



Experimental data and calibration processes to a new and simple device dedicated to the thermo-optical properties of a polycarbonate construction material

Ali Hamada Fakra, Blazquez Recio Alfonso José, Nour Murad, Ando Ny Aina
Randriantsoa, Jean Claude Gatina

► To cite this version:

Ali Hamada Fakra, Blazquez Recio Alfonso José, Nour Murad, Ando Ny Aina Randriantsoa, Jean Claude Gatina. Experimental data and calibration processes to a new and simple device dedicated to the thermo-optical properties of a polycarbonate construction material. Data in Brief, 2020, 32, pp.106289. 10.1016/j.dib.2020.106289 . hal-02936586

HAL Id: hal-02936586

<https://hal.univ-reunion.fr/hal-02936586>

Submitted on 11 Sep 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0
International License



Data Article

Experimental data and calibration processes to a new and simple device dedicated to the thermo-optical properties of a polycarbonate construction material



Damien Ali Hamada Fakra^{a,*}, Blazquez Recio Alfonso José^b,
Nour Mohammad Murad^c, Ando Ny Aina Randriantsoa^d,
Jean Claude Gatina^a

^a PIMENT Laboratory - University of la Réunion, 117 Rue du General Ailleret, 97430 Le Tampon, Reunion

^b Escuela Tecnica Superior de ICCP - University of Granada, Calle Doctor Severo Ochoa, S/N, 18001 Granada, Spain

^c Energy Lab (LE2P) Laboratory - University of la Réunion, 40 Avenue de Soweto, 97410 Saint-Pierre, Reunion

^d Higher Institute of Technology of Antananarivo (I.S.T), Ministry of Higher Education and Scientific Research, Iadiambola Ampasampito, PO Box 8122, Antananarivo 101, Madagascar

ARTICLE INFO

Article history:

Received 12 August 2020

Revised 30 August 2020

Accepted 31 August 2020

Available online 8 September 2020

Keywords:

Reflectance

Transmittance

Absorbance

Thermal conductivity

Low-cost

Device

Experimentation

Polycarbonate

ABSTRACT

Thermo-optical properties of construction materials are important factors while designing a building. Human comfort and environmental issues are the main reasons inciting researchers to work in this field. For instance, the thermal conductivity coefficient, the optical reflectance, the optical transmittance and the optical absorbance of materials are frequently measured properties in civil engineering. Currently, each of these physical coefficients is measured separately by various devices. A new experimental device is therefore designed to measure these properties in a single unit. The data presented in the article consists of the experimentation process of designing a new type device. This paper includes data for calibration, measurements and validation for the elements of the new device. This data has been collected in the laboratory and is made available for reproducibility and improvement research in the field of thermo-optical properties of construction materials. This data article is related to

DOI of original article: [10.1016/j.job.2020.101708](https://doi.org/10.1016/j.job.2020.101708)

* Corresponding author.

E-mail address: fakra@univ-reunion.fr (D.A.H. Fakra).

<https://doi.org/10.1016/j.dib.2020.106289>

2352-3409/© 2020 Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

the original research article of Fakra et al. denoted “A new simple experimental device for measuring the thermo-optical properties of translucent construction materials.” [1].

© 2020 Published by Elsevier Inc.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Specifications Table

Subject	Materials science
Specific subject area	Materials Science (General) and Instrumentation
Type of data	Table Figure
How data were acquired	Laboratory measurements with fluxmeter, thermocouples K type, Peltier plates, photodiode, CR3000 Micrologger. Data was been collected in Microsoft Excel 2019.
Data format	Raw Analyzed
Parameters for data collection	The data was been collected in a laboratory condition. A 200 mW monochromatic laser was been utilized to create a thermo-optical flux emission source ($\lambda = 650$ nm). The laser was been used to the measure the optical reflectance, transmittance and absorbance coefficients of translucent material. Two Peltier plates (heat sources) were used for the thermal conductivity measurement; two thermocouples (K type) for surfaces temperature measurement and finally three photodiodes (PINs) for optical fluxes measurement.
Description of data collection	The data on the paper has been collected from a new experimental device dedicated to the measure the thermo-optical properties of a polycarbonate construction material. A datalogger (CR3000) was used for this purpose. Databases were created and exported to a calculation code in Microsoft Excel environment to been analysed.
Data source location	Institution: University of Réunion City/Town/Region: Le Tampon, La Réunion Country: France Latitude and longitude (and GPS coordinates) for collected data: Le Tampon 55.519603/-21.286278 (21° 17' 10.601" S 55° 31' 10.571" E)
Data accessibility	With the article [1]
Related research article	[1] Damien Ali Hamada Fakra, Blazquez Recio Alfonso José, Nour Mohammad Murad, Ando Ny Aina Randrianisoa, Jean Claude Gatina, “A new simple experimental device for measuring the thermo-optical properties of translucent construction materials”, Journal of Building Engineering, “in press”, 2020 (https://authors.elsevier.com/tracking/article/details.do?aid=101708&jid=JOBE&surname=Fakra)

Value of the Data

- The data shows the result of the experiment of a new thermo-optical translucent material measuring device.
- The data also show calibrations tests values of two specific measuring sensors: photodiode PIN (the photodiode transformation into a fluxmeter) and thermocouple (K type)
- Building engineering Researchers, as well as building materials and experimentation experts in materials construction, can benefit the database to have complementary information about the thermo-optical characteristics of polycarbonate.
- The data can be used as a reference for the validation of other similar measurement devices.

1. Data Description

This paper reports raw and analysed data realized by Fakra et al. [1] on the experimentation of a new device for measuring the thermo-optical properties of polycarbonate material. A calibration of photodiodes PIN was conducted in order to use them as sensors flux (i.e. fluxmeter). The data related the calibration process to establish the linearity (from a constant coefficient

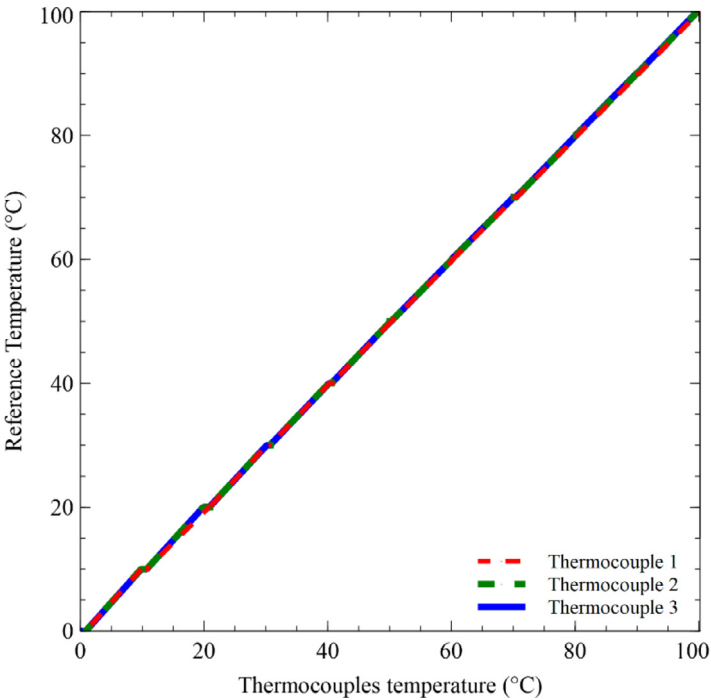
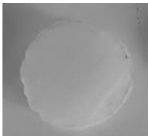


Fig. 1. Reliability tests of the three thermocouples (1, 2 and 3): comparison test with reference calibrator temperature value.

Table 1
Material dimension of the polycarbonate sample.

Material	Picture	Diameter (m)	Area (m²)	Thickness(m)
Polycarbonate		0.04	0.00126	0.006

value) between a reference fluxmeter and the voltage delivered by the photodiodes PIN (see [1]). Then, the data related to the thermocouple calibration compared to a reference calibrator system (EUROLEC thermostat model CECS3) reported in Fig. 1. Finally, the measurement of the thermal conductivity coefficient was conducted on a reference Polycarbonate sample (see Table 1). For this purpose, two Peltier plates were used as heat sources (one of the Peltier plate representing the hot source and the other the cold source). The data related the temperature difference between these Peltier plates and the experimental value obtained from the thermal conductivity coefficient of the polycarbonate (see Table 2). Finally, three database types were given in this work: the first database (i.e. **data_1.xlsx**) concerns the calibration measurement values of the photodiodes PINs which will be used as a fluxmeter in experimentation to characterize the optical parameters of the construction material, the second database (i.e. **data_2.xlsx**) provides the experimental adjustment (i.e. calibration) values of the type k thermocouple which will also be used in the measurement of the thermal conductivity of the used material and finally, the last database (i.e. **data_3.xlsx**) gathers the measured values which aids in the characterization of the thermal conductivity constant of the studied polycarbonate.

Table 2
Thermal conductivity coefficient of the polycarbonate sample.

Voltage (V)	Intensity (A)	Thickness (m)	Area (m ²)	ΔT (°K)	Flux (W)	$K_{\text{Meas.}}$ (Wm ⁻¹ K ⁻¹)	$K_{\text{ref.}}$ (Wm ⁻¹ K ⁻¹)	Relative error (%)
7	0.565	0.006	0.00126	85.5	3.955	0.22086	0.234	-4.54

2. Experimental Design, Materials, and Methods

2.1. Flux sensors: photodiodes calibration tests

2.1.1. Experimental design and materials

In order to measure the thermo-optical incident flow of a curvilinear surface (i.e. the indoor form of an integrating spheres systems), the study of Fakra et al. [1] has suggested to use a tiny photodiode PIN. These photodiodes, which adapts perfectly to the curvature of the sphere, must be capable to detect the surfacing heat flow coming from the monochromatic source (laser) over a range of the visible spectrum (Infrared and Ultraviolet). The photodiodes PIN used in the experiment has thus been calibrated to serve as flux detectors. Adjustment constants for the Photodiodes were defined from a measurement protocol by comparison to a second reference standard (reference fluxmeter). The experimentation is constituting of laser with variable intensity ranging from 0 to 200 mW, a box with a white interior surface color, two photodiode PINs and one fluxmeter (see work of Fakra et al. [1] for the characteristics of the PIN and reference fluxmeter). The three sensors positions are equidistant from the center of the box (thus making a circle with a diameter equal to 10 cm from the center of the box). The laser was directed towards the center of the box at the height of 30 cm. Positions of the photodiode PIN, fluxmeter and laser in the box are as shown in [1]. As the box can be closed, the three sensors are in total darkness during the experiment.

2.1.2. Data acquisition methods

During the experiment the laser intensity varies from 5 mW every 2 mn. Each measurement is carried out in a duration of 30 s. All the measurements databases (i.e. the tension delivered by the photodiodes in one hand and the thermal flux of the reference fluxmeter in the other hand) obtained as a result of the experimentation are instantaneously and simultaneously collected by the datalogger then exploited in Excel table. The data related to this calibration is reported in "data_1.xlsx" file. The calibration results are shown in [1], and the value of the adjustments coefficient of the photodiode (i.e. $K=2671$) is calculated from the measurements. K indicates the linear relation between the voltage of the photodiode PINs and the flux given by a reference fluxmeter.

2.2. Temperature sensors: thermocouple calibration tests

2.2.1. Experimental design and materials

For the measurement of the thermal conductivity, the research of Fakra et al. [1] needed thermocouples. Two K type thermocouples (TEC1-12706) [2] have been used to measure the surface temperature of the sample in contact with Peltier plates. Before the study, the authors verified the reliability of the temperature sensors used in the experimentation. The EUROLEC thermostat (CECS3 model) was considered as the reference for the calibration of these thermocouples. All the thermocouples were connected to a CR3000 datalogger [3] (see [1] for the illustration of the measurement environment).

2.2.2. Data acquisition methods

The CR3000 collected temperature values of the thermocouples, then sends all the information to a computer. Then, the data is recorded in a table on Microsoft Excel. The reference temperature values read directly on the calibrator machine (i.e. CECS3 model) and completed the data file of the thermocouple temperature values tested.

The data related to this calibration process is found in “**data_2.xlsx**” file (Thermocouple calibration). Fig. 1 shows the graph resulting from the calibration of the three thermocouples. The measurements were accomplished by varying the calibrator temperature to 10 °C every 10 mn and between 0 °C until 100 °C. The calibration protocol was based on the comparison test with the reference standard of the calibrator machine.

2.3. Thermal conductivity measurements of polycarbonate

2.3.1. Experimental design and materials

The research of Fakra et al. [1] was been applied to three construction materials. In this paper, only the result of the Polycarbonate was shown. A cylindric sample was used for the measurement of the thermal conductivity. The dimension of the sample is reported in Table 1.

Two Peltier plates (model TEC1-12706) [2] were used to measure the thermal conductivity of the material. The first Peltier plate was used to cool down the sample and is placed at the bottom. A heat sink is then attached to that first Peltier plate to dissipate the heat. The second Peltier plate is used to heat up the sample and is placed on the top of the material (see [1] for more information about the position of the sample compared with the two Peltier plates used). A polystyrene is then placed around the material for thermal insulation (see [1]). The thermocouples are then connected to these Peltier plates to measure the temperature difference.

2.3.2. Data acquisition methods

In order to measure the thermal conductivity of each material, the temperature of the first Peltier plate is decreased while the temperature of the second Peltier plate is increased until the temperature difference (ΔT) is in a steady-state. The temperature variation of the Peltier plates in direct contact with each surface of the sample is collected by the datalogger and exported in a Microsoft Excel table for the material study. This data is available in “**data_3.xlsx**”. The voltage, intensity, dimension and temperature difference applied to the material are used to determine the thermal conductivity coefficient (K) as shown in Table 2.

The reference values of polycarbonate specimen used are those defined in the technical document (with the conformity test) of the following manufacturer. See page 6 of [4] for thermal conductivity (K_{ref}) for a 6mm thickness panel of model 2RS/1.3 (i.e. $K_{Ref} = 0.006 \text{ m} \times 3.9 \text{ Wm}^{-2}\text{K}^{-1} = 0.234 \text{ Wm}^{-1}\text{K}^{-1}$)

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

Acknowledgments

The authors would like to thank the European project ERASMUS+ for the financial support of this research project through internship grants.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.dib.2020.106289](https://doi.org/10.1016/j.dib.2020.106289).

References

- [1] D. Fakra, B.R. Alfonso José, N. Mohammad Murad, A. Ny Aina Randriantsoa, J.C. Gatina, A new simple experimental device for measuring the thermo-optical properties of translucent construction materials, *J. Build. Eng.* (2020) *In press* <https://authors.elsevier.com/tracking/article/details.do?aid=101708&jid=JOB&surname=Fakra> .
- [2] [En ligne]. Available: <https://peltiermodules.com/peltier.datasheet/TEC1-12706.pdf>. [Accès le 26 February 2020].
- [3] [En ligne]. Available: <https://www.campbellsci.fr/cr3000>. [Accès le 26 February 2020].
- [4] Sun Clear, [En ligne]. Available: https://www.sunclear.fr/sites/default/files/Thermoclear_Plus_AT_6_14_2192_v1_07_2020.pdf. [Accès le 15 May 2020].