusses and belt truss. The outcomes of the study are increasing thickness of floor slab affects movement of faced rigger, increment in the deflection reduction and also it is significant too. By increasing the restraining moment there is an increment in the reduction of the bending moment. This method shows positive signs for allowing façade riggers perpendicular to the direction of horizontal loading.

Abeena mol N M, Rose mol K George, this research work is carried out on a 30 storied high rise core wall building. For this study a building with plinth area 38.5m X 38.5m is taken for consideration. This study is carried out by time history analysis and push over analysis. Maximum storey displacement is taken as key parameter to evaluate the performance of various outrigger systems with respect to conventional structure by E tabs software. Also we need to make this model economic along with structurally feasible. The aim of the study also includes excessive drift control due to lateral load and to evaluate the outrigger efficiency at various levels in multistory building. The results of the study shows with the increment of storey height lateral displacement are also increases. Also the major concluding outcome is stiffness and stability substantially increases against lateral loads while using outrigger structural system for high rise building.

Akshay A. Khanorkar, Mr. S. V. Denge, Dr. S. P. Raut, in this review paper the work is done on study of various research work done previously in the field of outrigger system. In some cases belt truss is used to resist lateral load and alter deflection. In some studies outrigger is proved better than belt truss system. In some research paper belt truss used in steel building to connect the entire periphery column, in this paper shear core is not directly connected to belt truss. Similarly a lot of research paper shows various techniques and methodologies adopted to resist lateral load i.e. both wind load and seismic forces against various constraints and also various valuable results and solution is also obtained which shows the use of outrigger and belt truss system along with shear wall and shear core is much beneficial and efficient. The conclusive outcomes of this study is the author find needs to further research on stiffness irregularity along with structural height.

Goman W. M. Ho, in this paper the special review is presented on the outrigger system that how the system works in tall buildings, its development history and its application. This paper initially tells about the early phase of high rise building, the first high rise building "Equitable Life assurance Building", a 40m tall building in New York (1870). Further the concept of evolution of structural resisting elements and development of structural systems which helps in fulfilling the dream of today's skyscrapers. Later the concept of outrigger is discussed in the paper which explains that perimeter and internal core is needed to be coupled and work as a system to resists the lateral load. After that location and topology is discussed in which the location identified in some paper is discussed. Also design issues are discussed. After that various types of adjustable outrigger system is suggested, some of them are cross jack system, Shim-plate correction method and retro casting techniques in outrigger construction. Various other methods are discussed like damped outrigger system and concrete outrigger system with structural fuse.

III. CONCLUSIONS AND OUTLINE OF PROPOSED WORK

The conclusive outcomes drawn from the study are enlisted below:

1) The reviewed literature confirms that agricultural waste ashes, recycled aggregates, and manufactured sand can be effectively utilized as sustainable alternatives to conventional concrete materials.
2) Most previous studies have focused on the individual application of Pigeon Pea Stalk Ash (PPSA), Recycled Coarse Aggregate (RCA), or Manufactured Sand (M-Sand), with limited research on their combined utilization.
3) Research related to PPSA is comparatively limited when compared with other agricultural waste ashes such as Rice Husk Ash and Bagasse Ash.
4) The influence of varying replacement percentages of PPSA combined with RCA and M-Sand on the strength characteristics of concrete has not been comprehensively established.
5) A detailed investigation is required to evaluate the suitability of PPSA as a partial replacement of cement and RCA as a partial replacement of natural coarse aggregate in M-Sand-based concrete.
6) The proposed work includes material characterization through sieve analysis, aggregate impact value, flakiness and elongation index, and silt content tests in accordance with relevant IS standards.
7) M30 grade concrete mixes containing different proportions of PPSA and RCA with 100% M-Sand will be prepared and tested to evaluate their compressive strength performance after curing.
8) The primary objective of the proposed study is to identify the optimum replacement levels of PPSA, RCA, and M-Sand that can achieve satisfactory strength while reducing the consumption of cement, natural aggregates, and river sand, thereby promoting sustainable concrete production.

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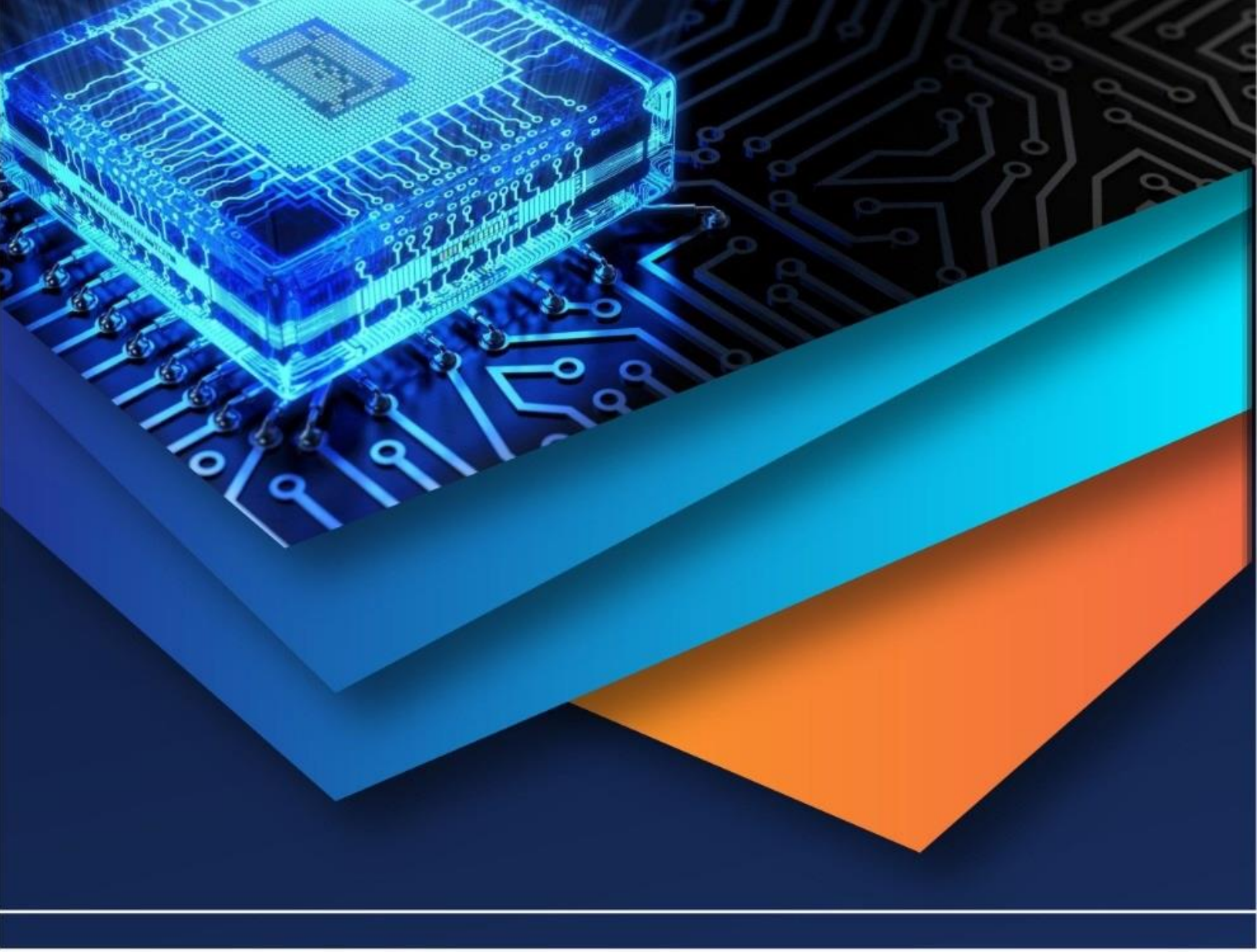

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