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8. Creating a web application to calculate predicted exploitative resistance to frost

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Abstract: A new program was created with a goal to ease material researchers' work by calculating predicted exploitation resistance to frost. Resistance to frost, conditional cold season amount and structural sample characteristics are calculated by inputting property values gotten during the experiment into the program's prepared windows – places designated for those values. Programming language Python was used for the new program's creation. In the newly created program user is presented with windows: starting in-formation data input, data gotten during the experiment input, as well as outputted intermediate and final calculation results. After the calculations researchers can generate a .pdf file which contains all the main information about carried out calculations and gotten results. This newly created program allows the simplification and acceleration of material researchers' work, as well as prevents mistakes gotten during calculations. The new program was expanded on by creating a web application for easier access. This application was created by a team using React and a programming language called Java.

Keywords: programming language Python, web application, React, programing language Java, exploitational resistance to frost, prediction of resistance to frost

8.1. Introduction

Predicted exploitational resistance to frost is calculated according to structural sample indicators (Malaiškienė et. al 2012). It is calculated by researching the longevity of ceramic materials and other porous building materials. This characteristic is important while comparing sample longevity, when created products from researched mass will be used in unprotected masonry in especially aggressive environment conditions. Physical sample properties and gotten data determined in the laboratory are used in formulas and sample structural indicators are calculated (Kizinievič et. al 2016). According to these indicators, after putting them into the formulas, it is possible to calculate predicted exploitational resistance to frost, as well as how many conditionally cold seasons from these masses (in determined conditions) created products can stay without disintegrating in these aggressive conditions.

Usually exploitational resistance to frost and other indicators are calculated using Microsoft Excel. Gotten sample property values and structure property calculation formulas are written into the program by hand. Each researcher does that individually. To calculate more precisely and faster structural sample characteristics, exploitational resistance to frost and conditionally cold seasons in this work a program created with Python programing language was used. After creating a new program researchers would not need to do all the calculations by hand. They, while in the laboratory, could input gotten weighing and measuring results directly into displayed input boxes in the window and by clicking the calculation button get both structural sample characteristics and final predicted exploitational resistance to frost results.

The goal of this work is to create a new program using Python programming language, which would be easy to incorporate into each user's device and would be easy and simple to use while doing the calculations. This new program would calculate exploitational resistance to frost and conditional cold season amount. This program was expanded on by creating a web application using React and programing language Java for easier access.

8.2. Used methods

For predictable exploitational resistance to frost calculation a program created with Python programing language was used, together with Tikinter (Roseman, 2007) and PyFPDF (PyFPDF, 2012) libraries and py2exe extension (Retzlaff, 2014). Python programming language is an interpreted, high-level, general-purpose programming language. The program's graphical user interface was written using Tikinter library functions. PDF file generated was created using PyFPDF.

This resistance to frost methodology is based on long-term laboratory research. When first samples were tested, their structural characteristics were determined, which are described in this article. Afterwards samples were tested according to resistance to frost methodology when wet samples were frozen and thawed. Freezing and thawing were on done one of the sides of the samples, this is called a one-sided freezing thawing method, when samples were mounted into a wall fragment and frozen and then thawed by pouring water on this wall fragment from one side. This method imitated façade product usage conditions.

Building ceramics predicted exploitative resistance to frost is calculated with this method, this methodology is sometimes used also in calculating concrete exploitative resistance to frost (Nagrockiene *et al*, 2004).

When predicting exploitational resistance to frost it is first determined if the sample is square shaped or not, then intermediate indicators are calculated.

Sample working surface area is calculated using:

$$S = a_a \cdot b_a, \text{cm}^2 \tag{8.1}$$

Where:

a_a – sample lower surface area, cm,
b_a – sample lower surface thickness, cm.

Sample volume is calculated using (when the sample is square shaped):

$$V = \big((a_a + a_v)/2\big) \cdot \big((b_a + b_v)/2\big) \cdot \big((h_1 + h_2)/2\big), \text{cm}^3 \tag{8.2}$$

Where:

a_v – sample upper surface area, cm,
b_v – sample upper surface thickness, cm,
h_1 – sample height (one dimension is measured on the left), cm,
h_2 – sample height (second dimension is measured on the right), cm.

Sample volume is calculated using (when the sample is non-square shaped):

$$V = \frac{m_4 - m_3}{\rho_V}, \text{cm}^3 \tag{8.3}$$

Where:

m_3 – impregnated in vacuum sample mass in water, g,
m_4 – impregnated in vacuum sample mass in air, g,
q_V – water density, g/cm^3.

Derivative sample structure indicators are calculated (Malaiškienė et. al 2012). Sample effective porousness WE are calculated according to this formula:

$$W_E = \frac{m_0}{V} \cdot \frac{m_1 - m_0}{m_0} \cdot 100, \% \tag{8.4}$$

Where:

m_0 – dry sample mass, g,
m_1 – impregnated in normal condition sample mass, g,

V – calculated sample volume water density, cm^3.

General sample porousness WR is calculated according to this formula:

$$W_R = \frac{m_0}{V} \cdot \frac{m_4 - m_0}{m_0} \cdot 100, \% \quad (8.5)$$

Structure direction unevenness indicator N is calculated according to this formula:

$$N = \frac{h_{max} - h_{min}}{h_{min}} \quad (8.6)$$

Where:

h_{max} – biggest capillary rise after moistening front value, mm,

h_{min} – smallest capillary rise after moistening front value, mm.

In further calculations intermediate indicators already calculated are used.

Porous space reserve R is calculated according to this formula:

$$R = \left(1 - \frac{W_E}{W_R}\right) \cdot 100, \% \quad (8.7)$$

Conditional pore and capillary wall thickness D is calculated according to this formula:

$$D = \frac{100 - W_R}{W_R}, \% \quad (8.8)$$

Capillary mass stream speed in normal conditions g1 is calculated according to this formula:

$$g_1 = \frac{m_2 - m_0}{S}, g/cm^2 \quad (8.9)$$

Capillary mass stream speed in vacuum in freezing direction G1 is calculated according to this formula:

$$G_1 = \frac{m_5 - m_0}{S}, g/cm^2 \quad (8.10)$$

Capillary mass stream speed in vacuum perpendicular to freezing direction G2 is calculated according to this formula:

$$G_2 = \frac{m_6 - m_0}{S}, g/cm^2 \quad (8.11)$$

After calculating sample structural indicators according to sample effective porousness W_E variable an appropriate exploitational resistance to frost conditional cycle prediction formula is chosen.

According to sample effective porousness W_E value exploitational resistance to frost conditional cycles prediction formula is chosen.

Formulas 12-16 were derived by using laboratory research done in research laboratories and calculated structural indicator influence on exploitative resistance frost according to (Maciulaitis and Malaiskiene, 2010).

If $W_E \leq 26$ %, then sample disintegration start $F_{RE\ 1}$ is calculated according to this formula:

$$F_{RE1} = 0{,}231\frac{R^{1{,}068}\cdot D^{1{,}345}\cdot G_1^{0{,}275}\cdot G_2^{0{,}663}}{N^{0{,}285}\cdot g_1^{0{,}830}}, \text{ conditional cycles} \quad (8.12)$$

while sample disintegration end FRE 2 is calculated according to this formula:

$$F_{RE2} = 0{,}223\frac{R^{1{,}465}\cdot D^{0{,}759}\cdot G_1^{0{,}383}\cdot G_2^{0{,}852}}{N^{0{,}168}\cdot g_1^{1{,}034}}, \text{ conditional cycles} \quad (8.13)$$

If $W_E \geq 26$ %, then sample disintegration start $F_{RE\,3}$ is calculated according to this formula:

$$F_{RE3} = 0{,}051\frac{R^{1{,}642}\cdot D^{2{,}332}\cdot G_1^{0{,}383}\cdot g_1^{0{,}852}}{N^{0{,}334}\cdot G_2^{1{,}145}}, \text{ conditional cycles} \quad (8.14)$$

while sample disintegration end FRE 4 is calculated according to this formula:

$$F_{RE4} = 0{,}063\frac{R^{1{,}813}\cdot D^{2{,}135}\cdot G_1^{0{,}179}\cdot g_1^{1{,}134}}{N^{0{,}395}\cdot G_2^{0{,}517}}, \text{ conditional cycles} \quad (8.15)$$

Porous material longevity is calculated according to the formula which is derived according to 30 year weather observation results. It has been described several times in various scientific articles and are used in calculating product longevity in Lithuania, this methodologist starter is prof. R. Maciulaitis.

Porous material longevity is predicted with this empirical formula:

$$\tau = e^{3{,}31981+0{,}00524F_{RE}}, \text{ conditionally cold seasons} \quad (8.16)$$

Where:

τ – conditionally cold seasons,

F_{RE} – exploitational resistance to frost conditional cycles, F_{RE1} or F_{RE3} are used.

8.3. Results and example solutions

A program was created that allows the user to input required data about experiment and samples. Fig. 8.1 shows the program's input window, in which the user inputs starting data.

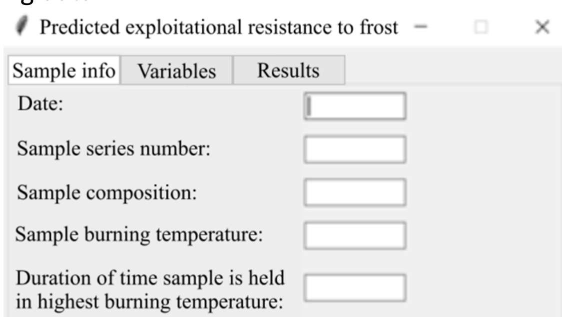


Fig. 8.1. The window for inputting starting information in the created program

After inputting starting data a second window can be opened, in which you can input values gotten during the experiment – variables (Fig. 8.2).

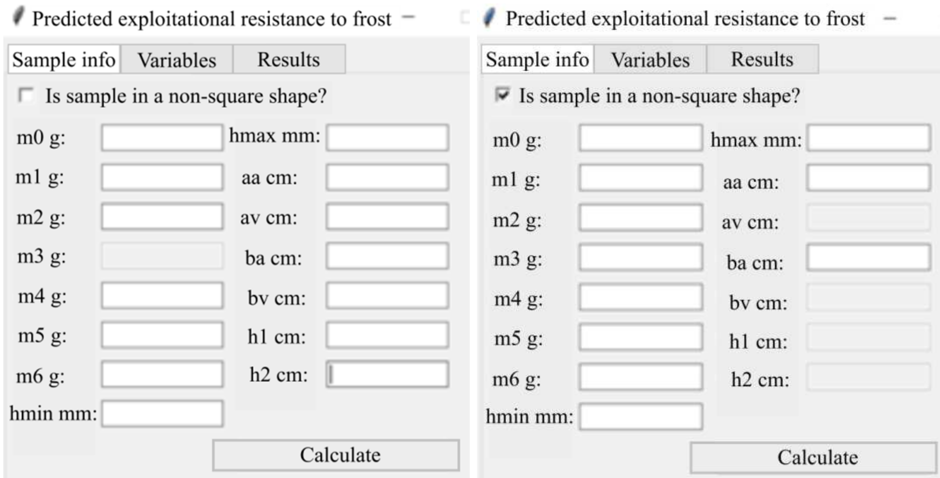


Fig. 8.2. The window for inputting information gotten from samples when the sample is of square shape (left) is of non-square shape (right)

Result window shows intermediate results and exploitation resistance to frost indicators (Fig. 8.3).

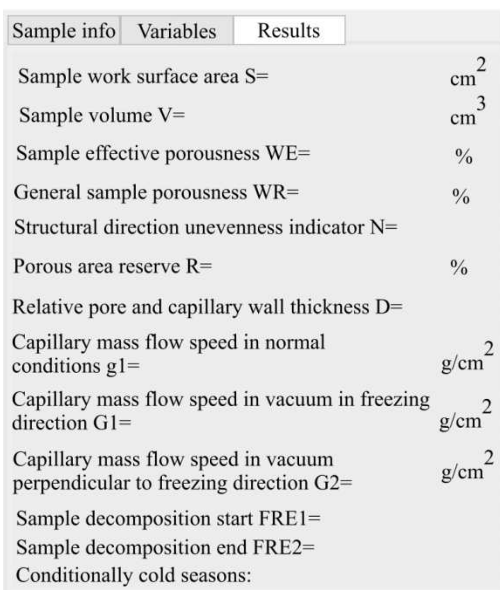


Fig. 8.3. The result outputting window

The program was tested by inputting real sample gotten variables. Two samples were used: square shaped sample exploitational resistance to frost calculation variables were input into appropriate program's variable windows (Fig. 8.4), outputted the results and generated a pdf file.

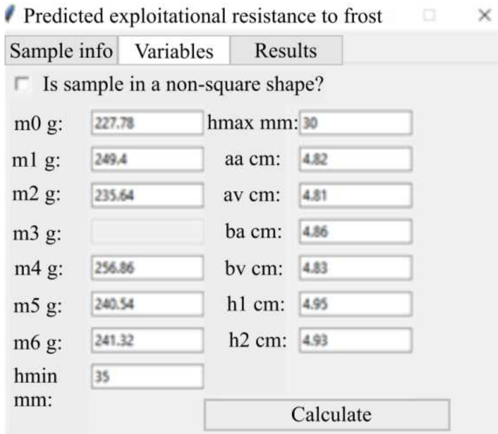
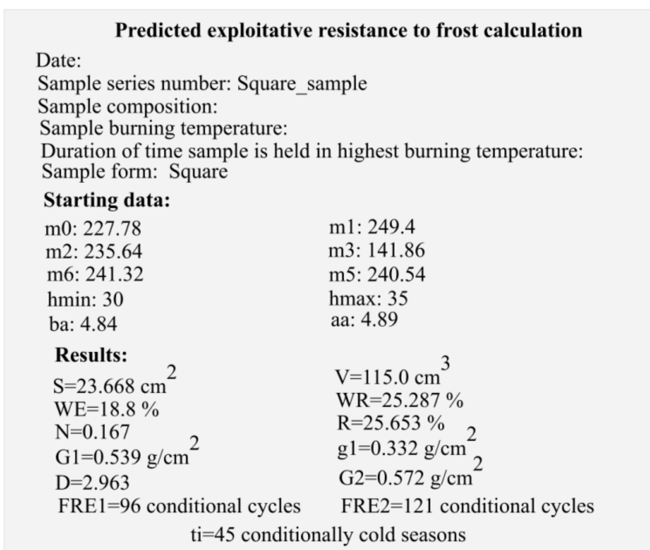


Fig. 8.4. The square shape sample variable input window with inputted values

The same was done with non-square shaped sample. Exploitational resistance to frost calculation determined variables were inputted into appropriate program windows, results were outputted and a pdf file was generated (Fig. 8.5 and Fig. 8.6).



Predicted exploitative resistance to frost calculation

Date:
Sample series number: Square_sample
Sample composition:
Sample burning temperature:
Duration of time sample is held in highest burning temperature:
Sample form: Square

Starting data:

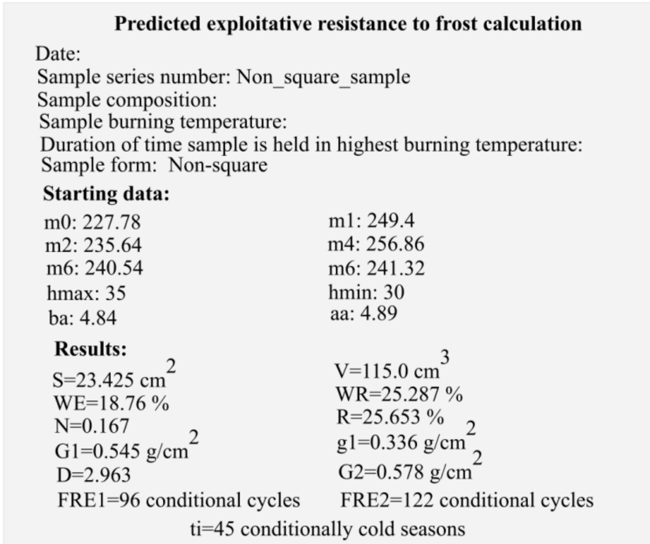
m0: 227.78	m1: 249.4
m2: 235.64	m3: 141.86
m6: 241.32	m5: 240.54
hmin: 30	hmax: 35
ba: 4.84	aa: 4.89

Results:

S=23.668 cm^2	V=115.0 cm^3
WE=18.8 %	WR=25.287 %
N=0.167	R=25.653 %
G1=0.539 g/cm^2	g1=0.332 g/cm^2
D=2.963	G2=0.572 g/cm^2
FRE1=96 conditional cycles	FRE2=121 conditional cycles

ti=45 conditionally cold seasons

Fig. 8.5. The generated pdf file of square shape sample



Predicted exploitative resistance to frost calculation

Date:
Sample series number: Non_square_sample
Sample composition:
Sample burning temperature:
Duration of time sample is held in highest burning temperature:
Sample form: Non-square

Starting data:

m0: 227.78	m1: 249.4
m2: 235.64	m4: 256.86
m6: 240.54	m6: 241.32
hmax: 35	hmin: 30
ba: 4.84	aa: 4.89

Results:

S=23.425 cm^2	V=115.0 cm^3
WE=18.76 %	WR=25.287 %
N=0.167	R=25.653 %
G1=0.545 g/cm^2	g1=0.336 g/cm^2
D=2.963	G2=0.578 g/cm^2
FRE1=96 conditional cycles	FRE2=122 conditional cycles

ti=45 conditionally cold seasons

Fig. 8.6. The generated pdf file of non-square shape sample

After the sample calculation testing the new program is prepared for usage. It can be used by material researchers, predicting exploitational resistance to frost. The program is accessible to both students and researchers. It is presented to VGTU Building material and fire safety department.

For convenience sake the Python language program, with a new team, was recreated as a web application using Java programming language for back-end and React for front-end. Picture below shows the most basic looking version of the web application (Fig. 8.7).

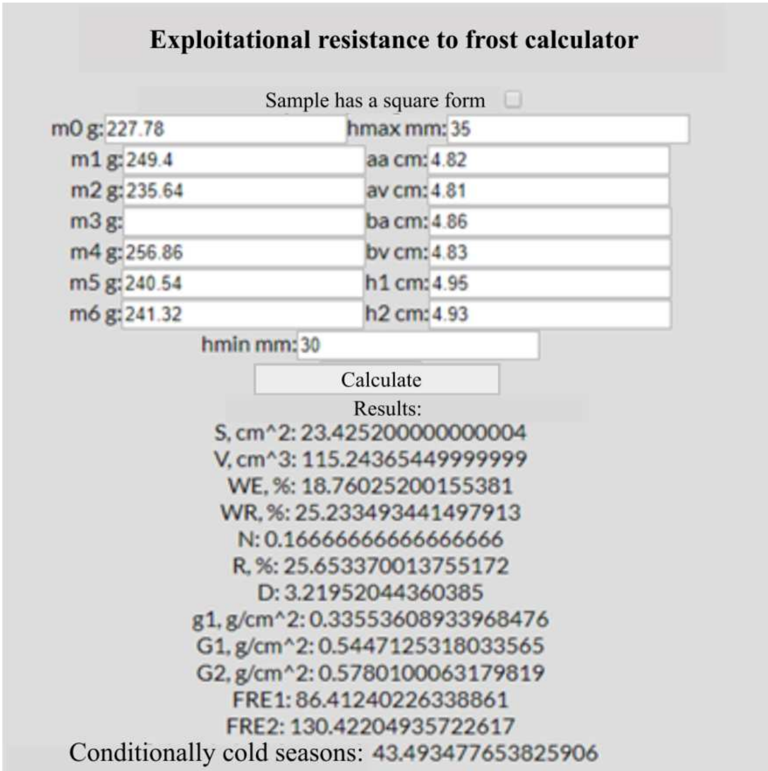


Fig. 8.7. Basic display of the web application

For this application creation a project was initiated. A team was formed that reused the Python application's code (Fig. 8.8). to recreate the program in web application form. To keep track of the progress Github website was used as version control and a Trello board was set up to keep track of current tasks and their status (Github 2018).

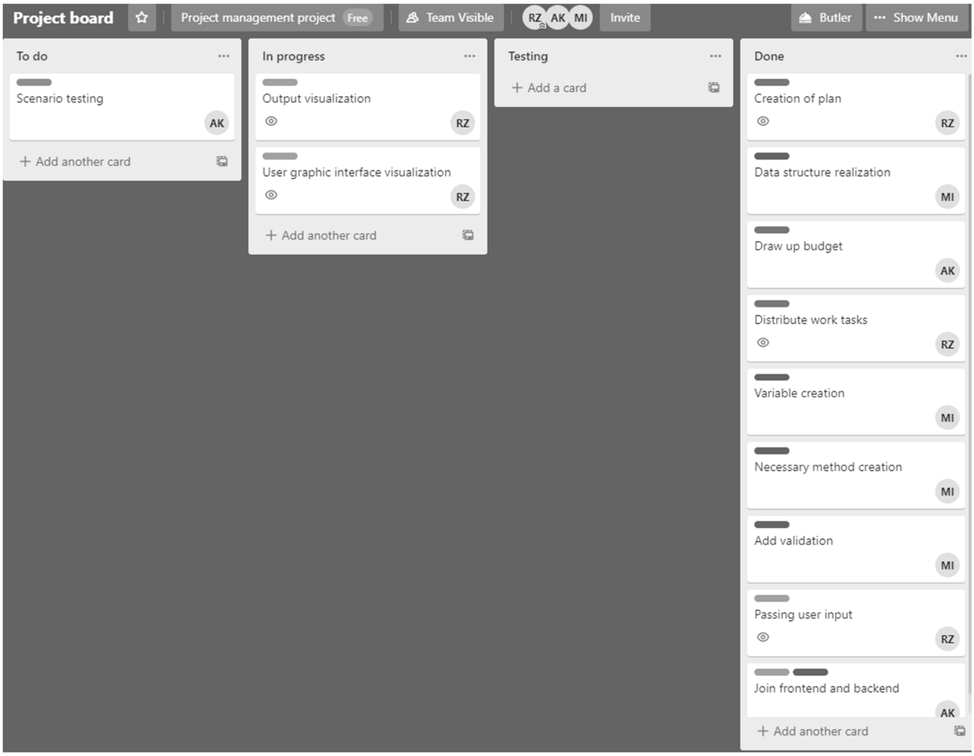


Fig. 8.8. Trello board used during the creation of the web application

8.4. Conclusion

1. Using Python programming language a new program was created. This program helps material science researcher's work with gotten laboratory sample results. Researchers can simply write in their gotten sample results into the program's window. The program displays the main calculation results – predicted exploitational resistance to frost and conditionally cold season amount.

2. Gotten results are more precise and trustworthy because of lower chance of mistakes and it lowers the amount of time used for calculations.

3. The created program allows predicting using both square and non-square shaped samples, which is convenient in the laboratory when a sample or a piece of a sample is being tested.

4. This program was expanded on by creating a web application using React and programing language Java for easier access.

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