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Design of tools for treatment lightweight mortars in supporting construction materials in Banyuwangi

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Abstract. The development of the construction industry in Banyuwangi has very rapid. This can be seen from the high-rise building construction projects such as hotels and others. Banyuwangi has located in a coastal area, this gives a signal that consideration of lateral loads that may occur is necessary. One of them is earthquake load which has a higher concept and building weight, so the greater the earthquake load received. So, we need the use of lightweight structural elements such as the use of lightweight aggregates. This requires innovation, which in this case was used fly ash in making lightweight mortars that were applied to non-structural elements such as lightweight bricks. Proportion that has been done in previous studies. In this follow-up research focused on the design of tools used to treat mortars in order to have good quality. Results of this study found the design of the steam curing device and the results of the mortar test. The mortar test results with tools could be have compression test a maximum of 7.47 MPa, with treatment on 70 degree C for six hours. These results have a better value when compared to the value of mortar on lightweight bricks on the market.

1. Introduction

Density of concrete has around 2400 kg/m³, affect the loading of structures that are relatively large and heavy, this will affect the total weight of the building which can cause the dimensions of the foundation which tends to be extravagant and have an impact on structural behaviour at high seismic regions that is increasingly the weight of the structure the greater the earthquake effect received by the building (static earthquake concept). According to SNI-03-2847-2002, lightweight concrete is concrete containing light aggregate and has a density of no more than 1900 kg/m3. Treatment with water vapor can be beneficial in maintaining hydration heat in concrete. The purpose of using water vapor is to get a high initial strength [1]. Treatment with high-pressure steam, atmospheric pressure steam, heating, and humidification or other processes that can be used to achieve compressive strength and reduce maintenance time. Mortar treatment using steam at ± 60ºC for 6 hours [2]. The hot conditions reduced the workability of the concrete, resulting in slump loss [3]. To realize the manufacture of lightweight steam curing-based mortars, it is necessary to design tools that have the appropriate mechanism. This design consists of several steps, namely the manufacture of electronic parts and mechanical parts. The material used is in the form of a waste-based lightweight mortar with a predetermined proportion. So, it was expected to produce a lightweight mortar that has good compressive strength.

2. Literature review

2.1. Tool design system
Design is one of the important things in making a program. The purpose of the design had to provide a completely clear picture of the programming and the technical experts involving. The building or building a system is an activity of creating a new system or replacing or repairing an existing system as a whole [4]. A system is a group of elements that are closely related to each other, which function together to achieve certain goals [5].

2.2. Concrete curing
Concrete treatment is a procedure after casting which is carried out to maintain concrete during the hydration process. When cement is mixed with water a chemical reaction called hydration occur. When hydration takes place the loss of water due to evaporation must be avoided because it can cause the hydration process to stop, this can cause the concrete to shrink and become cracked. Concrete curing is strongly influenced by the temperature and humidity of the concrete itself, therefore concrete treatments not only affect the strength of concrete but can also affect the durability of concrete. The use of effective maintenance methods depends on the type of material used, the type of construction, and the expected utilization of concrete. There are two concrete treatment methods based on the temperature used, which are normal maintenance and treatment at elevated temperature [6]. Concrete curing at elevated temperature is a concrete treatment carried out at temperatures used above room temperature to accelerate the increase in compressive strength of concrete. Because the hydration rate of the cement increases with increasing temperature, the achievement of the compressive strength of concrete can be accelerated by treating concrete at elevated temperatures. Therefore, the concrete produced has a more rapid maturity than the concrete that is treated in the usual way. Whereas in paving block curing, 70ºC treatment temperature is the optimum temperature to be applied to the steam curing method [7].

2.3. Material review
The first material is used cement, fine aggregate, water, fly ash and rice husk ash. Further, the suitability of using a binder of rice husk ash and fly ash to produce alkali-activated construction bricks was investigated [4]. The pozzolanic nature of fly ash, unburnt carbon content, surface area, lime content, and water-curing periods were chosen as the input parameters, and free lime remaining in the mixes after different water-curing periods was chosen as the output parameter [7]. the other specification of fly ash about porosity. The porosity of the samples sintered using unpickled fly ash and clay reduces sharply when the temperature increased from 1300°C to 1400°C [14]. The ingress of sulphate and sodium into the microstructure of the fly ash cement pastes activated the fly ash pozzolanic reaction, causing a pore refinement and a decrease of porosity [6].

2.4. Mortar with another treatment
The mortar will be made become concrete brick with composition fly ash and rice hush ash. Fly ash bricks have also been found to have higher crushing strengths than their conventional concrete counter parts [3]. The production of concrete is usually divided into three basic stages, the raw material stage, the transportation stage, and the manufacturing stage [8]. After that for the curing is used curing system. The standard wet-cured mortars containing finer fly ash exhibited higher compressive strength at all ages than that containing coarser fly ash [2]. Conclusion, the results of another treatment of mortar with composition fly ash and rice husk ash have been increasing in the focus in compression test of mortar. This judgment had representation for our research [9-14].

3. Methodology
The method used in this research had an experimental study conducted at the Concrete Test Laboratory of Civil Engineering in Banyuwangi State Polytechnic and design simulation through software.

3.1. Preliminary test
The preliminary test aims to find out the basic concepts of making tools so that everything intended for the design of the tool has been considered based on the concept. The preliminary test is in the form of a series of mortar compressive strength tests based on the temperature variable given during the steam treatment process. Based on the test, some notes will appear as a basic material to complete the design of the tool.

3.2. Design
The design of this tool was done using software assistance, but the shape and characteristics of the material, researchers still consider creativity and safety factors. The design of the tool prioritizes in terms of usability and functionality.

3.3. Simulation
The simulation aims to determine the quality of the material designed according to ability so that there had no error in the tool. Simulation was also intended to determine the system that occurs when the tool operates. This simulation tool is assisted by SolidWorks software.

3.4. Prototype test
Prototype test aims to determine the functionality of the microcontroller hardware and the working system of the tool, so it can be seen whether the tool can work optimally.

4. Results and discussion

4.1. Static simulation
Static analysis of this research has been using Generative Structural Analysis in Solid Works software. The results of this analysis show the results of stresses, displacement, and strain in each construction, the file will help as a reference for the design of the tool.

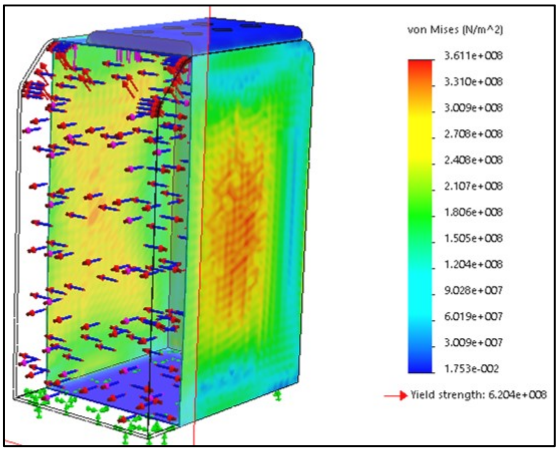

Figure 1. Static analysis of stress on the boiler body.

This analysis produces a stress on the boiler body which was indicated by the colour change in the image. Figure 1 shows the direction of the stress caused by applying pressure of 14.501 psi (1 bar), water load of 450 N and the maximum planned temperature in 150ºC. The blue colour indicates the part that experiences a small stress while the red colour had the part that receives a large voltage. From these files, it can be seen that the maximum yield strength value of the boiler material had 6.204e+008 N/mm^2 (620.4 MPa). The highest value after material simulation, the yield strength obtained had 3.611e+008 N/mm^2 (361.1 MPa). The result of maximum strain had 7.937e-004 N/m^2 approaching 0.0 MPa. Limit of maximum strain had 0.2% from the maximum yield strength 1.24 MPa. So, this design and materials can be used.

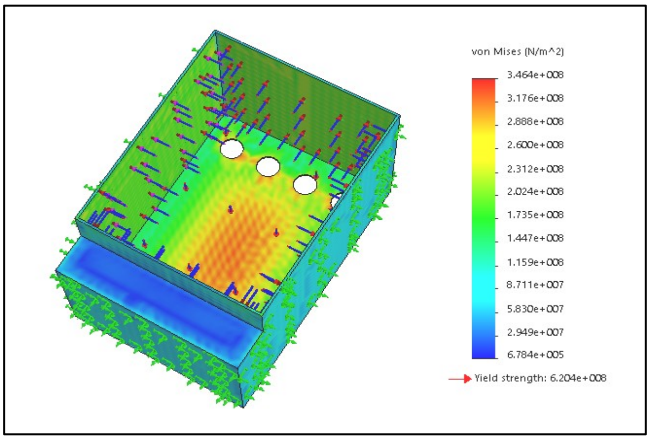

Figure 2. Static analysis of stress on the container body.

This analysis produces a stress on the body container which was indicated by the colour change in the image. The maximum yield strength of body container had 6.204e+008 N/m^2 (620.4 MPa). The highest value after material simulation, the yield strength obtained had 3.464e+008 N/m^2 (346.4 MPa). So, this design and materials can be used.

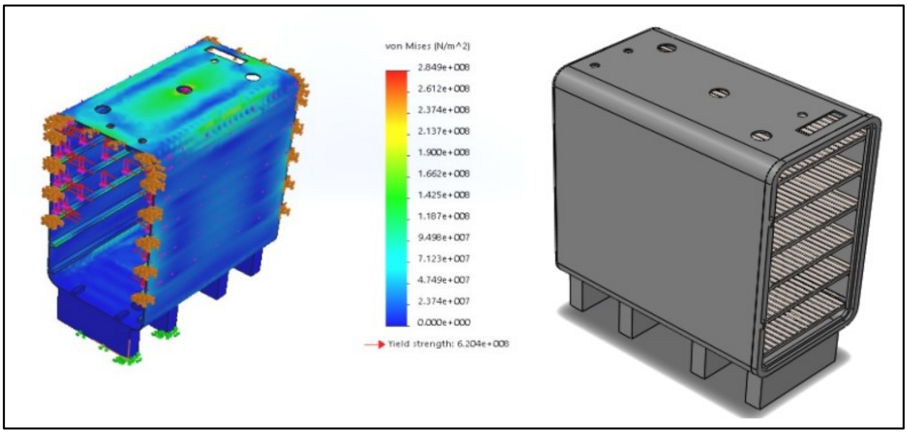

Figure 3. Static analysis of strength on the steam room body.

This analysis had to determine the value of the stress that occurs in the form of material from the color change after getting loaded. The maximum stress had 2.849e+008 N/m^2 (284.9 MPa). The limit of maximum yield strength had 6.204e+008 N/m^2 (620.4 MPa). So, this design and materials can be used.

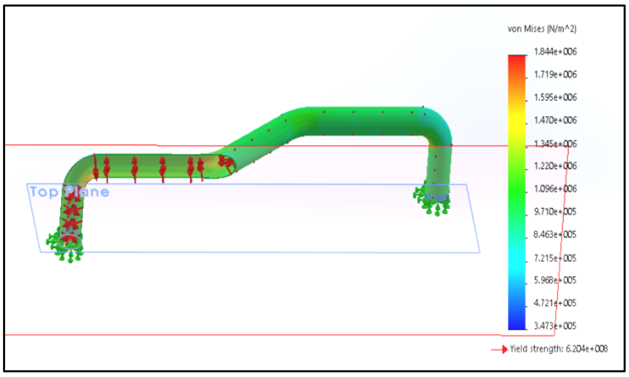

Figure 4. Stress analysis of top pipe.

The flow in the top pipe is the flow of steam, this pipe carries steam to the steam room through the top, so that the steam can spread evenly through the roof of the steam room. The result of maximum yield strength had 1.844e+006 N/m^2 (184.4 MPa). While the limit of maximum yield strength on this material had 6.204e+008 N/m^2 (620.4 MPa). So, this pipe can be used.

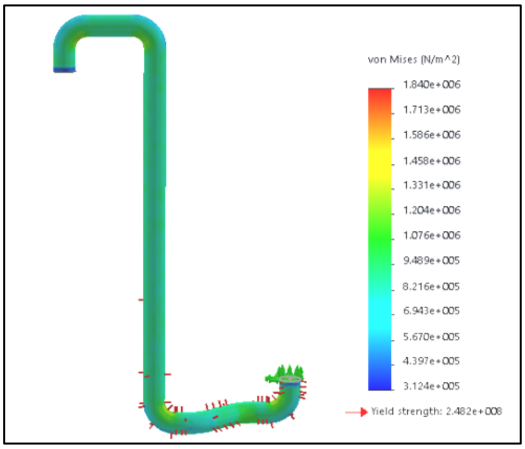

Figure 5. Stress analysis of bottom pipe.

The result of maximum yield strength had 1.840e+006 N/m^2 (184 MPa). While the limit of maximum yield strength on this material had 6.204e+008 N/m2 (620.4 MPa). So, this pipe can be used.

4.2. Microcontroller

The microcontroller has a series of input programs to be translated as commands on each component of the tool. The tool input process flow had as follows:

- The power supply will continue the current to and will be changed by the adapter following the allowable voltage which was the main power of the tool.
- The microcontroller will first translate the temperature input button as a variable for the circuit breaker in the relay, followed by the translation of the desired time input as the power supply circuit breaker variable.
- As the input data was completed, the microcontroller will be received data on the condition of the volume of water in the reservoir, along with opening an electric current from the adapter to the coil which is then converted to heat energy as heat for the heated water.
- The evaporation process will be taken place during in the allotted time. There are temperature and pressure sensors to control data input at the beginning and maintaining the safety factor.

- If an error occurs in the process of operating the tool, then the emergency button functions as a breaker for all voltage working on the tool, so the tool will have been stop operating completely.

4.3. Steam construction
Commissioning of steam construction on the mortar can be seen below:

Figure 6. Curing of mortar with steam.

4.4. Mortar test result
In this test, light mortar weight and compressive strength were carried out at the age of 1 day after treatment with the steam curing method for six hours. Compression strength test results are shown in the Table 1 seen that the temperature at 70ºC shows the best compressive strength. Then the higher the temperature also causes the quality to decrease. This shows that the temperature had too high, causing the hydration process inside the mortar to be incomplete.

Table 1. Result of compression test.

Steam Curing on Temperature (ºC)	Compression Test Result (MPa)
40	5.11
50	5.54
60	6.66
70	7.47
80	6.06

5. Conclusions
This research can be concluded that the results of the mortar treatment, it shows that the tool designed give a good compressive strength. Mortar compressive strength test results indicate the recommended treatment in the temperature range of 60ºC to 70ºC.

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