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Study of Thermal Properties of Lightweight Concrete: Review based on SCOPUS and SCIELO (2009-2019)

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ABSTRACT

This work presents part of the theoretical framework about the thermal properties of lightweight concrete.The cut of scientific production, in the period from 2009 to 2019, represented by scientific articles in the Scopus and Capes databases will be presented. This is a review of the main methodological tools used by the various authors to determine the thermal conductivity of lightweight concretes.Research shows, in general, different light aggregates for the production of concretes, such as: expanded clay, airgel, perlite, glass, polypropylene fiber, palm bark oil, expanded polystyrene and gum tragacanth. The main methods and techniques for the evaluation of thermal conductivity were: guarded hot plate method and hot wire parallel technique, among others. The results of thermal conductivity of lightweight concrete ranged from 0.04 W / (m.k) to 2.6 W / (m.k), and in all studies they were satisfactory demonstrating the technical feasibility of the production of lightweight concrete.

KEYWORDS: Lightweight concrete. Thermal conductivity. Thermal performance.

1. INTRODUCTION

The use of materials that have low thermal conductivity, for example, on walls and ceilings, can reduce energy consumption in buildings. For this reason, lightweight concretes are the object of study by many researchers because they have low density, low thermal conductivity and architectural flexibility. (DEMIRBOGA; GÜL, 2003); (UYSAL *et al.,* 2004); (TOMMY *et al.*, 2007); (SENGÜL *et al.*, 2011); (CHEN; LIU, 2013); (DEVECIOĞLU; BIÇER, 2015).

Recent studies by Jhatial *et al*. (2018) stated that the thermal conductivity value of concrete produced with fine aggregate is lower than that of conventional concrete, ranging from 0.1 w / (m.k) to 0.7 w / (m.k). The lower thermal conductivity is due to the amount of voids in the cementitious matrix, determined by the fine aggregate, which slows the flow of heat, preventing the passage of air.

Thermal conductivity is a measure characterized by the capacity that a material can conduct a certain amount of heat through a unitary thickness, due to a temperature gradient under certain conditions. Previous studies indicate that specific mass (or porosity), the shape of the aggregates and the moisture content determine the properties of the concrete and influence its thermal conductivity (MYDIN; WANG, 2011); (SERRI *et al.,* 2014).

According to ACI 213R-87 lightweight concretes can be prepared by partially or completely replacing conventional aggregates and must have a specific mass in the hardened state between 1400 to 2000 kg / m³. The main characteristic of lightweight concrete is its reduced specific mass compared to conventional concrete. The thermal and acoustic performance of lightweight concrete is influenced by the fine aggregates used in its production (DÍAZ *et al.*, 2010); (ANGELIN *et al.*, 2017).

In view of this scenario, the present article carried out a review in the Scopus and Scielo databases, with the purpose of analyzing the thermal conductivity of lightweight concretes and discussing the main results achieved in the researches of the different authors, as well as analyzing the materials and methods used in the evaluation of the thermal conductivity of lightweight concrete.

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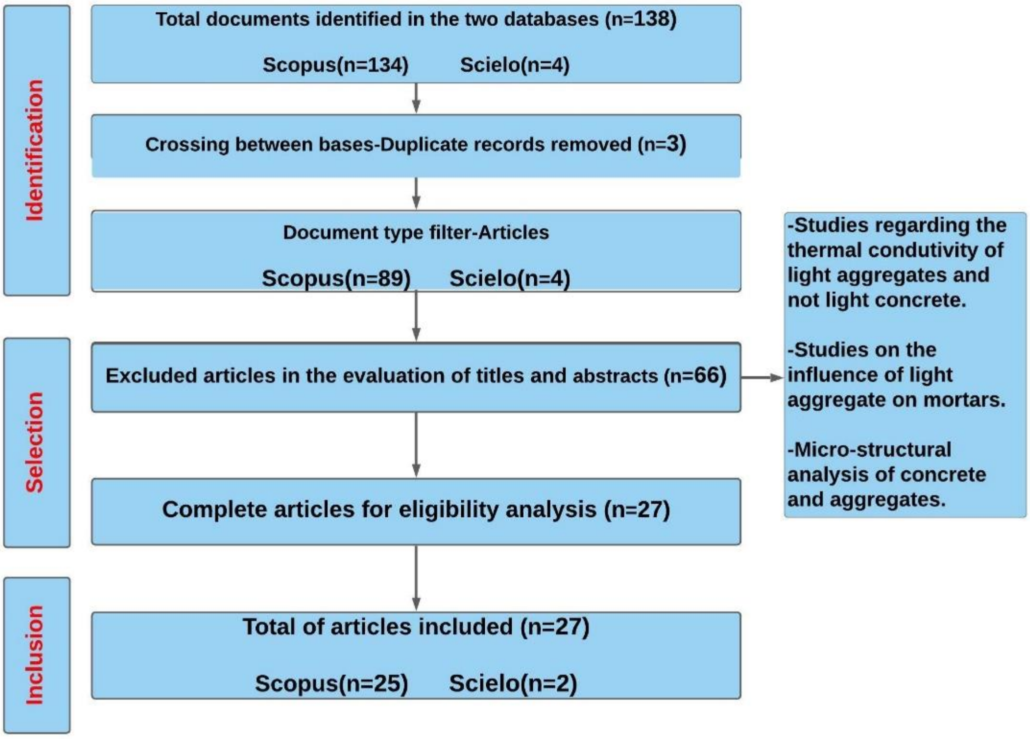
2. OBJECTIVES

These study presents part of the theoretical framework about the thermal properties of lightweight concretes, with the objective of identifying the materials used in the dosing of lightweight concretes; analyze the methods and techniques used to evaluate the thermal conductivity of the produced concretes and compare the results achieved by the authors, through a review in the Scopus and Scielo databases (2009-2019).

3. METHODOLOGY

This is a qualitative and quantitative study through a review of two digital databases (Scopus and Scielo), from 2009 to 2019. For the search of the documents, the following keywords were inserted in English: Lightweight concrete, thermal conductivity and thermal performance with the application of Boolean logic "and" for both bases. The following flowchart presents the clipping of articles with adherence to the research subject:

Figure 1: Flowchart



Source: THE AUTHORS, 2020. Based on the model PRISMA, Silva *et al.* (2015).

In the SCOPUS database, 134 searches were found, while in SCIELO 4 searches were found, in a total of 138 searches illustrated in the flowchart, in Portuguese, Spanish and English. After a deeper reading of the 93 articles (titles and abstracts), 27 articles were selected that presented results regarding the thermal properties of lightweight concretes, the main objective of the study. The other 66 articles were excluded because they did not adhere to the objectives of this research as illustrated in the previous flowchart.

4. RESULTS AND DISCUSSIONS

In the SCOPUS database, 25 researches were found between 2012 to 2019. Generally, the researches showed results regarding the thermal properties of light concretes, characteristics of light aggregates, dosage, porosity and water absorption results. In addition, in the SCIELO database, two researches were found, respectively, from 2010 and 2017 regarding the thermal properties of lightweight concrete.

4.1. DATABASE RESULTS

The results obtained by the researchers regarding the thermal properties of lightweight concretes and methods and techniques for evaluating thermal conductivity are presented below. It is emphasized that the procedures standardized in technical standards, national and international, will not be presented in the text, only, citation of the specific standard.

The most relevant results are presented in the text, concisely, regarding the thermal properties of lightweight concrete (Table 1).

Table 1: Thermal conductivity result

Database	Authors/ Year	Research country	Title of the Article	Materials and Methods	Main Results
SCIELO	SACHIT *et al* (2010)	Brazil	Evaluation of thermal conductivity of concrete sheets with expanded clay	Light aggregate: expanded clay Standards: ABNT NBR 15220-Part 2, DIN 51046-Part 2 Evaluation of thermal conductivity: parallel hot wire.	Traces 4 and 5 achieved better results in relation to the other traces, respectively, with values of 0.94 and 0.54 w / (m.k). The highest value reached was 1.18 w / (m.k), reference line, a value close to that recommended by NBR 15220.
SCOPUS	AWANG *et al* (2012)	Malaysia	Effect of additives on mechanical and thermal properties of lightweight foamed concrete	Light aggregates: polypropylene fiber, lime and fly ash. Standards: ISO 22007-2. Thermal conductivity / rating: Hot Disk	The values were between 0.19 to 0.61 w / (m.k), values lower than the norm established. Therefore, all traits obtained satisfactory results. It is noteworthy that the addition of lime influenced the reduction of thermal conductivity.
SCOPUS	BAJARE e KORJAKINS (2013)	Latvia	Lightweight Concrete with Aggregates Made by Using Industrial Waste	Aggregate: expanded clay. Standards: DIN EN 12667, ISO 8301. Thermal conductivity assessment: LaserComp-Fox 600 heat flow meter	The traces showed conductivity values between 0.31 to 0.33 W / (m.k), results considered satisfactory. In this way, it is possible to produce lightweight concrete with low thermal conductivity with expanded clay.
SCOPUS	BUMANIS *et al*	Latvia	Mechanical and Thermal	Light aggregate: expanded glass	The results indicate the feasibility of producing

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	(2013)		Properties of Lightweight Concrete Made from Expanded Glass	Standards: DIN EN 12667, ISO 8301. Evaluation of thermal conductivity: LaserComp-Fox 600 heat flow meter.	lightweight concrete with expanded glass. The addition of expanded glass improved the thermal conductivity of the concrete. The values of thermal conductivity were between 0.138 to 0.177 W / (m.k), results considered adequate.
SCOPUS	LIU *et al* (2013)	Malaysia	Evaluation of Thermal Conductivity, Mechanical and Transport Properties of Lightweight Aggregate Geopolymer concrete	Light aggregates: palm bark oil and fly ash. Standards: BS EN 12664. Thermal conductivity rating: Hot plate	The values for the 4 traces remained between 0.47 to 0.58 W / (m.k), lower values compared to the materials.
SCOPUS	SERRI *et al* (2014)	Malaysia	Thermal Properties of Oil Palm Shell Lightweight Concrete with Different Mix Designs	Light aggregate: Palm Oil Palm Shell (OPS) Standards: ISO 22007-2. Thermal conductivity rating: Hot disk TPS2500	The results of thermal conductivity vary between 0.54 to 1.1 w / (m.k) and are considered suitable for the elaboration of concrete walls with acceptable thermal properties.
SCOPUS	BORHAN, Tumadhir Merawi (2015)	Iraq	Effect of Using Recycled Lightweight Aggregates on the Properties of Concrete	Light aggregates: waste of crushed lightweight concrete. Standards: ASTM C 177-04. Evaluation of thermal conductivity: Hot plate.	The results of thermal conductivity gradually decreased with the addition of the recycled light aggregate, until reaching 1.18 w / (m.k) for 100% replacement of the natural aggregate.
SCOPUS	DAVRAZ *et al* (2015)	Turkey	The effects of Physical properties on the Thermal Conductivity of Lightweight Aggregates	Light aggregates: pumice, perlite, expanded clay, diatomaceous earth Standards: TS EN 12664. Thermal conductivity assessment: fox 314 heat flow meter.	The results obtained show thermal conductivity between 1.26 to 1.33 W / (m.k), satisfactory values in accordance with EN 12664. It is noteworthy that the addition of perlite to the concrete improved the thermal conductivity in comparison to the other aggregates
SCOPUS	DEVECIOĞLU e BIÇER (2015)	Turkey	The Effects of Tragacanth Addition on the Thermal and Mechanical Properties of Lightweight Concretes Mixed with Expanded Clay	Light aggregate: tragacanth gum Standard: DIN 51046 Thermal conductivity rating: Parallel Hot Wire	The use of tragacanth gum is unusual and new in construction, however, results were obtained between 0.215 to 0.418 w / (m.k) suitable for the production of lightweight concrete with low thermal conductivity.

SCOPUS	JEDIDI *et al* (2015)	Tunisia	Effect of Expanded Perlite Aggregate Dosage on Properties of Lightweight Concrete	Light aggregate: expanded perlite Standards: NF EN ISO 8990, 1996 Evaluation of thermal conductivity: Hot surface	The values achieved were satisfactory and varied between 0.13 to 0.62 W / (m.k). The percentage of substitution of expanded perlite influenced the thermal conductivity response of lightweight concrete.
SCOPUS	XU *et al* (2015)	China	Experimental study and modeling on effective thermal conductivity of EPS lightweight concrete	Light aggregate: expanded polystyrene (EPS) Standard: GB10294-2008. Thermal conductivity assessment: Hot disk CD-DR3030A and 6 mathematical models (Parallel, Series, Campbell, Maxwell, Hamilton and EMT models)	The results show that the addition of EPS provided a reduction in the thermal conductivity of the concrete. Various methods were used to purchase the results. There were no significant differences between the methods. The values were between 0.10 to 0.90 w / (m.k). The values achieved in all methods are in accordance with the established.
SCOPUS	REAL *et al* 2016	Portugal	Thermal conductivity of structural lightweight aggregate concrete	Light aggregate: expanded clay Standards: ASTM D5930, 2009, ASTM D5334, 2014. Thermal conductivity rating: Isomet 2114	As the density of the concrete decreased, there was a significant decrease in thermal conductivity. The results were satisfactory in all traces with the addition of expanded clay, between 0.8 to 2 W / (m.k).
SCOPUS	ŠEPUTYTĖ -JUC e SINICA (2016)	Lithuania	The Effect Of Expanded Glass And Polystyrene Waste On The Properties Of Lightweight Aggregate Concrete	Light aggregates: expanded glass and polystyrene Standards: EN 826, EN ISO 8302 and LST EN 12664. Thermal conductivity rating: hot plate	The amount of voids in the concrete provided a reduction in thermal conductivity and the results ranged from 0.07 to 0.1 W / (m.k). These values achieved are acceptable and are in accordance with the established by the current regulation in this research.
SCOPUS	STRZAŁKO WSKI e HALINA (2016)	Poland	THERMAL AND STRENGTH PROPERTIES OF LIGHTWEIGHT CONCRETES WITH ADDITION OF AEROGEL PARTICLES	Light Aggregate: Aerorgel Standards: ASTM D5930, 2009, ASTM D5334, 2014. Thermal conductivity rating: Isomet 2114	The results obtained were acceptable between 0.75 to 1.25 w / (m.k). The use of this aggregate in the civil construction sector is uncommon, but it has proved to be suitable for the preparation of lightweight concrete with low thermal conductivity.
SCIELO	ANGELIN *et al* (2017)	Brazil	Uso da argila expandida e sílica ativa no	Light aggregate: expanded clay Standards: EM 12667.	According to the results, the lightweight concrete studied was adequate,

			melhoramento dos desempenhos mecânicos, físicos e térmicos de concretos leves estruturais.	Evaluation of thermal conductivity: hot surface.	reaching values of thermal conductivity between 0.61 to 1 w / (m.k). The results indicate that it is possible to use it in the production of lightweight concrete.
SCOPUS	CHUNG *et al* (2017)	Germany	Evaluation of the Effects of Crushed and Expanded Waste Glass Aggregates on the Material Properties of Lightweight Concrete Using Image-Based Approaches	Light aggregate: expanded glass Standards: DIN EN 12390-7, ISO 22007-2. Evaluation of thermal conductivity: Hot Disk and Isomet	The results of thermal conductivity ranged from 0.15 to 1.85 w / (m.k). The expanded glass provided a significant reduction in thermal conductivity, which is why the values achieved are within the established.
SCOPUS	CHUNG *et al* (2017)	Germany	Effect of Different Gradings of Lightweight Aggregates on the Properties of Concrete	Light aggregate: expanded glass Standards: ISO 22007-2 and EN 12390-4 Thermal conductivity assessment: Hot Disk.	The results demonstrate that the thermal conductivity values decrease with the addition of glass in the concrete. The values between 0.07 to 0.31 w / (m.k) were those reached in the studied traces.
SCOPUS	JEONG *et al* (2017)	South Korea	Experimental Evaluation of Thermal Performance and Durability of Thermally-Enhanced Concretes	Light aggregate: crushed diatomite. Standards: ASTM C1363 and ISO 8990 Thermal conductivity rating: hot plate	The results indicate that the light aggregate can be used in the production of light concrete with low thermal conductivity. The achieved values varied between 0.7 to 1.5 W / (m.k).
SCOPUS	JHATIAL *et al* (2017)	Malaysia	Effect of Polypropylene Fibres on the Thermal Conductivity of Lightweight Foamed Concrete	Light aggregate: polypropylene (PP) fibers Standards: BS EN 12644: 2001 Thermal conductivity rating: hot plate	The values of thermal conductivity were in accordance with the norm in force in this research, values between 0.66 to 0.71 w / (m.k).
SCOPUS	ABDULA MEER (2018)	Iraq	Assessment the thermal properties lightweight concrete produced by using local industrial waste materials	Light aggregates: crushed tire rubbers and wood residues. Norms: not presented in the research. Thermal conductivity rating: Hot Disk (Lees Disc)	The traces with crushed rubber vary between 0.42 to 0.70 W / (m.k) and the traces with wood residue were between 0.21 to 0.70. The wood residue showed the best result.
SCOPUS	ASADI *et al* (2018)	Malaysia	Thermal conductivity of concrete – A review	Aggregate: expanded polystyrene (EPS) Standards: BS EM 12664, ISO8301. Thermal conductivity assessment: parallel	Various methods of evaluating thermal conductivity were used. The results of thermal conductivity, for 30 different traces, were

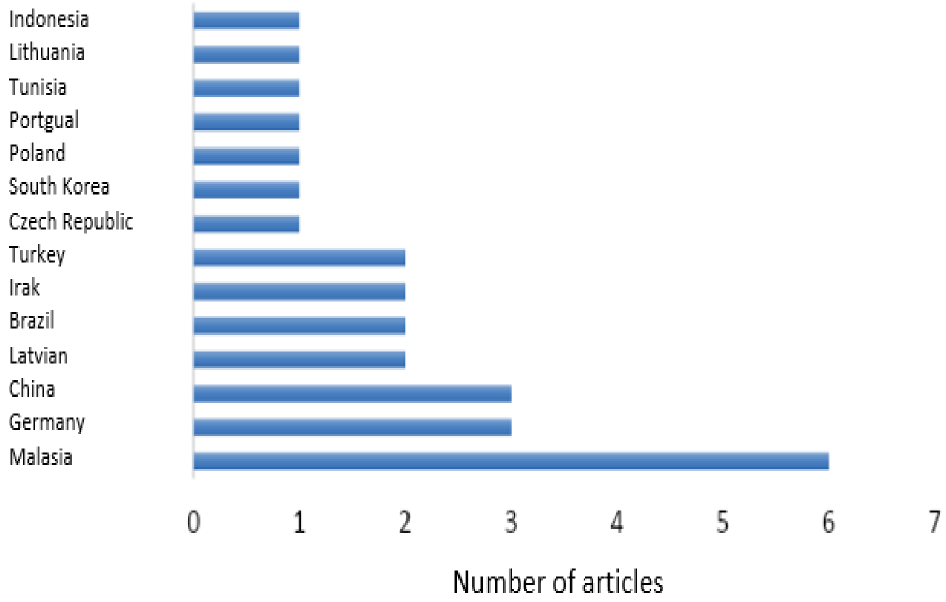
				hot wire, hot plate, hot boxes .	from 0.43 to 0.97 w / (m.k).
SCOPUS	CHIN *et al* (2018)	Malaysia	Thermal Properties of Concrete Incorporated with Shape-stable Phase Change Material	Light aggregate: vermiculite Standards: ASTM D533414 Thermal conductivity rating: Hot plate and KD2Pro	The results demonstrate that this light aggregate is suitable for the production of light concrete with low thermal conductivity, reaching values between 0.8 to 2.6 W / (m.k).
SCOPUS	HABSYA *et al* (2018)	Indonesia	Physical, mechanical and thermal properties of lightweight foamed concrete with fly ash	Light aggregate: flywheel gray Norm: Not disclosed by the authors. Evaluation of thermal conductivity: HVS-40-200SE-TokyoMeter Co .	The values obtained for thermal conductivity between 0.083 to 0.090 w / (m.k) were relevant when compared with other studies.
SCOPUS	HUANG *et al* (2018)	China	A Novel, Multifunctional, Floatable, Lightweight Cement Composite: Development and Propertie	Light aggregate: polyethylene fibers Standards: ASTM C518 and ASTM C177. Evaluation of thermal conductivity: hot plate.	The thermal conductivity values achieved were excellent in all traces and the values were between 0.15 to 0.9 W / (m.k). Elaborate concrete is a good constructive alternative with low thermal conductivity.
SCOPUS	ZÁLESKÁ *et al* (2018)	Czech Republic	Lightweight Concrete Made With Waste Expanded Polypropylene-Based Aggregate And Synthetic Coagulated Amorphous Silica	Light aggregate: expanded polypropylene. Standards: EN 196-1 (2016) and EN ISO 12572 (2001). Thermal conductivity rating: Isomet 2114	The results demonstrate that the addition of the aggregate to the concrete considerably improved the thermal conductivity. The results were satisfactory and the values varied between 0.71 to 1.8 W / (m.k).
SCOPUS	ELRAHMAN *et al* 2019	Germany	Preparation and Characterization of Ultra-Lightweight Foamed Concrete Incorporating Lightweight Aggregates	Light aggregate: Perlite Standard: EN 206-1, EN 12390-3 and ISO 122007-2. Thermal conductivity rating: Hot Disk	Perlita provided a reduction in the thermal properties of concrete. The thermal conductivity values were between 0.11 to 0.14 w / (m.k).
SCOPUS	SHI *et al* (2019)	China	Temperature Effect on the Thermal Conductivity of Expanded Polystyrene Foamed Concrete: Experimental Investigation and Model Correction	Light aggregate: expanded polystyrene (EPS) Standards: GB / T11969-2008 Thermal conductivity rating: Isomet 2114	It was possible to verify satisfactory results of thermal conductivity with a maximum value of 0.1 w / (m.k).

Source: THE AUTHORS, 2020

It is possible to observe in Table 1 the main values of thermal conductivity that the different authors reached, as well as the technical standards, materials and methods used in the research. However, some authors did not present the technical norms or methodologies used in the research. Noteworthy are the innovations made by researchers in the use of new lightweight aggregates that are uncommon in the construction industry.

Figure 2 shows the co-authorship between the countries with the most investigations, with emphasis on Malaysia with 6 articles, followed by China and Germany with 3 articles.

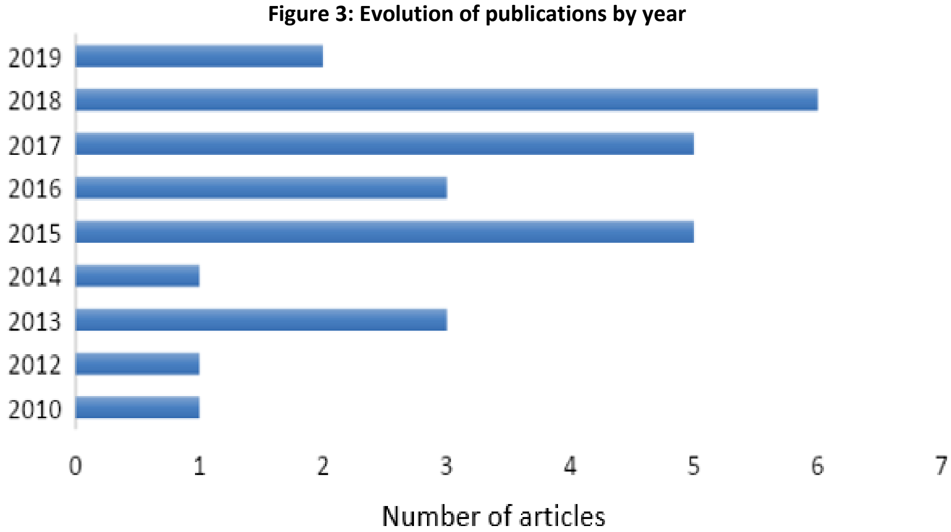
Figure 2: Articles published by country



Source: THE AUTHORS, 2020.

Figure 3 shows the evolution of the publications of the articles during the last 10 years (2009-2019). In 2013, 2015, 2016, 2017 and 2018 there was a significant increase in research, with emphasis on 2018 with a more expressive number of publications.

Figure 3: Evolution of publications by year

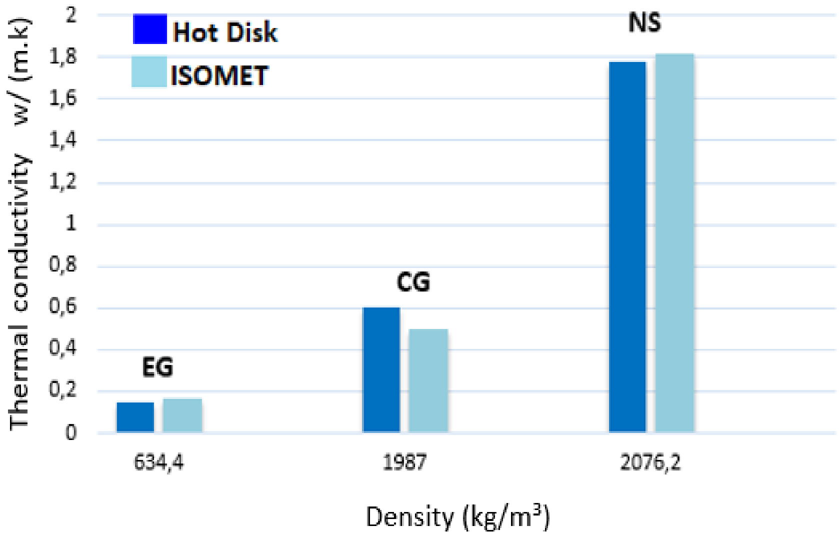


Source: THE AUTHORS, 2020.

Some relevant research results are presented to affirm the thermal conductivity assessment methodologies, below.

Chung *et al.* (2017) evaluated the thermal properties of light concrete made from recycled material from glass with three different traces, namely: natural sand (NS - Natural Sand), crushed glass (CG- Crushed Glass) and expanded glass (EG - Expanded Glass) using the methods and techniques presented in the following normative text: ISO 22007-2. The dosage proposal was to replace 100% natural sand with crushed glass and expanded glass, respectively, for the CG and EG lines, the other constituents of the traces were kept, for example, 306 kg / m³ of cement, 34 kg / m³ of silica fume, 0.6 of the water / cement ratio, except for the superplasticizer 6.12 kg / m³ (EG), 8.75 kg / m³ (CG) and 3.4 kg / m³ (NS). The results of thermal properties are shown in Figure 4.

Figure 4: Results of thermal conductivity



Source: CHUNG *et al*, 2017.

Thermal conductivity was determined using Hot Disk and Isomet for greater precision of the results as shown in Figure 4, and there was no significant difference between the two methods, approximately 7%. The EG line presented the result of thermal conductivity of 0.15 W / (m.k) lower than the results of NS (Reference) and CG, that is, the best result. In general, the results were satisfactory for all traces.

Abdulameer (2018) evaluated the thermal properties of lightweight concrete from crushed tire rubbers and wood residues and the addition of fly ash. The study produced five traces for the tire rubber aggregate and the wood waste aggregate to compare the two results. The thermal conductivity was evaluated using the Hot Disk (Lees Disc). The results are shown in Table 2.

Tabel 2: Results

Traces	Mixtures (%)	Thermal conductivity with addition of crushed tire rubber w/ (m. k)	Thermal conductivity with added wood residue w/ (m. k)
1	0	0,704	0,704
2	5	0,638	0,539
3	10	0,550	0,441
4	15	0,480	0,322
5	20	0,420	0,218

Source: THE AUTHORS, 2020

The addition of these materials has considerably reduced thermal conductivity compared to the reference concrete. The best results were achieved in trace 5 with the addition of crushed rubber and wood waste. The mixture with the addition of wood residue showed a reduction of approximately 15% in the thermal conductivity, in relation to the rubber mixture.

Angelin *et al*. (2017) analyzed the thermal properties of lightweight concrete from Brazilian expanded clay CINEXPAN with the addition of active silica. The content of silica fume used was 10% in relation to the weight of the cement and the water / cement ratio was 0.40. Five different strokes were developed with varying percentages of aggregates and two types of expanded clay (C05 and C15) were used. Still, the natural coarse aggregate (Brita1) was used to compare the results with the concretes made with expanded clay. Table 3 details the compositions of the features:

Tabel 3: Composition of the traces

Trace	Proportions (in mass)						
	Cement	Silica	Light aggregate	C_{05}	Coarse aggregate	C_{15}	Superplasticizer
1	1	0,1	1,28	0,23	1,60	0	0,04
2					1,19	0,18	0,04
3					0,80	0,37	0,02
4					0,40	0,55	0,02
5					0	0,75	0,02

Source: adapted of ANGELIN *et al*, 2017

The thermal conductivity was evaluated using the hot plate according to EN 12667. The values achieved for all traces were according to ABNT NBR 15220: 2005. The results are shown in table 4.

Tabel 4: Results of the thermal conductivity

Trace	Specific mass (kg/m³)	Void index (%)	Thermal conductivity w/ (m. k)
T1	2400	8,83	1
T2	2205	11,32	0,77
T3	2033	11,68	0,73
T4	1902	13,07	0,72
T5	1687	13,37	0,61

Source: THE AUTHORS, 2020.

The values of thermal conductivity for concretes with 100% expanded clay were lower than the reference concrete, obtaining a maximum value of 0.77 w / (m.k). Trace 5 showed the lowest result of thermal conductivity in comparison with the other traces, obtaining a value of 0.61 w / (m.k).

Sachit *et al*. (2010) studied the thermal properties of lightweight concrete with the addition of two types of expanded clay, Cinexpan 0500 and Cinexpan 1506. In addition, a mineral additive (Metacaulin) and a superplasticizer (Glenium) were added to the concrete. Five different traces were elaborated, described in table 5.

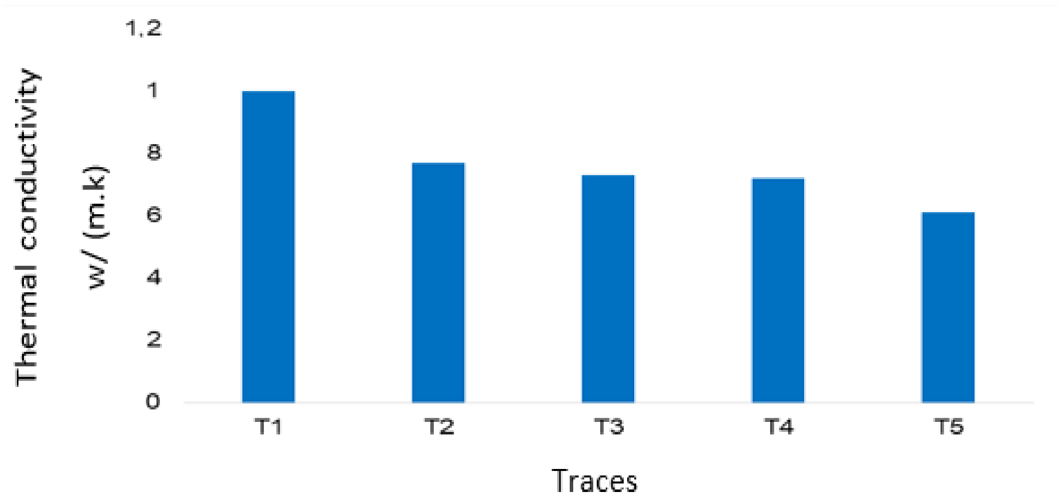
Tabel 5: Composition of the traces

Traces	Cement (Kg/m³)	Metacaulin (Kg/m³)	Sand (Kg/m³)	Brita 01 (Kg/m³)	Cinexpan 0500 (Kg/m³)	Cinexpan 1506 (Kg/m³)	Glenium (%)	Water (kg/m³)
T1	310,68	31,07	894,77	1093,6	0	0	2,33	178
T2	312,06	31,21	858,15	686,52	0	171,63	2,34	172
T3	313,38	31,34	902,53	300,84	0	300,84	2,35	192
T4	307,77	30,78	899,91	0	0	423,49	2,31	212
T5	307,88	30,79	95,44	0	362,68	496,30	2,31	200

Source: SACHIT *et al*, 2010

The thermal conductivity was determined through the parallel hot wire according to ABNT NBR ISO8894-2, the results of which are shown below in figure 5:

Figura 5: Results of the thermal conductivity



Source: THE AUTHORS, 2020

The results clearly show that the low values of thermal conductivity are achieved with the reduction in specific mass due to the replacement of the coarse aggregate by the expanded clay. The values achieved for thermal conductivity are close to the recommended values (0.46 to 1.05 w / (m.k)) by NBR 15220-2 in its item B.2. All traces showed satisfactory results, with emphasis on trace 5 with thermal conductivity of 0.61 w / (m.k).

4.2. ANALYSIS OF THERMAL CONDUCTIVITY RESULTS

The studies of the theoretical framework of the thermal properties of lightweight concretes present, in general, different lightweight aggregates for the production of concretes, such as: expanded clay, airgel, perlite, glass, polypropylene fiber, crushed tire rubber, wood residue, palm bark oil and tragacanth gum. The methodologies used in the studies carried out by the researchers to assess the thermal properties of lightweight concretes are based on national and international standards. Thermal conductivity was assessed using: Hot disk, hot plate, parallel hot wire, Isomet 2114 device, KD2Pro, hot boxes, transient plane source, HVS-40-200SE device and mathematical models.

The results obtained for thermal conductivity in all studies were satisfactory, demonstrating that all light aggregates added to the concrete offer a good thermal performance to the concrete, between 0.08 to 2.61 w / (m.k).

5. FINAL CONSIDERATIONS

Expanded clay is the material most used as a light aggregate for concrete in the studies studied. However, some authors are looking for new materials for the production of lightweight concrete, such as tragacanth gum, perlite and airgel. The appearance of new light aggregates is important and has been the subject of studies in recent years by several researchers. Thermal conductivity assessments were predominant by means of parallel hot wire and Hot Disk. Although the values reached by the authors are different, it should be noted that all values were satisfactory and met the requirements established in the current rules. It is noteworthy, Habsya *et al*., (2018) who obtained thermal conductivity values ranging from 0.083 to 0.09 W / (m.k).

The thermal properties were evaluated according to the regulations in force in the country where the research was carried out. The standards cited for this purpose were: ISO 122007-2, BS EN 12644:2001, (DIN) 51046, GB10294-2008, ASTM C332, ISO/DIS 22007-2.2, ASTM (C192-07), NBR 15220, EN 12667, ACI 213R-03 (2003), ABNT NBR 9778:2009, NBR 9778, ASTM C495-99ª, BS EN 12350-6:2009, EN 12390-3:2009, EN 12350-5, EN 12390-7 and EN 206-1.

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