CIBv2024
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Missing data for forecasting the properties of concrete containing waste bricks: state of the art and missing results

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IM4StEM

INTELLIGENT METHODS FOR STRUCTURES, ELEMENTS AND MATERIALS

Erasmus+

Agenda

- Introduction
- Data collection
- Research methods
- Analysis results
- Conclusions

About the Project

- Multidisciplinary team with a consortium of 7 partners.

Croatia | Spain | Serbia | Turkey | Poland | Croatia | Romania

- Creation of an international (freely available) database containing the characteristics of buildings, elements and materials.

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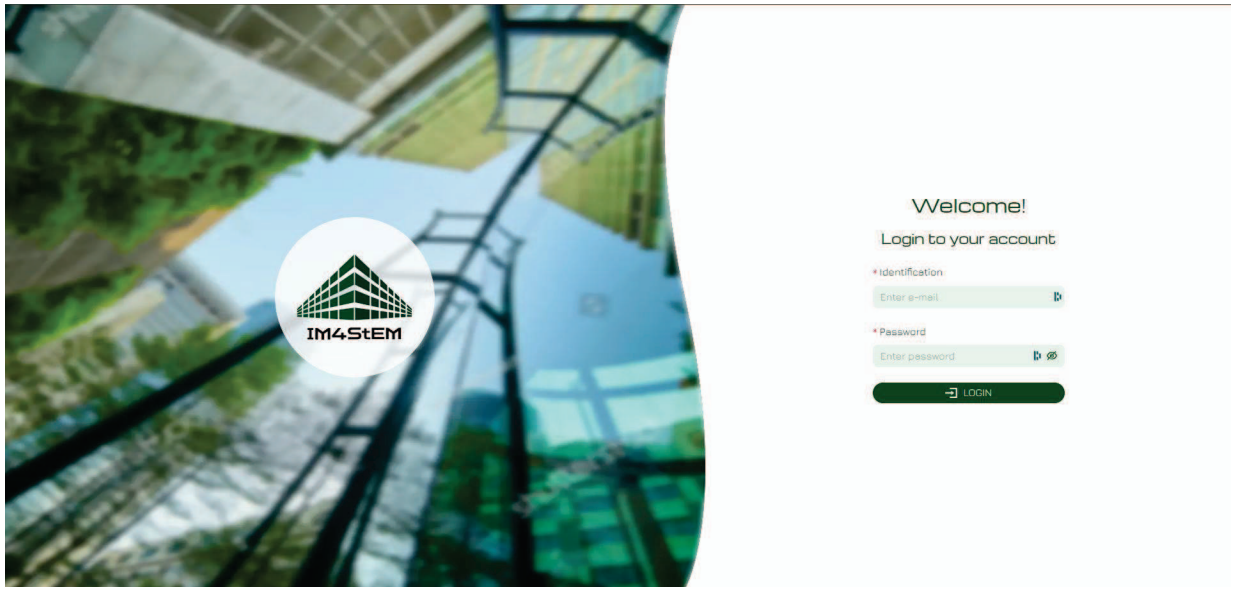
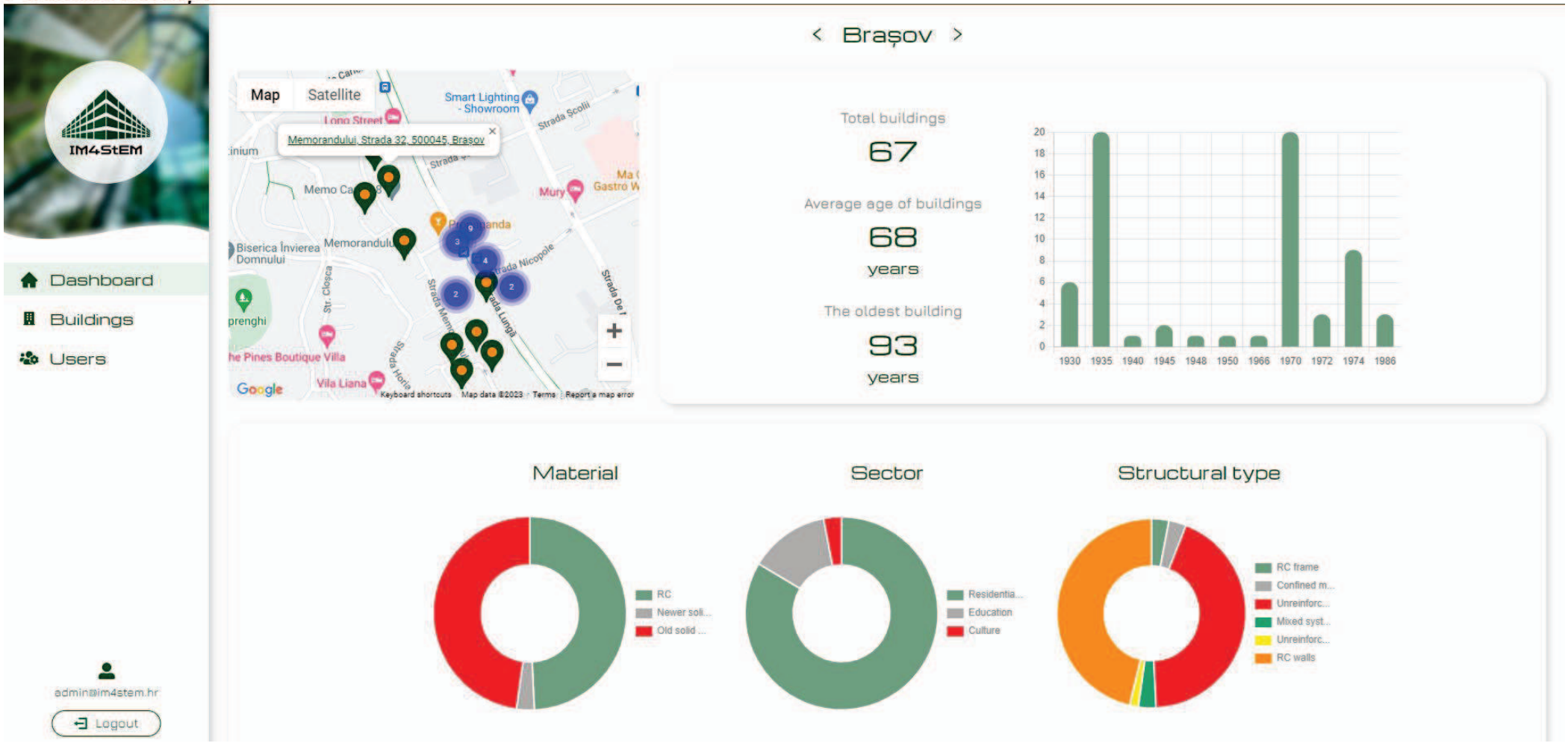


About the Project



Goals of our Work Package (WP)

The goals of our WP (work package) include:

- creating an international database of elements and materials;
- supporting the circular economy;
- analyzing data on the reuse of secondary building materials, such as **crushed bricks** (coarse aggregate), **as a component of concrete**;
- using digital tools and machine learning.

Compressive strength of concrete

The compressive strength of concrete is the most important criterion for assessing its quality and durability.

- **Safety of construction**: Compressive strength determines how much load concrete can withstand, which is crucial for safety.
- **Durability and longevity**: Higher compressive strength means that concrete will be more resistant to various types of damage.
- **Cost efficiency**: Concrete with high compressive strength can allow for less material consumption in construction (e.g. thinner walls), which reduces costs.

Concrete with crushed bricks

Crushed bricks can be used as a substitute for some aggregate, which causes:

Reduced compressive strength	Improved thermal insulation	Lower weight
Higher water absorption	Impact on the setting process	Impact on consistency

Compressive strength testing methods

Methods of assessing the compressive strength of concrete

Standard methods:

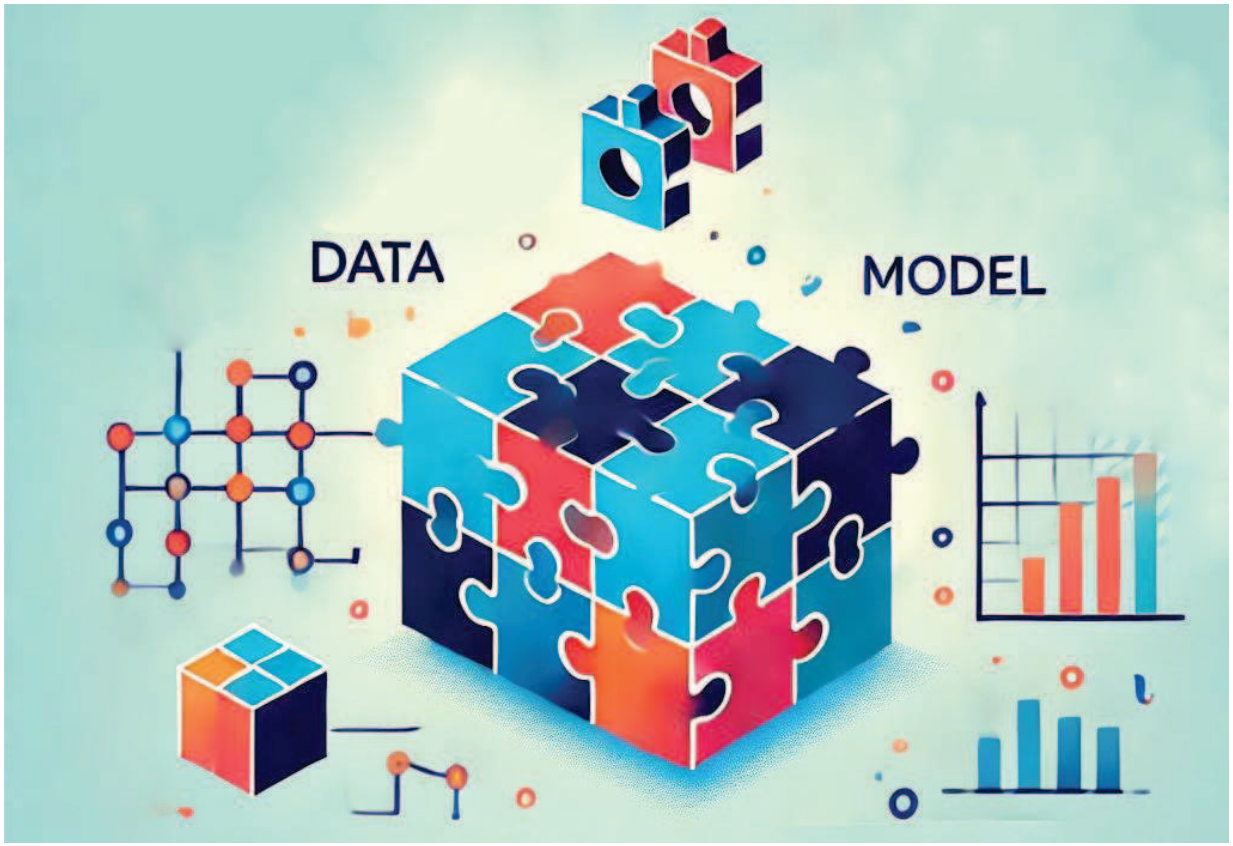
- Testing of cylindrical or cubic samples
- Non-destructive methods (sclerometric method)
- Ultrasonic method

Maybe a new method?

Machine learning

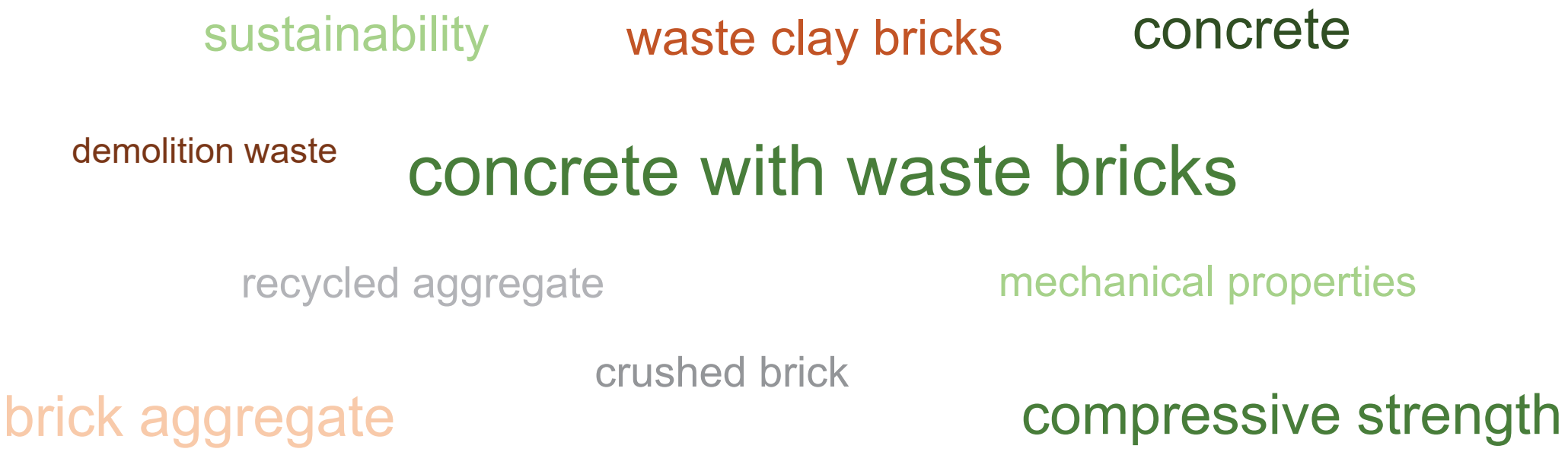
Data collection

To build a model we need data!



Data collection

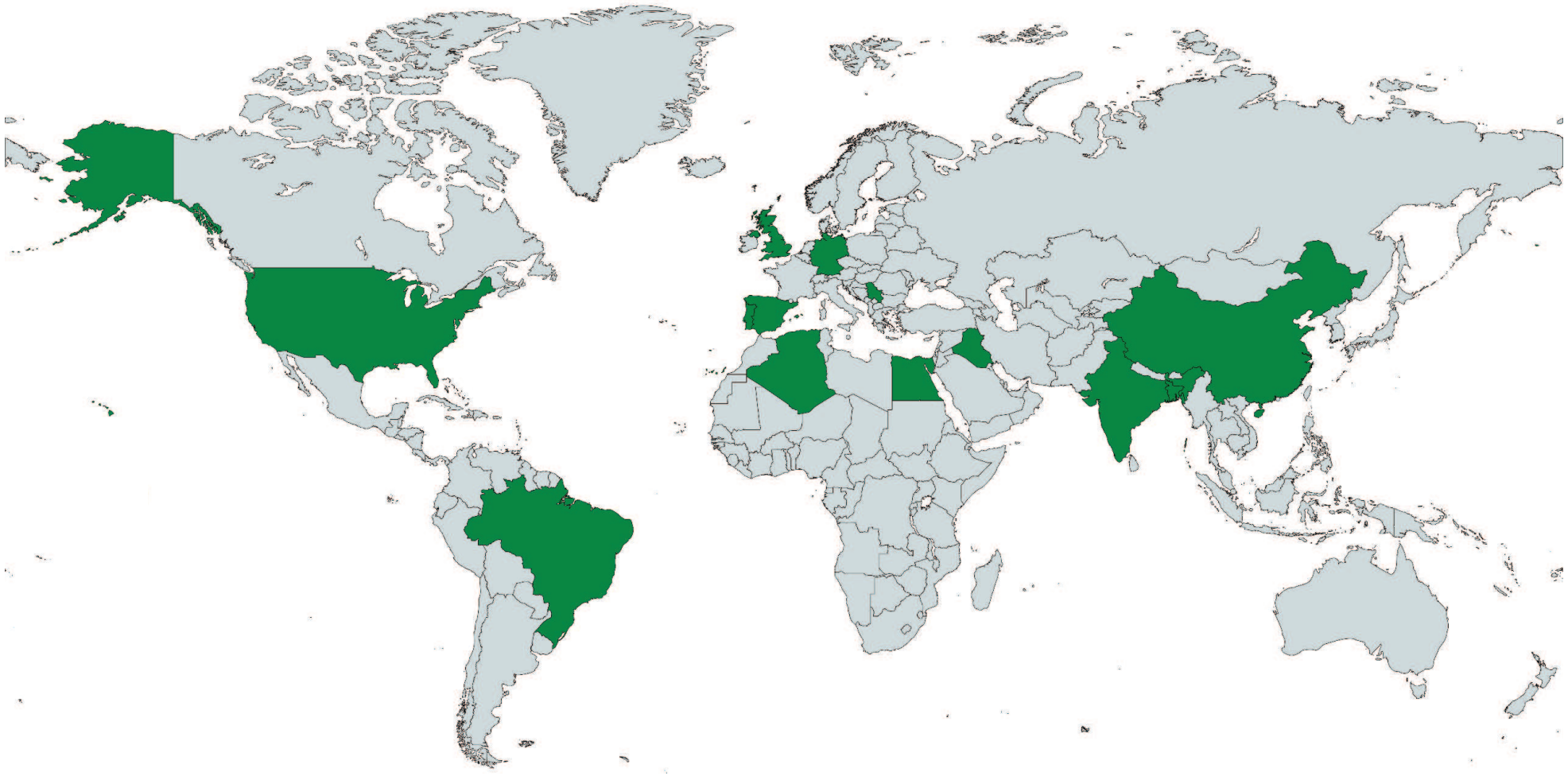
Collection of data on experimental studies available in the literature



Data collection

No.	Authors	Article
1	Pei Ge, Wei Huang, Jiarui Zhang, Wenli Quan, Yuting Guo	Microstructural analysis of recycled brick aggregate concrete modified by silane. Structural Concrete. 2022; 23: 2352–2364
2	Ksenija Janković, Dragan Bojović, Dragan Nikolić, Ljiljana Lončar, Zoran Romakov	Frost resistance of concrete with crushed brick as aggregate. Facta universitatis - series: Architecture and Civil Engineering 2010 Volume 8, Issue 2, 155-162
3	J.M. Khatib	Properties of concrete incorporating fine recycled aggregate, Cement and Concrete Research, Volume 35, Issue 4, 2005, 763-769
4	Paulo B. Cachim	Mechanical properties of brick aggregate concrete, Construction and Building Materials, 23/3, 2009, 1292-1297
5	Tara L. Cavalline David C. Weggel	Recycled brick masonry aggregate concrete. Structural Survey, Vol. 31 Iss 3, 160 - 180
6	Juntao Dang, Jun Zhao	Influence of waste clay bricks as fine aggregate on the mechanical and microstructural properties of concrete. Construction and Building Materials, 228, 2019, 116757
7	Syed Ishtiaq Ahmad and Mohammad Anwar Hossain	Water Permeability Characteristics of Normal Strength Concrete Made from Crushed Clay Bricks as Coarse Aggregate. Advances in Materials Science and Engineering, Volume 2017, Article ID 7279138
8	ABOALELLA, Alaa Abdeltawab; ELMALKY, Abeer	Use of crushed bricks and recycled concrete as replacement for fine and coarse aggregates for sustainable concrete production. Challenge Journal of Concrete Research Letters, [S.l.], v. 14, n. 2, 39-46
9	H Adem, E Athab, S Thamer, AT Jasim	The behavior of Lightweight Aggregate Concrete Made with Different Types of Crushed Bricks. IOP Conf. Series: Materials Science and Engineering 584 (2019) 012040
10	T. Vieira, A. Alves, J. de Brito, J.R. Correia, R.V. Silva	Durability-related performance of concrete containing fine recycled aggregates from crushed bricks and sanitary ware, Materials & Design, 90, 2016, 767-776
11	Rathinam, R.Kumutha & Vijai, Kumutha	Strength of concrete incorporating aggregates recycled from demolition waste. Journal of Engineering and Applied Sciences. VOL. 5, NO. 5, MAY 2010
12	Ihab S. Saleh, Saddam Kh Faleh, and Aqeel H. Chkheiwer	Flexural Behavior of RC Two Way Slabs Made With Crushed Melted Bricks as Coarse Aggregate. Springer International Publishing AG, part of Springer Nature 2019 H. Khabbaz et al. (eds.), New Prospects in Geotechnical Engineering Aspects of Civil Infrastructures, Sustainable Civil Infrastructures
13	Ahmed Tareq Noaman, Ghassan Subhi Jameel, Shamil K. Ahmed	Producing of workable structural lightweight concrete by partial replacement of aggregate with yellow and/or red crushed clay brick (CCB) aggregate, Journal of King Saud University - Engineering Sciences, 33/4, 2021, 240-247
14	Chunlin Su, Jinyan Shi, L.U.D. Tambara Jr, Yuanxia Yang, Baoju Liu, Víctor Revilla-Cuesta	Improving the mechanical properties and durability of steam-cured concrete by incorporating recycled clay bricks aggregates from C&D waste, Powder Technology 438 (2024) 119571
15	Farid Debieb, Said Kenai	The use of coarse and fine crushed bricks as aggregate in concrete, Construction and Building Materials Volume 22, Issue 5, May 2008, 886-893
16	Ali A. Aliabdo, Abd-Elmoaty M. Abd Elmoaty, Hani H. Hassan	Utilization of crushed clay brick in concrete industry, Alexandria Engineering Journal, 2014, 53, 151-168
17	Yongcheng Ji, Dayang Wang	Constitutive model of waste brick concrete based on Weibull strength theory, Case Studies in Construction Materials 18 (2023) e01738

Data collection



Research methods

Depending on the reference, different cement and different sample shapes were used.

- cubes 10x10x10 cm,
- cubes 15x15x15 cm,
- cylinders 15x30 cm.

Reference no.	Cement type	Sample shape
1	Portland 32.5	Cube 15x15x15
2	Portland CEM I 42.5 R	Cube 10x10x10
3	Portland	Cube 10x10x10
4	Portland CEM II 32.5	Cube 15x15x15
5	Portland PCC	Cylinder 15x30
6	Portland CEM I 42.5	Cube 10x10x10
7	Portland CEM I	Cylinder 15x30
8	Portland CEM I	Cylinder 15x30
9	Portland CEM I	Cube 15x15x15
10	Portland CEM II A-L 42.5 R	Cube 15x15x15
11	Portland PCC	Cube 15x15x15
12	Portland CEM I	Cube 10x10x10
13	Portland CEM I 42.5R	Cube 10x10x10
14	Portland CEM I 42.5	Cube 10x10x10
15	Portland CEM I 32.5	Cube 10x10x10
16	Portland CEM I 42.5N	Cube 15x15x15
17	Silicate cement P.O 42.5	Cube 15x15x15

Analysis results

The following parameters of the concrete mix were searched:

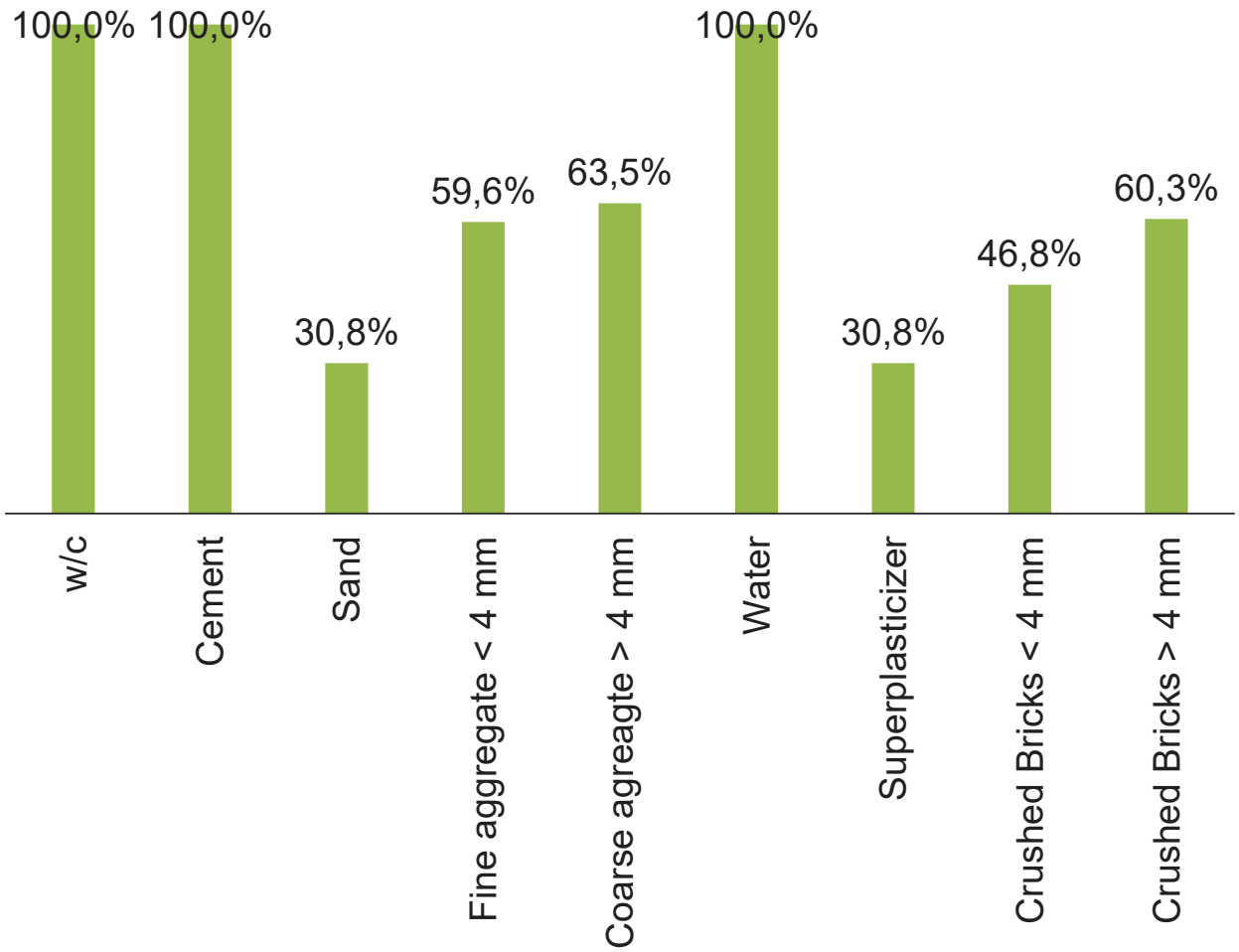
- w/c
- cement content
- sand content
- fine aggregate content (< 4 mm)
- coarse aggregate content (> 4 mm)
- water content
- superplasticizer content
- crushed bricks content (< 4 mm)
- crushed bricks content (> 4 mm)

} in kg/m^3

and the compressive strength (in MPa) of concrete after a specified number of days after making the samples.

Analysis results

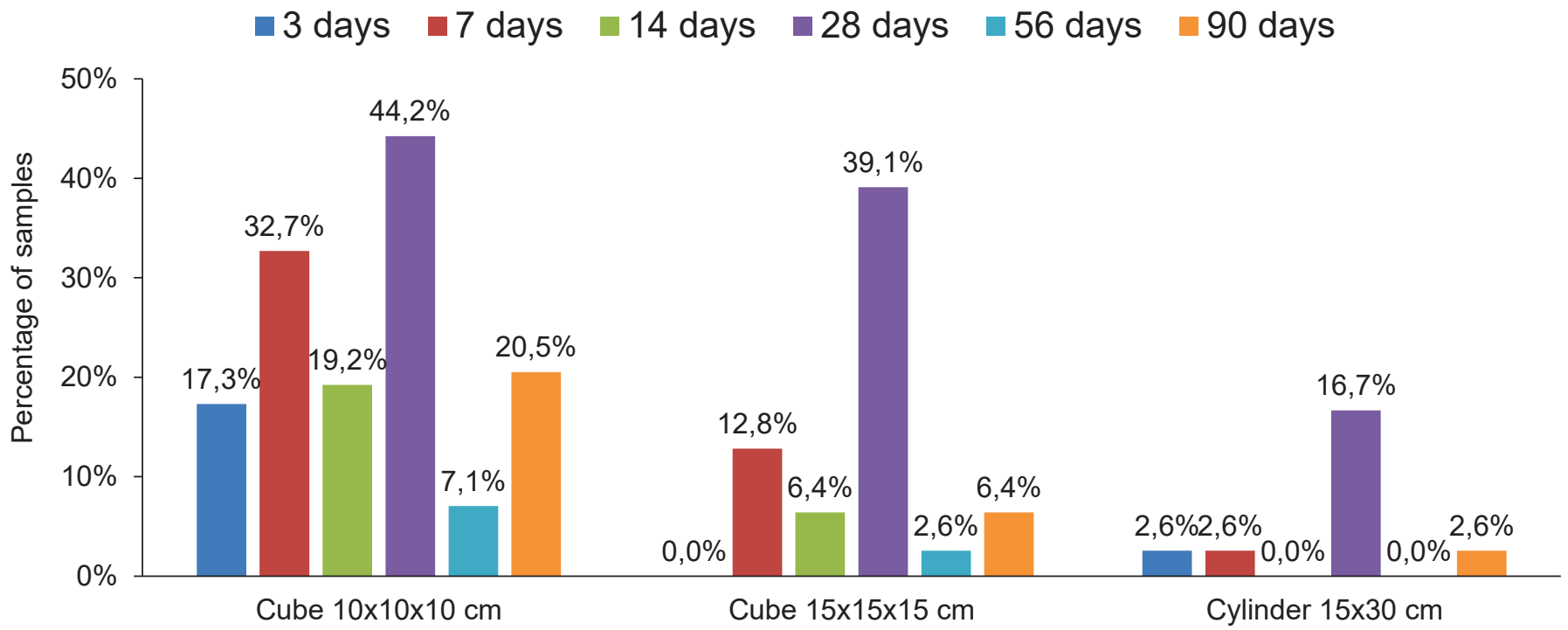
Graph showing how many samples have information about a given component of the concrete mix.



Total number of samples: 156

Analysis results

Graph showing what percentage of samples had compressive strength information after a specified number of days.

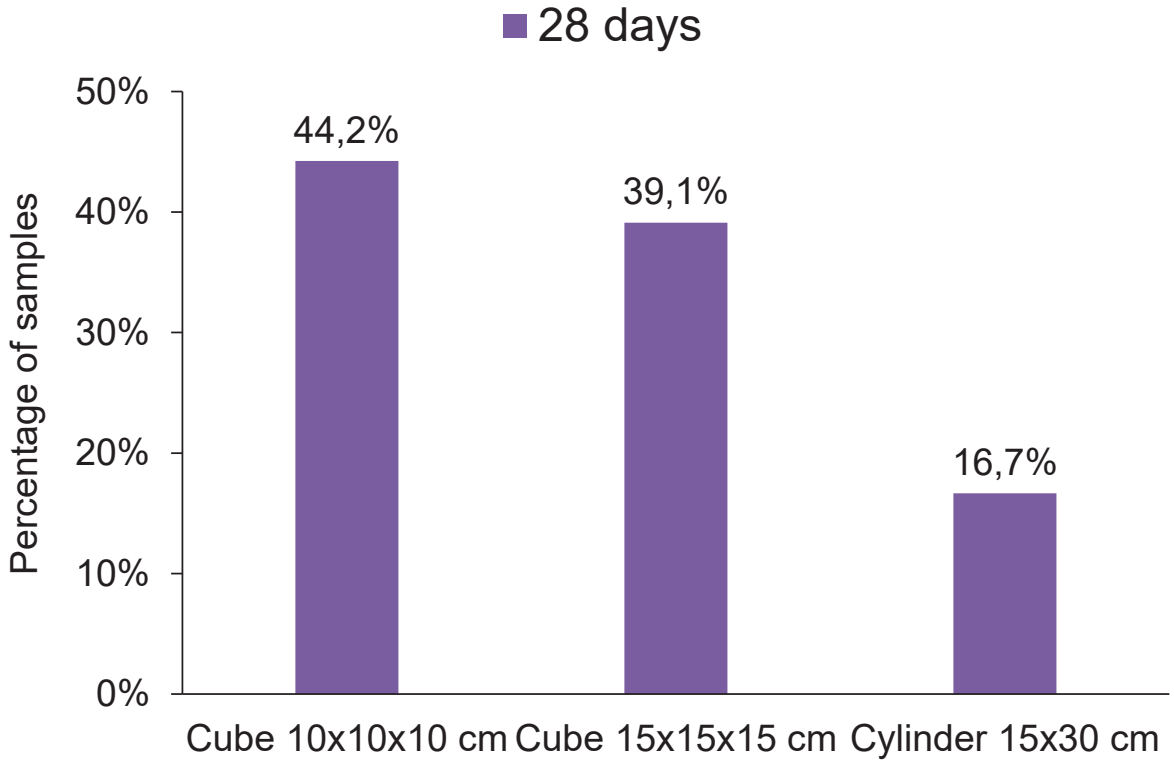


Total number of samples: 156

Analysis results

The compressive strength of concrete is normally tested after 28 days, so this information was obtained in each test.

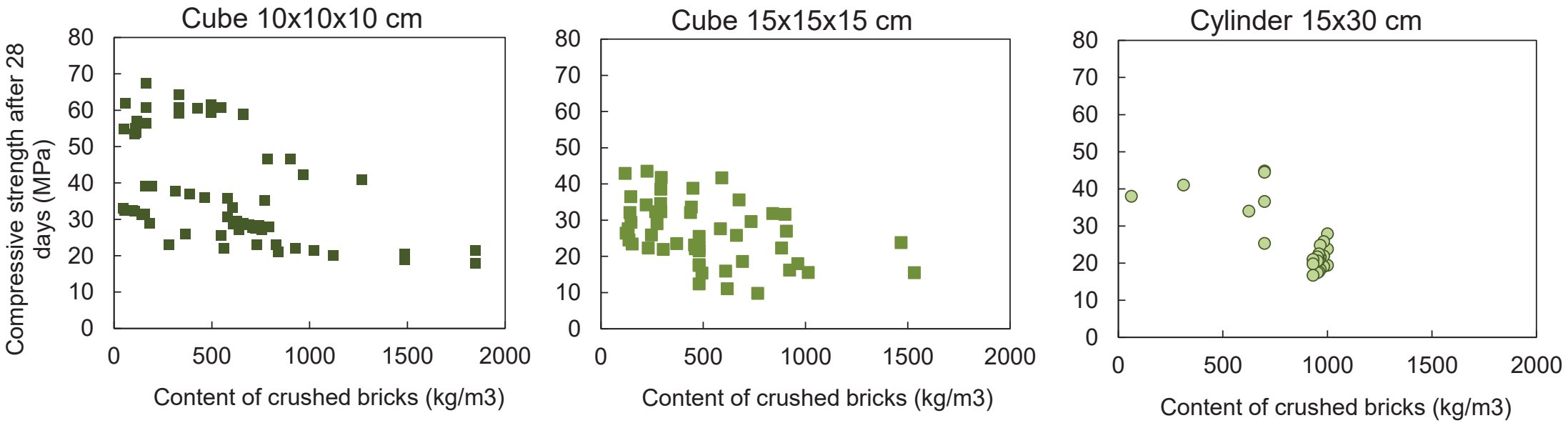
Total number of samples: 156



However, the samples had different dimensions!

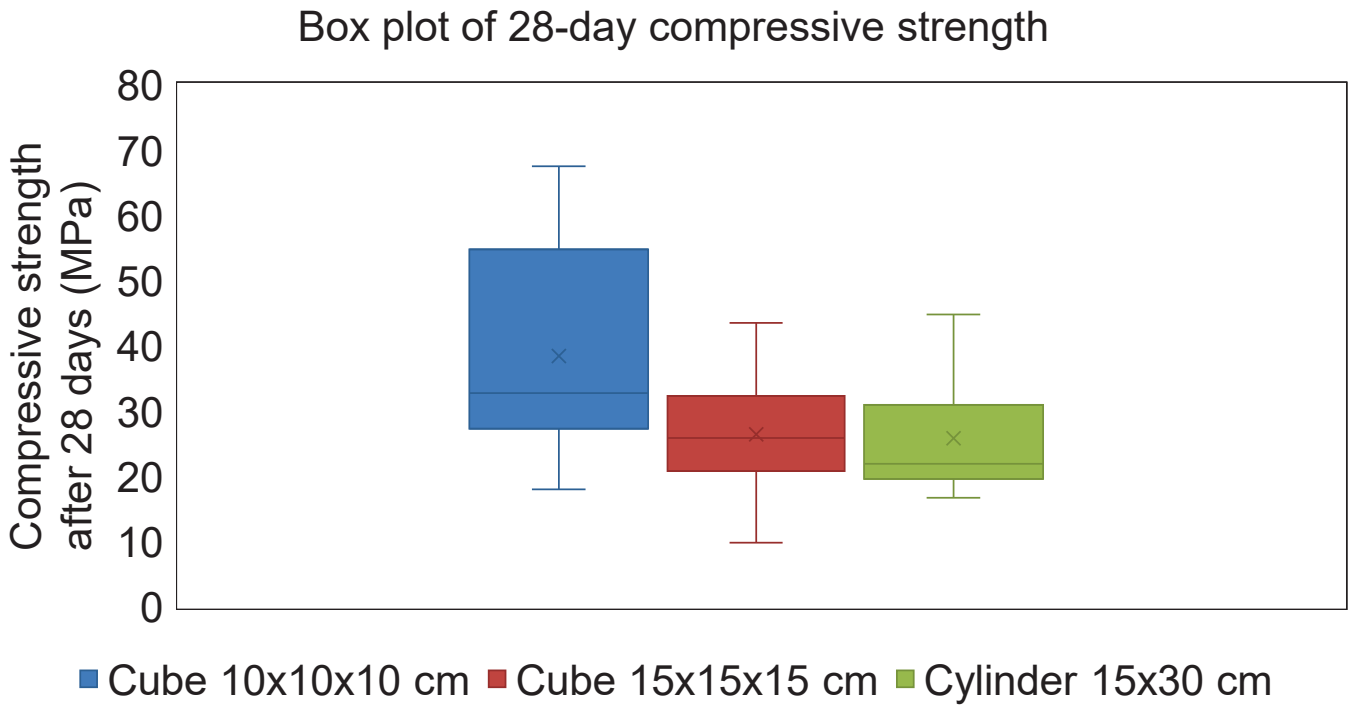
Analysis results

Adding crushed bricks as an ingredient to a concrete mixture deteriorates the compressive strength of the concrete.



Analysis results

For the 10x10x10 cubic samples the highest median and variability of strength results were obtained.



Conclusions

Based on the collected data, the following conclusions were drawn:

- Data for modeling purposes are not standardized.
- Tests performed at different times after samples were prepared.
- In all studies, tests were performed after the standard 28 days, but on samples of different sizes and shapes.
- The samples vary in composition.
- Generally, crushed bricks reduce the compressive strength of concrete.

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