LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel) : The Behavior of Reinforced Concrete Members with Section Enlargement Using Self-Compacting Concrete

Jumlah Penulis : 4 orang (**Nuroji**, Chung-Chan Hung, Blinka Hermawan Prasetya, Aylie Han)

Status Pengusul : Penulis ke 1

Identitas Jurnal Ilmiah :

a. Nama Jurnal : International Review of Civil Engineering (IRECE)
b. Nomor ISSN : ISSN:2036-9913; E-ISSN:2533-168X
c. Vol, No., Bln Thn : Vol 11, No 3 (2020)
d. Penerbit : Praise Worthy Prize
e. DOI artikel (jika ada) : -
f. Alamat web jurnal : https://www.praiseworthyprize.org/jsm/index.php?journal=irece&page=article&op=view&path%5B%5D=24440
   Alamat Artikel : https://doc-pak.undip.ac.id/7867/1/The%20Behavior%20of%20Reinforced%20Concrete%20Members.pdf
g. Terindex : Scopus

Kategori Publikasi Jurnal Ilmiah : [√] Jurnal Ilmiah Internasional
(beri ✓pada kategori yang tepat) [ ] Jurnal Ilmiah Nasional Terakreditasi
[ ] Jurnal Ilmiah Nasional Tidak Terakreditasi

Hasil Penilaian *Peer Review* :

Komponen Yang Dinilai	**Nilai Reviewer**		**Nilai Rata-rata**
	Reviewer I	**Reviewer II**	
a. Kelengkapan unsur isi jurnal (10%)	4	4	4
b. Ruang lingkup dan kedalaman pembahasan (30%)	10	8	9
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	11	8	9,5
d. Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	10	11	10,5
Total = (100%)	**35**	**31**	**33**
Nilai Pengusul = (60% x 33) = 19,8			

Semarang, September 2022

Reviewer 1

Prof. Stefanus Adi Kristiawan, S.T., M.Sc., Ph.D.
NIP. 196905011995121001
Unit Kerja : Departemen Teknik Sipil FT UNS

Reviewer 2

Prof. Dr. Ir. Sri Tudjono, M.S.
NIP. 195303091981031005
Unit Kerja : Departemen Teknik Sipil FT UNDIP

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel)	**:**	The Behavior of Reinforced Concrete Members with Section Enlargement Using Self-Compacting Concrete			
Jumlah Penulis	**:**	4 orang (**Nuroji**, Chung-Chan Hung, Blinka Hermawan Prasetya, Aylie Han)			
Status Pengusul	**:**	Penulis ke-1			
Identitas Jurnal Ilmiah	**:**	a.	Nama Jurnal	:	International Review of Civil Engineering
		b.	Nomor ISSN	:	ISSN:2036-9913 ; E-ISSN:2533-168X
		c.	Vol, No., Bln Thn	:	Vol 11, No 3 (2020)
		d.	Penerbit	:	Praise Worthy Prize
		e.	DOI artikel (jika ada)	:	https://doi.org/10.15866/irece.v11i3.18574
		f.	Alamat web jurnal	:	https://www.praiseworthyprize.org/jsm/index.php?journal=irece&page=article&op=view&path%5B%5D=24440
			Alamat Artikel	:	https://doc-pak.undip.ac.id/7867/1/The%20Behavior%20of%20Reinforced%20Concrete%20Members.pdf
		g.	Terindex	:	Scopus

Kategori Publikasi Jurnal Ilmiah (beri ✓pada kategori yang tepat) :
- [√] Jurnal Ilmiah Internasional
- [ ] Jurnal Ilmiah Nasional Terakreditasi
- [ ] Jurnal Ilmiah Nasional Tidak Terakreditasi

Hasil Penilaian *Peer Review* :

Komponen Yang Dinilai	**Nilai Maksimal Jurnal Ilmiah**			**Nilai Akhir Yang Diperoleh**
	Internasional [40]	**Nasional Terakreditasi** [ ]	**Nasional Tidak Terakreditasi** [ ]	
a. Kelengkapan unsur isi jurnal (10%)	4.00			4
b. Ruang lingkup dan kedalaman pembahasan (30%)	12.00			10
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	12.00			11
d. Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	12.00			10
Total = (100%)	**40.00**			**35**
Nilai Pengusul = 60% x 35 = 21				

Catatan Penilaian artikel oleh Reviewer :

1. **Kesesuaian dan kelengkapan unsur isi jurnal:**
Artikel telah ditulis dengan unsur-unsur lengkap. Abstrak cukup memberikan gambaran yang utuh tentang isi keseluruhan artikel. Introduction mengandung gagasan dan argumentasi yang mendasari pentingnya penelitian dan kontribusi apa yang diharapkan dari penelitian tersebut. Unsur-unsur lain yaitu Metode, Hasil & Pembahasan, Kesimpulan, dan daftar pustaka telah disajikan sesuai kaidah.

2. **Ruang lingkup dan kedalaman pembahasan:**
Artikel menyajikan hasil eksperimen antara balok normal (reference) dan balok yang telah diperkuat dengan pembesaran penampang menggunakan beton SCC. Masing-masing hanya diwakili oleh 1 buah benda uji. Hasil eksperimen disajikan dengan disertai diskusi yang mengungkap peningkatan engineering parameters yang diperoleh pada balok perkuatan. Hasil eksperimen juga diperluas dengan kajian analitis untuk mensimulasikan pengaruh rasio penulangan yang lebih beragam. Asumsi yang digunakan dalam kajian analitis diverifikasi dengan membandingkan hasil analitis dan eksperimen. Meskipun hasilnya telah terverifikasi, mungkin pertanyaannya adalah apakah asumsi yang sama dapat dipertahankan untuk rasio penulangan yang berbeda mengingat perubahan rasio penulangan juga sedikit banyak mempengaruhi letak garis netral.

3. **Kecukupan dan kemutakhiran data/informasi dan metodologi:**
Data-data eksperimen disajikan secara lengkap, dan metodologi yang digunakan dijelaskan secara detil sehingga pembaca dapat melihat bagaimana pelaksanaan penelitian telah dilakukan. Referensi yang digunakan cukup memadai, memenuhi syarat dan kelayakan dalam penulisan artikel pada jurnal internasional.

4. **Kelengkapan unsur dan kualitas terbitan:**
Jurnal dapat dikategorikan sebagai jurnal internasional bereputasi, yang dibuktikan dengan unsur-unsur sebagai berikut: Editor dari beberapa negara seperti USA, Turkey, Canada, Hongkong, United Kingdom, New Zealand, dll;

penulis dalam satu terbitan juga dari beragam negara antara lain Italia, United Kingdom, dll selain Indonesia; jurnal terindek scopus, SJR 0.283. Diterbitkan oleh Praise Worthy Prize. Artikel dapat dilacak secara online.
Jurnal juga merupakan jurnal khusus dibidang teknik sipil. Nilai similarity artikel berdasarkan cek turnitin 8%.
Namun demikian, editorial offcie dapat meningkatkan pemeriksaan lebih teliti sebelum di published agar penyajian artikel sehingga tidak terjadi pengulangan paragraph. “The additional stirrup had a confining effect on the concrete [20]-[24]; the analysis was based on the assumption of a 20% increase of compression strength in the compression area, especially since the stirrups were extending into the extreme concrete fibers in compression”.
....

Semarang,   Juni 2020
Reviewer 1

Prof. Stefanus Adi Kristiawan, S.T., M.Sc., Ph.D.
NIP. 196905011995121001
Unit Kerja : Departemen Teknik Sipil FT UNS

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel)	:	The Behavior of Reinforced Concrete Members with Section Enlargement Using Self-Compacting Concrete
Jumlah Penulis	:	4 orang (**Nuroji**, Chung-Chan Hung, Blinka Hermawan Prasetya, Aylie Han)
Status Pengusul	:	Penulis ke-1
Identitas Jurnal Ilmiah	:	a. Nama Jurnal : International Review of Civil Engineering
		b. Nomor ISSN : ISSN:2036-9913 ; E-ISSN:2533-168X
		c. Vol, No., Bln Thn : Vol 11, No 3 (2020)
		d. Penerbit : Praise Worthy Prize
		e. DOI artikel (jika ada) : https://doi.org/10.15866/irece.v11i3.18574
		f. Alamat web jurnal : https://www.praiseworthyprize.org/jsm/index.php?journal=irece&page=article&op=view&path%5B%5D=24440
		Alamat Artikel : https://doc-pak.undip.ac.id/6915/1/The%20Behavior%20of%20Reinforced%20Concrete%20Members%20with%20Section%20Enlargement%20Using%20Self-Compacting%20Concrete.pdf
		g. Terindex : Scopus

Kategori Publikasi Jurnal Ilmiah : [√] Jurnal Ilmiah Internasional
(beri ✓pada kategori yang tepat) [ ] Jurnal Ilmiah Nasional Terakreditasi
[ ] Jurnal Ilmiah Nasional Tidak Terakreditasi

Hasil Penilaian *Peer Review* :

Komponen Yang Dinilai	Nilai Maksimal Jurnal Ilmiah: Internasional [40]	Nasional Terakreditasi [ ]	Nasional Tidak Terakreditasi [ ]	Nilai Akhir Yang Diperoleh
a. Kelengkapan unsur isi jurnal (10%)	4.00			4
b. Ruang lingkup dan kedalaman pembahasan (30%)	12.00			8
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	12.00			8
d. Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	12.00			11
Total = (100%)	**40.00**			**31**
Nilai Pengusul = 60% x 31 = 18.6				

Catatan Penilaian artikel oleh Reviewer :

1. **Kesesuaian dan kelengkapan unsur isi jurnal:**
Unsur isi jurnal lengkap dan sesuai
2. **Ruang lingkup dan kedalaman pembahasan:**
Asumsi peningkatan kuat pecah beton balok SB sebesar 20 % oleh efek pengekangan sengkang sangat lemah, karena tanpa dilakukan pembahasan hasil pengukuran regangan beton tekan. Balok SB mengalami pecah beton yang menunjukkan balok SB ada kemungkinan over reinforced. Tidak ada pembahasan tentang hal ini.
3. **Kecukupan dan kemutakhiran data/informasi dan metodologi:**
Dalam metodologi terdapat pengukuran regangan beton tekan tapi tidak disajikan. Kesimpulan metoda perkuatan dengan pembesaran penampang lebih murah dibanding perkuatan eksternal fibre reinforced plastic/steel tidak didukung analisis. 3 jurnal kadaluwarsa > 10 tahun, 5 jurnal usia terbitan lebih dari 5 tahun s/d 10 tahun.
4. **Kelengkapan unsur dan kualitas terbitan:**
Q3 Civil and Structural Engineering SJR 0.283 2020 H Index 9. Similarity Turnitin 8 %. Sesuai bidang Teknik Sipil Struktur

Semarang, Juni 2020
Reviewer 2

Prof. Dr. Ir. Sri Tudjono, M.S.
NIP. 195303091981031005
Unit Kerja : Departemen Teknik Sipil FT UNDIP

Document type
Article

Source type
Journal

ISSN
20369913

DOI
10.15866/irece.v11i3.18574

View more

International Review of Civil Engineering • Volume 11, Issue 3, Pages 121 - 126 • May 2020

The behavior of reinforced concrete members with section enlargement using self-compacting concrete

Nuroji[a], Hung C.-C.[b], Prasetya B.H.[c], Han A.[a]

Save all to author list

[a] Engineering Faculty, Diponegoro University, Semarang, Indonesia

[b] Department of Civil Engineering, National Cheng Kung University, Tainan, Taiwan

[c] Magister Program in Civil Engineering, Diponegoro University, Indonesia

Abstract

Author keywords

SciVal Topics

Metrics

Funding details

Abstract

This paper presents the experimental results of section enlargement effects on prismatic reinforced concrete members . 125 by 200 mm reinforced concrete members with a compressive strength of 20.3 MPa reinforced with D12 steel bars having a yield stress of 335 MPa situated in the tension and compression area, were produced. Two specimens were prepared, the first functioning as the control

Praise Worthy Prize

INFORMATION

- For Readers
- For Authors
- For Reviewers

FONT SIZE

USER

Username syahirma
Password ••••••••
Remember me
Login
Privacy Policy

Praise Worthy Papers

Most cited papers
Powered by Scopu

Highly commended papers
Commended papers

Most Popular Papers

Deformations in Round-Profiled Threads and their Influence on the Screw Durability
I. Penkov et al.
1453 views since: 2014-03-31

New Strengthening Technique Using FRP to Improve the Confinement

HOME PRAISE WORTHY PRIZE ABOUT
LOGIN REGISTER PWP ONLINE LIBRARY
CURRENT ARCHIVES ANNOUNCEMENTS
OTHER JOURNALS DOWNLOAD ISSUES
SUBMIT YOUR PAPER SPECIAL ISSUE

Home > **International Review of Civil Engineering (IRECE)**

International Review of Civil Engineering (IRECE)

ISSN: 2036-9913
eISSN: 2533-168X

Journal Metrics NEW

2.2 CiteS

81st percentile

Powered by Sc

Supports Open Access

Submit Your Paper

Journal Aims

The **International Review of Civil Engineering (IRECE)** is a peer-reviewed journal that publishes original theoretical papers, applied papers, review papers and case studies on all fields of civil engineering.

PRAISE WORTHY PRIZE HOMEPAGE

SUBSCRIPTION

Login to verify subscription
Give a gift subscription

NOTIFICATIONS

- View
- Subscribe / Unsubscribe

JOURNAL CONTENT

Search

All
Search

Browse

- By Issue
- By Author
- By Title
- Other Journals

Praise Worthy Prize

International Review of Civil Engineering (IRECE)

INFORMATION

- For Readers
- For Authors
- For Reviewers

FONT SIZE

USER

Username syahirma
Password ••••••••
Remember me
Login
Privacy Policy

Praise Worthy Papers

Most cited papers
Powered by Scopu

Highly commended papers
Commended papers

Most Popular Papers

Deformations in Round-Profiled Threads and their Influence on the Screw Durability
I. Penkov et al.
1453 views since: 2014-03-31

New Strengthening Technique Using FRP to Improve the

HOME PRAISE WORTHY PRIZE ABOUT
LOGIN REGISTER PWP ONLINE LIBRARY
CURRENT ARCHIVES ANNOUNCEMENTS
OTHER JOURNALS DOWNLOAD ISSUES
SUBMIT YOUR PAPER SPECIAL ISSUE

Home > About the Journal > **Editorial Board**

Editorial Board

PRAISE WORTHY PRIZE HOMEPAGE

SUBSCRIPTION

Login to verify subscription
Give a gift subscription

NOTIFICATIONS

- View
- Subscribe / Unsubscribe

JOURNAL CONTENT

Search

All

Search

Browse

- By Issue
- By Author
- By Title
- Other Journals

Praise Worthy Prize

International Review of Civil Engineering (IRECE)

Home > Archives > **Vol 11, No 3 (2020)**

Vol 11, No 3 (2020)

Open Access Subscription or Fee Access

Full Issue

View or download the full issue VOL_11_N_3

Table of Contents

Articles

Praise Worthy Prize

International Review of Civil Engineering (IRECE)

An Adaptive Resilience Approach for a High Capacity Railway

Mario Di Nardo[1], Mariano Clericuzio[2], Teresa Murino[3], Marianna Madonna[4]*

[1] Department of Chemical, Materials and Production Engineering, University of Naples Federico II, Italy
[2] Department of Chemical, Materials and Production Engineering, University of Naples Federico II, Italy
[3] Department of Chemical, Materials and Production Engineering, University of Naples Federico II, Italy
[4] University of Naples Federico II, Italy
[*] *Corresponding author*

DOI: https://doi.org/10.15866/irece.v11i3.19025

Abstract

Any event can be analyzed as a system, which is a set of parts performing a specific function. Systems that do not have simple interconnections are called complex. A qualitative and quantitative systems behaviour analysis is lead in the literature review. The issue of resilience needs particular attention and is defined as the ability of a system to resist, adapt, recover from unpredictable events. The concept of resilience is evaluated in a railway network, generally more sensitive to disruption than the road ones. The study focuses on a high capacity railway section in the presence of a breakdown. The goal is to have a general reliability evaluation of an automatic logic reconfiguration, from its implementation to its operating phases. The added value of this formalization methodology consists of using fundamental knowledge of both the system's functioning and malfunctioning. The controller

Praise Worthy Prize

International Review of Civil Engineering (IRECE)

The Influence of Steel Connection on Fire Resistance of Composite Steel-Framed Buildings

Mohammed Abbas Kadhim[1], Zhaohui Huang[2]*

[1] Brunel University London, United Kingdom
[2] Brunel University London, United Kingdom
[*] *Corresponding author*

DOI: https://doi.org/10.15866/irece.v11i3.16681

Abstract

Steel connections play a significant part in enhancing the robustness of structures in the event of a fire. Therefore, it is important to examine the impact of steel connections on the fire resistance of composite steel framed buildings. In this paper, both the behaviour of steel connections and their effect on composite steel frames are analysed using the non-linear finite element computer software VULCAN at various temperatures. The chosen frame is subjected to ISO834 fire. A comparison between end plate connections, pinned connection and rigid connection has been carried out. By applying different compartment fires, some cases are studied to show the behaviour of steel connection when the fire is applied at certain beams. In addition, different plate thickness has been analysed to examine the behaviour of the chosen steel connection under ISO834 fire. From the analytical results, it was found that the beam with extended end plate is stronger and has better performance in terms of axial forces than those beams with flush end-plate connection. Furthermore, that extended end plate connection has highest limiting temperatures compared to the flush end plate connection. In addition, it was observed that the performance of end-plate

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET DAN TEKNOLOGI
UNIVERSITAS DIPONEGORO
FAKULTAS TEKNIK

Jalan Prof. Sudarto, S.H.
Tembalang Semarang Kode Pos 50275
Tel. (024) 7460055, (024) 7460053, Faks. (024) 7460053
www.ft.undip.ac.id email: teknik@undip.ac.id

Nomer : 253/UN7.F3/UP/III/2023
Lampiran : 1 berkas
Hal : Klarifikasi Usulan Kenaikan Jabatan ke Guru Besar An.Dr.Ir.Nuroji,MT

10 MAR 2023

Yth. Wakil Rektor Sumber Daya
Universitas Diponegoro
Semarang

Menanggapi surat dari Wakil Rektor Sumber Daya No. 250/UN7.A2/UP/II/2023 tanggal 23 Februari 2023 tentang klarifikasi Usulan Kenaikan Jabatan ke Guru Besar atas nama *Dr. Ir. Nuroji, MT*. Bersama ini kami menyampaikan sebagai berikut :

Menanggapi kesan lemahnya review substansi dari reviewer jurnal, maka pengusul meyampaikan penjelasan sebagai berikut

> Reviewer 1 memberikan masukkan: "*The paper misses modeling details*". Komentar ini mempunyai dampak yang sangat signifikan dan substansial, yaitu tentang detail pemodelan, karena tanpa deskripsi pemodelan yang baik maka akan berpengaruh pada interpretasi hasil. Tanggapan penulis atas koreksi tersebut adalah dengan menambahkan deskripsi mulai dari rincian, alasan pemodelan, desain penampang dan model pembebanan yang dikenakan. Lampiran A menunjukkan revisi yang disebabkan karena komentar reviewer 1, tercetak dalam kuning.

Dugaan kurang cermatnya penerbit:

1. Figure 4 dalam paragraph terakhir section IV yang diduga seharusnya Fig. 3. Penunjukkan ke Fig. 4 dalam karil memang benar, dan bukan kesalahan editing karena akan mengkaitkan out-put dengan response displacement. Kalimat yang mengandung notasi Fig. 4 diawali dengan "*The horizontal average strain could further be calculated from the comparative **displacement**....*" Pada keterangan Fig. 4 tertulis: "Load-***displacement*** response of CB and SB. Fig. 4 ditempatkan setelah sub-section V.I. karena dalam paragraph ini kembali Fig. 4 digunakan sebagai penjelasan dalam paragraph ini

2. Kalimat Ganda "*The additional stirrup had a confining effect on the concrete [20]-[24]; the analysis was based on the assumption of a 20% increase of compression strength in the compression area, especially since the stirrups were extending into the extreme concrete fibers in compression*". Kalimat tersebut yang tertulis dua kali merupakan kesalahan publisher yang telah diklarifikasi melalui Errata. Lampiran B menunjukkan permohonan maaf dari penerbit, Lampiran C menunjukkan *Camera Ready* manuscript yang kami submit, tampak tak ada kalimat ganda. Errata dalam publikasi sangat sering terjadi bahkan pada jurnal yang bereputasi: ASCE (*The American Society of Civil Engineers*) dan *Journal of Structural Engineering*

(Elsevier) - Lampiran D. Errata secara umum bukan merupakan indentikasi buruknya jurnal.

Pengusul juga sedang dalam proses menyiapkan berkas karil pendukung berjudul: *"Prediction of crack development and crack propagation on flexural elements through Finite Element simulation"* yang segera akan di submit ke *Engineering Fracture Mechanics*, Scopus Indexed (Q1).

Demikian surat tanggapan dan klarifikasi yang kami sampaikan sebagai dasar penilaian angka kredit usulan kenaikan pangkat. Atas perhatiannya disampaikan terima kasih.

Dekan,

Prof. Ir. M. Agung Wibowo, MM, MSc, PhD
NIP. 196702081994031005

Tembusan:
Manajer Kepegawaian UNDIP

LAMPIRAN A

Perbaikan sesuai komentar substantif reviewer 1

International Review of Civil Engineering (I.RE.C.E.), Vol. xx, n. x
June 2010

Section Enlargement Strengthening of Reinforced Concrete Beam by Using Self-Compacting Concrete

Nuroji[1*], Chung-Chan Hung[2], Blinka H. Prasetya[3], Aylie Han[1]

Abstract – *This paper presents the experimental results of section enlargement effects on prismatic reinforced concrete members. 125 by 200 mm reinforced concrete members with a compressive strength of 20.3 MPa reinforced with D12 steel bars having a yield stress of 335 MPa situated in the tension and compression area, were produced. Two specimens were prepared, the first functioning as the control element and designated as the control beam (CB). The second strengthened with a section enlargement using self-compacting concrete (SCC) marked as the strengthened beam (SB). The SCC had a 28-day compressive strength of 23.9 MPa. The dimensions of the enlarged beam were 200 by 300 mm. The two specimens CB and SB were tested with a two-point loading system. Based on the tests data, the load–displacement and moment–curvature relationships characterizing the beams were generated. From the results it was concluded that the enlargement affected the load-carrying capacity and stiffness positively. The SB member had a six times higher moment capacity, while the stiffness performance was enhanced seven times when compared to the CB specimen. On the other hand, it was also demonstrated that the ductility of the SB decreased as a consequence of the increase in span-to-depth ratio. The study was expanded based on the rational analyses to evaluate the influence of the additional tensile steel and concrete strength ratio of the enlarged section.*

***Keywords**: Flexural member, Concrete beam, Section-enlargement, Self-compacting-concrete, External strengthening*

Nomenclature

a	*distance of vertical load to the supports in mm*
d	*effective depth of the section in mm*
f'_c	Cylindrical concrete strength in MPa
f_y	Steel yield stress in MPa
f_u	Ultimate steel yield strength in MPa
ACI	American Concrete Institute
CB	Control beam
D12	Deformed steel bar diameter in mm
$M_{ult\text{-}exp}$	Experimental ultimate moment in kN-m
$M_{ult\text{-}th}$	Theoretical ultimate moment in kN-m
SB	Strengthened beam
SCC	Self-compacting concrete
FRP	Fiber-reinforced polymers
LVDT	Linear vertical displacement transducer
ρ	Tensile steel ratio to concrete

I. Introduction

Structural strengthening is customarily aimed to fulfil the structure's capacity requirements originating from changes in code, increase in service load demands, or functional alterations of the structure [1]-[3]. Additional justifications include inappropriate or inaccurate design, deviations during the construction process, and structural damage caused by natural disaster or hazards such as fires. A widely used strengthening technique involves superimposing external reinforcement, namely steel plates or fiber-reinforced polymers (FRP) at the tension zone surface of the member, to increase the capacity and stiffness of the structure's element [4]-[9].

While external reinforcement is relatively easy and proven to be effective, researchers have reported cases of debonding and delaminating in the interface between the external reinforcing component and the concrete [10]-[15]. Other statements highlighted the presence of shear failure in the longitudinal direction and shifting from the flexural to the flexure–shear mode of failure. This will further affect the ductility behavior of the member [11], [16], [1], [17]. Further, the possibility of an alteration from under-reinforced to over-reinforced behavior should be accounted for. The above-mentioned factors could lead to the premature collapse of the member, before the targeted load-carrying capacity is reached. The use of section enlargement has many advantages when compared to the use of steel plates and FRP, since a better compatibility is achieved, while increased stiffness is guaranteed. This research focuses on strengthening by section enlargement to enhance the flexural capacity of reinforced concrete members.

Manuscript received and revised xx 2010, accepted xx 2010

II. Outline and Research Review

The research work was based on experimental tests on strengthened beams. A detailed description of material properties and section dimensions were outlined, and interesting issues concerning the use of self-compaction concrete were highlighted. Then, the set-up of the experimental tests and the loading sequences and details of the precision apparatus that were utilized to evaluate the behavior of the member, were explained.

Data evaluation was distinguished into analyses of the load-displacement responses, the moment-curvature behavior, the failure mode and crack propagation pattern. Since multiple factors contributed to the observed behavior deviation, a numerical simulation to assess each influence was conducted.

The conclusion summarizes the observed facts, and sheds a light on the positive and negative aspects of this strengthening system.

III. Research Methodology

Two perfectly identical 125 by 200 mm reinforced concrete beams with a length of 2.40 meters were cast, namely the control beam (CB) and the strengthened beam (SB). The latter was prepared for further treatment using self-compacting concrete (SCC) to generate the external reinforcement [18], [19]. An average cylindrical concrete strength f'_c of 20.3 MPa was obtained from five test cylinders, cast during the process and tested at the age of 56 days. This concrete age difference with the SCC was to simulate the actual condition in the field, where the enlargement part is cast at a later stage.

The steel reinforcement bars were tested. The primary reinforcement D12 had a yield stress f_y of 335 MPa and an ultimate strength of 497 MPa. The stirrups were placed 150 mm apart and had a diameter of 6 mm. The yield stress and ultimate strength were measured to be 363 MPa and 535 MPa respectively.

All specimens were kept moist for 28 days to ensure that no micro-cracks developed in the member. The SB specimen was then strengthened by enlarging the section and placement of the additional longitudinal reinforcing bars. Supplementary shear reinforcement had to be added to ensure that the failure mode remained in flexure. The stirrups were located parallel to the original stirrups and had the same diameter and spacing as the original configuration. To achieve stability within the core and to create a confined area to help prevent debonding, two 8 mm steel bars were placed longitudinally, on the transversal side of the enlarged section, as can be seen in Fig 1. These bars had a yield stress f_y and ultimate strength f_u of 362 MPa and 518 MPa respectively. The CB specimen remained in its original state.

The section enlargement of the tensile area was mainly to improve the stiffness of the member and to enlarge the moment capacity through the moment contribution of the additional tensile steel. The 37.5 mm enlargement on the left and right side of the original member was mainly to accommodate the process of casting, and to house the secondary shear reinforcements.

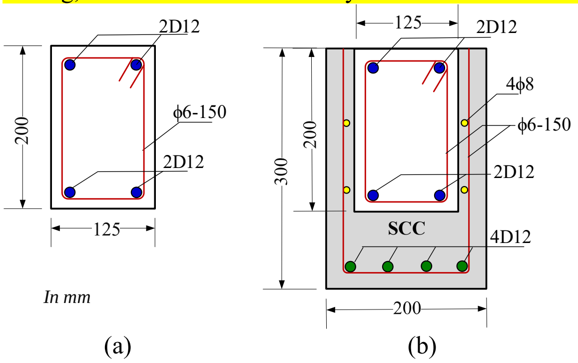


Fig. 1. Details of (a) CB and (b) SB

The enlarged section was constructed using SCC. This became a necessity due to the limitation in casting space, measuring only 37.5 mm at each side of the section, whereas the bottom part that had to be filled was substantially larger, measuring 100 mm in depth. The very narrow spacing between the reinforcing steel bars also made the production of a well-compacted enlarged section a challenge. The solution was to use a very high flowable SCC. The flowability of SCC was measured by the slump flow method, and an average measurement of 650 mm as shown in Fig. 2 was obtained. In accordance with the ACI 237R code, a minimum of 600 mm is mandated for a concrete mix designated as SCC. The average 28-day compressive strength of three SCC cylinders was 23.9 MPa, which was slightly higher than the CB concrete strength.

Fig. 2. SCC flowability measurement

IV. Experimental Set-up

To observe the specimen's flexural behavior, both the specimens were subjected to a two-point loading system with a 450 mm load-to-load distance. This simply supported set-up was favored to ensure a state of pure-flexure in between the lines of loading. The load distance to the effective section depth ratio *a/d* was designed to a minimum of 3, to minimize the shear response within the element. The supports were located at a distance of 75 mm from the far ends of the beam. The load was induced, and controlled by a hydraulic jack producing an increment loading rate of 2.00 kN /minute. The load response was recorded by a load cell. Five LVDTs were utilized, one to measure the vertical displacement at mid-span and two pairs of LVDTs located longitudinally on each face at mid-span to measure the relative displacement in the compression and tension zone (Fig. 3). The horizontal average strain could further be calculated from the comparative displacement between the two opposite LVDTs, divided by their distance. The curvature was determined as the horizontal average strain ratio to the distance of the horizontal LVDTs in the compression and tension zone (Fig. 4). Strain gauges were attached on the extreme compression concrete fibers and the reinforcing bars to record the strain. All devices were connected to a data logger.

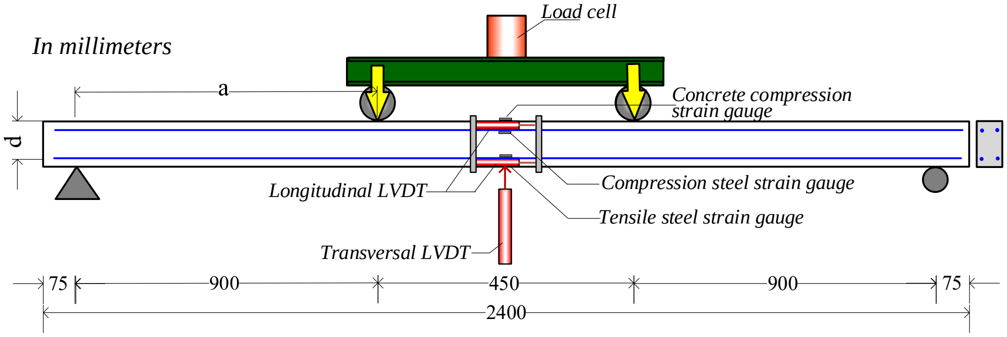


Fig. 3. Experimental set-up

V. Analysis and Discussion

V.1. Load-carrying capacity behavior

The test specimens CB and SB were tested monotonically up till failure. In Fig. 4 the load–displacement relationships at mid-span are shown. The SB specimen differs significantly from CB in terms of the ultimate loading capacity, initial stiffness and ductility behavior. The ultimate load of SB was measured to be 145 kN, compared to the 26 kN that could be carried by CB. A 5.6 times higher capacity is reached for a depth ratio of 1.5 and a tensile reinforcement ratio increase of 0.002.

The capacity increase is a contribution of the additional tensile steel reinforcement, the 1.6 concrete compression-width-ratio enlargement, and the shifting of the neutral axis downwards. Secondary points that could influence the moment capacity are the presence of longitudinal steel bars that, to a degree, subsidized the tensile capacity to the member, since the neutral axis fell above the two rows of longitudinal steel bars. The stirrups in the enlarged section provided confinement to the compression zone of the member, while on the other hand this confinement also postponed the delaminating process in the interface to some extent. The span-to-depth ratio of the enlarged member also has an impact on the enhancement behavior. To investigate the contribution of these factors, a theoretical simulation was conducted, the results of which are shown in Table 1.

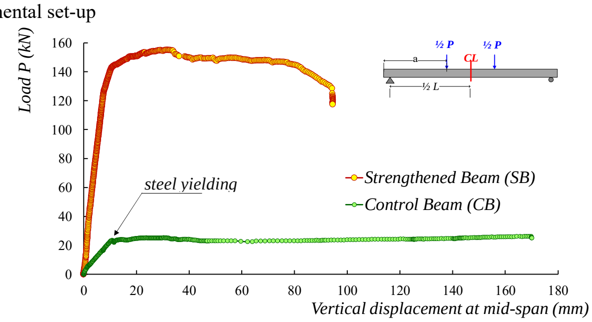
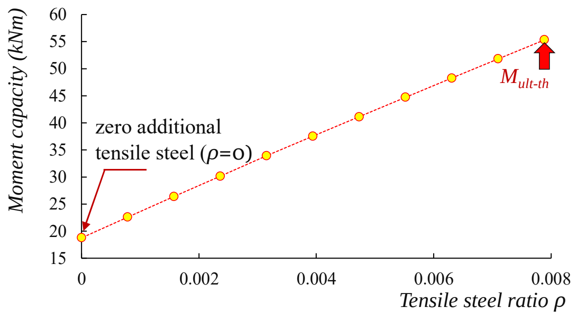


Fig. 4. Load-displacement reponses of CB and SB

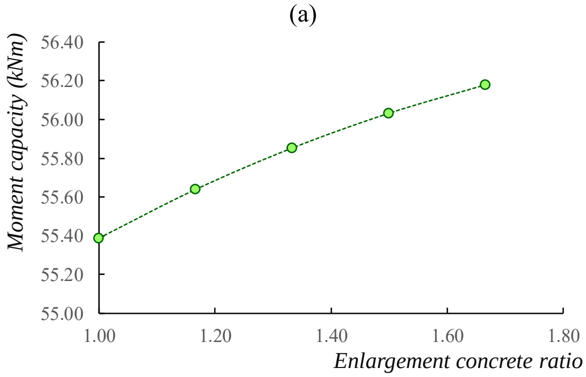
TABLE I
EXPERIMENTAL AND ANALYTICAL RESULTS

Specimen	$M_{ult\text{-}exp}$ (kNm)	$M_{ult\text{-}th}$ (kNm)	Deviation ratio to experiment	Neutral axis to the compression fibers (mm)
CB	11.8	12.1	0.03	34
SB	69.8	55.3	-0.21	37

The additional stirrup had a confining effect on the concrete [20]-[24]; the analysis was based on the assumption of a 20% increase of compression strength in the compression area, especially since the stirrups were extending into the extreme concrete fibers in compression. This was proven to be effective for the case of confinement of the flexural element [17]. To study the contribution of the additional steel reinforcement, the moment capacity as a function of a variation in steel tensile ratio ρ was determined and is shown in Fig. 5 (a).



(a)



(b)

Figs. 5. Influence of (a) reinforcement ratio and (b) concrete strength ratio

The case with zero additional reinforcement in the extended section resulted in a moment capacity of 18.8 kNm. Since the original CB section had a theoretical moment capacity of 12.1 kNm, the contribution of the enlarged section was 6.7 kNm, responsible for only 12% of the capacity enhancement. The concrete enlargement had little effect on the behavior of the overall strengthened beam. This finding underlined that the supplementary tensile reinforcement contributes the most to the increase in performance. It can also be concluded from the pattern of reinforcement ratio that the increase effect follows a straight line.

Fig. 5 (b) illustrates the provision of concrete strengthening to the capacity of the beam. It is shown that the enhancement pattern followed a concave trajectory influenced by the non-linear behavior of the concrete. The contribution of the increase of concrete compression strength to the capacity of the member was diminishing, and a concrete strength of 50 MPa resulted in only a 1.4% improvement in the load-carrying capacity for the member.

V.2. Moment–curvature and cracking pattern

Fig. 6 presents the moment–curvature behavior of the beams.

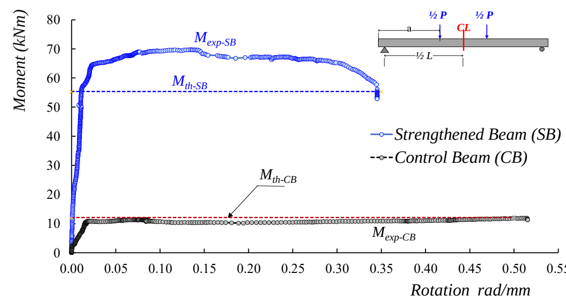
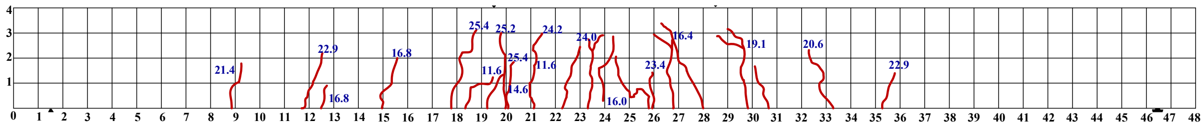


Fig. 6. Moment-rotation behavior of CB and SB and theoretical capacity

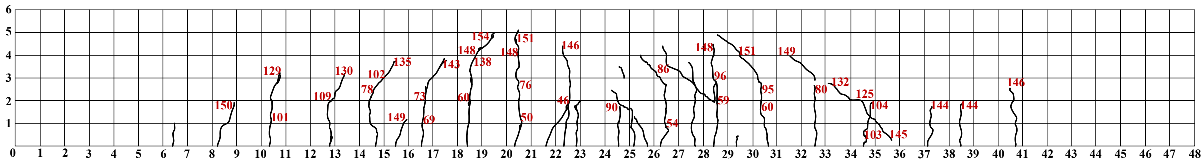
The curves present a similar pattern to the load–displacement relationships. The SB specimen has an almost zero curvature at early loading stages, underlining the very high stiffness of the member. It can also be demonstrated that in the elastic range, the stiffness of specimen SB is 5.4 times higher than CB. The ultimate curvature, however, is only 0.7 for CB. The origin of this divergence is influenced by the span-to-depth ratio (a/d), and the effective depth of the SB member is 50% higher than that of CB due to section enlargement. Tensile steel yielding of specimens CB and SB was found at curvatures of 0.016615 rad/mm and 0.016615 rad/mm, respectively.

Fig. 7 (a) shows the crack pattern of both the specimens. Crushing of concrete in the compression zone is clearly seen. To evaluate the disparity in cracking modes between CB and SB, a graphical representation is presented in Figs. 7 (b) and 7 (c).

(a)



(b)



(c)

Figs. 7. (a) Cracking pattern of CB and SB (b) Graphical presentation of CB (c) Graphical presentation of SB

The cracks were marked in the order of the loading sequence under which the cracks appear. Beam CB underwent the first cracking at very low loading levels as small as 12 kN. The cracks increased in number, and propagated vertically towards the neutral axis of the beam. Beam SB experienced the first cracks at a much higher load level. The recorded load was measured to be 54 kN, and horizontal expansion as well as vertical crack propagation occurred almost simultaneously. Examining the crack trajectory, it can be seen that beam SB exhibited extended flexure–shear cracks in the line of applied loads, while beam CB has an unmistakable flexure failure behavior. In changing the section's depth-to-width ratio, the failure mode shifted away from the flexure behavior [25].

VI. Conclusion

The method of capacity enhancement using concrete section enlargement has proven to be very effective in increasing the moment-carrying capacity and stiffness of the beam. The method is less expensive than strengthening using fiber-reinforced plastics or steel, and the debonding phenomenon can be controlled. However, the ultimate ductility of the newly obtained member reduced significantly.

Rational analysis of both sections revealed that, even though the effect of confinement in the compression zone and the contribution of longitudinal reinforcement were accounted for, other factors, yet to be determined, resulted in a less accurate prediction of the SB specimen's ultimate moment capacity.

Further evaluation of the contribution of the additional reinforcing steel disclosed that the increase in capacity was dominated by this steel, while the stiffness improvement was a provision of the concrete. The rate of capacity increase as a function of the reinforcement ratio followed a linear path, while the influence of the concrete strength ratio followed a quadratic path, designated by the characteristics of the non-linear concrete behavior. The use of high-strength concrete was proven to be insignificant and contributed only very little to the moment capacity of a member.

This strengthening method has the potential to alter the failure mode of the beam, shown from the deviations in cracking patterns between CB and SB. The method described in this study is only effective for positive bending moments. Contradictory to strengthening with fibers, this method cannot easily be applied at near-beam-column areas since it will create a physical change to the inhabited space of a building. The response of this strengthening technique is also the subject of further investigation into the combination of high shear stresses with high flexural stresses, since the two-point loading system creates a pure flexure state between the line of loads.

Acknowledgements

The authors express their gratitude to the Dean and the Department Head of the Civil Engineering Department, Engineering Faculty, Diponegoro University for providing the DIPA funding that made this research work possible.

References

[1] Attari N., Amziane S., Chemrouk M., Flexural Strengthening of Concrete Beams Using CFRP, GFRP and Hybrid FRP Sheets, *Construction and Building Materials, Vol. 37:746–757, December 2012.* https://doi.org/10.1016/j.conbuildmat.2012.07.052

[2] Wang Y., Yang S., Han M., Yang X., Experimental Study of Section Enlargement with Reinforced Concrete to Increase Shear Capacity for Damaged Reinforced Concrete Beams, *Applied Mechanics and Materials, Vol. 256-259: 1148-1153, 2013.* https://doi.org/10.4028/www.scientific.net/AMM.256-259.1148

[3] Zhang H.Y., Yan J., Kodur V., Cao L., Mechanical behavior of concrete beams shear strengthened with textile reinforced geopolymer mortar, *Engineering Structures, Vol. 196, Art. 109348, October 2019.* https://doi.org/10.1016/j.engstruct.2019.109348

[4] Vatovec M., Kelley P.L., Alkhrdaji T., and Nanni A., Evaluation and CFRP Strengthening of Existing Garage: Case Study, *ASCE Journal of Composites for Construction, Vol. 6(3), 184 – 193, 2002.* https://doi.org/10.1061/(ASCE)1090-0268(2002)6:3(184)

[5] Zhang Y., Repair and Strengthening of Reinforced Concrete Beams, *Honors Thesis*, The Ohio State University, 2012.

[6] Li L., Lo S.H., Su R.K.-L., Study of Moderately Reinforced Concrete Beams Strengthened by Bolted-Side Steel Plates, *Design, Fabrication and Economy of Metal Structures, Ch. 86, Springer Berlin Heidelberg (2013).*

https://doi.org/10.1007/978-3-642-36691-8
[7] Demir A., Ercan E., Demir D.D., Strengthening of reinforced concrete beams using external steel members, Steel and *Composite Structures, Vol. 27 (4), 453-464, May 2018.* https://doi.org/10.12989/scs.2018.27.4.453
[8] Djeddi F., Ghernouti Y., Abdelaziz Y., Experimental Investigation of FRP-Concrete Hybrid Beams, *International Review of Civil Engineering, Vol. 6 (6), 2015* https://doi.org/10.15866/irece.v6i6.8187
[9] Mattar I. S., FE Model for R.C Beams Strengthened/Retrofitted with FRP, *International Review of Civil Engineering, Vol. 6 (1), 2015* https://doi.org/10.15866/irece.v6i1.6200
[10] Leung C.K.Y., FRP Debonding from a Concrete Substrate: Some Recent Findings Against Conventional Belief, Cement & *Concrete Composites, Vol. 28 (8): 742–748, September 2006.* https://doi.org/10.1016/j.cemconcomp.2006.05.015
[11] Ceroni F., Experimental Performances of RC Beams Strengthened with FRP Materials. *Construction and Building Materials Vol. 24 (9):1547–1559, September 2010.* https://doi.org/10.1016/j.conbuildmat.2010.03.008
[12] Spadea G., Bencardino F., Sorrenti F., Swamy R.N., Structural Effectiveness of FRP Materials in Strengthening RC Beams, *Engineering Structures, Vol. 99:631–641, 2015.* https://doi.org/10.1016/j.engstruct.2015.05.021
[13] Sri T., Han A.L., Banu A.H., An Experimental Study to the Influence of Fiber Reinforced Polymer (FRP) Confinement on Beams Subjected to Bending and Shear, *Procedia Engineering, Vol. 125:1070-1075, 2015.* https://doi.org/10.1016/j.proeng.2015.11.164
[14] Sri T., Han A.L., Buntara S.G., Revitalization of Cracked Flexural Members Using Retrofitting and Synthetic Wrapping, *Procedia Engineering, Vol. 171:1123-1128, 2017.* https://doi.org/10.1016/j.proeng.2017.01.472
[15] Bekkar I., Djermane M., Bounoua T., Repairing of Reinforced Concrete Beam by Composite Plate, *International Review of Civil Engineering, Vol. 7 (1), 2016* https://doi.org/10.15866/irece.v7i1.5633
[16] Ceroni F., Ianniciello M., Pecce M., Bond Behavior of FRP Carbon Plates Externally Bonded Over Steel and Concrete Elements: Experimental Outcomes and Numerical Investigations, *Composites, Part B, Vol. 92:434–446, May 2016.* https://doi.org/10.1016/j.compositesb.2016.02.033
[17] Huang L., Yan B., Yan L., Xu Q., Haozhi, Kasal B., Reinforced concrete beams strengthened with externally bonded natural flax FRP plates, *Composites, Part B, Vol. 91:569–578, April 2016.* https://doi.org/10.1016/j.compositesb.2016.02.014
[18] Ghazy M.F., Performance of Self Compacting Concrete, *Ain Shams Journal of Civil Engineering (ASJCE), Vol. 2:23-39, September 2009.*
[19] Mittal M., Basu S., Sofi A., Effect of Sika Viscocrete on Properties of Concrete, *International Journal of Civil Engineering (IJCE), Vol. 2 (4):61-66, September 2013.*
[20] Han A., Antonius, Okiyarta A.W., Experimental Study of Steel-fiber Reinforced Concrete Beams with Confinement, *Procedia Engineering, Vol. 125:1030-1035, 2015.* https://doi.org/10.1016/j.proeng.2015.11.158
[21] Bouamra Y., Ait Tahar K., Mechanical performance of a confined reinforced concrete beam, *Procedia Structural Integrity, Vol. 5:155-162, 2017.* https://doi.org/10.1016/j.prostr.2017.07.086
[22] Huang L., Zhang C., Yan L., Kasal B., Flexural behavior of U-shape FRP profile-RC composite beams with inner GFRP tube confinement at concrete compression zone, *Composite Structures, Vol. 184:674-687, January 2018.* https://doi.org/10.1016/j.compstruct.2017.10.029
[23] Moodi Y., Sohrabi M.R., Mousavi S.R., Effects of stirrups in spliced region on the bond strength of corroded splices in reinforced concrete (RC) beams, *Construction and Building Materials, Vol. 230, Art. 116873, January 2020.* https://doi.org/10.1016/j.conbuildmat.2019.116873
[24] Hung C. C., Chen, Y. S., Innovative ECC Jacketing for Retrofitting Shear-Deficient RC Members. *Construction & Building Materials. Vol.111: 408-418, 2016.* https://doi.org/10.1016/j.conbuildmat.2016.02.077
[25] Slowik M., The Influence of Effective Length on Shear Failure in Concrete Beams. *International Journal of Earthquake Engineering and Hazard Mitigation (IREHM), Vol.5 (4): 117-123,* 2017

Authors' information

[1]Engineering Faculty, Diponegoro University, Semarang, Indonesia.

[2]Department of Civil Engineering, National Cheng Kung University, Tainan, Taiwan.

[3]Magister Program in Civil Engineering, Diponegoro University.

Nuroji was born in Pemalang, Indonesia. He obtained his bachelor's degree form the Diponegoro University and his Master and Doctorate from the ITB in Bandung, Indonesia. Nuroji is an associate professor in structural and material engineering, and specialized in concrete innovations and modeling. An active member of the Indonesian Structural Engineering Association (HAKI), Nuroji has served as consultant for numerous projects with complicated design structures. His most recent research work involves strengthening and external reinforcement of beams and frames.

Chung-Chan Hung obtained his Ph.D. from the University of Michigan, Ann Arbor, USA and is an active member and editor of the ASCE Journal of Structural Engineering. He is also Chair of the Committee on International and Cross-strait Affairs for Taiwan Concrete Institute. Prof. Hung research is in the field of durable and sustainable concrete infrastructure. He is particularly interested in the development of advanced cement-based materials and earthquake-resistant RC structures. To investigate his research problems, Prof. Hung applies materials and large-structural tests, hybrid tests, and computational modeling techniques.

Blinka H. Prasetya was born in Semarang, Indonesia, 24 November 1995. He completed his bachelor in Civil Engineering from Diponegoro University cum laude. Currently, he studies at Magister Program in Civil Engineering, Diponegoro University. Prasetya is a research assistant at the Material and Construction Laboratory of the Civil Engineering Department, Diponegoro University. His major interests are concrete structures and structural systems

Aylie Han was born in Semarang-Indonesia. She completed her doctoral degree in Structural Engineering at Diponegoro University in a join research with the National University of Singapore and North Carolina State University (USA). Currently a professor in civil engineering at the Diponegoro University, Semarang-Indonesia. Her research interests include concrete technology, graded concrete, and finite element modelling. As a researcher, she works with the NCKU in Tainan-Taiwan, and other state and private universities in Indonesia. Han Ay Lie is also the president of *fib*-Indonesia and a member of *fib* COM7-Sustainability, while serving as board for HAKI (the Indonesian Association of Structural Engineers). She is also a member of the new Indonesian Concrete Code (SNI 2020) formulation team and a long-time member of ACI.

LAMPIRAN B

Permohonan maaf dari penerbit

Errata to: The behavior of reinforced concrete members with section enlargement using self compacting concrete (Journal irece, 11, 3, 121-126)

Nuroji, Chung Chan Hung, Blinka H. Prasetya, Aylie Han

Department of Civil Engineering

Research output: Contribution to journal › Comment/debate › peer-review

Overview Fingerprint

Abstract

The additional stirrup had a confining effect on the concrete [20]-[24]; the analysis was based on the assumption of a 20% increase of compression strength in the compression area, especially since the stirrups were extending into the extreme concrete fibers in compression." Many apologies to the authors and to our readers for this mistake.

Original language	English
Pages (from-to)	284
Number of pages	1
Journal	International Review of Civil Engineering
Volume	12
Issue number	4
Publication status	Published - 2021

All Science Journal Classification (ASJC) codes

Computational Mechanics
Civil and Structural Engineering
Architecture
Building and Construction
Safety, Risk, Reliability and Quality
Mechanics of Materials

Access to Document

10.15866/irece.v12i4.21157

Other files and links

Link to publication in Scopus

Link to the citations in Scopus

Fingerprint

Dive into the research topics of 'Errata to: The behavior of reinforced concrete members with section enlargement using self compacting concrete (Journal irece, 11, 3, 121-126)'. Together they form a unique fingerprint.

- Reinforced Concrete — Mathematics
- Self compacting concrete — Engineering & Materials Science
- Enlargement — Mathematics
- Compression — Mathematics
- Reinforced concrete — Engineering & Materials Science
- Concretes — Engineering & Materials Science
- Compaction — Engineering & Materials Science
- Fibers — Engineering & Materials Science

View full fingerprint ›

Cite this

APA Author BIBTEX Harvard Standard RIS Vancouver

Nuroji, Hung, C. C., Prasetya, B. H., & Han, A. (2021). Errata to: The behavior of reinforced concrete members with section enlargement using self compacting concrete (Journal irece, 11, 3, 121-126). *International Review of Civil Engineering*, *12*(4), 284. https://doi.org/10.15866/irece.v12i4.21157

LAMPIRAN C

Camera ready manuscript

International Review of Civil Engineering (I.RE.C.E.), Vol. xx, n. x
June 2010

Section Enlargement Strengthening of Reinforced Concrete Beam by Using Self-Compacting Concrete

Nuroji[1*], Chung-Chan Hung[2], Blinka H. Prasetya[3], Aylie Han[1]

Abstract – *This paper presents the experimental results of section enlargement effects on prismatic reinforced concrete members. 125 by 200 mm reinforced concrete members with a compressive strength of 20.3 MPa reinforced with D12 steel bars having a yield stress of 335 MPa situated in the tension and compression area, were produced. Two specimens were prepared, the first functioning as the control element and designated as the control beam (CB). The second strengthened with a section enlargement using self-compacting concrete (SCC) marked as the strengthened beam (SB). The SCC had a 28-day compressive strength of 23.9 MPa. The dimensions of the enlarged beam were 200 by 300 mm. The two specimens CB and SB were tested with a two-point loading system. Based on the tests data, the load–displacement and moment–curvature relationships characterizing the beams were generated. From the results it was concluded that the enlargement affected the load-carrying capacity and stiffness positively. The SB member had a six times higher moment capacity, while the stiffness performance was enhanced seven times when compared to the CB specimen. On the other hand, it was also demonstrated that the ductility of the SB decreased as a consequence of the increase in span-to-depth ratio. The study was expanded based on the rational analyses to evaluate the influence of the additional tensile steel and concrete strength ratio of the enlarged section.*

***Keywords**: Flexural member, Concrete beam, Section-enlargement, Self-compacting-concrete, External strengthening*

Nomenclature

a	*distance of vertical load to the supports in mm*
d	*effective depth of the section in mm*
f'_c	Cylindrical concrete strength in MPa
f_y	Steel yield stress in MPa
f_u	Ultimate steel yield strength in MPa
ACI	American Concrete Institute
CB	Control beam
D12	Deformed steel bar diameter in mm
$M_{ult\text{-}exp}$	Experimental ultimate moment in kN-m
$M_{ult\text{-}th}$	Theoretical ultimate moment in kN-m
SB	Strengthened beam
SCC	Self-compacting concrete
FRP	Fiber-reinforced polymers
LVDT	Linear vertical displacement transducer
ρ	Tensile steel ratio to concrete

I. Introduction

Structural strengthening is customarily aimed to fulfil the structure's capacity requirements originating from changes in code, increase in service load demands, or functional alterations of the structure [1]-[3]. Additional justifications include inappropriate or inaccurate design, deviations during the construction process, and structural damage caused by natural disaster or hazards such as fires. A widely used strengthening technique involves superimposing external reinforcement, namely steel plates or fiber-reinforced polymers (FRP) at the tension zone surface of the member, to increase the capacity and stiffness of the structure's element [4]-[9].

While external reinforcement is relatively easy and proven to be effective, researchers have reported cases of debonding and delaminating in the interface between the external reinforcing component and the concrete [10]-[15]. Other statements highlighted the presence of shear failure in the longitudinal direction and shifting from the flexural to the flexure–shear mode of failure. This will further affect the ductility behavior of the member [11], [16], [1], [17]. Further, the possibility of an alteration from under-reinforced to over-reinforced behavior should be accounted for. The above-mentioned factors could lead to the premature collapse of the member, before the targeted load-carrying capacity is reached. The use of section enlargement has many advantages when compared to the use of steel plates and FRP, since a better compatibility is achieved, while increased stiffness is guaranteed. This research focuses on strengthening by section enlargement to enhance the flexural capacity of reinforced concrete members.

Manuscript received and revised xx 2010, accepted xx 2010

II. Outline and Research Review

The research work was based on experimental tests on strengthened beams. A detailed description of material properties and section dimensions were outlined, and interesting issues concerning the use of self-compaction concrete were highlighted. Then, the set-up of the experimental tests and the loading sequences and details of the precision apparatus that were utilized to evaluate the behavior of the member, were explained.

Data evaluation was distinguished into analyses of the load-displacement responses, the moment-curvature behavior, the failure mode and crack propagation pattern. Since multiple factors contributed to the observed behavior deviation, a numerical simulation to assess each influence was conducted.

The conclusion summarizes the observed facts, and sheds a light on the positive and negative aspects of this strengthening system.

III. Research Methodology

Two perfectly identical 125 by 200 mm reinforced concrete beams with a length of 2.40 meters were cast, namely the control beam (CB) and the strengthened beam (SB). The latter was prepared for further treatment using self-compacting concrete (SCC) to generate the external reinforcement [18], [19]. An average cylindrical concrete strength f'_c of 20.3 MPa was obtained from five test cylinders, cast during the process and tested at the age of 56 days. This concrete age difference with the SCC was to simulate the actual condition in the field, where the enlargement part is cast at a later stage.

The steel reinforcement bars were tested. The primary reinforcement D12 had a yield stress f_y of 335 MPa and an ultimate strength of 497 MPa. The stirrups were placed 150 mm apart and had a diameter of 6 mm. The yield stress and ultimate strength were measured to be 363 MPa and 535 MPa respectively.

All specimens were kept moist for 28 days to ensure that no micro-cracks developed in the member. The SB specimen was then strengthened by enlarging the section and placement of the additional longitudinal reinforcing bars. Supplementary shear reinforcement had to be added to ensure that the failure mode remained in flexure. The stirrups were located parallel to the original stirrups and had the same diameter and spacing as the original configuration. To achieve stability within the core and to create a confined area to help prevent debonding, two 8 mm steel bars were placed longitudinally, on the transversal side of the enlarged section, as can be seen in Fig 1. These bars had a yield stress f_y and ultimate strength f_u of 362 MPa and 518 MPa respectively. The CB specimen remained in its original state.

The section enlargement of the tensile area was mainly to improve the stiffness of the member and to enlarge the moment capacity through the moment contribution of the additional tensile steel. The 37.5 mm enlargement on the left and right side of the original member was mainly to accommodate the process of casting, and to house the secondary shear reinforcements.

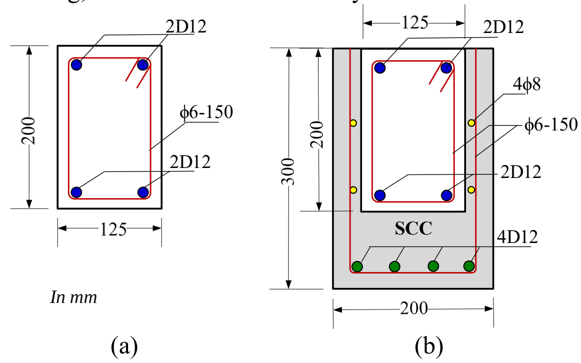


Fig. 1. Details of (a) CB and (b) SB

The enlarged section was constructed using SCC. This became a necessity due to the limitation in casting space, measuring only 37.5 mm at each side of the section, whereas the bottom part that had to be filled was substantially larger, measuring 100 mm in depth. The very narrow spacing between the reinforcing steel bars also made the production of a well-compacted enlarged section a challenge. The solution was to use a very high flowable SCC. The flowability of SCC was measured by the slump flow method, and an average measurement of 650 mm as shown in Fig. 2 was obtained. In accordance with the ACI 237R code, a minimum of 600 mm is mandated for a concrete mix designated as SCC. The average 28-day compressive strength of three SCC cylinders was 23.9 MPa, which was slightly higher than the CB concrete strength.

Fig. 2. SCC flowability measurement

IV. Experimental Set-up

To observe the specimen's flexural behavior, both the specimens were subjected to a two-point loading system with a 450 mm load-to-load distance. This simply supported set-up was favored to ensure a state of pure-flexure in between the lines of loading. The load distance to the effective section depth ratio *a/d* was designed to a minimum of 3, to minimize the shear response within the element. The supports were located at a distance of 75 mm from the far ends of the beam. The load was induced, and controlled by a hydraulic jack producing an increment loading rate of 2.00 kN /minute. The load response was recorded by a load cell. Five LVDTs were utilized, one to measure the vertical displacement at mid-span and two pairs of LVDTs located longitudinally on each face at mid-span to measure the relative displacement in the compression and tension zone (Fig. 3). The horizontal average strain could further be calculated from the comparative displacement between the two opposite LVDTs, divided by their distance. The curvature was determined as the horizontal average strain ratio to the distance of the horizontal LVDTs in the compression and tension zone (Fig. 4). Strain gauges were attached on the extreme compression concrete fibers and the reinforcing bars to record the strain. All devices were connected to a data logger.

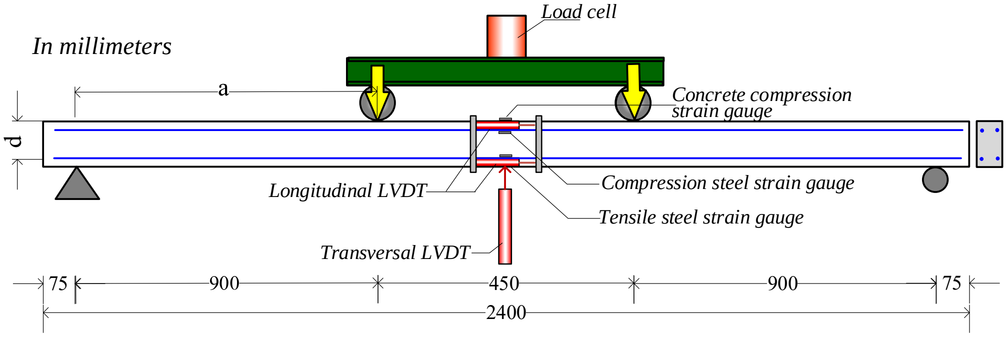


Fig. 3. Experimental set-up

V. Analysis and Discussion

V.1. Load-carrying capacity behavior

The test specimens CB and SB were tested monotonically up till failure. In Fig. 4 the load–displacement relationships at mid-span are shown. The SB specimen differs significantly from CB in terms of the ultimate loading capacity, initial stiffness and ductility behavior. The ultimate load of SB was measured to be 145 kN, compared to the 26 kN that could be carried by CB. A 5.6 times higher capacity is reached for a depth ratio of 1.5 and a tensile reinforcement ratio increase of 0.002.

The capacity increase is a contribution of the additional tensile steel reinforcement, the 1.6 concrete compression-width-ratio enlargement, and the shifting of the neutral axis downwards. Secondary points that could influence the moment capacity are the presence of longitudinal steel bars that, to a degree, subsidized the tensile capacity to the member, since the neutral axis fell above the two rows of longitudinal steel bars. The stirrups in the enlarged section provided confinement to the compression zone of the member, while on the other hand this confinement also postponed the delaminating process in the interface to some extent. The span-to-depth ratio of the enlarged member also has an impact on the enhancement behavior. To investigate the contribution of these factors, a theoretical simulation was conducted, the results of which are shown in Table 1.

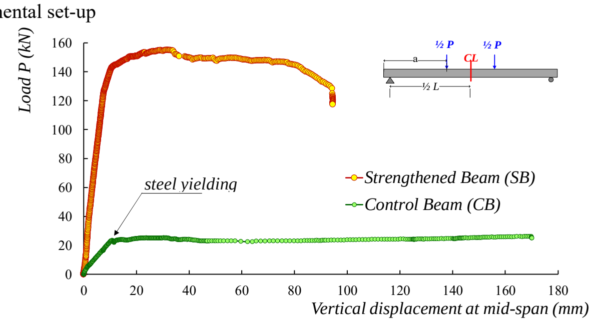
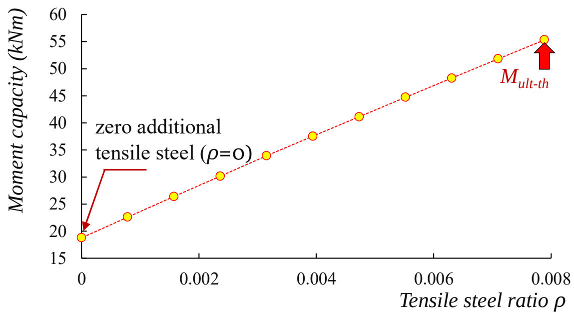


Fig. 4. Load-displacement reponses of CB and SB

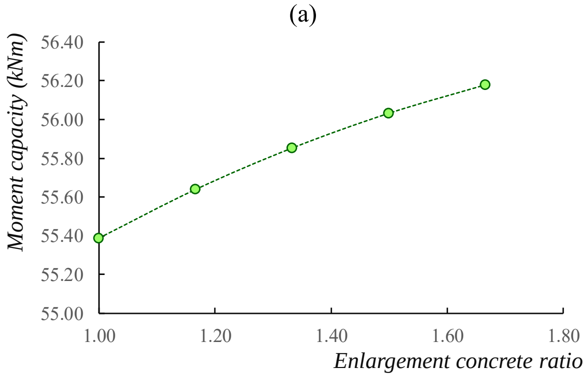
TABLE I
EXPERIMENTAL AND ANALYTICAL RESULTS

Specimen	$M_{ult\text{-}exp}$ (kNm)	$M_{ult\text{-}th}$ (kNm)	Deviation ratio to experiment	Neutral axis to the compression fibers (mm)
CB	11.8	12.1	0.03	34
SB	69.8	55.3	-0.21	37

The additional stirrup had a confining effect on the concrete [20]-[24]; the analysis was based on the assumption of a 20% increase of compression strength in the compression area, especially since the stirrups were extending into the extreme concrete fibers in compression. This was proven to be effective for the case of confinement of the flexural element [17]. To study the contribution of the additional steel reinforcement, the moment capacity as a function of a variation in steel tensile ratio ρ was determined and is shown in Fig. 5 (a).



(a)



(b)

Figs. 5. Influence of (a) reinforcement ratio and (b) concrete strength ratio

The case with zero additional reinforcement in the extended section resulted in a moment capacity of 18.8 kNm. Since the original CB section had a theoretical moment capacity of 12.1 kNm, the contribution of the enlarged section was 6.7 kNm, responsible for only 12% of the capacity enhancement. The concrete enlargement had little effect on the behavior of the overall strengthened beam. This finding underlined that the supplementary tensile reinforcement contributes the most to the increase in performance. It can also be concluded from the pattern of reinforcement ratio that the increase effect follows a straight line.

Fig. 5 (b) illustrates the provision of concrete strengthening to the capacity of the beam. It is shown that the enhancement pattern followed a concave trajectory influenced by the non-linear behavior of the concrete. The contribution of the increase of concrete compression strength to the capacity of the member was diminishing, and a concrete strength of 50 MPa resulted in only a 1.4% improvement in the load-carrying capacity for the member.

V.2. Moment–curvature and cracking pattern

Fig. 6 presents the moment–curvature behavior of the beams.

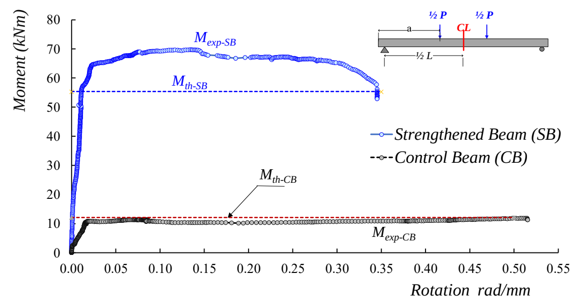
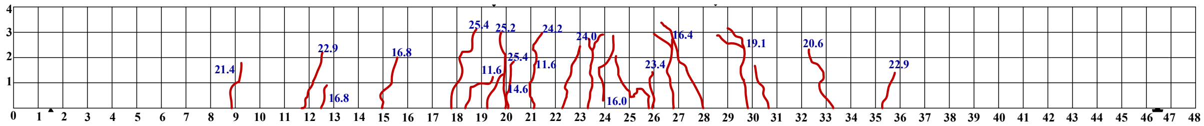


Fig. 6. Moment-rotation behavior of CB and SB and theoretical capacity

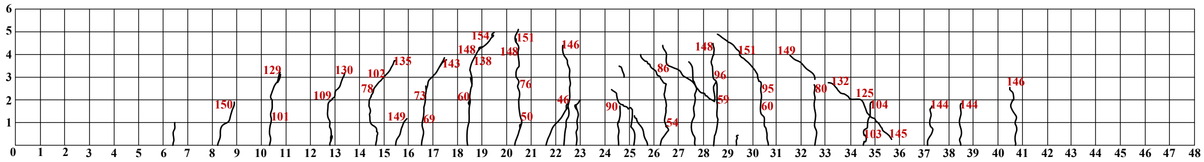
The curves present a similar pattern to the load–displacement relationships. The SB specimen has an almost zero curvature at early loading stages, underlining the very high stiffness of the member. It can also be demonstrated that in the elastic range, the stiffness of specimen SB is 5.4 times higher than CB. The ultimate curvature, however, is only 0.7 for CB. The origin of this divergence is influenced by the span-to-depth ratio (a/d), and the effective depth of the SB member is 50% higher than that of CB due to section enlargement. Tensile steel yielding of specimens CB and SB was found at curvatures of 0.016615 rad/mm and 0.016615 rad/mm, respectively.

Fig. 7 (a) shows the crack pattern of both the specimens. Crushing of concrete in the compression zone is clearly seen. To evaluate the disparity in cracking modes between CB and SB, a graphical representation is presented in Figs. 7 (b) and 7 (c).

(a)



(b)



(c)

Figs. 7. (a) Cracking pattern of CB and SB (b) Graphical presentation of CB (c) Graphical presentation of SB

The cracks were marked in the order of the loading sequence under which the cracks appear. Beam CB underwent the first cracking at very low loading levels as small as 12 kN. The cracks increased in number, and propagated vertically towards the neutral axis of the beam. Beam SB experienced the first cracks at a much higher load level. The recorded load was measured to be 54 kN, and horizontal expansion as well as vertical crack propagation occurred almost simultaneously. Examining the crack trajectory, it can be seen that beam SB exhibited extended flexure–shear cracks in the line of applied loads, while beam CB has an unmistakable flexure failure behavior. In changing the section's depth-to-width ratio, the failure mode shifted away from the flexure behavior [25].

VI. Conclusion

The method of capacity enhancement using concrete section enlargement has proven to be very effective in increasing the moment-carrying capacity and stiffness of the beam. The method is less expensive than strengthening using fiber-reinforced plastics or steel, and the debonding phenomenon can be controlled. However, the ultimate ductility of the newly obtained member reduced significantly.

Rational analysis of both sections revealed that, even though the effect of confinement in the compression zone and the contribution of longitudinal reinforcement were accounted for, other factors, yet to be determined, resulted in a less accurate prediction of the SB specimen's ultimate moment capacity.

Further evaluation of the contribution of the additional reinforcing steel disclosed that the increase in capacity was dominated by this steel, while the stiffness improvement was a provision of the concrete. The rate of capacity increase as a function of the reinforcement ratio followed a linear path, while the influence of the concrete strength ratio followed a quadratic path, designated by the characteristics of the non-linear concrete behavior. The use of high-strength concrete was proven to be insignificant and contributed only very little to the moment capacity of a member.

This strengthening method has the potential to alter the failure mode of the beam, shown from the deviations in cracking patterns between CB and SB. The method described in this study is only effective for positive bending moments. Contradictory to strengthening with fibers, this method cannot easily be applied at near-beam-column areas since it will create a physical change to the inhabited space of a building. The response of this strengthening technique is also the subject of further investigation into the combination of high shear stresses with high flexural stresses, since the two-point loading system creates a pure flexure state between the line of loads.

Acknowledgements

The authors express their gratitude to the Dean and the Department Head of the Civil Engineering Department, Engineering Faculty, Diponegoro University for providing the DIPA funding that made this research work possible.

References

[1] Attari N., Amziane S., Chemrouk M., Flexural Strengthening of Concrete Beams Using CFRP, GFRP and Hybrid FRP Sheets, *Construction and Building Materials, Vol. 37:746–757, December 2012.* https://doi.org/10.1016/j.conbuildmat.2012.07.052

[2] Wang Y., Yang S., Han M., Yang X., Experimental Study of Section Enlargement with Reinforced Concrete to Increase Shear Capacity for Damaged Reinforced Concrete Beams, *Applied Mechanics and Materials, Vol. 256-259: 1148-1153, 2013.* https://doi.org/10.4028/www.scientific.net/AMM.256-259.1148

[3] Zhang H.Y., Yan J., Kodur V., Cao L., Mechanical behavior of concrete beams shear strengthened with textile reinforced geopolymer mortar, *Engineering Structures, Vol. 196, Art. 109348, October 2019.* https://doi.org/10.1016/j.engstruct.2019.109348

[4] Vatovec M., Kelley P.L., Alkhrdaji T., and Nanni A., Evaluation and CFRP Strengthening of Existing Garage: Case Study, *ASCE Journal of Composites for Construction, Vol. 6(3), 184 – 193, 2002.* https://doi.org/10.1061/(ASCE)1090-0268(2002)6:3(184)

[5] Zhang Y., Repair and Strengthening of Reinforced Concrete Beams, *Honors Thesis*, The Ohio State University, 2012.

[6] Li L., Lo S.H., Su R.K.-L., Study of Moderately Reinforced Concrete Beams Strengthened by Bolted-Side Steel Plates, *Design, Fabrication and Economy of Metal Structures, Ch. 86, Springer Berlin Heidelberg (2013).*

https://doi.org/10.1007/978-3-642-36691-8
[7] Demir A., Ercan E., Demir D.D., Strengthening of reinforced concrete beams using external steel members, *Steel and Composite Structures, Vol. 27 (4), 453-464, May 2018.* https://doi.org/10.12989/scs.2018.27.4.453
[8] Djeddi F., Ghernouti Y., Abdelaziz Y., Experimental Investigation of FRP-Concrete Hybrid Beams, *International Review of Civil Engineering, Vol. 6 (6), 2015* https://doi.org/10.15866/irece.v6i6.8187
[9] Mattar I. S., FE Model for R.C Beams Strengthened/Retrofitted with FRP, *International Review of Civil Engineering, Vol. 6 (1), 2015* https://doi.org/10.15866/irece.v6i1.6200
[10] Leung C.K.Y., FRP Debonding from a Concrete Substrate: Some Recent Findings Against Conventional Belief, Cement & *Concrete Composites, Vol. 28 (8): 742–748, September 2006.* https://doi.org/10.1016/j.cemconcomp.2006.05.015
[11] Ceroni F., Experimental Performances of RC Beams Strengthened with FRP Materials. *Construction and Building Materials Vol. 24 (9):1547–1559, September 2010.* https://doi.org/10.1016/j.conbuildmat.2010.03.008
[12] Spadea G., Bencardino F., Sorrenti F., Swamy R.N., Structural Effectiveness of FRP Materials in Strengthening RC Beams, *Engineering Structures, Vol. 99:631–641, 2015.* https://doi.org/10.1016/j.engstruct.2015.05.021
[13] Tudjono, S., Han A.L., Hidayat B. A., An Experimental Study to the Influence of Fiber Reinforced Polymer (FRP) Confinement on Beams Subjected to Bending and Shear, *Procedia Engineering, Vol. 125:1070-1075, 2015.* https://doi.org/10.1016/j.proeng.2015.11.164
[14] Tudjono S., Han A.L., Gan B. S., Revitalization of Cracked Flexural Members Using Retrofitting and Synthetic Wrapping, *Procedia Engineering, Vol. 171:1123-1128, 2017.* https://doi.org/10.1016/j.proeng.2017.01.472
[15] Bekkar I., Djermane M., Bounoua T., Repairing of Reinforced Concrete Beam by Composite Plate, *International Review of Civil Engineering, Vol. 7 (1), 2016* https://doi.org/10.15866/irece.v7i1.5633
[16] Ceroni F., Ianniciello M., Pecce M., Bond Behavior of FRP Carbon Plates Externally Bonded Over Steel and Concrete Elements: Experimental Outcomes and Numerical Investigations, *Composites, Part B, Vol. 92:434–446, May 2016.* https://doi.org/10.1016/j.compositesb.2016.02.033
[17] Huang L., Yan B., Yan L., Xu Q., Haozhi, Kasal B., Reinforced concrete beams strengthened with externally bonded natural flax FRP plates, *Composites, Part B, Vol. 91:569–578, April 2016.* https://doi.org/10.1016/j.compositesb.2016.02.014
[18] Ghazy M.F., Performance of Self Compacting Concrete, *Ain Shams Journal of Civil Engineering (ASJCE), Vol. 2:23-39, September 2009.*
[19] Mittal M., Basu S., Sofi A., Effect of Sika Viscocrete on Properties of Concrete, *International Journal of Civil Engineering (IJCE), Vol. 2 (4):61-66, September 2013.*
[20] Han A., Antonius, Okiyarta A.W., Experimental Study of Steel-fiber Reinforced Concrete Beams with Confinement, *Procedia Engineering, Vol. 125:1030-1035, 2015.* https://doi.org/10.1016/j.proeng.2015.11.158
[21] Bouamra Y., Ait Tahar K., Mechanical performance of a confined reinforced concrete beam, *Procedia Structural Integrity, Vol. 5:155-162, 2017.* https://doi.org/10.1016/j.prostr.2017.07.086
[22] Huang L., Zhang C., Yan L., Kasal B., Flexural behavior of U-shape FRP profile-RC composite beams with inner GFRP tube confinement at concrete compression zone, *Composite Structures, Vol. 184:674-687, January 2018.* https://doi.org/10.1016/j.compstruct.2017.10.029
[23] Moodi Y., Sohrabi M.R., Mousavi S.R., Effects of stirrups in spliced region on the bond strength of corroded splices in reinforced concrete (RC) beams, *Construction and Building Materials, Vol. 230, Art. 116873, January 2020.* https://doi.org/10.1016/j.conbuildmat.2019.116873
[24] Hung C. C., Chen, Y. S., Innovative ECC Jacketing for Retrofitting Shear-Deficient RC Members. *Construction & Building Materials. Vol.111: 408-418, 2016.* https://doi.org/10.1016/j.conbuildmat.2016.02.077
[25] Slowik M., The Influence of Effective Length on Shear Failure in Concrete Beams. *International Journal of Earthquake Engineering and Hazard Mitigation (IREHM), Vol.5 (4): 117-123,* 2017

Authors' information

[1]Engineering Faculty, Diponegoro University, Semarang, Indonesia.

[2]Department of Civil Engineering, National Cheng Kung University, Tainan, Taiwan.

[3]Magister Program in Civil Engineering, Diponegoro University.

Nuroji was born in Pemalang, Indonesia. He obtained his bachelor's degree form the Diponegoro University and his Master and Doctorate from the ITB in Bandung, Indonesia. Nuroji is an associate professor in structural and material engineering, and specialized in concrete innovations and modeling. An active member of the Indonesian Structural Engineering Association (HAKI), Nuroji has served as consultant for numerous projects with complicated design structures. His most recent research work involves strengthening and external reinforcement of beams and frames.

Chung-Chan Hung obtained his Ph.D. from the University of Michigan, Ann Arbor, USA and is an active member and editor of the ASCE Journal of Structural Engineering. He is also Chair of the Committee on International and Cross-strait Affairs for Taiwan Concrete Institute. Prof. Hung research is in the field of durable and sustainable concrete infrastructure. He is particularly interested in the development of advanced cement-based materials and earthquake-resistant RC structures. To investigate his research problems, Prof. Hung applies materials and large-structural tests, hybrid tests, and computational modeling techniques.

Blinka H. Prasetya was born in Semarang, Indonesia, 24 November 1995. He completed his bachelor in Civil Engineering from Diponegoro University cum laude. Currently, he studies at Magister Program in Civil Engineering, Diponegoro University. Prasetya is a research assistant at the Material and Construction Laboratory of the Civil Engineering Department, Diponegoro University. His major interests are concrete structures and structural systems

Aylie Han was born in Semarang-Indonesia. She completed her doctoral degree in Structural Engineering at Diponegoro University in a join research with the National University of Singapore and North Carolina State University (USA). Currently a professor in civil engineering at the Diponegoro University, Semarang-Indonesia. Her research interests include concrete technology, graded concrete, and finite element modelling. As a researcher, she works with the NCKU in Tainan-Taiwan, and other state and private universities in Indonesia. Han Ay Lie is also the president of *fib*-Indonesia and a member of *fib* COM7-Sustainability, while serving as board for HAKI (the Indonesian Association of Structural Engineers). She is also a member of the new Indonesian Concrete Code (SNI 2020) formulation team and a long-time member of ACI.

LAMPIRAN D

Errata pada beberapa
jurnal bereputasi

Erratum for “Explicit Analytic Solutions for the Accurate Evaluation of the Shear Stresses in Sandwich Beams” by Lorenzo Bardella and Daniele Tonelli

October 2012 · Journal of Engineering Mechanics 138(10):1302
DOI: 10.1061/(ASCE)EM.1943-7889.0000476
Project: Modelling the flexure of sandwich panels and composite beams

Lorenzo Bardella · Daniele Tonelli

Abstract

Page 1

Erratum for “Explicit Analytic Solutions for the Accurate Evaluation of the Shear Stresses in Sandwich Beams” by Lorenzo Bardella and Daniele Tonelli

May 2012, Vol. 138, No. 5, pp. 502–507.
DOI:

Lorenzo Bardella
Associate Professor, DICATA, Univ. of Brescia, via Branze, 43-25123 Brescia, Italy (corresponding author). E-mail:

Daniele Tonelli
Student, Faculty of Engineering, Univ. of Brescia, via Branze, 43-25123 Brescia, Italy. E-mail

An error was introduced into Eq. during typesetting of this paper. The operator in the second line of the set should be $\in$ as follows:

$$\chi_i(y) = \begin{cases} 1 & \text{if} \quad y \in A_i \\ 0 & \text{if} \quad y \notin A_i \end{cases} \quad \text{with} \quad i = s, \tag{2}$$

An error was introduced into Eq. , whereby the minus sign was not included within the horizontal brace for $M_c(x)$. The equation should have read

$$M(x) = \underbrace{-\frac{E_s b t^3}{6}\phi_s'(x) - \frac{E_s b t^2}{2}\left[c\phi_c'(x) + t\phi_s'(x)\right]}_{M_s(x)} \underbrace{-\frac{E_s btc}{2}\left[c\phi_c'(x) + t\phi_s'(x)\right] - \frac{E_c bc^3}{12}\phi_c'(x)}_{M_c(x)} \tag{6}$$

Two errors were also introduced into Eq. , with one of the subscript terms and one exponent in a denominator being typeset online. The corrected equation is

$$f(\xi) = \frac{24C_0}{k^4}\left[\frac{e^{-k}-1}{1-e^{-2k}}e^{k(\xi-1)} - \frac{1}{2}(\coth k - \operatorname{csch} k + 1)e^{-k\xi}\right] + C_0\xi^4 - 2C_0\xi^3 + \frac{12C_0}{k^2}\xi^2 + C_0\left(1-\frac{12}{k^2}\right)\xi + \frac{24C_0}{k^4} \tag{18}$$

ASCE regrets these errors

Additionally, the right-hand sides of Eqs. (19), (20), and (23b should be of opposite sign, as follows:

$$\phi(\xi) = -\frac{\beta_1\alpha_2}{\beta_2\alpha_1 L^3}\frac{d^3f(\xi)}{d\xi^3} + \frac{\beta_1\beta_3 - \beta_2^2}{\alpha_1\beta_2 L}\frac{df(\xi)}{d\xi}, \qquad \psi(\xi) = -\frac{1}{L^3}\frac{d^3f(\xi)}{d\xi^3}$$

$$v(\xi) = \frac{\alpha_2}{\beta_2 L^4}\frac{d^4f(\xi)}{d\xi^4} - \left(\beta_3 + \beta_1\frac{\alpha_2}{\alpha_1}\right)\frac{1}{\beta_2 L^2}\frac{d^2f(\xi)}{d\xi^2} + \frac{\beta_1\beta_3 - \beta_2^2}{\alpha_1\beta_2}f(\xi)$$

$$\beta_2 = -\int_A G(y)\frac{dw(y)}{dy}\,dA$$

In the unnumbered display equation following Eq. (29) on p. 505, the denominator of the first fraction should be multiplied by k, as follows:

$$\frac{A_2^{\mathrm{sd}}}{kA_3} = \frac{3L}{4c}\frac{1+4\epsilon+4\epsilon^2}{1+6\epsilon+12\epsilon^2+8\epsilon^3} = \frac{3L}{4c}\frac{1}{1+2\epsilon} = \frac{3L}{4h}$$

Finally, in the Krajcinovic (1971) reference, the publication year should have read 1972. Citations to this reference appear on pp. 502, 503, 504, 505, and 507 of the published article. The corrected reference appears in this erratum.

References

Krajcinovic, D. (1972). “Sandwich beam analysis.” *J. Appl. Mech.*, 39(3), 773–778.

J. Eng. Mech., 2012, 138(10): 1302-1302

Details

Journal of Structural Engineering
Volume 125, Issue 11
Nov 1999
Pages 1211-1354

ARTICLE
Errata
View article page
CITE
https://doi.org/10.1061/(ASCE)0733-9445(1999)125:11(1354)

Publisher American Society of Civil Engineers
ISSN 0733-9445
eISSN 1943-541X
Print November 1999
Pages 1354 - 1354

ERRATA

In the article **Seismic Reliability of Special Moment Steel Frames with Welded Connections: II** by Jianlin Song and Bruce R. Ellingwood, which appeared in April 1999, Vol. 125(4), 372–384, the following correction should be made.

On page 383, errors appeared in Table 7, Column 1. The correct table is shown here.

TABLE 7. Annual Probability of Failure of Building C

Deformation limit states (1)	Simulated Ground Motion $k = 2.0$ (2)	$k = 2.38$ (3)	$k = 3.5$ (4)	Records—$k = 2.38$ (5)	Eq. (10)—$k = 2.38$ (6)
		(a) ISDA			
0.5%	1.10×10^{-1}	2.29×10^{-1}	8.45×10^{-1}	2.99×10^{-1}	2.67×10^{-1}
1%	2.83×10^{-2}	4.89×10^{-2}	2.03×10^{-1}	8.09×10^{-2}	5.05×10^{-2}
2%	5.54×10^{-3}	7.11×10^{-3}	1.37×10^{-2}	1.17×10^{-2}	7.14×10^{-3}
Bil→	4.87×10^{-3}	6.11×10^{-3}	1.11×10^{-2}	8.51×10^{-3}	6.12×10^{-3}
5%	7.37×10^{-4}	6.49×10^{-4}	4.21×10^{-4}	1.09×10^{-3}	6.49×10^{-4}
Bil→	5.71×10^{-4}	4.80×10^{-4}	2.71×10^{-4}	8.31×10^{-4}	4.80×10^{-4}
		(b) RDA			
0.5%	—	1.17×10^{-1}	—	9.93×10^{-2}	—
1%	—	1.17×10^{-2}	—	1.65×10^{-2}	—
2%	—	2.81×10^{-3}	—	1.68×10^{-3}	—
Bil→	—	2.17×10^{-3}	—	9.48×10^{-4}	—
5%	—	3.38×10^{-4}	—	4.98×10^{-4}	—
Bil→	—	1.90×10^{-4}	—	2.53×10^{-4}	—