High volume fly ash as substitution of fine aggregates with the proportion of 50%, 60%, and 70% to the shear strength of reinforced concrete beams

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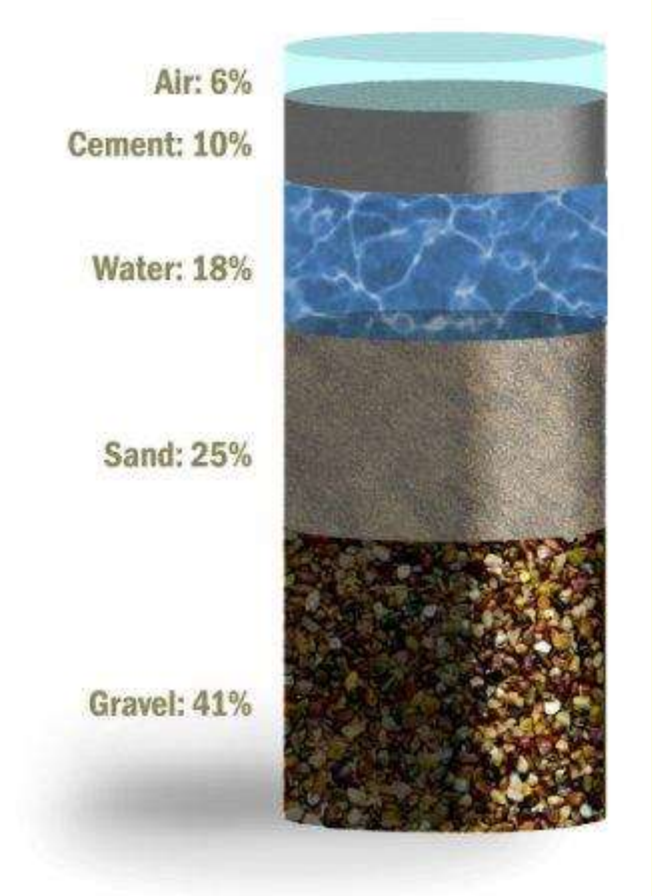
Outline of Presentation

- Introduction
- Literature Review
- Experimental Program
- Results and Discussion
- Conclusion

Introduction



The basic material of concrete:

- **Portland Cement**
- **Water**
- **Fine Aggregates**
- **Coarse Aggregates**

(https://en.wikipedia.org/wiki/air_pollution)

Roy (1999) stated that portland cement contribution to global warming because of production of one ton ordinary portland cement will produce one ton carbondioxide (CO2) which is released to the air and it makes climate change

One of the solution for global warming issue is reducing the utility of portland cement in concrete

To reduce the portland cement in production of concrete is the use of supplementary cementitious materials.

the most available supplementary cementitious material is fly ash which is produced by coal-burning thermal power stations (Bilodeau and Malhotra, 2000)

The utilization of fly ash as supplementary in concrete has benefit such as reducing heat generation, low permeability, and high durability (Arezoumandi et al., 2015)

Therefore, development of utilization of fly ash as supplementary in concrete is still promising for future research.

Literature Review

Siddique [2003] studied the substitution of fine aggegates using fly ash class F with the proportion of substitution 10 %, 20 %, 30 %, 40 %, and 50 % by weight. Siddique [2013] continued the study but with the proportion of substitution being 35 %, 45 %, and 55 % by weight. The result of the study shows that the mechanical properties of concrete increases when the proporsion of fly ash also increases

Koyama et al. [2008] studied the mechanical properties of concrete beams made of a large amount of fine fly ash. Their study showed that the shear strength and the beam deformation increase linearly with the increasing of fly ash.

Khanti and Kavitha [2014] carried out an experimental program about the substitution of fine aggregates using fly ash in concrete with the proportion of substitution being 20 %, 40 %, 60 %, 80 %, and 100 % by weight. The result shows that substitution with the proportion 50 % gave a good result

According to the previous studies, the mechanical property of concrete increase with increasing fly ash substitution of fine aggregates. Therefore, it needs research to study the optimum proportion of the high volume fly ash concrete (HVFAC) that will give the maximum shear strength of the beam. This study will give the basis for future research.

Experimental Program

Materials :

The fine aggregates were taken from Progo River the Northern part of Yogyakarta Province which had properties as follows: fineness modulus = 2.924; mud content = 0.8%; bulk specific gravity = 2.604 gr/cm^3; bulk specific SSD = 2.664 gr/cm^3; apparent specific gravity = 2.770 gr/cm^3; absorption = 2.308%; and water content = 1.595%.
The coarse aggregates were taken from Clereng in the Western part of Yogyakarta Province which had a maximum size of 20 mm and had properties as follows: fineness modulus = 7.168; mud content = 1.57%; bulk specific gravity = 2.470 gr/cm^3; bulk specific SSD = 2.551 gr/cm^3; apparent specific gravity = 2.687 gr/cm^3; absorption = 3.266%; and water content = 3.704

Materials :

Fly ash that was used in this study classified was as F type, because based on the chemical testing the fly ash that was used in this study had $SiO_2+Al_2O_3+Fe_2O_3$ = 82,034 % and CaO = 7,246 %. The reinforcement that was used for beam specimens were reinforcements with a diameter of 12 mm for longitudinal reinforcement with f_y average of three samples = 314.927 MPa and a diameter of 6 mm for stirrup with f_y average of three samples = 358.287 MPa.

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Materials :

The mix design of concrete was designed following the ACI 211.1-91 (1995).

The mix proportion per m^3 of concrete with 0 % replacement of cement was as follows:

- Portland pozzolan cement=336.07 kg;
- Water=207.39 kg;
- Fine aggregates=958.67 kg;
- Coarse aggregates=892.09 kg;
- super plasticizer=2.073 kg.

For HVFAC just replaced the fine aggregates in the proportion with 50 %, 60 %, and 70 % of fly ash.

Materials :

Fly ash was tested in the Laboratory of Chemical Engineering, Universitas Gadjah Mada to see the chemical composition

No	Chemical element	Content (%)	Note
1	SiO2	43.250	
2	Al_2O_3	27.492	
3	Fe_2O_3	11.292	
4	SiO2 + Al_2O_3 + Fe_2O_3	82.034	> 70 %
5	Lost of ignition	-	
6	CaO	7.246	< 10 %
7	MgO	7.125	
8	SO_3	1.499	
9	K_2O	0.864	
10	Na_2O	-	
11	H_2O	-	

Specimens Preparation:

- Cylinder specimens with the size of 150 mm x 300 mm were cast for testing of compressive strength and modulus elasticity of concrete.
- Thirty six cylinder specimens were tested in this study

Cylinder Designation	Fly ash content (%)	For 7 days testing	For 14 days testing	For 28 days testing
0FA	0	3	3	3
50FA	50	3	3	3
60FA	60	3	3	3
70FA	70	3	3	3

Specimens Preparation:

- **Eight beam specimens were tested in this study**

Beam Designation	Fly ash content (%)	The number of beam specimen
B1-Normal	0	2
B2-Normal	0	
B1-50FA-SS	50	2
B2-50FA-SS	50	
B1-60FA-SS	60	2
B2-60FA-SS	60	
B1-70FA-SS	70	2
B2-70FA-SS	70	

Designation of the eight beam specimens was written as follow:

B1-Normal	**: Beam was made and cast with normal concrete (specimen 1)**
B2-Normal	**: Beam was made and cast with normal concrete (specimen 2)**
B1-50FA-SP	**: Beam was made and cast with 50% of fly ash (specimen 1)**
B2-50FA-SP	**: Beam was made and cast with 50% of fly ash (specimen 2)**
B1-60FA-SP	**: Beam was made and cast with 60% of fly ash (specimen 1)**
B2-60FA-SP	**: Beam was made and cast with 60% of fly ash (specimen 2)**
B1-70FA-SP	**: Beam was made and cast with 70% of fly ash (specimen 1)**
B2-70FA-SP	**: Beam was made and cast with 70% of fly ash (specimen 2)**

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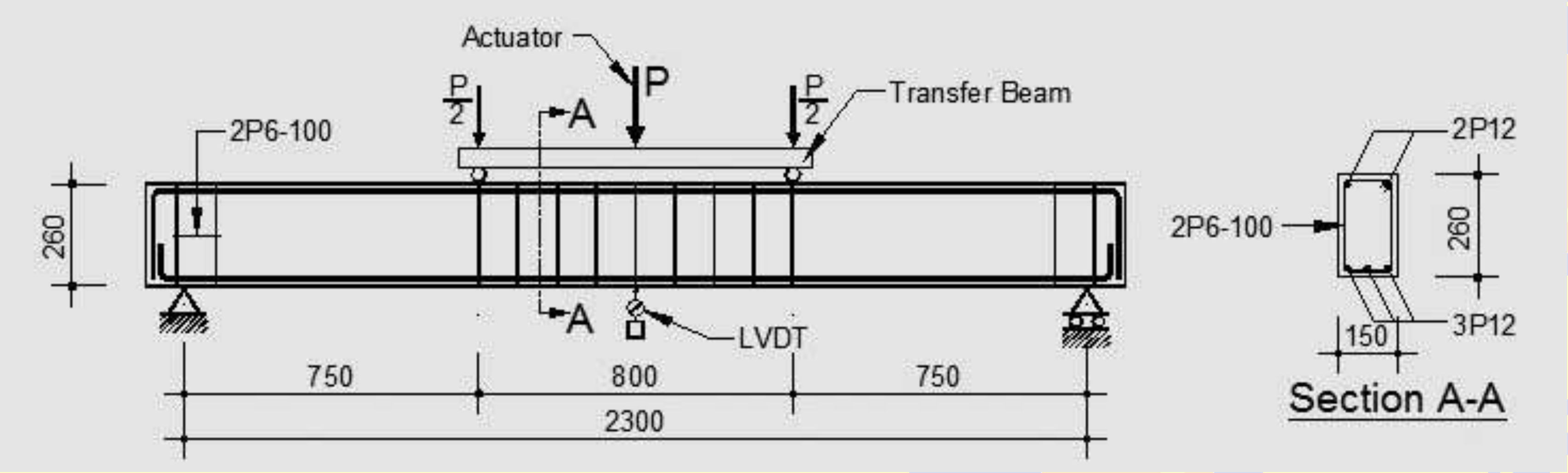
Setup of Beam Specimens

The beam specimens were tested on the loading frame of the Laboratory of Structures and Materials, Department of Civil Engineering, Faculty of Engineering, Universitas Atma Jaya Yogyakarta.



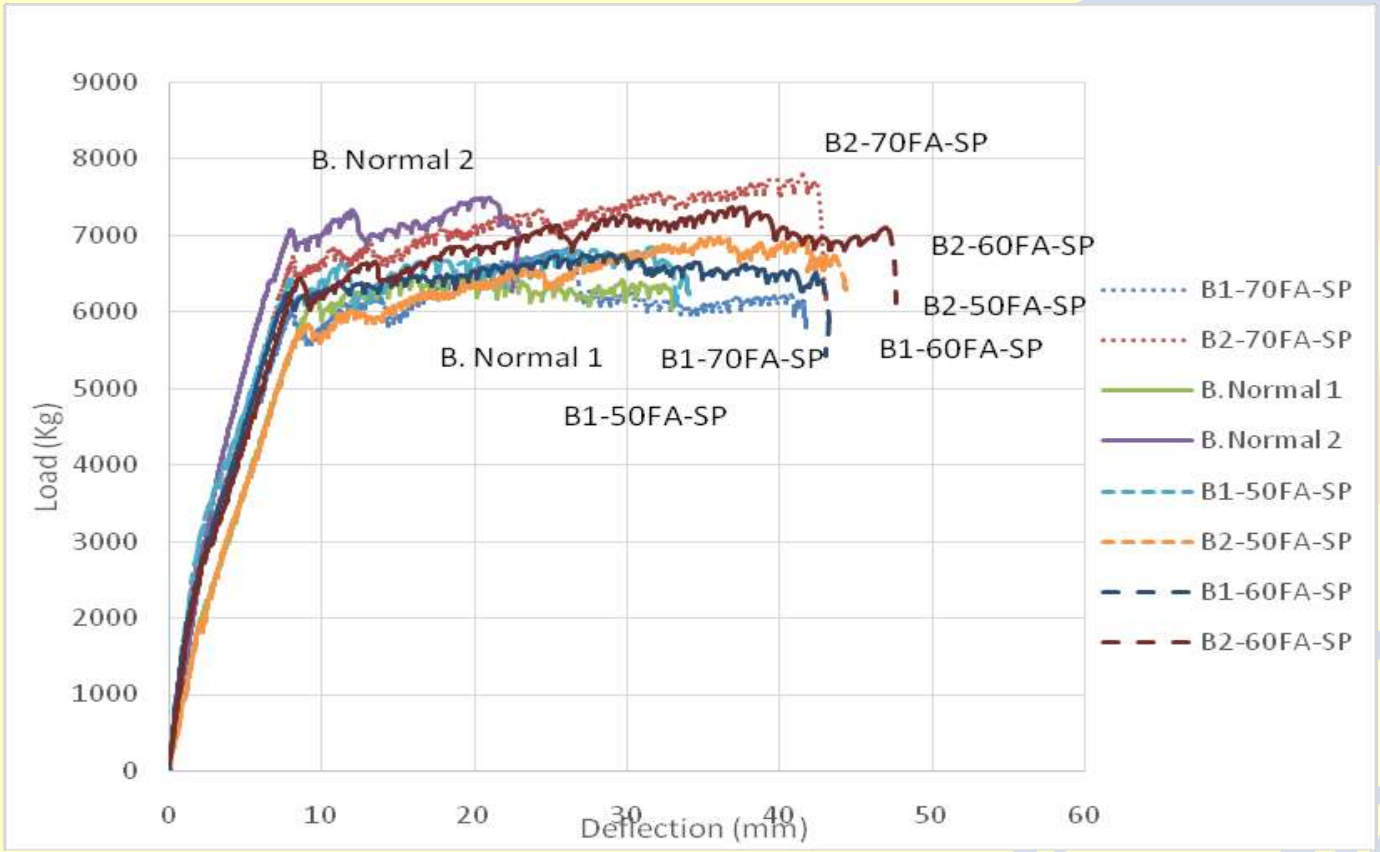
Setup of Beam Specimens

Results and Discussion

The density, compressive strength and modulus of elaticity of concrete at 28 days

Cylinder specimen	Content of fly ash	Average density (kg/m^3)	Average compressive stfrength f_c' (MPa)	Average modulus elasticity E (MPa)
0FA	0%	2256.22	20.44	19817.17
50FA	50%	2380.50	39.98	30006.89
60FA	60%	2399.50	45.53	30295.42
70FA	70%	2443.08	56.00	27543.29

The load-deflection relationship of the beam specimen



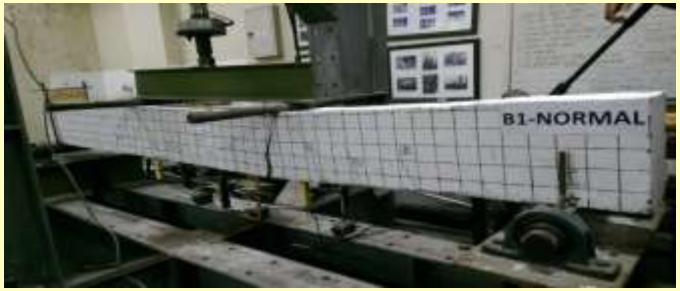
The beam specimens cast by fly ash have longer deformation compared to the beam specimens cast by normal concrete. This indicates that the beam specimen made of fly ash concrete as substitution of fine aggregates has better ductility compared to the beam specimen made of normal concrete

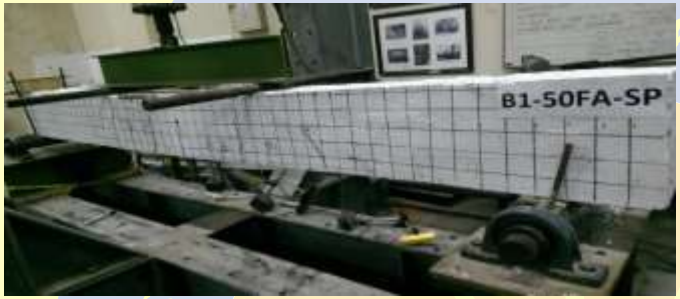
The load-carrying capacity of the beam specimen

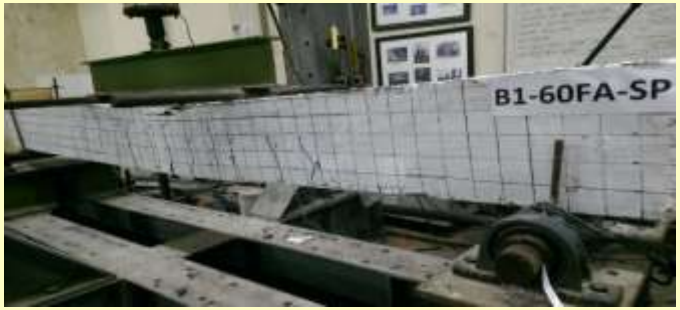
Content of fly ash	Beam specimen	Maximum load (kg)	Average load (kg)
0%	B1-Normal	6509.47	7000.37
	B2-Normal	7491.28	
50%	B1-50FA-SP	6840.73	6910.95
	B2-50FA-SP	6981.18	
60%	B1-60FA-SP	6751.71	7059.62
	B2-70FA-SP	7367.54	
70%	B1-70FA-SP	6829.13	7311.39
	B2-70FA-SP	7793.66	

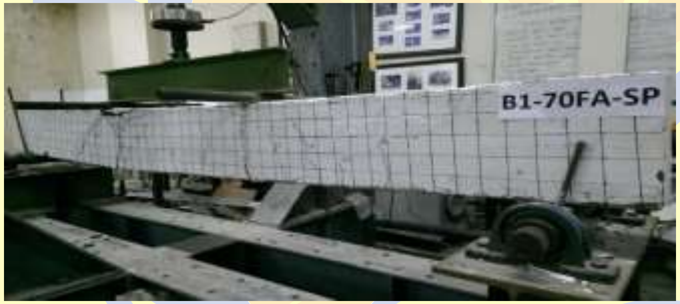
The beam specimen with 70 % fly ash as substitution of fine aggregates has the highest load-carrying capacity. The highest load-carrying capacity of this beam specimen is due to the fact that this specimen has the highest compressive strength

The crack pattern of the beam specimen









It can be seen that none of the beam specimens failed due to the shear. This indicates that the shear capacity of the concrete was higher than the maximum shear force of the beam, as no shear crack failure occurs on the shear region of the beam.

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Conclusions

1. Substitution of fine aggregates in concrete using fly ash will increase the compressive strength of concrete. The increase of compressive strength due to the fly ash as pozzolanic material reacts with the portland-cement and gives the hardened concrete better properties through the hydraulic or the pozzolanic activity of the fly ash and portland-cement

2. The behavior of the beam specimens made of fly ash have better ductility compare to the beam specimens made of normal concrete. This indicates that the reinforced concrete beam cast with high volume fly ash was able to have large deflection prior to failure.

3. The load-carrying capacity of the beam specimens with 70 % fly ash as substitution of fine aggregates has the highest load-carrying capacity. The highest load-carrying capacity of this beam specimen is due to the fact that this specimen has the highest compressive strength.

4. None of the beam specimens was failed due to shear, because the shear capacity of the concrete made with fly ash was higher than the maximum shear force of the beam.

Thank You Very Much