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Review report of the PhD thesis of Ms MSc Eng. Sofija Kekez

"Prediction of the Mechanical and Electrical Properties of Cementitious Composites Using Artificial Neural Networks"

This review report of the Doctoral Thesis of Ms Sofija Kekez. was written by request of the Chairman of the Discipline Council for Civil Engineering and Transport of Silesian University of Technology, reference RDILT.512.10.2022.

Thesis outline

The PhD thesis is divided into nine chapters and two appendices. These are broadly divided into two parts: the theoretical studies, comprising Chapters Two and Three; and the practical studies, comprising Chapters Four, Five, Six and Seven. Chapters One, Eight and Nine are the introduction and the conclusions.

Chapter 1 presents the introduction to the thesis, together with the research context, motivation, objectives and methodology of research. Chapter 2 comprises a literature review with critical analysis about the two main topics that the candidate dealt with during the thesis: concrete mix design and Artificial Neural Networks (ANN). Chapter 3 presents some theoretical background that was needed for the thesis, such as some electronics fundamentals, concrete mix design, self-sensing concrete, software used, and ANN. Chapter 4 summarizes the assumptions and the hypothesis used for the work. Chapter 5 presents the experimental works that were used in the numerical simulations. Chapter 6 describes the simulations made with the Material Designer of the software package ANSYS. Chapter 7 describes the simulations and results of the use of ANN and respective results. Chapter 8 presents the conclusions of the work, and Chapter 9 presents some directions for future research in the field.

General comments

The thesis is well written, and it is easily readable. The candidate performed a huge and remarkable amount of work, both in terms of numerical simulations and ANN simulations.

As a first comment, the title of the thesis should be more specific in the sense that only a particular type of cementitious composites was actually analysed in the thesis.

There are some issues regarding the thesis structure and layout that, in my opinion, although not sound from a scientific perspective, do not benefit the work:

a) the *numbering* referencing style adopted in the dissertation is not very well suited for a PhD thesis; the total number of references of the work makes it hard for the reader to remember to whom a particular reference number belongs; an *author-date* referencing would be better, in my opinion;

b) the section numbering inside the chapters, without the chapter number as a prefix, makes it difficult to the reader to know exactly where he is in the text; if the headers of the page had some reference to the chapter this could be overcome, but without these it makes the reading a little more difficult;

c) the number of pages per chapter is somewhat unbalanced, with the number of pages per chapter ranging from one to fifty-one; eventually, some of the chapters could be merged (for example Chapter 2 with Chapter 3, or Chapter 9 with Chapter 8);

d) some figure numbers are not correct; I think that the figure numbers include the chapter number, the section number, and then a sequential numbering; however, in some situations it isn't like this (for example Figure 2.2.1, or Figure 3.5.1 in section 4.6 of Chapter 3); in my opinion figures should be numbered like the tables with the chapter number and a sequential number;

e) there are some numbering problems in Chapter 3 that should be corrected:

    i) in section 2, it doesn't make much sense to have a 2.1 subsection without a 2.2.

    ii) subsections of section 5 are not correctly numbered (they are numbered as 4.1, 4.2 , 4.3, 5.3.1 – again a 1 without a 2, 4.4, …);

f) tables and figures spawning through several pages, for example in pages 101 to 106, should be separated in different figures or tables or have some reference to their number in each page;

g) chapters should all start in a new page (for example this does not happen in Chapter 9, page 147) and, oppositely, sections and subsections don't (for example, subsection 5.5 of Chapter 7, on page 130);

h) page numbers of some subsections in Chapter 3 are not correct.

In all, In the thesis would benefit from a more cared final editing.

Specific comments

Chapter 2. The state of the art is extremely concise but presents a very good overview of the use of methods for mix design and the use of ANN for predicting concrete properties. My comment on this

chapter is that it could be better if it is somehow merged with Chapter 3, section 5, since only then the ANN are presented to the reader. The same happens with concrete mix design, which in this case has a section of just 3 pages on section 2 of Chapter 3.

Chapter 3. It is a very important chapter to understand the whole thesis, providing insight about the material and methods used. In page 29, references for all methods should be provided. In my opinion, section 4 (numerical simulations) was better located in the beginning of Chapter 6, since it is just a small introduction to the software.

Chapter 4. Regarding the assumptions for the experimental research, it is not clear why data that do not give good results were just discarded, without being analysed, since those are results that, for some reason, happen. Regarding the numerical simulations, it looks like that ANSYS Material Designer have too many limitations for properly modelling the composite material. Finally, regarding the hypotheses adopted, I don't understand the last hypotheses. I'm not discussing it, just want to understand the reason behind it.

Chapter 5. Presents a very good description of the experimental research used to build the dataset.

Chapter 6. The main question regarding this chapter is, why it is in this thesis? It doesn't seem to add substantial value to the thesis. It looked like something that was performed and, as such, included in the thesis. I understand all the work and time devoted to it, but it should have some additional explanation regarding its inclusion on the thesis.

Chapter 7. This is, undoubtedly, the core chapter of the thesis and presents some excellent guidelines for the use of ANN in modelling concrete properties. Why using results of ANSYS simulation? What was the expected added value? Some of the input neurons described in Table 7.3 are not shown in Appendix. In page 91 it is not clear if the complete results discarded were immediately discarded or were first included in the analysis and then discarded. In page 95, why were the 3Ni neurons in hidden layer tested? It is very important to show that the results of ANN for electrical properties prediction were not satisfactory, although this is not completely understood, indicating that further research is needed in the topic.

Chapter 8. Is it really ANSYS Material Modeler a good tool (page 143) for this type of material?

Regarding the datasets and scripts presented in the appendices, it would be better to also provide them as digital files so that others can use them. The way they are presented is not verry useful except to show the work necessary to compile them. Services like Figshare, Zenodo, or other, could be used to preserve authorship and provide referencing, and doi, to them.

Final considerations

Considering all that was previously written in this review, it is my opinion that the thesis addresses a very interesting topic, providing valuable information on the use of Artificial Neural Networks for prediction of the increasingly used self-sensing concrete. The work performed is completely compatible with what is expected from a PhD thesis. As a result of the work, the candidate presented several scientific publications. Therefore, the thesis should be admitted to public defence.

Aveiro, 27th September 2022

Paulo Barreto Cachim
(Associate Professor with Habilitation)

* wyłączenie jawności w zakresie danych osobowych oraz prywatności osoby fizycznej na podstawie art. 5 ust. 2 ustawy z dnia 6 września 2001 r. o dostępie do informacji publicznej (tj. Dz. U. z 2026 r. poz. 1764) Marzena Gaura