The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM), 2025

Volume 37, Pages 223-232

ICEAT 2025: International Conference on Engineering and Advanced Technology

Mechanical Properties of Modified Porous Concrete Incorporating Different Types of Lightweight Aggregate

Mosah Salman Abdulsada
University of Al-Qadisiyah

Huda Haroon Gghail
University of Al-Qadisiyah

Tumadhir Merawi Borhan
University of Al-Qadisiyah

Abstract: The objective of this experimental study is to explore the impact of utilizing two kinds of lightweight aggregates ‹as partial substitutions for natural coarse aggregate ‹on the porous concrete mechanical performance. The study focuses on splitting tensile, compressive and flexural strength tests of such type of concrete incorporated pumice and LECA at a replacement volumetric ratio of 10%. The effect of internal curing provided by the lightweight aggregates on compressive strength was also examined. To enhance the mechanical performance styrene butadiene rubber (SBR) was added to selected mixes. The results obtained showed that replacing natural coarse aggregate with LECA significantly increased compressive strength while pumice led to a reduction. The inclusion of SBR further improved compressive strength particularly in the LECA mix under dry curing conditions where a maximum strength of 15.4 MPa was recorded. Although the incorporation of both lightweight aggregates initially led to a decline in tensile and flexural strengths, the addition of SBR effectively minimized these losses resulting in significant improvements especially in mixes containing pumice. Furthermore, the LECA mix under dry curing achieved a compressive strength of 10.7 MPa relative to 8.8 MPa for the reference mix which highlights the benefits of internal curing via pre-wetted lightweight aggregates. Overall, the findings obtained suggest that the combination of LECA and SBR delivers superior mechanical performance making it a promising solution for parking lots, pavers, and light traffic roads.

Keywords: Porous concrete, Mechanical properties, Styrene butadiene rubber, Lightweight aggregate

Introduction

The widespread and continuous urban development across the globe involving building and road development has significantly impacted the environment, especially through the substitution of green spaces with impermeable asphalt and concrete surfaces, particularly in metropolitan areas. This transformation presents major challenges for cities in managing rainwater and surface runoff which often becomes contaminated with organic and inorganic pollutants threatening the quality of both surface water and freshwater resources. As noted by Soulé (1991) "by the time the disappearance of wildlife is observed by the human inhabitants of a new subdivision, it is too late to take any action". Consequently, mitigating the environmental effects of rainwater and runoff has led to the development of alternative paving systems such as porous concrete (PC), which offers a more environmentally friendly infrastructure solution.

PC, also known as fine-free concrete, supports sustainable development by meeting current needs without compromising those of future generations (Obla & Sabnis, 2011). It is used in various paving applications including footpaths, parking lots, tennis arenas, slope stabilization, road shoulders, alleys, and roads with low traffic volumes. Although PC is highly effective for surface water management, its practical use is limited by its low strength and high porosity (Neithalath et al., 2010). To address some of these limitations, lightweight aggregates (LWAs) have been introduced into PC. Due to their porous structure, LWAs reduce overall weight and provide excellent thermal and sound insulation.

Pumice aggregate (PA) is a type of lightweight natural aggregate with a sponge like structure formed from volcanic lava that has solidified after releasing gases (Bnci et al., 2012). There are two natural kinds of pumice: acidic and basaltic, with basaltic pumice having a strongly higher density (Zaetang et al., 2013). Pumice has been widely used in several countries in porous concrete applications due to its availability, ease of transport, and cost effectiveness (Hossain, 2004; Hariyadi & Tamai, 2015; Stratoura et al., 2018). Another commonly used LWA is Lightweight expanded clay aggregate (LECA) made by heating natural clay in rotary kiln at a temperature between 1100°C and 1300°C. At this temperature the clay expands and forms lightweight granules with a porous and solid structure (Qureshi et al., 2017). The LECA characteristics depend on the raw materials, production process, and any additives used (Vaickelionis et al., 2011).

Teymouri et al. (2020) explored the potential of PC to improve the quality of wastewater and rainwater by incorporating mineral sorbents such as pumice, LECA, perlite, and zeolite. Their study investigated the effects of these materials on compressive strength, the water permeability coefficient and porosity by replacing natural coarse aggregates at 5%, 10%, and 15% by weight. Results obtained showed that zeolite was the most effective in reducing suspended solids biochemical oxygen demand, and chemical oxygen demand achieving reductions of 40%, 48%, and 30.5%, respectively.

Furthermore, zeolite and pumice mixes demonstrated the highest values of permeability compressive strength, and porosity relative to other types of aggregate. Despite the benefit of pollutant removal, a drawback of using absorbent materials in PC is their interaction with cement which can penetrate their pores and reduce their absorption capacity (Azad et al., 2019). Karami et al. (2018) found that using pumice and LECA in PC did not negatively impact performance while contributing to a reduction in weight.

PC’s low compression strength is primarily a result of the weakness of cement paste and aggregates' bond as well as its high porosity resulting from the absence of fine aggregates. To improve its mechanical performance, polymeric latex such as Styrene Butadiene Rubber (SBR) can be incorporated (Diab et al., 2013). Latex is a water-based emulsion of spherical polymer particles that integrates well into concrete mixtures (Jamshidi et al., 2014). These particles coalesce during curing to form membranes, which improve mechanical performance by enhancing the bond between components (Ohama, 1998).

Although several studies have explored porous concrete, few have focused on lightweight porous concrete modified with polymers. This study, therefore, investigates the use of two kinds of LWAs pumice and LECA in PC, with and without the addition of 5% SBR by cement mass. The LWAs replaced 10% of the natural coarse aggregates by volume. The mixes mechanical characteristics including splitting tensile, compressive, and flexural strengths were examined and contrasted to a reference mix containing only natural coarse aggregate.

Materials and Methods

Materials

In the present experimental study, CEM I 42.5R-SR3.5 sulphate-resistant Portland cement, commercially known as Al Jiser and conforming to Iraqi specification (IQS. No.5, 2019), was used. Its chemical composition, along with its physical characteristics are tabulated in Table 1. Uncrushed spherical gravel, conforming to Iraqi specification (IQS. No.45, 1984) was utilized as a natural coarse aggregate (NCA). The gravel has a specific gravity of 2.6 and a water absorption rate of 0.9%. Two types of lightweight aggregates (LWAs) were incorporated: pumice aggregate (PA) and a structural lightweight expanded clay aggregate, commercially known as HD. Table 2 summarizes LWA's physical characteristics.

All aggregates utilized in this study were sieved to obtain a monogranular gradation with 5-10 mm grain size (passing through a 10 mm sieve and retained on a 5 mm sieve). The morphological characteristics of the aggregates are depicted in Fig. 1. A Styrene butadiene rubber latex (SBR), commercially available as Cempatch SBR 100, was also employed. This latex is a milky fluid characterized by pH value of 10.7, solid content of 57%, and specific gravity of 1.02,.

Table 1. Cement chemical composition and physical characteristics

Chemical Composition			
Chemical analysis		IQS. No.5:2019 Limits	Test value %
SiO_2		---------	22.788
CaO		---------	62.942
Fe_2O_3		---------	3.372
Al_2O_3		---------	3.321
MgO		$\leq$ 5%	2.819
SO_3		C3A < 3.5% $\leq$ 2.5% or C3A > 3.5% $\leq$ 2.8%	1.814
I.R.		$\leq$ 1.5%	0.936
L.S.F.		0.66–1.06	0.875
L.O.I.		$\leq$ 4%	2.864
C_2S		---------	28.313
C_3S		---------	49.073
C_3A		$\leq$ 3.5%	3.095
C_4AF		---------	10.261
Physical characteristics			
Test		IQS. No.5:2019 Limits	Test value %
Initial setting time minutes		$\geq$ 45	60
Final setting time hours: minutes		$\geq$ 45	60
Fineness (m^2/kg)		$\geq$ 280	312
Compressive strength (MPa)	2 days	$\geq$ 20	21.98
	28 days	$\geq$ 42.5	57.44

Table 2. LWAs physical characteristics

Characteristic	PA	HD	Testing standard
Specific gravity	1.8	1.1	ASTM C1761
Water absorption	14%	14%	ASTM C1761
Crushing strength (MPa)	2.77	5.5	BS EN 13055-1
Loose bulk density (Kg/m^3)	728	643	ASTM C29

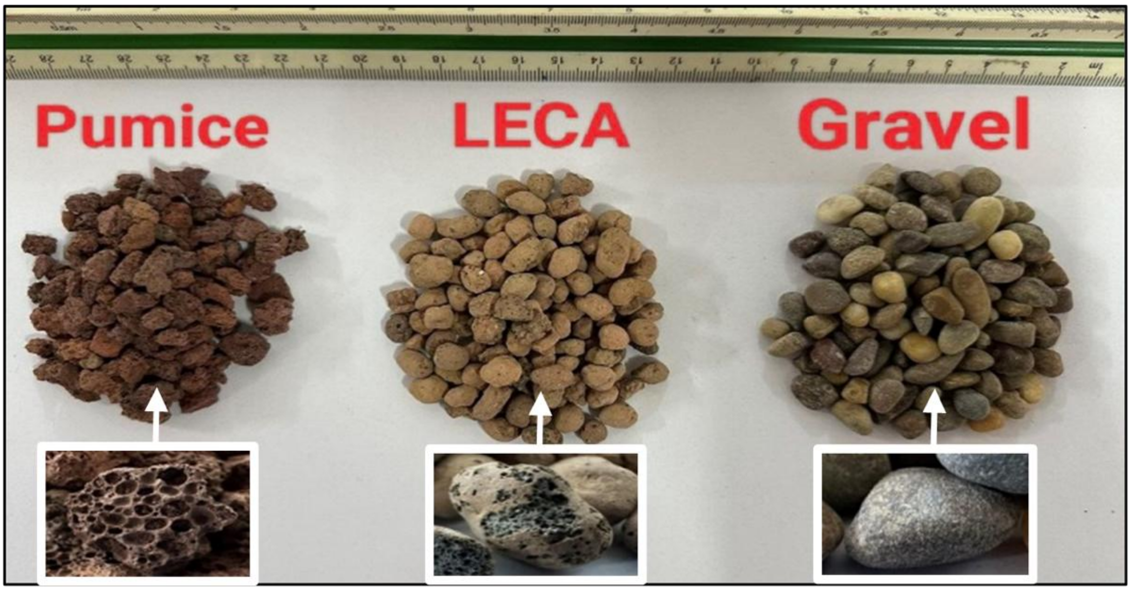

Figure 1. The morphological characteristics of the used aggregates

Mix Proportions

Five porous concrete mixes were designed with a cement: aggregate (C:A) ratio of 1:4.127 by mass and a fixed water/cement ratio (w/c) of 0.32, based on the recommendations of (ACI 522R-10, 2010). To assess the effect of LWAs on the mechanical characteristics, 10% of the natural coarse aggregate was volumetrically replaced with

LWAs in four mixes. Additionally, SBR was incorporated at 5% by cement mass in two mixes to enhance the mechanical performance, following the methodology of previous studies (Bhutta et al., 2013; Borhan & Al Karawi, 2020). Table 3 displays the mix proportions adopted in this experimental study. The symbol in this table is described as follows;

- MR refers to the reference mix containing 100% natural coarse aggregate
- MPA and MHD represent mixes in which 10% of natural aggregate was replaced with pumice and LECA, respectively.
- MPAP and MHDP denote the same replacements (10% pumice and 10%LECA, respectively), but with the addition of 5% SBR by cement mass.

Table 3. Porous concrete mix proportions (kg/m^3)

Mix ID.	w/c	C:A	Cement	Water	NCA	PA	HD	SBR
MR	0.32	1:4.127	378	121	1560	-	-	-
MPA	0.32	1:4.127	378	121	1404	108	-	-
MHD	0.32	1:4.127	378	121	1404	-	66	-
MPAP	0.32	1:4.127	378	121	1404	108	-	19
MHDP	0.32	1:4.127	378	121	1404	-	66	19

Sample Preparation

A rotary mixer was used to prepare the porous concrete mixes. Prior to mixing, the LWAs were immersed in water for 72 hr in accordance with (ASTM C1761, 2015) to saturate them and prevent additional water absorption during mixing thereby supporting internal curing. Initially, the aggregates were mixed with a small amount of water for 30 seconds to moisten their surfaces to improve the cement and aggregates bond. Next, cement was added to the wet aggregates, and mixing continued for approximately 1 minute. Finally, the remaining water was gradually introduced, and mixing proceeded until a homogenous mixture was achieved. For mixes containing SBR, the polymer was first dissolved in water before being added to the mix, following the same procedure as above. The fresh concrete was cast and compacted in accordance with (ASTM C192, 2019). The specimens were then covered with a nylon sheet, demoulded after 24 hours and cured by immersion in a water tank maintained at (23 ± 2) °C until the testing age. To evaluate the internal curing effect provided by the LWAs three cylindrical specimens from each mix were lifted from the water after 7 days and stored under laboratory conditions at (20 ± 5) °C until testing.

Test Methods

To evaluate the porous concrete compression strength, a total of 45 cylindrical specimens with φ100 × 200 mm dimensions were tested following (ASTM C39, 2018) (Fig.2a). To ensure a uniform load distribution all specimens were capped prior to testing following (ASTM C1231, 2014). For each mix, a compression strength test was performed after 7 and 28 days of water curing, and 7 days of water curing followed by 21 days of air curing. The mean value of three replicate specimens was recorded as the representative test result.

Figure 2. The performed tests: (a) compression resistance, (b) tensile splitting strength, and (c) flexural strength

Tensile splitting strength was assessed in accordance with (ASTM C496, 2017) (Fig.2b). A total of 15 cylindrical specimens (φ100 × 200 mm) were utilized. For each mix, three specimens were tested after curing in water for 28 days, and the mean value was reported. To determine the flexural strength, 15 prismatic specimens (100 × 100 × 500 mm) were tested following (ASTM C78, 2018) (Fig.2c), also after curing in water for 28 days. For each mix the mean value of three replicate specimens was reported.

Results and Discussion

Table 4 displays a summary of the mechanical properties obtained in this experimental research study.

Table 4. Mechanical properties results.

Mix ID.	Compressive Strength (MPa) at 7-Day water curing	Compressive Strength (MPa) at 7-Day water curing + 21-Day air curing	Compressive Strength (MPa) at 28-Day water curing	Tensile Strength (MPa) at 28-Day water curing	Flexural Strength (MPa) at 28-Day water curing
MR	8.3	8.8	9.7	1.8	2.8
MPA	7.9	8.3	8.7	1.79	2.24
MHD	10.3	10.7	12.1	1.35	2.37
MPAP	8.2	12.3	8.8	2.1	2.7
MHDP	10.9	15.4	14.4	1.68	2.69

Compressive Strength

Fig. 3 illustrates the compression strength outcome findings of porous concrete mixes containing LWAs at a 10% replacement ratio for natural coarse aggregate. As previously mentioned, 5% SBR by cement mass was added to certain mixes to enhance strength. The specimens were subjected to two different curing regimes. As depicted in Fig. 3, the inclusion of HD in the MHD mix resulted in a 24.7% rise in compression strength in comparison to the reference mix after 28 days of curing in water. This improvement in strength may be attributed to HD's rough and porous surface which facilitates partial penetration of the cement matrix. As a result, this enhances the interfacial transition zone (ITZ) and improves mechanical interlock (Hilal, 2021; Lo & Cui, 2004). Conversely the addition of PA in the MPA mix led to a 10.3% decline in compressive strength compared to the reference mix. This reduction may be due to the lower crushing strength of PA (Lo et al., 2008). As a result, this lower crushing strength causes cracks to propagate through the aggregate more easily following a quicker failure path.

For the mixes with SBR, the compressive strength of MHDP boosted from 12.1 to 14.4 MPa. According to Borhan and Al Karawi (2020) and Ohama (1995), this enhancement is due to the formation of the membrane from the polymerization process of SBR. On the other hand, the inclusion of SBR in the MPAP mix marginally increased the compression strength from 8.7 to 8.8 MPa.

It is clear from Fig.3 that among all porous concrete mixes, the MHDP exhibited the highest compressive strength after 7 days of water curing followed by 21 days of air curing. It reached approximately 15.4 MPa, which represents a 75% increase compared to the reference mix. This significant gain in compression strength can be attributed to two reasons; The first is the formation of a membrane caused by the polymerization process of SBR, which is very effective under dry curing conditions. Second, is the rough and porous surface of HD which improves cement matrix and the aggregate bond, subsequently enhances the interfacial transition zone (Bhutta et al., 2013; Hilal, 2021; Lo & Cui, 2004; Ohama, 1995;). Furthermore, the impact of internal curing provided by the LWAs played a critical role as illustrated in Fig. 3. For the MHD mix subjected to the combined curing regime the compression strength increased by 21.6% relative to the reference mix. This enhancement is due to the gradual release of absorbed water from pre-wetting HD which promotes the hydration of cement particles and improves the ITZ (Ding et al., 2020). On the other hand, the MPA mix showed a decline in compressive strength of approximately 5.7% compared to the reference mix likely due to the lower crushing strength of PA (Lo et al., 2008).

Notably, the 7-day compressive strength values obtained ranged between 76 to 93% of the corresponding 28-day values for all porous concrete, which is somewhat greater than that of conventional concrete (70-80%). This can be attributed to the low water/cement ratio and the type of cement utilized, both of which contribute to the rapid cement paste strength development at an early age (Brooks & Neville, 2010). Similar outcomes were recorded by Nguyen et al. (2013) and Zaetang et al. (2013)

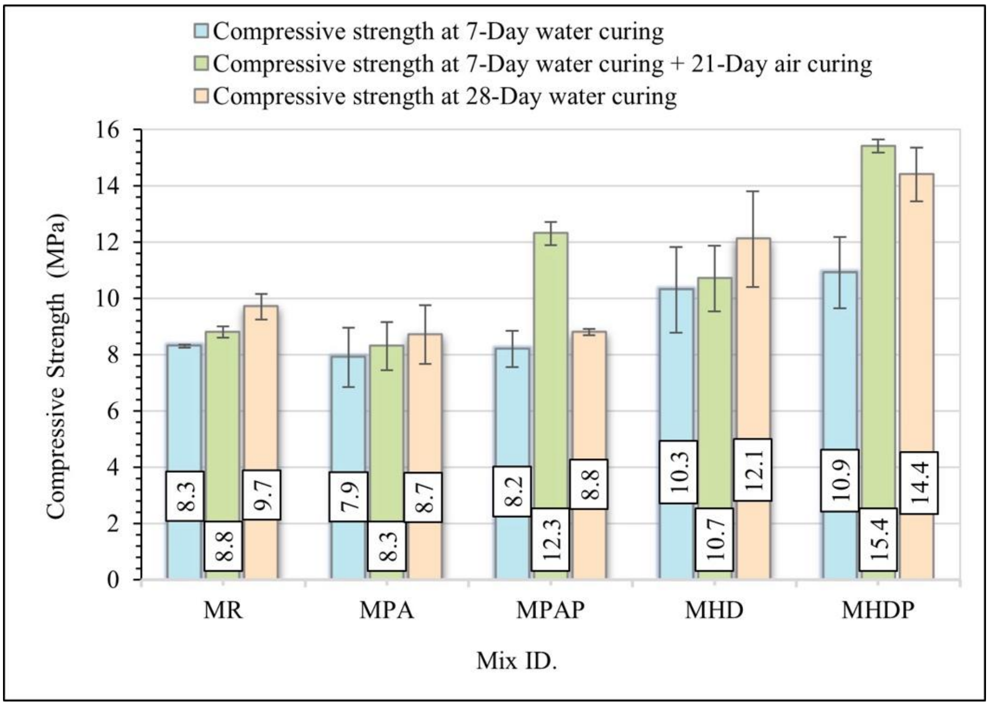

Figure 3. Effect of LWAs and SBR on the porous concrete compressive strength

Splitting Tensile Strength

Fig. 4 depicts the impact of replacing 10% of the natural coarse aggregate with two kinds of LWAs and the effect of incorporating SBR at 5% by cement mass on the porous concrete splitting tensile strength. The use of PA had a negligible impact on the splitting tensile strength, resulting in a 0.5 % reduction in the MPA mix relative to the reference mix. In comparison, a more obvious effect was noted with the utilization of HD, which led to a 25% reduction in the MHD mix in comparison to the reference mix. This difference may be attributed to the fact that in the case of HD, the ITZ was strengthened to the extent that the crack tries to take the shortest path rather than the path of least resistance, which makes the mix more brittle compared to the reference mix and the mix with PA (Güneyisi et al., 2016;Lo & Cui, 2004; Zaetang et al., 2013).

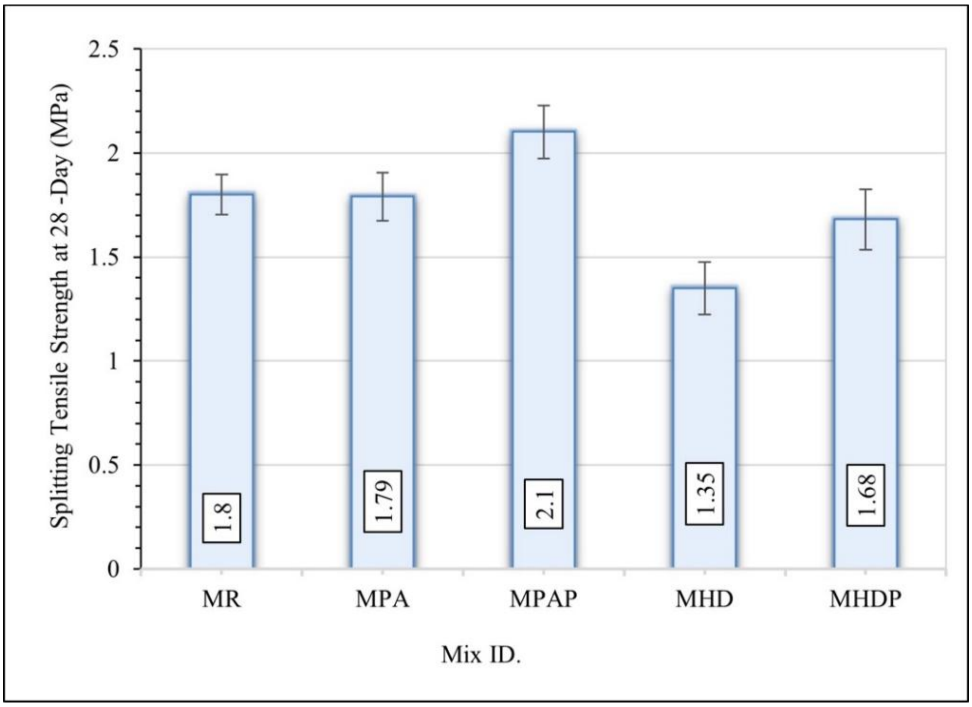

Figure 4. Effect of LWAs and SBR on the porous concrete splitting tensile strength

On the other hand, SBR inclusion led to a 16.6% rise in tensile splitting strength for the MPAP mix in contrast to the reference mix. This improvement in tensile splitting strength is prone to the formation of a membrane during the SBR polymerization process as indicated in the previous section. This membrane improves the cement paste and the aggregate bond, leading to improved tensile strength (Borhan & Al Karawi, 2020; Huang et al., 2010; Ohama, 1995). However, the MHDP mix, despite containing SBR, exhibited a 6.6% decline in the tensile splitting strength relative to the reference mix. Specifically, the tensile splitting strength for MHDP increased from 1.35 MPa to 1.68 MPa, yet remained lower than the reference mix, indicating that the combined effect of HD aggregate and SBR was less effective in enhancing tensile strength than compressive resistance.

Flexural Strength

Fig. 5 presents the obtained findings of flexural strength tests. Generally, with the addition of LWAs a reduction was observed in flexural strength by approximately 20% for MPA mix and 15.3% for the MHD mix in contrast to the reference mix. This decrease can be ascribed to the inherently lower flexural strength of LWAs compared to natural coarse aggregates. However, mixes incorporating both LWAs and SBR, namely MPAP and MHDP, demonstrated significantly smaller reductions, with declines of only 3.5% and 3.9%, respectively, due to the SBR effect on the cement paste hydration and enhancing the ITZ as explained previously.As depicted in Fig.5, the flexural strength outcomes of the all mixes ranged between 2.24 MPa to 2.8 MPa, which falls within the typical range of porous concrete reported to be between 1 MPa and 3.8 MPa according to (ACI 522R-10, 2010).

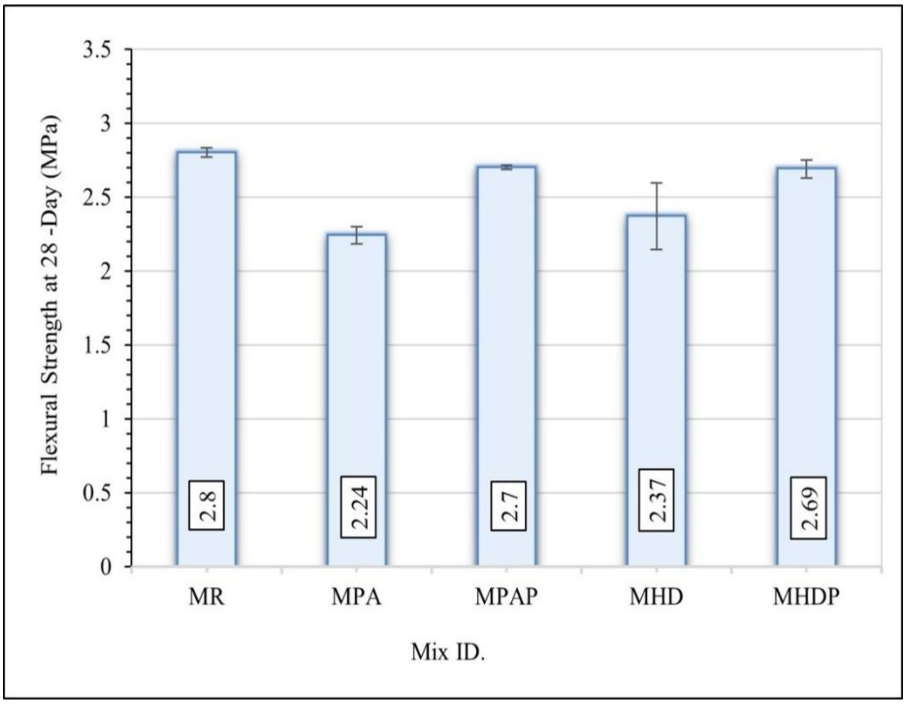

Figure 5. Effect of LWAs and SBR on the porous concrete flexural strength

Conclusion

The current experimental research study examined the impact of incorporating LWAs: PA and HD, in addition to SBR, on the porous concrete mechanical properties. According to the experimental outcomes, the following inferences can be established:

- The partial replacement of natural coarse aggregate with HD significantly improved the porous concrete compression strength. After curing in water for 28 days, the compression strength reached 12.1 MPa, compared to 9.7 MPa for the reference mix. In contrast, the use of PA reduced the compressive strength to 8.7 MPa.
- Utilizing SBR improved the compression strength of both porous concrete mixes containing LWAs. The mix that included HD and SBR when cured in dry conditions yielded the highest compressive resistance of 15.4 MPa, representing a 75% increase in contrast to the reference mix.

- Replacing the natural coarse aggregate with HD reduced the splitting tensile strength while PA resulted in a negligible reduction. However, the addition of SBR mitigated this effect especially improving the mix with PA.
- The flexural strength of porous concrete decreased when LWAs were used showing reductions of about 20% for PA and 15.3% for HD. However, using SBR significantly reduced this decline resulting in only a minor decrease compared to the reference mix.
- The pre-wetting of HD showed benefits by enhancing internal curing which promotes ongoing hydration and improves compressive strength under dry curing conditions.
- The combined use of HD and SBR in porous concrete was found to be the most effective in enhancing porous concrete mechanical properties compared to PA making it a promising material for paving applications, such as roads subjected to light traffic, parking areas, and pavers.

Recommendations

This experimental study examines the LWA's impact on the modified porous concrete mechanical properties. Future research should also consider assessing porous concrete containing LWAs' hydraulic and durability characteristics including properties such as porosity, permeability, and abrasion resistance.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

Funding

* There was no Funding.

Acknowledgements or Notes

*This article was presented as an oral presentation at the International Conference on Engineering and Advanced Technology (ICEAT) held in Selangor, Malaysia, on July 23-24, 2025.

References

ACI 522R-10. (2010). *Report on pervious concrete.* American Concrete Institute.

ASTM C39. (2018). *Test method for compressive strength of cylindrical concrete specimens.* ASTM International

ASTM C78. (2018). *Test method for flexural strength of concrete (using simple beam with third-point loading).* ASTM International

ASTM C192. (2019). *Practice for making and curing concrete test specimens in the laboratory*. ASTM International.

ASTM C496. (2017). *Splitting tensile strength of cylindrical concrete specimens 1.* ASTM International.

ASTM C1231. (2014). *Practice for use of unbonded caps in determination of compressive strength of hardened concrete cylinders.* ASTM International.

ASTM C1761. (2015*). Standard specification for lightweight aggregate for internal curing of concrete 1*. ASTM International.

Azad, A., Mousavi, S. F., Karami, H., & Farzin, S. (2019). Application of talc as an eco-friendly additive to improve the structural behavior of porous concrete. *Iranian Journal of Science and Technology, Transactions of Civil Engineering, 43*, 443–453.

Bhutta, M. A. R., Hasanah, N., Farhayu, N., Hussin, M. W., Tahir, M. B. M., & Mirza, J. (2013). Properties of porous concrete from waste crushed concrete (recycled aggregate). *Construction and Building Materials, 47*, 1243–1248.

Bnci, H., Durgun, M. Y., Rızaoğlu, T., & Koluçolak, M. (2012). Investigation of durability properties of concrete pipes incorporating blast furnace slag and ground basaltic pumice as fine aggregates. *Scientia Iranica, 19*(3), 366–372.

Borhan, T. M., & Al Karawi, R. J. (2020). Experimental investigations on polymer modified pervious concrete. *Case Studies in Construction Materials, 12*, e00330.

Diab, A. M., Elyamany, H. E., & Ali, A. H. (2013). Experimental investigation of the effect of latex solid/water ratio on latex modified co-matrix mechanical properties. *Alexandria Engineering Journal, 52*(1), 83–98.

Ding, Q., Xiang, W., Zhang, G., & Hu, C. (2020). Effect of pre-wetting lightweight aggregates on the mechanical performances and microstructure of cement pastes. *Journal of Wuhan University of Technology, Materials Science Edition, 35*(1), 140–146.

Güneyisi, E., Gesoğlu, M., Kareem, Q., & Ipek, S. (2016). Effect of different substitution of natural aggregate by recycled aggregate on performance characteristics of pervious concrete. *Materials and Structures, 49*(1–2), 521–536.

Hariyadi, & Tamai, H. (2015). Enhancing the performance of porous concrete by utilizing pumice aggregate. *Procedia Engineering, 125*, 732–738.

Hilal, A. A. (2021). Effect of aggregate roughness on strength and permeation characteristics of lightweight aggregate concrete. *Journal of Engineering, 2021*(1), 9505625.

Hossain, K. M. A. (2004). Properties of volcanic pumice-based cement and lightweight concrete. *Cement and Concrete Research, 34*(2), 283–291.

Huang, B., Wu, H., Shu, X., & Burdette, E. G. (2010). Laboratory evaluation of permeability and strength of polymer-modified pervious concrete. *Construction and Building Materials, 24*(5), 818–823.

I.Q.S. No. 5. (2019). *Portland cement*. Central Agency for Standardization and Quality Control.

I.Q.S. No. 45. (1984). *Iraqi standard specification for aggregate from natural sources for concrete*. Central Organization for Standardization and Quality, Ministry of Housing and Construction.

Jamshidi, M., Pakravan, H. R., & Pourkhorshidi, A. R. (2014). Application of polymer admixtures to modify concrete properties: Effects of polymer type and content. *Asian Journal of Civil Engineering, 15*(5), 779–787.

Karami, H., Teymouri, E., Mousavi, S. F., & Farzin, S. (2018). Experimental investigation of the effect of adding LECA and pumice on some physical properties of porous concrete. *Engineering Journal, 22*(1), 205–213.

Lo, T. Y., & Cui, H. Z. (2004). Effect of porous lightweight aggregate on strength of concrete. *Materials Letters, 58*(6), 916–919.

Lo, T. Y., Cui, H. Z., Tang, W. C., & Leung, W. M. (2008). The effect of aggregate absorption on pore area at the interfacial zone of lightweight concrete. *Construction and Building Materials, 22*(4), 623–628.

Neithalath, N., Sumanasooriya, M. S., & Deo, O. (2010). Characterizing pore volume, sizes, and connectivity in pervious concretes for permeability prediction. *Materials Characterization, 61*(8), 802–813.

Neville, A. M., & Brooks, J. J. (2010). *Concrete technology* (2nd ed.). Prentice Hall.

Nguyen, D. H., Boutouil, M., Sebaibi, N., Leleyter, L., & Baraud, F. (2013). Valorization of seashell by-products in pervious concrete pavers. *Construction and Building Materials, 49*, 151–160.

Obla, K. H., & Sabnis, G. (2011). Pervious concrete for sustainable development. In *Green building with concrete: Sustainable design and construction* (pp. 151–174).

Ohama, Y. (1998). Polymer-based admixtures. *Cement and Concrete Composites, 20*(2–3), 189–212.

Qureshi, L. A., Mehmood, M. S., Tasaddiq, R. M., & Nosheen, H. (2017). Investigation of properties of lightweight aggregate concrete for structural applications. *NED University Journal of Research, 14*(1), 37–48.

Soulé, M. E. (1991). Land use planning and wildlife maintenance: Guidelines for conserving wildlife in an urban landscape. *Journal of the American Planning Association, 57*(3), 313–323.

Stratoura, M., Iaz, D. R., & Badogiannis, E. (2018). Chloride penetration in lightweight aggregate mortars incorporating supplementary cementing materials. *Advances in Civil Engineering,* 9759167.

Teymouri, E., Mousavi, S. F., Karami, H., Farzin, S., & Hosseini Kheirabad, M. (2020). Municipal wastewater pretreatment using porous concrete containing fine-grained mineral adsorbents. *Journal of Water Process Engineering, 36*, 101264.

Vaickelionis, G., Kantautas, A., & Vaičiukyniene, D. (2011). Production of expanded clay pellets by using non-selfbloating clay, lake sapropel and glycerol. *Medžiagotyra (Materials Science), 17*(3), 314–321.

Ohama, Y. (1995). *Handbook of polymer-modified concrete and mortars: Properties and process technology*. Noyes Publications.

Zaetang, Y., Wongsa, A., Sata, V., & Chindaprasirt, P. (2013). Use of lightweight aggregates in pervious concrete. *Construction and Building Materials, 48*, 585–591.

Author(s) Information

Mosah Salman Abdulsada
University of Al-Qadisiyah, Al-Diwaniyah, Iraq
Contact e-mail:*mosahsalman@qu.edu.iq*

Huda Haroon Gghail
University of Al-Qadisiyah, Al-Diwaniyah, Iraq

Tumadhir Merawi Borhan
University of Al-Qadisiyah, Al-Diwaniyah, Iraq

To cite this article:

Abdulsada, M. S., Gghail, H. H., & Borhan, T. M. (2025). Mechanical properties of modified porous concrete incorporating different types of lightweight aggregate. *The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM), 37,* 223-232.