BETON BERSERAT BAJA PADA SUHU TINGGI

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Semarang

Beton berserat/fiber

Keuntungan:

- Ikatan matrix antar penyusun sangat baik,
- Ketegaran retak yang sangat baik
- Menambah kuat tarik beton
- Meningkatkan kuat lentur beton
- Mengurangi sifat getas beton atau lebih daktail

→ **SANGAT BAIK UNTUK STRUKTUR DI DAERAH RAWAN GEMPA**

- Mengurangi lendutan

Latar belakang

- Pada struktur bangunan yang mengalami kebakaran, perlindungan baja tulangan pada suhu tinggi sangat diperlukan
- Pengaruh suhu tinggi terhadap beton yang mengandung serat baja perlu dievaluasi

Permasalahan

- Beton berserat baja sangat sensitif terhadap suhu, terlebih pada suhu tinggi,
- Kandungan baja di dalam beton adalah faktor utama yang mempengaruhi perilaku struktur
- Apabila kebakaran yang terjadi cukup lama maka suhu bias mencapai 900^{o}C atau bahkan lebih

Tujuan

- Kapasitas lentur beton berserat baja pada suhu normal hingga suhu tinggi
- Evaluasi tingkat daktilitas lentur

Kasus-kasus kebakaran hingga 900^{o}C atau lebih

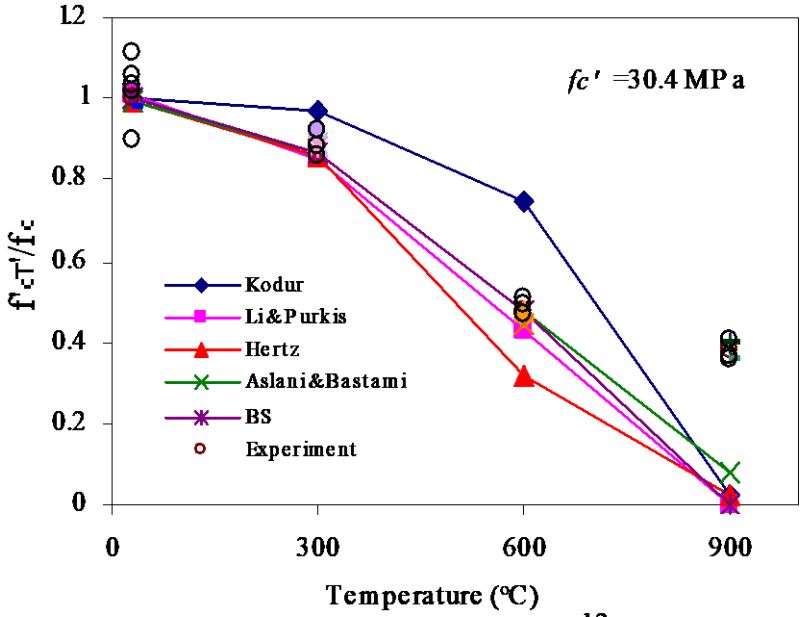
Pasar Bitingan – Kudus, 2007

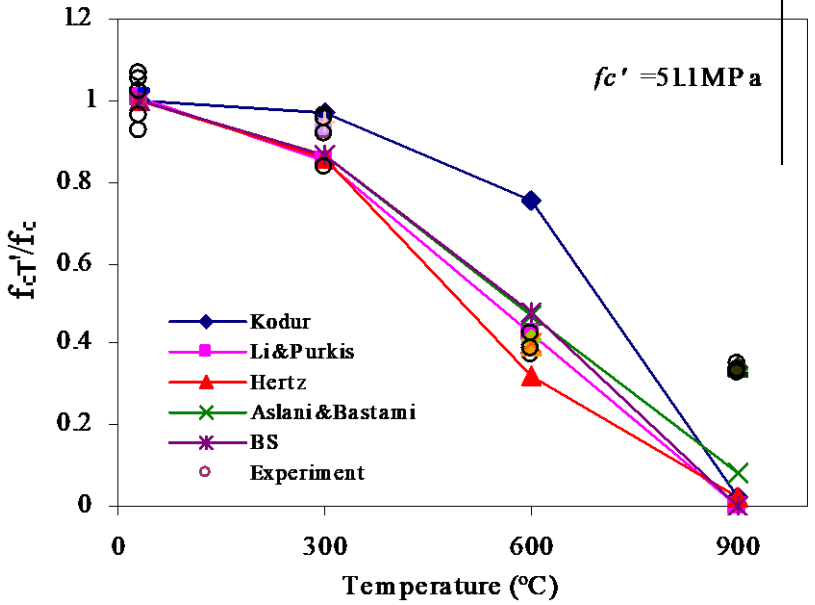
Pasar Kliwon – Kudus, 2010

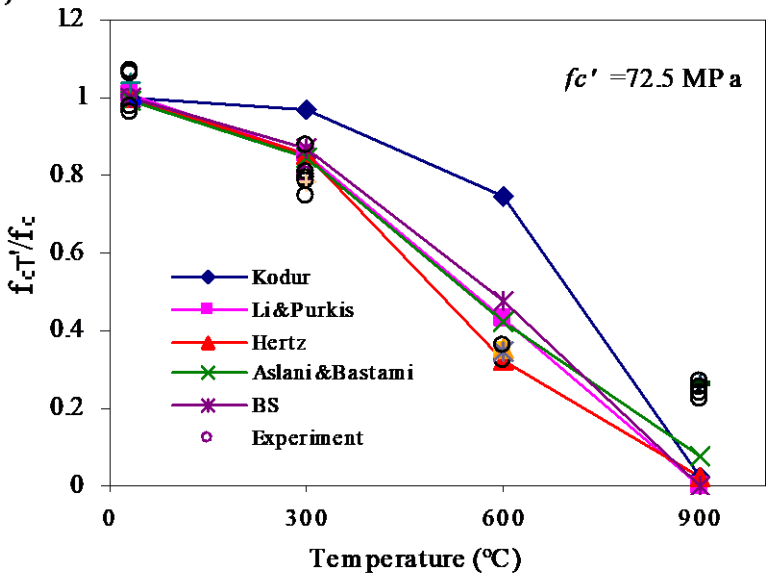
Pasar Johar semarang , 2015

Penelitian awal

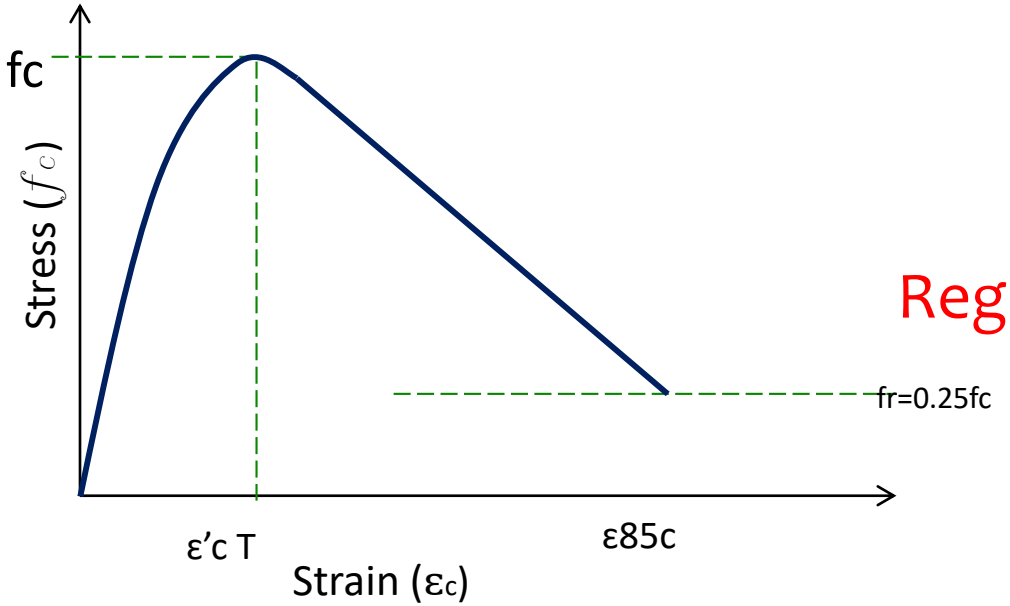
Degradasi Kuat Tekan Beton Berserat Baja terhadap Suhu (Antonius,2014)







Stress-strain model for SFRC at elevated temperatures (2014)



$$\varepsilon_c T = 0.005$$

Tegangan

$$T < 300^{o}C \quad : \frac{f_{cT}'}{f_c'} = 1.0219 - 0.0004T$$

$$300^{o}C \le T < 600^{o}C : \frac{f_{cT}'}{f_c'} = 1.3795 - 0.0016T$$

$$T \ge 600^{o}C \quad : \frac{f_{cT}'}{f_c'} = 0.591 - 0.0003T$$

Regangan

$$T < 300^{o}C \quad : \frac{\varepsilon_{cT}'}{\varepsilon_c'} = 1.0074 - 0.0002T$$

$$300^{o}C \le T < 600^{o}C : \frac{\varepsilon_{cT}'}{\varepsilon_c'} = 1.225 - 0.001T$$

$$T \ge 600^{o}C \quad : \frac{\varepsilon_{cT}'}{\varepsilon_c'} = 0.8467 - 0.0003T$$

Ascending Branch $\varepsilon_c \le \varepsilon'_{cT}$

$$f_c = f_{cT}'\left[1 - \left(\frac{\varepsilon_{cT}' - \varepsilon_c}{\varepsilon_{cT}'}\right)^{H}\right]$$

Descending Branch $\varepsilon_c > \varepsilon'_{cT}$

$$f_c = f_{cT}'\left[1 - \left(\frac{30(\varepsilon_c - \varepsilon_{cT}')}{(130 - f_c')\varepsilon_{cT}'}\right)\right]$$

Eksperimen balok (Antonius et al. 2019)

Parameter:

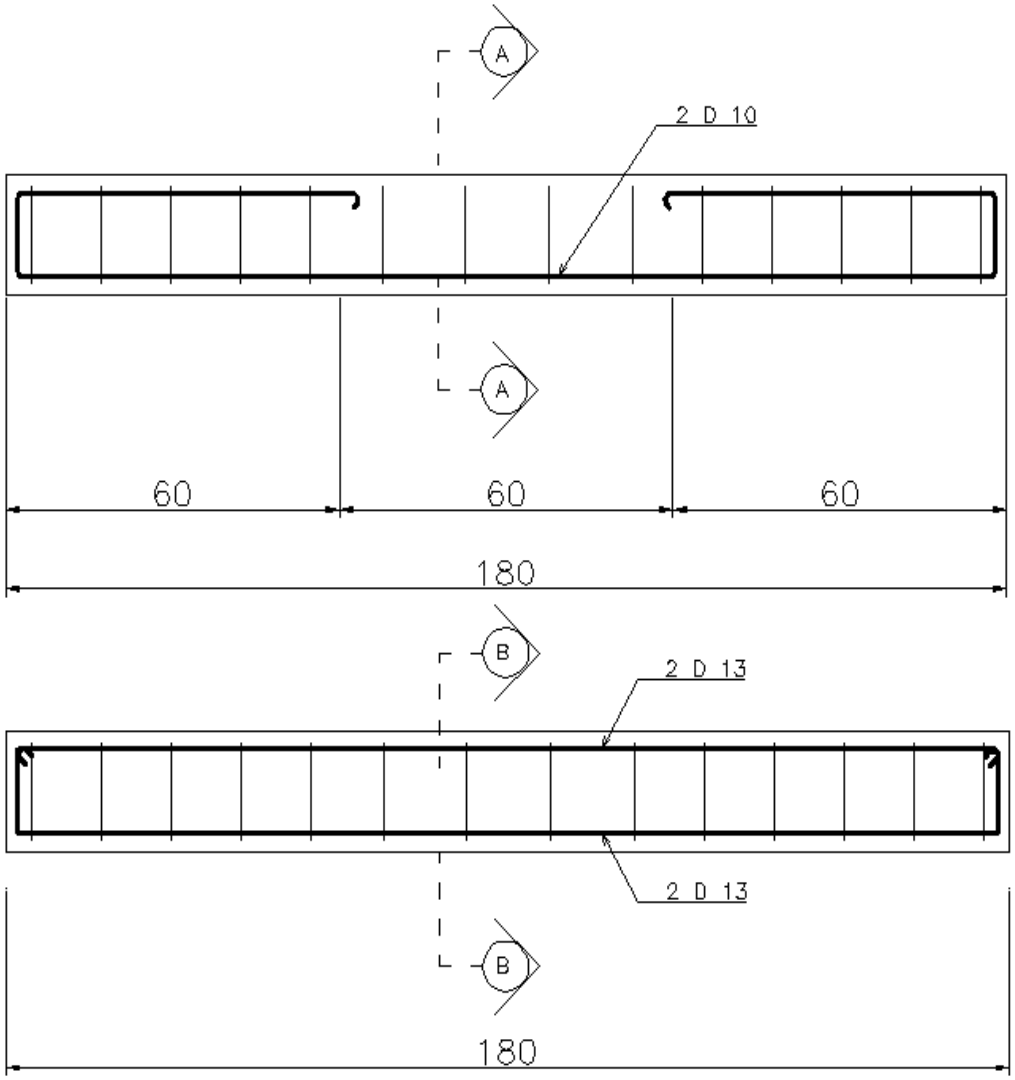
- suhu pembakaran (Normal s/d 900^{o}C),
- pengaruh tulangan tunggal dan ganda

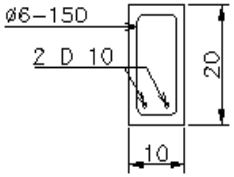
Manfaat:

- Aplikasi praktis beton berserat baja terhadap suhu tinggi
- Masukan terhadap standar beton Indonesia (beton berserat)
- Membuka penelitian lanjut: i.e. Beton berserat terkekang (confined), beam-column joint dll

Program Eksperimen

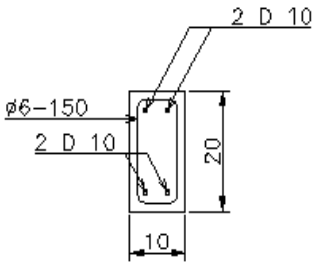
Specimen balok lentur





POT A–A

Balok Tulangan Tunggal (SR)



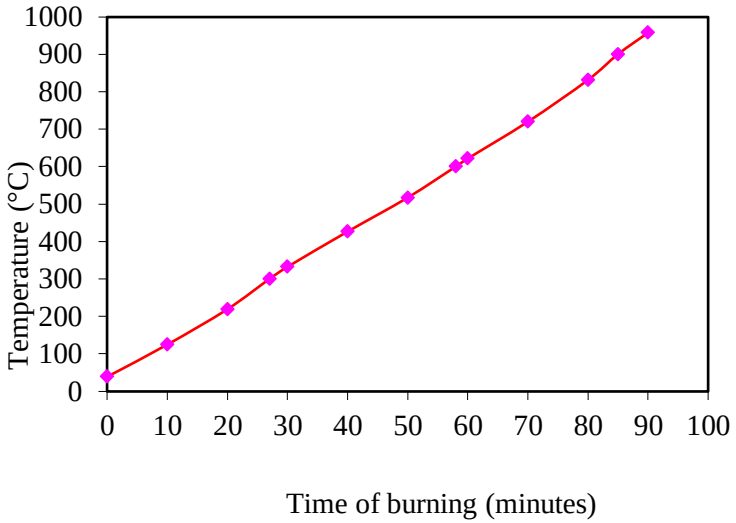
POT B–B

Balok Tulangan Ganda (DR)

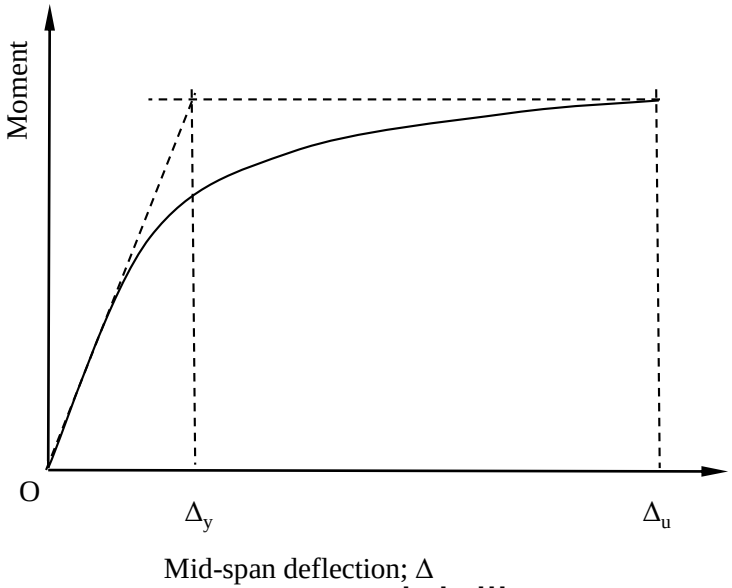
Material

Materials	Kuantitas
Cement (Kg/m^3)	420
Fly Ash (Kg/m^3)	74.11
Water (Lt/m^3)	160
w/c	0.38
Viscocrete 0,5% (lt/m^3)	6.23
Fine Aggregate (Kg/m^3)	697
Coarse Aggregate (Kg/m^3)	1045
fibre/volume %	0.5

Serat baja



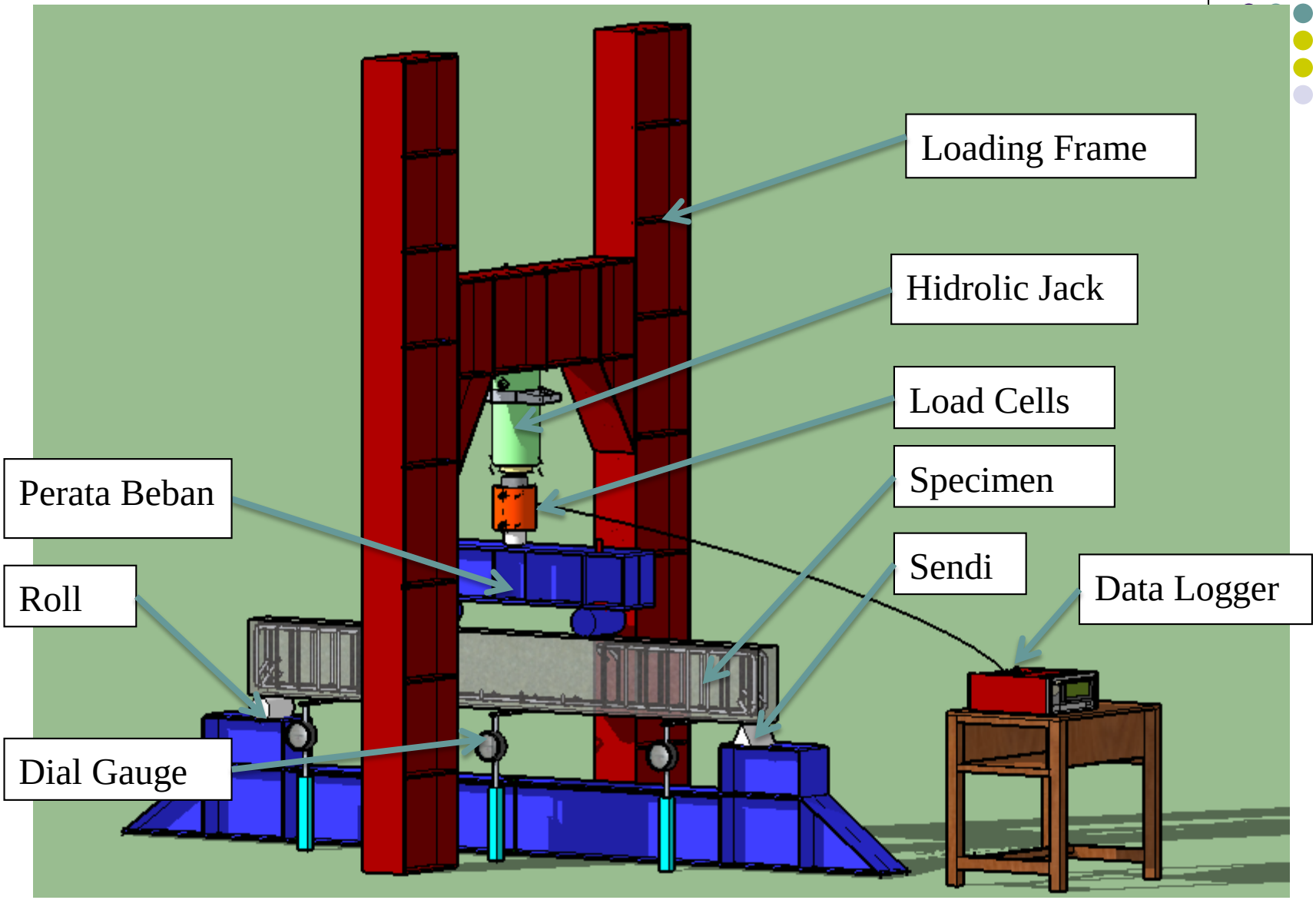
Hubungan waktu pembakaran vs temperatur



$$\mu = \frac{\Delta_u}{\Delta_y}$$

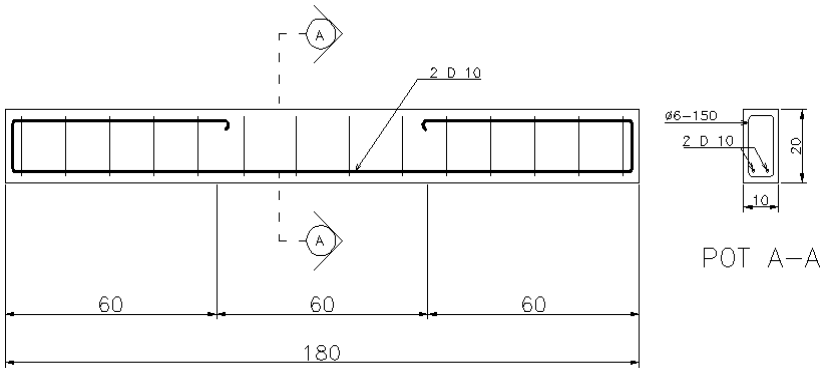
Penentuan daktilitas

Skema Pembebanan Lentur



Hasil Eksperimen

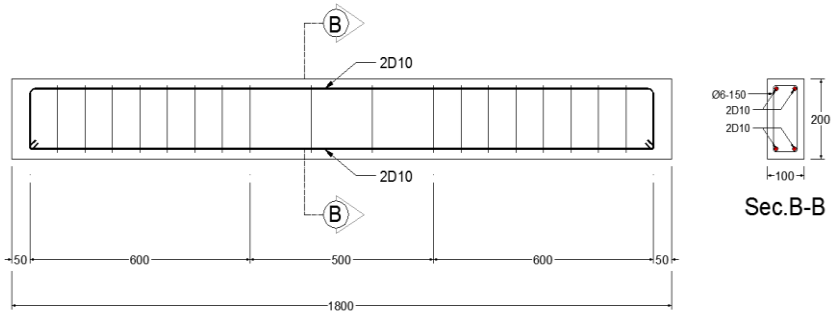
- Balok lentur tulangan tunggal



Temperatur	f'c (MPa)	Mode keruntuhan	Momen (kN-m)	Daktilitas
Normal (38^{o}C)	55.9		13.56	10.3
300^{o}C	38.1		12.23	6.7
600^{o}C	28.4		11.13	5.1
900^{o}C	23.8		10.05	5.1

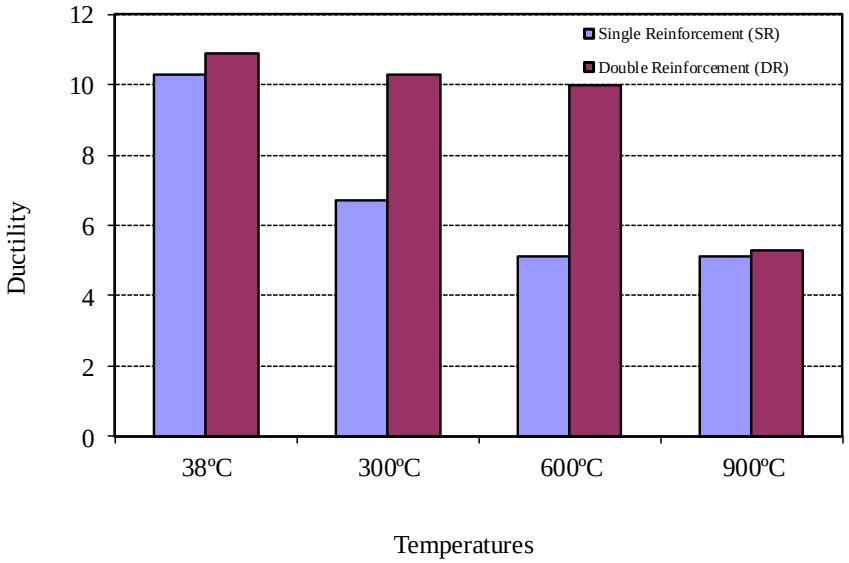
Hasil Eksperimen

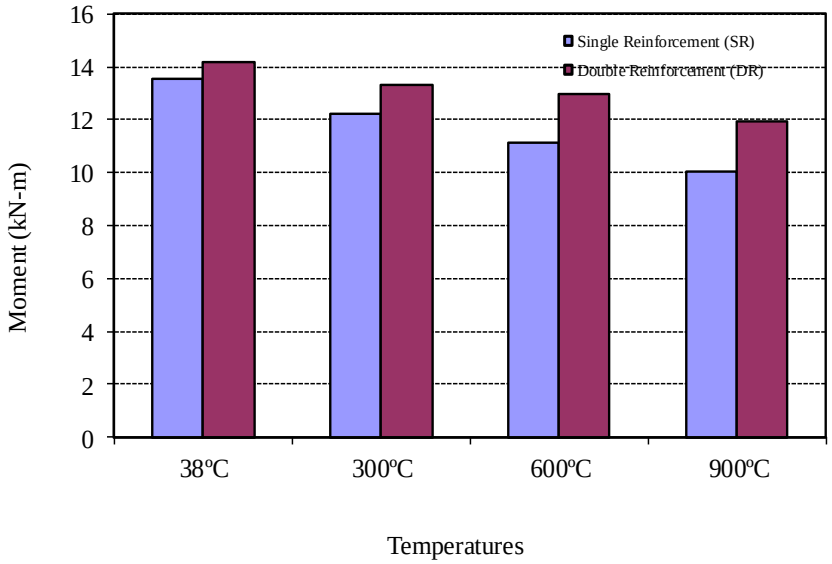
- Balok lentur tulangan ganda

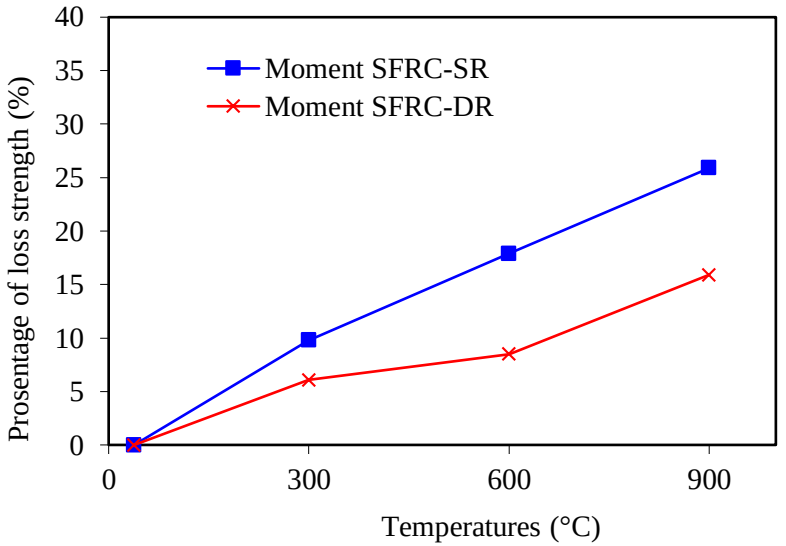


Temperatur	f'c (MPa)	Mode keruntuhan	Momen (kN-m)	Daktilitas
Normal (38^{o}C)	55.9		14.19	10.9
300^{o}C	38.1		13.32	10.3
600^{o}C	28.4		12.98	10
900^{o}C	23.8		11.94	5.3

Hasil Eksperimen

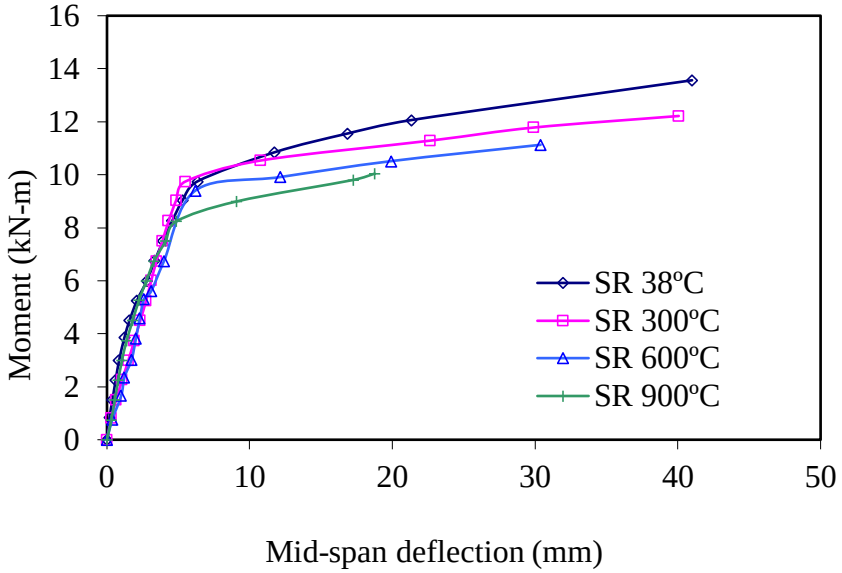




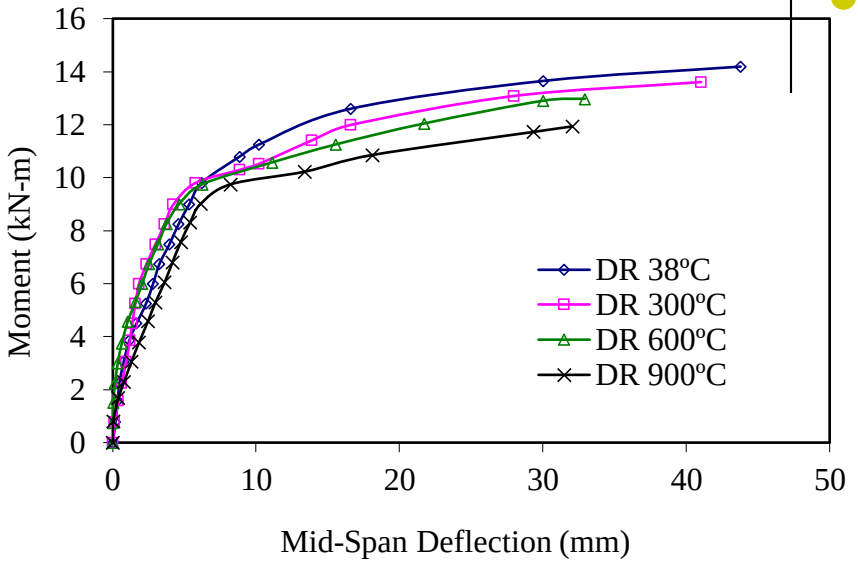


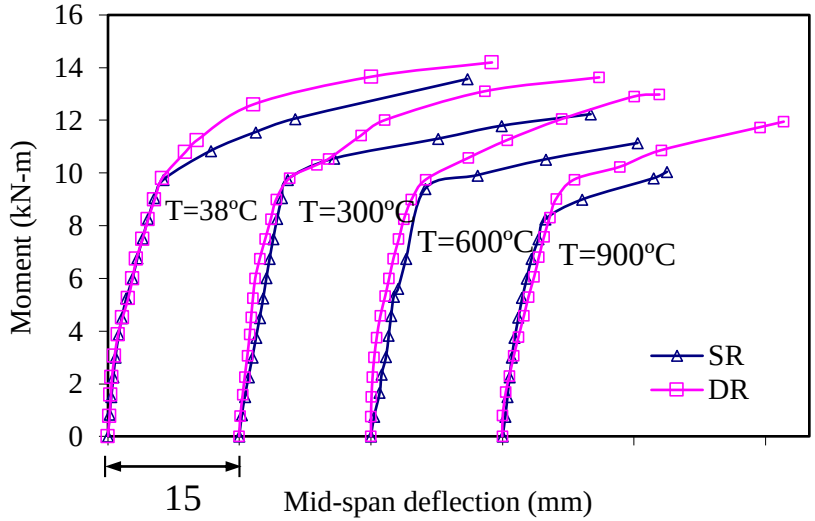
Perilaku Beban – Lendutan Balok

Tulangan Tunggal (SR)



Tulangan Ganda (DR)

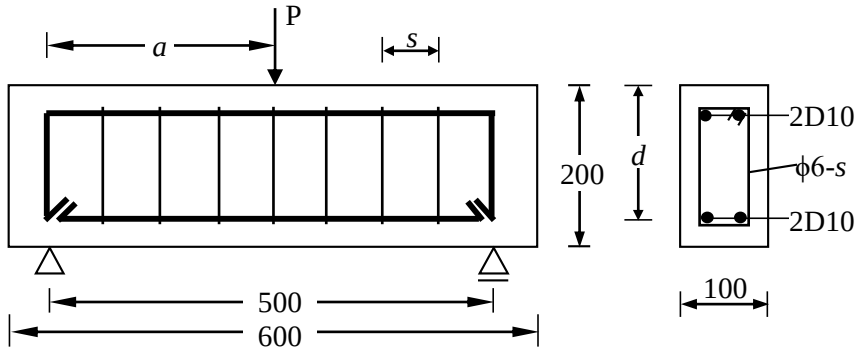




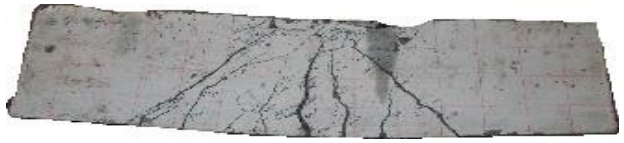
Komparasi analitik vs eksperimen

Specimens	Momen (kN-m)		$M_{analitik}/M_{eksp.}$
	Analitik	Eksp.	
SR-Normal (38^{o}C)	15.67	13.56	1.15
SR-300^{o}C	13.41	12.23	1.10
SR-600^{o}C	12.08	11.13	1.09
SR-900^{o}C	11.41	10.05	1.14
DR-Normal (38^{o}C)	15.64	14.19	1.10
DR-300^{o}C	13.39	13.32	1.00
DR-600^{o}C	12.56	12.98	0.97
DR-900^{o}C	12.35	11.94	1.03

Mode keruntuhan balok berserat baja terhadap geser (Antonius et al. 2020)



s=150 mm

a) T=38°C (flexural failure)	b) T=300°C (flexural failure)
	
c) T=600°C (flexural failure)	**d) T=900°C (diagonal tension failure)**
	

Kesimpulan

- Kapasitas lentur balok beton berserat baja yang dipasang tulangan tekan masih lebih tinggi dibandingkan kapasitas balok tanpa menggunakan tulangan tekan pada balok suhu normal hingga suhu tinggi, meskipun perbedaan tersebut tidak terlalu signifikan (<10%).
- Daktilitas balok berserat baja bertulangan tunggal mengalami penurunan signifikan (40%) jika balok dibakar mulai suhu 300C,
- Daktilitas balok dapat terjaga (relative tidak ada perubahan) pada balok bertulangan ganda jika balok dibakar hingga 600C.
- Analisis kapasitas momen balok beton berserat kawat baja yang menggunakan model tegangan-regangan yang diusulkan cukup akurat dalam memprediksi kapasitas momen balok hasil eksperimen.
- Serat baja memegang peranan signifikan dalam mengontrol mode keruntuhan, kapasitas lentur dan daktilitas, meskipun balok dibakar hingga suhu tinggi.

Referensi utama

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