Stability And Insulation Of Sandwich Reinforced Concrete Slab With Lightweight Concrete Core Under Flexural Loading Exposed To Fire

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Stability and insulation of sandwich reinforced concrete slab with lightweight concrete core under flexural loading exposed to fire

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Abstract. The application of concrete structural building material has a favourite position in the construction industry. However, its large density is a disadvantage of concrete with a higher risk of collapse in dangerous earthquake areas because the earthquake load is directly proportional to the mass of the building. On this basis it is necessary to reduce building mass by using lightweight material. The purpose of this research is to exploit pumice waste material of Lombok Island in order to create lightweight structural building component with better earthquake resistance as well as fire resistance. Experimental investigation has been carried out in the Laboratory of Research and Development Board, Minister of Public Works and Public Housing, Bandung. Two slabs specimen of 3500 x 3700 x 20 mm have been tested under Indonesian Standard Fire Test with flexural loading of 40 kN/m2. Normal concrete slab and sandwich concrete slab with 50 mm skins thickness and 100 mm core thickness were prepared. The skins were normal concrete with compressive strength of 25 MPa and the lightweight core concrete compressive strength was 15 MPa. Both slabs have been reinforced with Ø12-100 as compressive reinforcement and Ø12-150 as tensile reinforcement with steel yield strength of 290 MPa. Test results indicated that the two slabs have fire resistance stability for 2 hours.

However, normal concrete slab has only 70 minutes insulation resistance compared to sandwich normal concrete which is has 80 minutes. This shows that the sandwich concrete has

1.14 greater insulation resistance. The temperature of unexposed fire after 2 hours of firing in normal concrete was 320 °C while in sandwich concrete is 240 °C shows that the sandwich concrete has 1.33 better resistance thermal conductivity than normal concrete.

Keywords: Slab, sandwich concrete, flexural load, fire resistance.

1. Introduction

Concrete has a favorite position in the construction building industry. But, its large density is a disadvantage of concrete with higher risk of collapse in dangerous earthquake areas since earthquake load is directly proportional to the mass of the building [1]. Consequently, it is necessary to reduce building mass by using lightweight material. This research exploited pumice waste material of Lombok Island in order to create lightweight structural building component with better earthquake resistance as well as fire resistance [2,3].

The main purpose of this research is directed to support the vision and mission of Mataram University with Research Strategic Planning under sub-sector building infrastructure. Local materials for construction are leading topic of this research strategic planning. In order to utilize abundant pumice waste in Lombok Island, a model of lightweight reinforced concrete slab has been developed [4,5,6]. The use of lightweight building materials will also save foundation and other supporting structures.

Road map of structural and building materials research group is presented in the Fig.1. The research group focus on the application of natural resources for building materials which available locally [7].

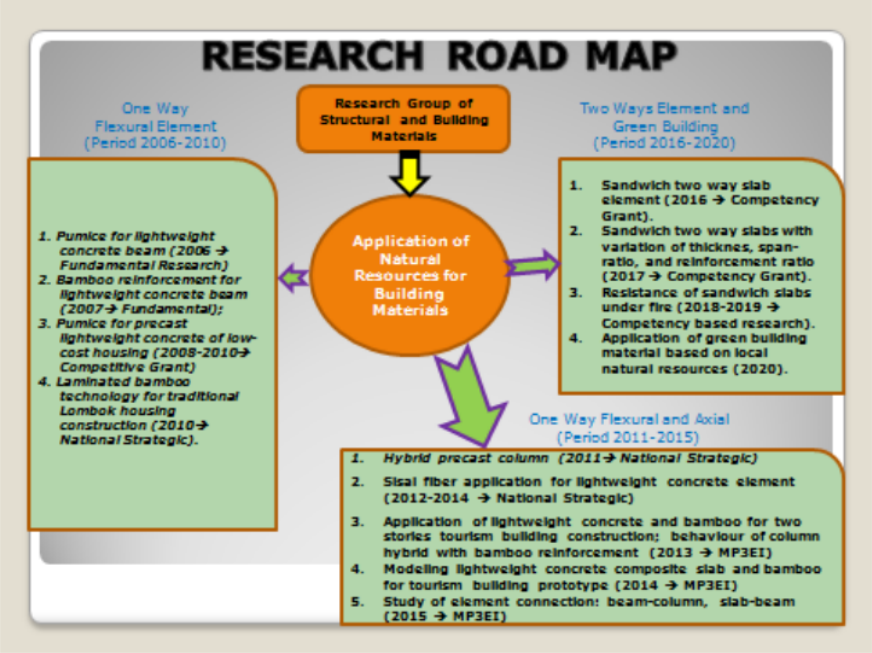

Figure 1. Road map structural and building materials research group

2. Experimental program

Two reinforced concrete slabs size 3500x 3700x200 mm have been prepared with 1.2% steel reinforcement ratio. The first slab was three layers sandwich concrete, 2 skins and 1 core, with each layer thickness of 50-100-50 mm. The 50 mm skin layers have compressive strength of 25 MPa and

the 100 mm lightweight concrete core has compressive strength of 15 MPa. The second slab was full normal concrete with compressive strength of 25 MPa has been used as a standard specimen.

2.1. Testing procedure

Experimental test have been carried out at the laboratory of Center for Housing and Settlement Research and Development, Research and Development Agency, Ministry of Public Works and Housing, Bandung. Based on Indonesian Standard, SNI 1741:2008 [8], the failure criteria have been defined in the following:

- *Stability* (load bearing capacity: collapse or exceed permitted deflection)
- *Integrity* (penetration of fire through cracks or holes)
- *Insulation* (temperature on an unexposed surface)

2.2. Standard fire test

Relationship between time-temperature of standard fire test [9] is presented in Figure 2.

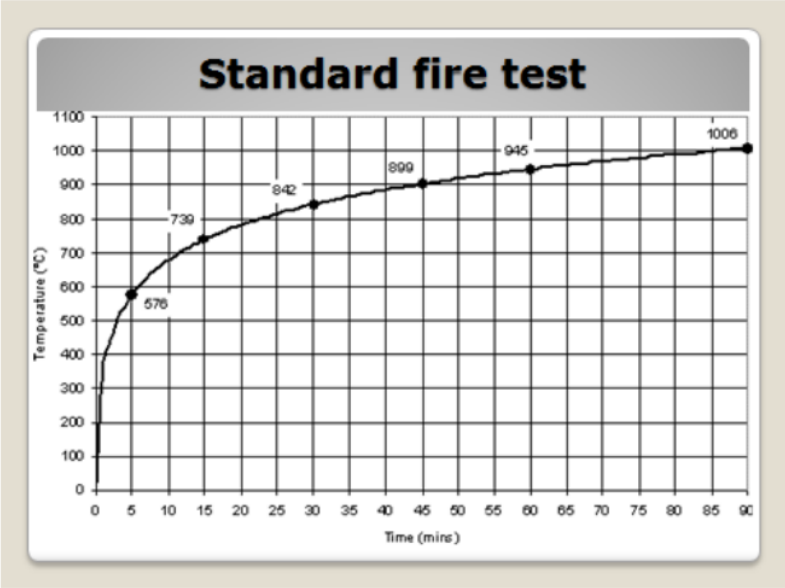

Figure 2. Time-temperature relationship of standard fire test

The standard fire test has been derived from the equation: $T = 20 + 345\ log(8t + 1)$, where T represented furnace temperature $(^{O}C)$and t represented time *(minutes)*. The curve looked very steep in the first 15 minutes and subsequently increase gradually afterwards.

The specimen's preparation, erection and experimental setup are presented in the Figures 3-7 in the following.

Figure 3. Preparation of specimens

Figure 4. Specimen's erection

Figure 5. Experimental

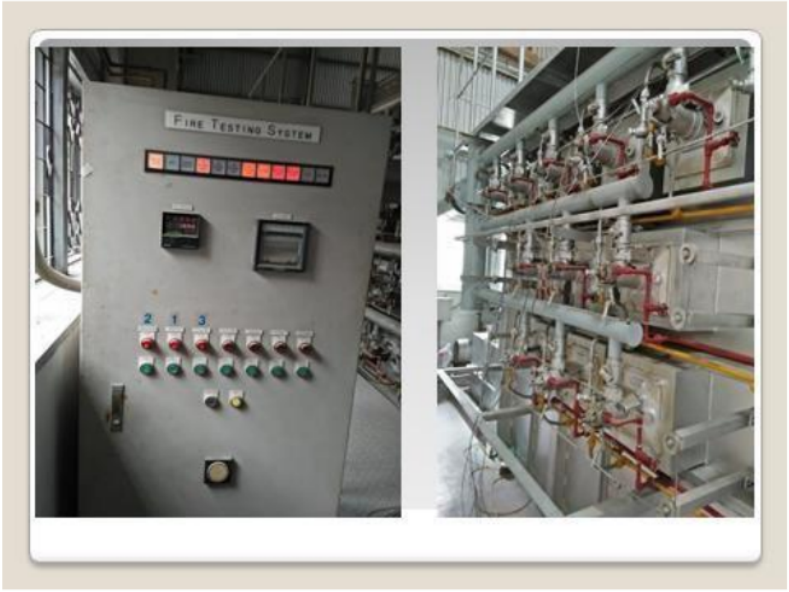

Figure 6. Fire testing system

Figure 7. Data acquisition system

3. Results and discussions

From experimental results, the relationship of Temperature – time can be seen in Figure 8, whilst Temperature – deflection diagram is presented Figure 9 in the following.

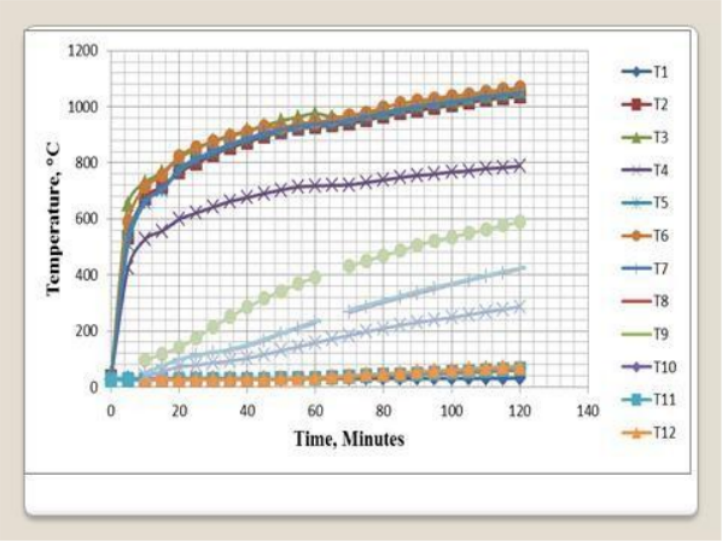

Figure 8. Time – temperature diagram

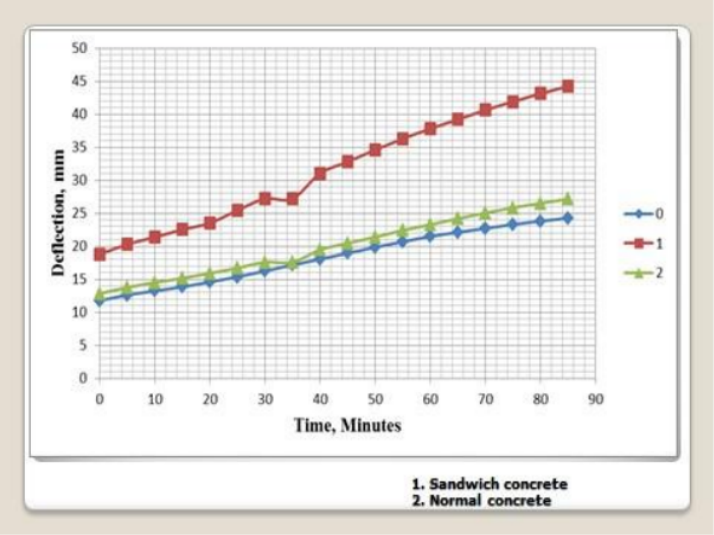

Figure 9. Time – deflection diagram

Figure 8 and 9 show that all specimens have sufficient stability to standard heating with a time of 2 hours (120 minutes). Compared to normal concrete, sandwich concrete slab with lightweight pumice concrete core has significant role in the insulation of slab structures under heating to

standard temperatures. Within 2 hours when the furnace temperature reached 1020 ^{O}C, the surface temperature not exposed to fire in normal concrete was 320 ^{O}C while in sandwich concrete was 240 ^{O}C. It was can be seen that the sandwich concrete has an insulation ability of 1.33 better than normal concrete.

However, all types of specimens are considered to fail when the unexposed temperature of the slabs reached 160 ^{O}C. It means that normal concrete has a resistance of 70 minutes while sandwich concrete has 80 minutes. In this case, the sandwich concrete has better insulation resistance compare to normal concrete.

On the other hand, sandwich concrete has disadvantages compared to normal concrete in terms of deflection. At the time of 80 minutes, with a furnace temperature of 1000 ^{O}C, the deflection that occurs in the sandwich concrete is 43 mm while in normal concrete is 27 mm. This means an increase in deflection of 1.59.

4. Conclusions and recommendation

Based on the results and discussions, concluding remarks and recommendations can be withdrawn in the following.

4.1. Conclusions

- All concrete structure slabs, both normal concrete and sandwich concrete, have sufficient resistance at standard temperatures within 2 hours.
- Sandwich concrete slab with lightweight core has a significant role in the insulation of under standard fire temperatures test with an increase in resistance of 1.33.
- However, sandwich concrete has disadvantages compared to normal concrete in terms of deflection. Deflection that occurs in the sandwich concrete has been 43 mm while in normal concrete has been 27 mm which means an increase in deflection of 1.59.

4.2. Recommendations

- To reduce the deflection effect on the sandwich concrete it is recommended to use deformed reinforcing steel. Better attachment between reinforcement and concrete will increase bond- strength of reinforcing steel and will increase structural rigidity. So that deflection that occurs in the sandwich concrete slab structure can be reduced.
- In general, the presence of pumice lightweight concrete has a significant role in the insulation of slab structures under heating to standard temperatures. Together with the significant self- weight reduction, the structure has also becomes more resistant to high temperatures. Thus, the use of pumice lightweight concrete as a core in sandwich concrete is highly recommended.

Acknowledgement

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