Journal of Technology Innovations and Energy ISSN: 2957-8809
https://doi.org/10.56556/jtie.v3i3.967

RESEARCH ARTICLE

Comparative Analysis of Autoclaved Aerated Concrete (AAC) vs. Traditional Building Materials for Energy-Efficient Green Building

Faraz Farahmand Azmodeh[1], Alireza Attar[2], Mohammad Maniat[2*], Mohammad Rahmati[2], Ramtin Bahmani[2]

[1]Department of Civil Engineering, Faculty of Technical and Engineering, University of Science and Culture
Faculty of Humanities , Tehran, Iran
[2]Department Civil Engineering, Islamic Azad University, Science and Research Branch, Tehran, Iran

Corresponding Author: Mohammad Maniat. Email: mohammad.maniat@srbiau.ac.ir
Received: 07 August, 2024, Accepted: 28 August, 2024, Published: 29 August, 2024

Abstract

This study evaluates a product that generates less pollution than traditional construction materials, focusing on its entire lifecycle from production to operational use. It highlights reductions in energy consumption and economic savings, emphasizing the environmental benefits of new materials. The research includes a case study of a five-story apartment, where autoclaved materials resulted in approximately 10% energy savings. During production, pressed bricks required 62 gigajoules to construct 100 square meters of wall, compared to 3.6 gigajoules for autoclaved blocks, indicating that pressed bricks consume 15.5 times more energy. Transportation also showed differences due to the lower weight of autoclaved blocks, with pressed bricks consuming 1.8 gigajoules of energy compared to 0.45 gigajoules for autoclaved materials. In implementation, the labor and time required for autoclaved materials were half that needed for brick walls in Iran. A high correlation ($R^2=0.92$) was found between thermal conductivity and density for AAC. The production of pressed bricks, which demands very high temperatures, leads to a fivefold increase in fuel consumption. Additionally, because autoclaved blocks require less material per square meter, there is a tenfold increase in fuel consumption per square meter. The study underscores the substantial benefits of adopting autoclaved aerated concrete in construction, both in terms of environmental impact and energy efficiency, highlighting its potential for more sustainable and cost-effective building practices.

Keywords: Autoclaved Aerated Concrete; Green building; Energy-Efficient

Introduction

The European Green Deal has catalyzed a heightened awareness of climate change adaptation and the critical imperative to mitigate CO_2 emissions (Maduta et al., 2023, Raufi and Maniat, 2024). Sustainable construction development is pivotal, given the substantial carbon footprint associated with traditional construction materials like conventional concrete, bricks and steel. One of the most critical directions in modern building material science is the development and introduction of new, effective heat-insulating materials(Plakhotnikov et al., 2018). This trend is primarily driven by the rising cost of electricity and the energy required for heating buildings(Ürge-Vorsatz et al., 2015). As energy efficiency becomes a more significant concern, there are increasingly stringent requirements for the thermal resistance of building enclosures(Ahmed and Asif, 2021, Patil et al., 2022). Additionally, there is a growing focus on improving the controlled environment within buildings. These advancements aim to enhance energy efficiency and reduce overall energy consumption, thereby addressing both economic and environmental concerns in the construction industry(Wang et al., 2022). Autoclaved aerated concrete (AAC) offers numerous benefits for construction, including heat and sound insulation(Kamal, 2020), fire resistance(Abhilasha et al., 2023), and reduced dead weight(Kumar et al., 2022). AAC products encompass blocks, wall panels, floor and roof panels, and lintels. Despite its long-standing use, there are still some aspects of AAC that require further investigation(Sherin and Saurabh, 2018). Autoclaved Aerated Concrete (AAC) stands out as an energy-efficient green building material when compared to traditional options like clay bricks and fly ash bricks. AAC offers numerous advantages such as high strength per unit weight, lower density, enhanced thermal insulation, and reduced carbon emissions, making it a sustainable choice for construction(Abhilasha et al., 2023). Additionally, AAC's eco-friendly nature contributes to energy conservation and cost-effectiveness, with the potential for waste utilization in its production to enhance physio-mechanical properties. Studies also highlight AAC's quick and easy installation process, along with its durability, fire resistance, and sound insulation properties (Qu and Zhao, 2017). Furthermore, research emphasizes the importance of analyzing the mechanical and physical properties of AAC under different curing conditions to optimize its performance and address concerns like humidity intrusion in specific climates. Overall, AAC emerges as a superior option for energy-efficient green buildings due to its sustainable characteristics and performance benefits compared to traditional building materials(Sudhakar et al., 2023).

The purpose of this study is to evaluate a construction material that generates less pollution than traditional materials. It aims to assess the material's lifecycle from production to operational use, highlighting potential reductions in energy consumption and economic savings. By comparing the new material with conventional materials, the study seeks to establish the environmental and economic benefits of sustainable building practices. Specifically, it compares the energy required for producing, transporting, and implementing AAC, and develops a model to predict AAC's thermal conductivity based on its density.

Literature review

Traditional bricks have long been the primary building materials used extensively in the construction and building industry. However, Autoclaved Aerated Concrete (AAC) blocks have recently emerged as a new alternative. AAC is produced using fly ash mixed with lime, cement, water, and an aerating agent. It is primarily manufactured in the form of cuboid blocks and prefabricated panels. This type of concrete is designed to contain numerous closed air voids, making AAC blocks energy-efficient, durable, less dense, and lightweight. These properties contribute to the growing adoption of AAC blocks in modern construction, offering significant advantages over traditional bricks(Kamal, 2020). In the study by Chen et al., the mechanical properties and thermal conductivity of autoclaved aerated concrete (AAC) were investigated, with a focus on the effects of pore structure. By varying the aluminum paste, foam stabilizer, and stirring time, the researchers found that pore size influenced thermal conductivity but had little impact on compressive strength. The results indicated that sand-based AAC had higher thermal conductivity and compressive strength compared to fly ash-based AAC. The thermal coefficient calculations and detailed results are presented in Table 1 (Chen et al., 2021).

Table 1. Thermal Conductivity of autoclaved aerated concrete (Chen et al., 2021)

Po (kg /m³)	P (%)	Pore Diameter (mm)	Maxim Diameter (mm)	Pore Number	(W /m -K)ג
429.88	82.91	0.4412			0.1223
433.84	82.75	0.4536			0.1184
432.66	82.80	0.4414			0.1147
434.88	82.71	0.4041			0.1096
418.82	83.35	0.3948	2.074	743	0.1094
421.34	83.25	0.4164	4.425	537	0.1044
429.39	82.93	0.3884			0.0999
426.99	83.02	0.3948	3.589	725	0.1051
434.64	82.72	0.4172	2.916	673	0.1155
428.27	82.97	0.3741	1		0.1010
421.51	83.24	0.3685	1		0.1011
423.76	83.15	0.3715			0.1011
424.87	83.11	0.3591			0.0837
433.87	82.75	0.3360	3.980	757	0.0999
434.66	82.72	0.3627	3.862	715	0.1071

Esmaily and Nuranian used alkali-activated slag instead of traditional cementitious materials in AAC production. This substitution replaced the autoclave curing stage with steam curing. Given the high density of the AAC, the thermal conductivity was also high(Esmaily and Nuranian, 2012).

There is a lack of models for predicting the effective thermal conductivity of AAC as a function of moisture content across a broad range. Given the success of using fractal theory to model the effective thermal conductivity of both structured and randomly distributed porous media(Chen and Shi, 2000), a few fractal-based thermal conductivity models have been developed for porous building materials, such as wood(Fan et al., 2006) and concrete(Pia and Sanna, 2013), in their dry state. Additionally, a study enhances AAC's thermal insulation by incorporating silica aerogels (SA) via physical impregnation, achieving up to 30% reduction in thermal conductivity at 7 wt.% SA. Fractal models (parallel and serial) accurately predict thermal conductivity. Increased compressive strength and reduced water absorption suggest enhanced durability(Qu et al., 2020). Additionally, fractal theory has been applied to analyze the multiscale pore structure of building materials, including earth-based materials, cement pastes, and concrete. Notably, inspired by fractal modeling of the effective thermal conductivity for unsaturated, three-phase porous media(Ma et al., 2004), fractal theory appears promising for developing a thermal conductivity model for moist AAC. While extensive research has been conducted on strengthening AAC (Song et al., 2022, Rafiza et al., 2022)or improving its thermal conductivity(Pehlivanlı and Uzun, 2022, Thai et al., 2022), a significant gap exists regarding its overall energy footprint. Specifically, fewer studies have compared the embodied energy (energy consumed during production, transportation, and construction) of AAC with traditional building materials. Research efforts are needed to analyze the entire lifecycle of AAC, from factory production to on-site construction, to understand its full energy consumption in comparison to established materials. full energy consumption in comparison to established materials.

Methodology

To compare the heat transfer coefficient of Autoclaved Aerated Concrete (AAC) with traditional construction bricks, the ASTM C177 standard test method should be utilized. This method measures steady-state heat flux and thermal transmission properties using the guarded-hot-plate apparatus. Here’s a detailed outline of the process.

Sample Selection

AAC Samples: Prepare 12 samples of AAC, ensuring they vary in density to cover a range of typical densities used in construction. Cut all samples to standard dimensions as specified by the ASTM C177 standard. Typically, samples should be large enough to ensure uniform heat flow and accurate measurement.

Test Procedure

Setup the Guarded-Hot-Plate Apparatus:

- Positioning: Place each sample between two plates— a hot plate and a cold plate. The plates should be insulated to minimize heat loss.
- Calibration: Calibrate the apparatus to ensure accuracy in measurements.
- Heating: Apply a controlled heat source to the hot plate.
- Steady-State Condition: Allow the system to reach a steady-state condition where the temperature gradients are stable.
- Sensors: Place thermocouples or RTDs on both surfaces of each sample to measure the temperature difference across the sample.
- Data Logging: Use a data logger to continuously record temperature readings during the test.
- Measure the amount of heat passing through the sample using heat flux sensors or by calculating based on the input power and temperature difference.
- Standard Test Method: The ASTM C177 standard method measures steady-state heat flux and thermal transmission properties using a guarded-hot-plate apparatus. Figure 1 illustrates the main components of the idealized system: two isothermal cold surface assemblies and a guarded-hot-plate. Some apparatuses may have more than one guard to enhance accuracy.
- Guarded-Hot-Plate Configuration: The guarded-hot-plate is composed of a metered section thermally isolated from a concentric primary guard by a definite separation or gap. The test specimen is sandwiched between these three units as shown in Figure 1. In the double-sided mode of measurement, the specimen is composed of two pieces, and the result is the average of these two pieces. It is important that the two pieces be closely identical to ensure accurate results.

To obtain the thermal conductivity for AAC, the device shown in Figure 2 is used. The general arrangement of the test setup is depicted in Figure 1.

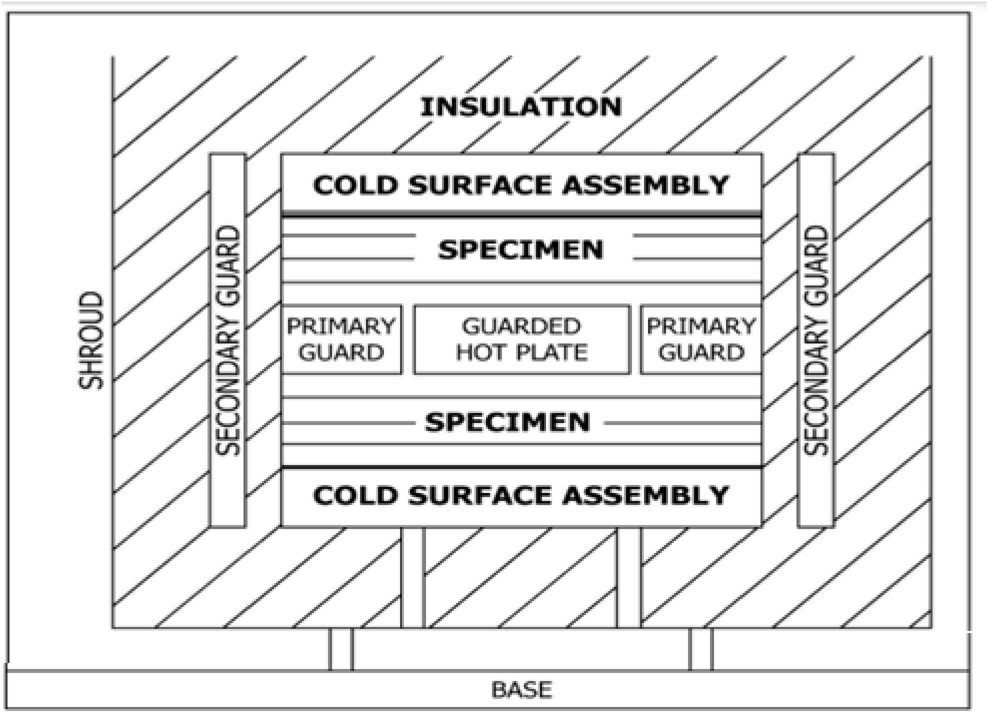

Figure 1. General Arrangement of the Test

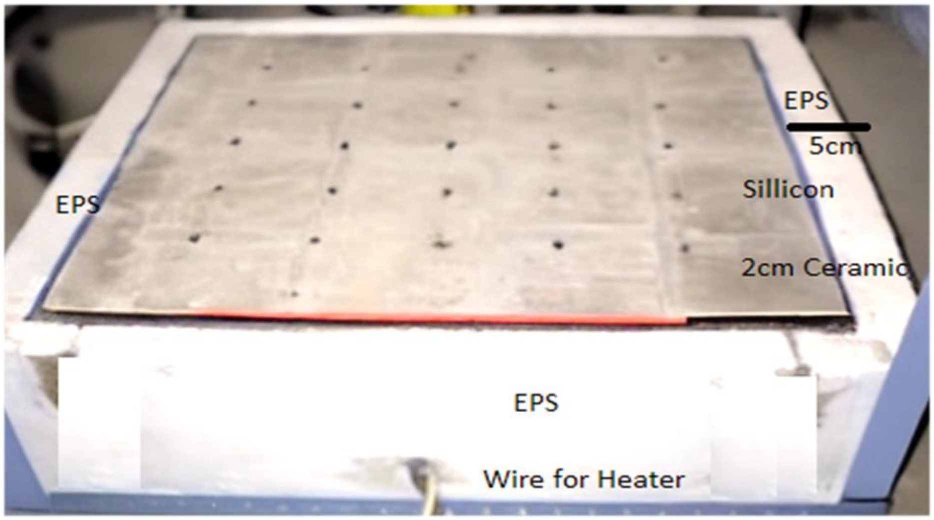

Figure 2. Test thermal conductivity for AAC

Data Analysis

Calculate Thermal Conductivity: Use Fourier's Law to calculate the thermal conductivity (k) of each sample.

$$k = \frac{q \times d}{A \times \Delta T} \tag{1}$$

where q is the heat flux, d is the thickness of the sample, A is the surface area, and ΔT is the temperature difference across the sample.

In most studies, researchers typically use Pearson correlation to assess relationships between variables. Although some studies utilize Kendall and Spearman correlations, the differences in results are generally minor(Maniat et al., 2024).We also employ Pearson correlation. Pearson's correlation coefficient (r) is a commonly used metric that assesses the strength, type, and direction of the relationship between two variables. The definition of Pearson correlation (r) is provided in Equation (2)(Akoglu, 2018).

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 (y_i - \bar{y})^2}} \tag{2}$$

where:
r=correlation coefficient,
x_i , y_i are the values of the variable in a sample i,
$\bar{x}$,$\bar{y}$= mean of the values of the y-variable.
Also ,linear regression is used for modeling linear relationships between variables.

Results and Discussion

Table 2 presents the thermal conductivity coefficients of various AAC blocks at different densities and across three temperatures. Typically, the temperature difference in the test conditions is approximately 10 degrees Celsius.

Table 2. Thermal conductivity for AAC

Experiment	Density	Thermal conductivity w/m.k		
	kg/m3	25-35^{0}c	15-25^{0}c	5-15^{0}c
1	300	0.071	0.07	0.06
2	350	0.078	0.068	0.07
3	400	0.111	0.078	0.08
4	450	0.129	0.111	0.098
5	500	0.129	0.129	0.128
6	550	0.137	0.129	0.127
7	600	0.131	0.137	0.134
8	650	0.135	0.13	0.132
9	700	0.16	0.157	0.154
10	750	0.156	0.156	0.156
11	800	0.169	0.167	0.162
12	850	0.185	0.185	0.186

The Table 3 shows the Pearson correlation coefficients among three variables: Density, Temperature, and Thermal Conductivity (TC). The correlation coefficient of 0.958 indicates a very strong positive linear relationship between Density and Thermal Conductivity. This means that as density increases, thermal conductivity also increases significantly. The significance value of 0.000 ($p < 0.01$) indicates that this result is statistically significant, providing strong evidence that the observed relationship is not due to random chance.

Table 3. Correlations

		Density	temperature	TC
Density	Pearson Correlation	1	0.000	.958**
	Sig. (2-tailed)		1.000	0.000
temperature	Pearson Correlation	0.000	1	0.099
	Sig. (2-tailed)	1.000		0.567
TC	Pearson Correlation	.958**	0.099	1
	Sig. (2-tailed)	0.000	0.567	

R-Square value of 0.927 means that approximately 92.7% of the variance in the dependent variable can be explained by the independent variables (Temperature and Density). This high value indicates that the model is very effective in explaining the variability of the dependent variable(Table 4).

Table 4. Coefficient of Determination

Model	R	R-Square	Adjusted R Square	Std. Error of the Estimate
1	.963[a]	0.927	0.922	0.01014

a. Predictors: (Constant), temperature, Density

The F-statistic is used to test the overall significance of the regression model. A high F-value indicates that the model is significant (Table 5).

Table 5. ANOVA test

ANOVAa

	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.043	2	0.021	209.150	.000[b]
Residual	0.003	33	0.000		
Total	0.046	35			

a. Dependent Variable: TC

b. Predictors: (Constant), temperature, Density

Table 6 suggests that density has a strong and statistically significant positive relationship with the dependent variable, while temperature has a weaker but potentially significant positive relationship.

Table 6 . Coefficients of model

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std.Eroor	Beta	t	Sig.
(Constant)	0.0044	0.007		0.622	0.538
Density	0.000199	0	0.958	20.345	0
temperature	0.00043	0	0.099	2.094	0.044

$$TC = 0.000199 density + 0.00043 temperature + 0.0044 \tag{3}$$

This section analyzes the manpower, materials, and embodied energy required for constructing a 100-meter wall with either AAC blocks or traditional clay bricks (as illustrated in **Figure 3**). Building a brick wall involves a team (builder and worker) laying 16 square meters per day. These walls require mortar on both sides for structural integrity, typically achieved with 1.5 cm of pressed brick and 0.5 cm of plaster lining. AAC block walls eliminate the need for mortar on the sides, reducing material usage compared to brick walls. While plaster lining (1 cm for stucco) might be desired for aesthetics, it's the only additional material typically needed.

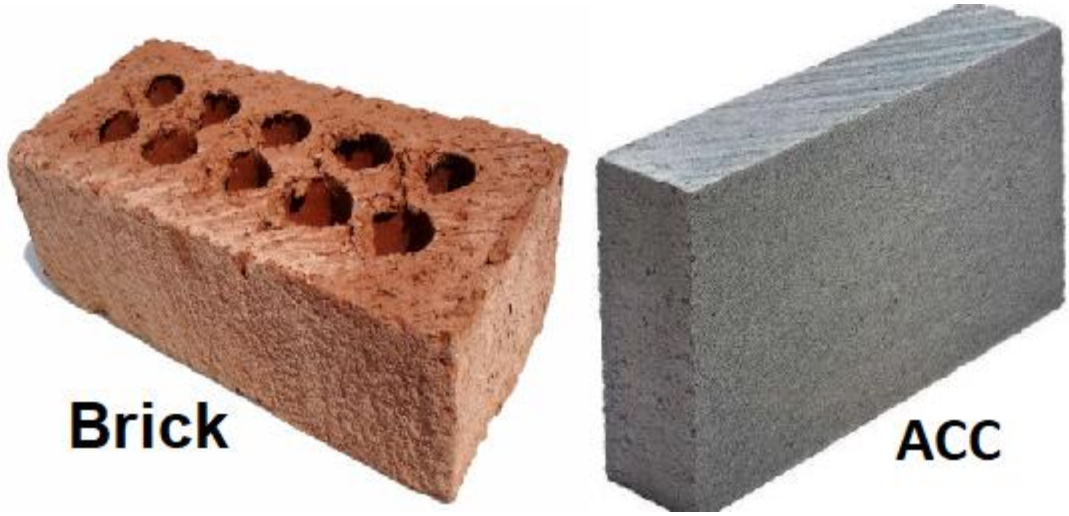

Figure 3. Test thermal

Table 7 with data about the number of workers needed for different tasks associated with building a wall with AAC blocks and bricks.

Table 7. Comparison of AAC and Brick for 100 m^2 Wall Performance

	Human Resources	
Task	brick(persen/day)	AAC(person/day)
Bricklaying	12.5	5
Plastering	3	6
Stucco	9	0
Total	24.5	11

Building a 100 m2 wall with AAC blocks only requires 700 blocks, with a total weight of 4.9 tons (Table 8). They eliminate the need for mortar on the sides, reducing overall material use. However, 2,600 kg of gypsum (2.6 tons) might still be needed for plaster lining. This table highlights the potential advantages of AAC blocks in terms of material efficiency. They require fewer blocks, eliminate the need for mortar on the sides, and have a lighter overall weight compared to brick walls. This can translate to reduced costs, faster construction times, and potentially lower environmental impact due to less material production and transportation.

Table 8. Material Requirements for 100 sqm Wall

	Brick		ACC	
Material	Quantity (Brick)	Weight (Ton) (Brick)	Quantity (Block)	Weight (Ton) (Block)
Brick	7,000	17.5	700	4.9
Cement	1,000 kg	1	200	0.2
Gypsum	3,600 kg	3.6	2,600 kg	2.6
Soil	2,500 kg	2.5	0	0
Sand & Gravel	3,000 kg	3	0	0
Total		27.6		7.7

Table 9 compares the energy consumption (in Giga Joules-GJ) for different sections. AAC blocks have significantly lower overall energy consumption (4.06 GJ) compared to bricks (62 GJ). This difference is primarily due to lower energy requirements in the factory stage for AAC blocks.

Table 9. Energy Consumption

	section			
Energy Consumption (GJ)	Human	Transportation	Factory	Total
Brick	0.0003	1.8	60.2	62.0003
AAC	0.00015	0.45	3.612	4.06215

The energy consumption for the human stage is minimal for both materials, indicating that labor-intensive processes are not a major factor in their energy footprint. Transportation energy consumption is higher for bricks (1.8 GJ) compared to AAC blocks (0.45 GJ), due to factors such as the weight and density of the materials, transportation distances, and transportation modes. The factory stage accounts for the majority of energy consumption in both materials, but the difference is substantial. Brick production consumes significantly more energy (60.2 GJ) in the factory compared to AAC blocks (3.612 GJ). This is likely due to the higher temperatures and energy-intensive processes involved in brick firing.

In the study by Chen et al., the thermal conductivity was measured between 0.09 and 0.12(Chen et al., 2021). In our study, it was calculated to range from 0.07 to 0.16. For a block density of 450 kg/m³, our study obtained a value of 0.11, compared to 0.10 in Chen's study. Therefore, the results are consistent with those of Chen et al. Additionally, this research found that the energy consumption (GJ) for traditional materials is 15.5 times that of AAC. Since the decrease in density affects the decrease in thermal conductivity for AAC due to their strong correlation, it can be concluded that the success of new materials like AAC is largely due to their low density. The lower the density, the lower the thermal conductivity, enhancing energy efficiency. Therefore, as a research path in the construction industry, there should be a focus on developing and utilizing materials with low density to produce buildings with better energy-saving properties.

The study demonstrates that autoclaved aerated concrete (AAC) materials significantly reduce environmental impact compared to traditional pressed bricks. The lifecycle analysis from production to operational use highlights considerable reductions in pollution and energy consumption. AAC blocks exhibit superior energy efficiency throughout their lifecycle. The study establishes a very strong positive linear relationship between density and thermal conductivity for AAC materials. This statistically significant result indicates that as density increases, thermal conductivity also increases significantly, providing reliable predictive capabilities for thermal performance based on material density. The lower energy consumption of AAC blocks throughout their lifecycle suggests that they are a more environmentally friendly construction material compared to traditional clay bricks.

Conclusions

This finding is particularly relevant in the context of sustainable building practices and reducing the environmental impact of the construction industry. AAC offers numerous benefits for construction, including heat and sound insulation, fire resistance, and reduced dead weight. These properties make AAC a sustainable choice for various construction applications, such as blocks, wall panels, floor and roof panels, and lintels. The production of pressed bricks, which demands very high temperatures, leads to a fivefold increase in fuel consumption compared to autoclaved blocks. Furthermore, because AAC blocks require less material per square meter, the fuel consumption per square meter for pressed bricks is ten times higher. This underscores the economic and environmental advantages of AAC materials. Due to the lower weight of AAC blocks, transportation energy consumption is markedly reduced. Despite its long-standing use, there are still aspects of AAC that require further investigation. Research emphasizes the importance of analyzing the mechanical and physical properties of AAC under different curing conditions to optimize its performance and address concerns like humidity intrusion in specific climates. Overall, the findings of this study underscore the substantial benefits of adopting autoclaved aerated concrete materials in construction, both in terms of environmental impact and energy efficiency. These benefits highlight the potential for AAC to contribute to more sustainable and cost-effective construction practices.

Declaration

Acknowledgment: N/A

Funding: N/A

Conflict of interest: The authors declare that they have no conflict of interest.

Ethics approval/declaration: All ethics of paper publications were observed

Consent to participate: All authors participated in writing this paper

Consent for publication: All authors consented to the publication of this paper

Data availability: Data available on request from the authors.

Authors contribution: Conceptualization: Alireza Attar, Methodology: Mohammad Maniat; Software: Ramtin Bahmani,Resources; Data Curation: Faraz Farahmand Azmodeh; Writing—Original Draft Preparation: Mohammad Rahmati,Writing—Review

References

ABHILASHA, KUMAR, R., LAKHANI, R., MISHRA, R. K. & KHAN, S. 2023. Utilization of solid waste in the production of autoclaved aerated concrete and their effects on its physio-mechanical and microstructural properties: Alternative sources, characterization, and performance insights. *International Journal of Concrete Structures and Materials*, 17**,** 6.

AHMED, W. & ASIF, M. 2021. A critical review of energy retrofitting trends in residential buildings with particular focus on the GCC countries. *Renewable and Sustainable Energy Reviews,* 144**,** 111000.

AKOGLU, H. 2018. User's guide to correlation coefficients. *Turkish journal of emergency medicine***,** 18(3): p. 91-93.

CHEN, G., LI, F., JING, P., GENG, J. & SI, Z. 2021. Effect of pore structure on thermal conductivity and mechanical properties of autoclaved aerated concrete. *Materials,* 14**,** 339.

CHEN, Y. & SHI, M. 2000. Study on effective thermal conductivity for porous media using fractal techniques. *Heat Transfer—Asian Research: Co-sponsored by the Society of Chemical Engineers of Japan and the Heat Transfer Division of ASME,* 29**,** 491-497.

ESMAILY, H. & NURANIAN, H. 2012. Non-autoclaved high strength cellular concrete from alkali activated slag. *Construction and Building Materials,* 26**,** 200-206.

FAN, L.-W., HU, Y.-C., TIAN, T. & YU, Z.-T. 2006. The prediction of effective thermal conductivities perpendicular to the fibres of wood using a fractal model and an improved transient measurement technique. *International Journal of Heat and Mass Transfer,* 49**,** 4116-4123.

KAMAL, M. A. 2020. Analysis of autoclaved aerated concrete (AAC) blocks with reference to its potential and sustainability. *Journal of Building Materials and Structures,* 7**,** 76-86.

KUMAR, M. A., PRASANNA, K., RAJ, C. C., PARTHIBAN, V., KULANTHAIVEL, P., NARASIMMAN, S. & NAVEEN, V. 2022. Bond strength of autoclaved aerated concrete manufactured using partial replacement of flyash with fibers–A review. *Materials Today: Proceedings,* 65**,** 581-589.

MA, Y., YU, B., ZHANG, D. & ZOU, M. 2004. Fractal geometry model for effective thermal conductivity of three-phase porous media. *Journal of applied physics,* 95**,** 6426-6434.

MADUTA, C., D'AGOSTINO, D., TSEMEKIDI-TZEIRANAKI, S., CASTELLAZZI, L., MELICA, G. & BERTOLDI, P. 2023. Towards climate neutrality within the European Union: assessment of the Energy Performance of Buildings Directive implementation in Member States. *Energy and Buildings***,** 113716.

MANIAT, M., HABIBI, H., MANSHOORINIA, E., RAUFI, P., MAROUS, P. & OMRANINAINI, M. 2024. Correlation or Causation: Unraveling the Relationship between PM2. 5 Air Pollution and COVID-19 Spread Across the United States. *Journal of Environmental Science and Economics,* 3**,** 27-41.

PATIL, M., BORASTE, S. & MINDE, P. 2022. A comprehensive review on emerging trends in smart green building technologies and sustainable materials. *Materials Today: Proceedings,* 65**,** 1813-1822.

PEHLIVANLı, Z. O. & UZUN, I. 2022. Effect of polypropylene fiber length on mechanical and thermal properties of autoclaved aerated concrete. *Construction and Building Materials,* 322**,** 126506.

PIA, G. & SANNA, U. 2013. A geometrical fractal model for the porosity and thermal conductivity of insulating concrete. *Construction and Building Materials,* 44**,** 551-556.

PLAKHOTNIKOV, K., BONDARENKO, D., DEDENYOVA, E., SALIIA, M. & KOSTUK, T. Heat-insulating materials in modern building industry. MATEC Web of Conferences, 2018. EDP Sciences, 02024.

QU, M.-L., TIAN, S.-Q., FAN, L.-W., YU, Z.-T. & GE, J. 2020. An experimental investigation and fractal modeling on the effective thermal conductivity of novel autoclaved aerated concrete (AAC)-based composites with silica aerogels (SA). *Applied Thermal Engineering,* 179**,** 115770.

QU, X. & ZHAO, X. 2017. Previous and present investigations on the components, microstructure and main properties of autoclaved aerated concrete–A review. *Construction and Building Materials,* 135**,** 505-516.

RAFIZA, A. R., FAZLIZAN, A., THONGTHA, A., ASIM, N. & NOORASHIKIN, M. S. 2022. The physical and mechanical properties of autoclaved aerated concrete (AAC) with recycled AAC as a partial replacement for sand. *Buildings,* 12**,** 60.

RAUFI, P. & MANIAT, M. 2024. Transport Policy's Impact on Auto Emissions: A Critical Review. *Available at SSRN 4719317*.

SHERIN, K. & SAURABH, J. Review of autoclaved aerated concrete:-advantages and disadvantages. Proc. Natl. Conf. Adv. Struct. Mater. Methodol. Civ. Eng.(ASMMCE–2018), 2018. 35-39.

SONG, Y., DONG, M., WANG, Z., QIAN, X., YAN, D., SHEN, S., ZHANG, L., SUN, G., LAI, J. & RUAN, S. 2022. Effects of red mud on workability and mechanical properties of autoclaved aerated concrete (AAC). *Journal of Building Engineering,* 61**,** 105238.

SUDHAKAR, R., BALAKRISHNAN, B., SANTHANAM, M. & SANTHANAM, H. 2023. Quantification of volume change of AAC blocks for various environmental conditions. *Journal of Sustainable Cement-Based Materials*, 12**,** 1205-1217.

THAI, H. N., KAWAMOTO, K., NGUYEN, H. G., SAKAKI, T., KOMATSU, T. & MOLDRUP, P. 2022. Measurements and modeling of thermal conductivity of recycled aggregates from concrete, clay brick, and their mixtures with autoclaved aerated concrete grains. *Sustainability,* 14**,** 2417.

ÜRGE-VORSATZ, D., CABEZA, L. F., SERRANO, S., BARRENECHE, C. & PETRICHENKO, K. 2015. Heating and cooling energy trends and drivers in buildings. *Renewable and Sustainable Energy Reviews,* 41**,** 85-98.

WANG, X., LI, W., LUO, Z., WANG, K. & SHAH, S. P. 2022. A critical review on phase change materials (PCM) for sustainable and energy efficient building: Design, characteristic, performance and application. *Energy and buildings,* 260**,** 111923.