Analysis Residual Strength of Post Fire Concrete

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ABSTRACT— ***The study is experimental to describe the residual strength of post fire concrete. The research was conducted in the laboratory by heating the concrete sample in the oven with temperature 400°C and 600°C for 3 hours, 6 hours and 9 hours. The results show that concrete after burning with heating 600oC causes slight residual strength or below 60%. This condition indicates that concrete that has been fired or heated above 600oC temperature is not feasible for reuse. In 400°C concrete combustion, concrete strength more than 35 Mpa shows the residual strength of over than 60%. This condition indicates that concrete that has been fired or heated to a temperature of less than 400oC is feasible for reuse, but with construction improvements***

Keywords— post fire concrete, residual strength, heating

1. INTRODUCTION

Building fires are a major disaster that often happens in Indonesia. Every day, there is news about the fire. Fire disaster management runs slow due to various factors. Regarding handling the building after the fire, the action was impressed still less quickly. The unclear reference about the after burning condition causes the limited decision about handling. Forensic experts have two actions on post fire buildings; that is tear down or repair the building for reuse.

The burned concrete structure can be re-functioned based on the residual compressive strength. The high temperature changes in the event of fire affect the elements of the concrete structure. Alternative heating and cooling cycles cause complex physical and chemical changes. The temperature changes affect the quality/strength of the concrete structure. Assessment of residual strength of post-fire buildings can be a reference in decision making re-utilization of burning concrete structures. Various methods of assessment have been used by researchers, both non-destructively and destructively.

Concrete has a resistance to fire and relatively better than other materials such as steel or wood. Concrete is a material with low heat conductivity. Furthermore, the thickness of concrete can protect the reinforcement from the high temperature outside in case of fire[1][2]. Heating on the concrete causes a decrease in its quality. Firming or heating with the exposure time of the decomposition of mechanical properties of all types of concrete [3]. Another study of the change like betine indicates that the relationship between strength and strain differs between burnt concrete and normal concrete[4].

The chemical characteristics of the concrete also change due to heating. Increasing temperature of concrete reaches 100°C, the volume of the paste enlarges linearly or expands. The condition of concrete above temperature 100°C, the volume of paste shrink (shrinkage) due to the process of discharge of water (dehydration). Cement and aggregate paste as a separate concrete composition due to differences in expansion coefficient between cement paste and aggregate are not equal. This condition causes paste cracking and aggregate release. Visually, the concrete also changes color. Heating above 300°C, the concrete will change color to pink. If above 600°C, it will be a bit gray green and if it reaches above 900°C becomes gray. However, if it reaches above 1200°C will turn to yellow. Thus, it can roughly be estimated how the highest temperatures during a fire take place based on the color of the concrete surface on the first inspection.

Previous studies about residual compressive strength indicated that the burned concrete at 200°C, the compressive strength of the residual average of 85.83% of the ordinary concrete. The concrete that burned to 400°C, the average compressive strength is 53.08%. This strength will continue to decrease to the remaining 35.08% at 600°C[5]. The

development of the study is a review of the residual compressive strength profile of various types of concrete compressive strength

2. MATERIAL AND METHOD

This research is an experimental research using cube test object with size 15 cm x 15 cm x 15 cm. The quality of concrete utilized for all specimens is 20 MPa, 30 MPa, and 35 MPa. The amount of sample for each type of concrete quality are ten samples at each temperature variation. The study design is presented in table 1.

Tabel 1. Design of sample

Target Strength (MPa)	Temperature of Heating (^oC)	Heating time (hours)	Control
25 (TS 25)	400	3	Normal
	600	6	
		9	
30 (TS 30)	400	3	Normal
	600	6	
		9	
35 (TS 35)	400	3	Normal
	600	6	
		9	

Sampling process for 28 days before heating by oven system. The day after heating, the compressive strength test with destructive test method to obtain the compressive strength (Fig 1).

Fig. 1. Testing of concrete compressive strength with sample of cube

The results of the compressive strength test were analyzed to obtain Residual Strength Concrete (RSC) and Loss Strength Concrete (LSC). The formula does RSC calculation:

$$RSC = (NSC - SCB)/NSC \times 100\% \quad .....(1)$$

$$LSC = 100\% - RSC \quad .....(2)$$

RSC = Residual Strength (%)

NSC = Normal Strength Concrete (MPa)

SCB= Strength of Concrete after heating (MPa)

LSC = Loss of Strength (%)

3. RESULT AND DISCUSS

3.1. The Relationship between the burning hours with Strength of Concrete

The heating temperature 400°C resulted in difference trend for three types of concrete accordance with the length of heating. In the sample, TS 35 obtained NSC strength is 38.67 MPa. After heating 3 hours with temperature 400°C, compressive strength reaches 35.92 MPa and heating 9 hours resulted in compressive strength of 28.34 MPa or just about 73% residual concrete. The lower concrete quality (TS 30), the corresponding strength value after 9 hours of burning with normal concrete strength is 52%. Description of concrete strength after burning 400°C is described in Fig 2.

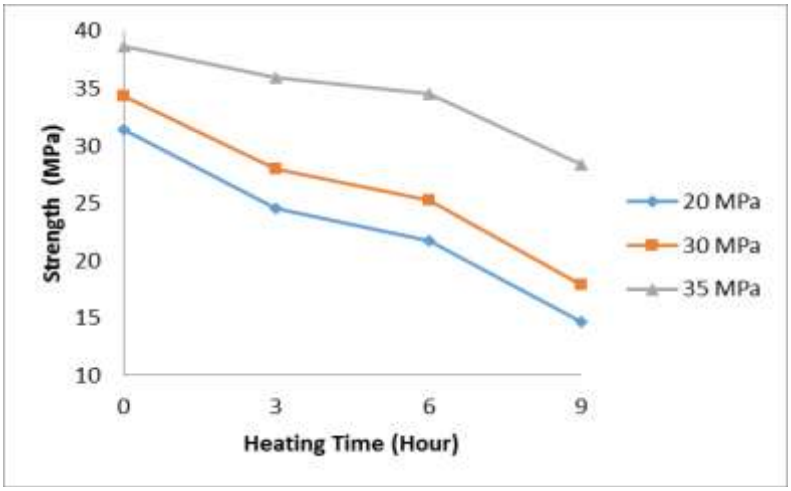

Fig.2. The relationship between the heating time with the compressive strength of the concrete (400oC) .

Furthermore, the heating process by the temperature of 600°C for 3 hours leads to a drastic reduction. In the sample, TS 35 shows the strength is 22,7 MPa., The compressive strength decreased to 19.27 MPa after heating 6 hours. Heating 9 hours gives a compressive yield of 17.3 MPa or just about 44%. At lower concrete quality (TS = 30 MPa), the corresponding strength value after 9 hours of burn with normal concrete strength is 36%. Description of concrete strength after burning 400°C is described in the Fig.3

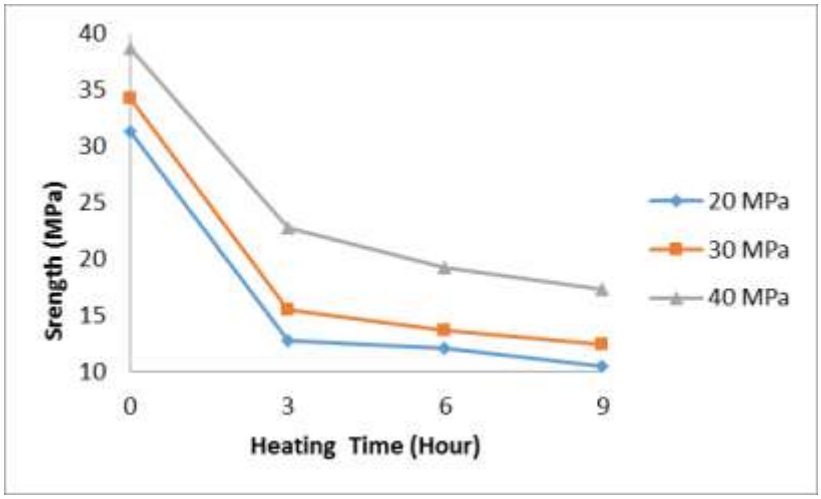

Fig.3. The relationship between the heating time with the compressive strength of the concrete (600°C)

3.2. Residual Strength of Concrete

Residual strength is the result of comparative analysis of the compressive strength of concrete that has been burned with a compressive strength of concrete sample that is not burned. The TS 20 concrete sample shows the remaining strength of 46.79% at a combustion temperature of 400°C, while at a temperature of 600°C the remaining strength is only about 33.27%. The burning process of 600°C causes radical drainage damage. (Fig.4) In contrast to the results of the RCS analysis on TS 30 with a combustion temperature of 400°C for 9 hours, the remaining compressive strength is still above 50%. The temperature heating 600oC for 9 hours, the concrete only has 36% strength of the condition compared to normal concrete strength. (Fig.5) Higher strength concrete (TS 35) showed a relatively small decline in the quality of concrete at 400°C burning. However, with the heating of 600°C, the residual strength demonstrated by all samples is very low. (Fig 6)

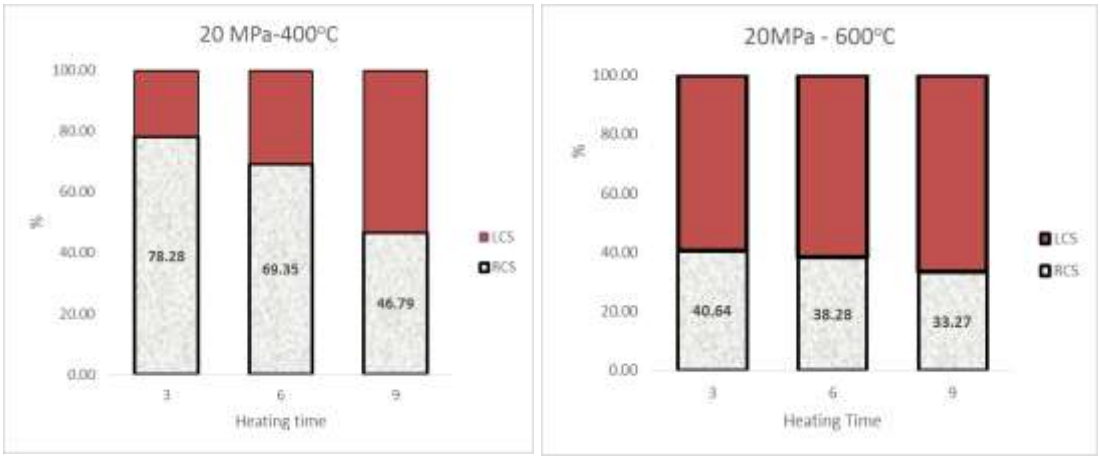

Fig.4. Residual Strength of Concrete (TS 20)

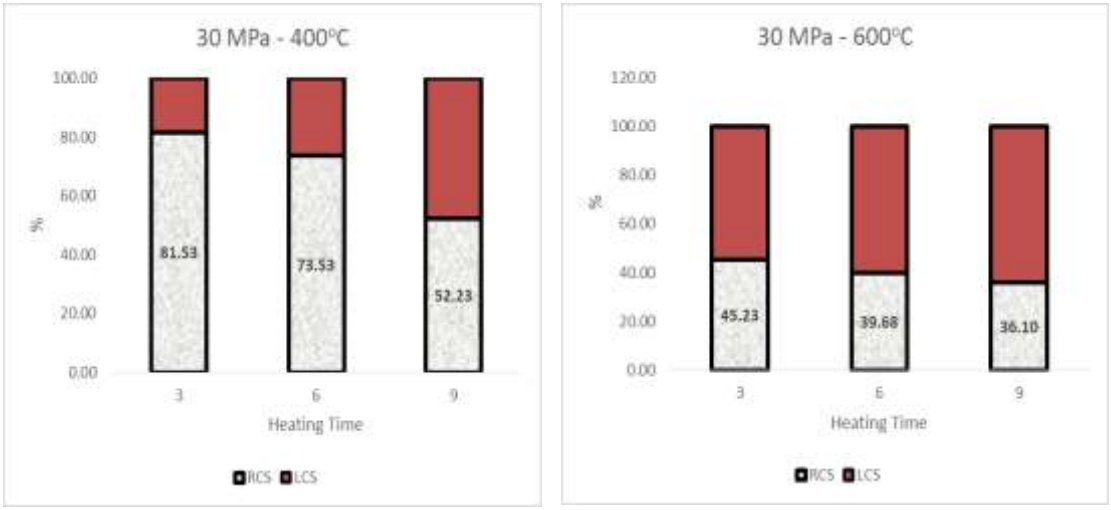

Fig.5. Residual Strength of Concrete (TS 30)

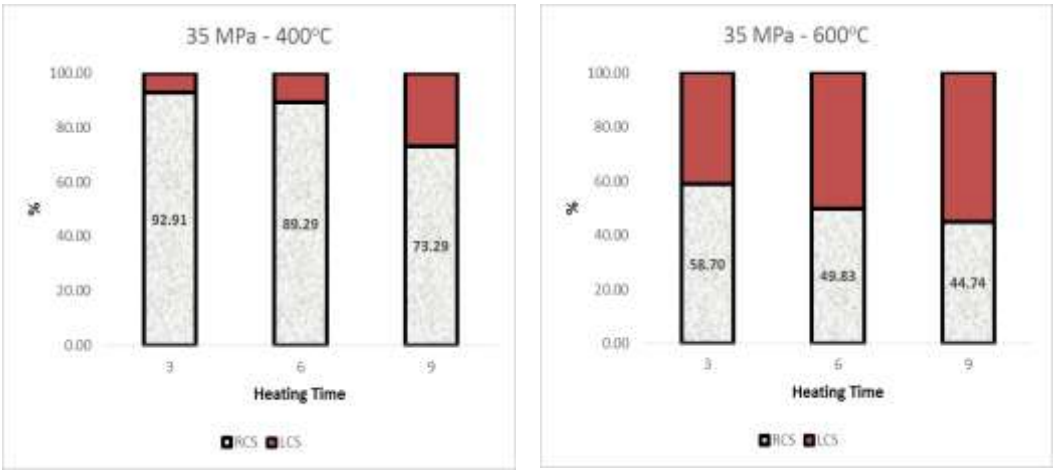

Fig.6. Residual Strength of Concrete (TS 35)

The results of the study show that burning 600°C causes a slight residual strength or below 60%. This condition indicates that concrete that has been fired or heated above 600°C temperature is not feasible for reuse. In 400°C concrete combustion, concrete strength exceeding 35 MPa shows the residual strength of over 60%. These conditions indicate that concrete that has been fired or heated with temperatures less than 400°C is feasible for reuse, but with construction improvements.

3.3. Discuss

The results showed that the higher compressive strength of concrete, the better of residual strength. High concrete strength can be achieved with excellent chemical characteristics or with higher cement content. The decreasing compressive strength indicated the C-S-H element occurring in the hydration process. As a result, of heating occurs decomposition process of C-S-H element that decomposes into chalk free CaO and SiO_2. This element has no power at all. Loss of the C-S-H element is the leading cause of the decline in the strength of the concrete. Furthermore, the bonding between aggregate and cement paste decreases due to the heating process.

Cracking of concrete occurs as a result of the decreasing of bonding. [6]The decreasing in adhesion is due to the difference in the expansion rate between aggregate and cement paste. This difference causes damage to the interfacial zone so that the attachment between the rocks becomes much reduced. The findings indicated severe bond strength among of constituent element reduction of up to 24 and 74% at temperatures of 600°C and 800°C [7]. Warming causes dehydration of the process on the concrete and causes the microstructure to be tenuous. It is characterized by the occurrence of cracking [8]

4. CONCLUSION

Burning of 600°C causes a slight residual strength or below 60%. This condition indicates that concrete that has been fired or heated above 600°C temperature is not feasible for reuse. In 400°C concrete combustion, concrete strength exceeding 35 MPa shows the residual strength of over 60%. These condition indicates that concrete that has been fired or heated with temperatures less than 400°C is feasible for reuse with construction improvements.

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