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Preface

Antoni, Ima Muljati, Djwantoro Hardjito

Pages 1-4

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Reini Wirahadikusumah, Betty Susanti, Vaughan Coffey, Charles Adighibe

Pages 5-11

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Sensitivity Analysis of Risk from Stakeholders' Perception Case Study: Semarang-solo Highway Project Section I (Tembalang-Gedawang)

Asri Nurdiana, M. Agung Wibowo, Jati Utomo D. Hatmoko

Pages 12-17

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Returns to Scale in Buildings Construction Costs: Indonesian Cases

Andreas Wibowo

Pages 18-24

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The Analysis of Supply Chain Performance Measurement at Construction Project

M. Agung Wibowo, Moh Nur Sholeh

Pages 25-31

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The Practice of Time Management on Construction Project

Lok Siew Chin, Abdul Rahim Abdul Hamid

Pages 32-39

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Analysis of Factors Affecting Design Changes in Construction Project with Partial Least Square (PLS)

A.A. Gde Agung Yana, Rusdhi H.A., M. Agung Wibowo

Pages 40-45

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Identification and Analyze of Influence Level on Waste Construction Management of Performance
Elizar, M. Agung Wibowo, Pinardi Koestalam
Pages 46-52

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Structural Equation Model for Investigating Risk Factors Affecting Project Success in Surabaya
Herry Pintardi Chandra
Pages 53-59

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Proactiveness of Contractors: A study of Indonesia
Harijanto Setiawan, Bilge Erdogan, Stephen O. Ogunlana
Pages 60-67

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Harijanto Setiawan, Bilge Erdogan, Stephen O. Ogunlana
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Farida Rachmawati, Ria A.A. Soemitro, Tri Joko W. Adi, Connie Susilawati
Pages 75-82

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Bambang Endroyo, Bambang E. Yuwono, Djemari Mardapi, Soenarto

Pages 83-88

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Knowledge Management Maturity in Construction Companies

Mochamad Agung Wibowo, Rudi Waluyo

Pages 89-94

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An Analysis of Bidding Strategy, Project Performance and Company Performance Relationship in Construction

Mohamad Agung Wibowo, I. Nyoman Yudha Astana, Rusdi H.A.

Pages 95-102

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Initial Investigation for Potential Motivators to Achieve Sustainable Construction Safety and Health

Herry Pintardi Chandra

Pages 103-108

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Riza Yosia Sunindijo

Pages 109-116

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Risk Analysis of BOT Scheme on Post-construction Toll Road

Yudi Harto Suseno, Muhammad Agung Wibowo, Bagus Hario Setiadji

Pages 117-123

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Best Practice for Financial Models of PPP Projects

Fredy Kurniawan, Sri Wiwoho Mudjanarko, Stephen Ogunlana

Pages 124-132

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Abu Naser Chowdhury, Po-Han Chen, Robert Tiong

Pages 133-142

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Md. Asrul Nasid Masrom, Mohd Hilmi Izwan Abd Rahim, Sulzakimin Mohamed, Goh Kai Chen, Riduan Yunus

Pages 143-149

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Setiono, Rintis Hadiani

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Yeri Sutopo, Budi S. Wignyosukarto, Bambang Yulistyanto, Istiarto
Pages 158-165

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The Application of Rainfall-Runoff-inundation (RRI) Model for Inundation Case in Upper Citarum Watershed, West Java-Indonesia
Kania Dewi Nastiti, Yeonsu Kim, Kwansue Jung, Hyunuk An
Pages 166-172

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Effects of Compost Thickness and Compaction on Methane Emissions in Simulated Landfills
Gabriel Andari Kristanto, Sesaria Marina Raissa, Evi Novita
Pages 173-178

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Rainfall Erosivity Estimation for Northern and Southern Peninsular Malaysia using Fourneir Indexes
Zul Azmi Mohtar, Ahmad Shukri Yahaya, Fauziah Ahmad
Pages 179-184

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Impact of Climate Change on Streamflow in the Tropical Lowland of Kapuas River, West Borneo, Indonesia
Henny Herawati, Suripin, Suharyanto
Pages 185-192

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Royal Commission at Yanbu Environmental Regulations
Ayedh Al Shehai
Pages 193-198

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Water Turbidity Impact on Discharge Decrease of Groundwater Recharge in Recharge Reservoir
Akhmad Azis, Hamzah Yusuf, Zulfiyah Faisal, Muhammad Suradi
Pages 199-206

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Mathematical Modelling of Injection Wells for Flooding Prevention in Jakarta
Mohajit
Pages 207-212

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Application of Large Scale Particle Image Velocimetry (LSPIV) to Identify Flow Pattern in a Channel
Tommy Ekamitra Sutarto
Pages 213-219

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Silvia G. Tonyes, Robert J. Wasson, Niels C. Munksgaard, Ken G. Evans, ... David K. Williams
Pages 220-228

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Hary Pradiko, Arwin, Prayatni Soewondo, Yadi Suryadi
Pages 229-235

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Tatas, Agung Budipriyanto, Mohamad Khoiri, Wien Lestari, Askur Rahman
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Sri Maryati, An Nisaa' Siti Humaira
Pages 243-249

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Maimun Rizalihadi, Dian Safiana
Pages 250-256

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Eldina Fatimah, Zouhrawaty, A. Ariff, Teuku Budi Aulia
Pages 257-262

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Pages 263-269

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Raden Djoko Goenawan, Ridwan Ridwan, Muhammad Sadly, Teddy Sudinda, ... Budi Harsoyo
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Muhammad Islamy Rusyda
Pages 277-283

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Eko Pradjoko, Imam Bachtiar, Nanang Matalatta, Gatot Sugihartono
Pages 284-290

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Vera Surtia Bachtiar, Slamet Raharjo, Yenni Ruslinda, Fitra Hayati, Desi Ratna Komala
Pages 291-297

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Wiwiek Setyawati, Enri Damanhuri, Puji Lestari, Kania Dewi
Pages 298-303

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Heri Kuswanto, Shofi Andari, Erma Oktania Permatasari
Pages 304-310

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John T. Hatmoko, Hendra Suryadharma
Pages 311-316

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Halil Ceylan, Sungwan Kim, Ali Ulvi Uzer, Bo Yang
Pages 317-323

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Luky Handoko, Ahmad Rifa'i, Noriyuki Yasufuku, Ryohei Ishikura
Pages 324-330

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Yulindasari Sutejo, Nurly Gofar
Pages 331-337

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Anissa Maria Hidayati, Sri Prabandiyani RW, I. Wayan Redana

Pages 338-344

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Adnan Zainorabidin, Mohd Jazlan Mad Said

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Didiek Djarwadi, Kabul B. Suryolelono, Bambang Suhendro, Hary C. Hardiyatmo

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Paravita Sri Wulandari, Daniel Tjandra

Pages 358-362

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Paravita Sri Wulandari, Daniel Tjandra

Pages 363-367

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Holger Pankrath, Marco Barthel, Alexander Knut, Matteo Bracciale, Ralf Thiele

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Matteo Lelli, Riccardo Laneri, Pietro Rimoldi

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Gogot Setyo Budi, Melisa Kosasi, Dewi Hindra Wijaya

Pages 406-410

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Machsus Machsus, Rachmad Basuki, Amalia Firdaus Mawardi

Pages 411-416

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Predicting the Remaining Service Life of Road Using Pavement Condition Index

Ary Setyawan, Jolis Nainggolan, Arif Budiarto

Pages 417-423

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The Effect of Pavement Condition on Vehicle Speeds and Motor Vehicles Emissions

Ary Setyawan, Irvan Kusdiantoro, Syafi'i

Pages 424-430

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Masaru Minagawa, Shunji Kusayanagi

Pages 431-437

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Joni Arliansyah, Adi Taruna, Rhaptyalyani, Astri Yuli Kurnia

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Joni Arliansyah, Yusuf Hartono

Pages 445-451

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Muhammad Karami, Hamid Nikraz

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Rhaptyalyani H. Della, Hanafiah, Joni Arliansyah, Riga Artiansyah

Pages 461-466

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Putu Alit Suthanaya

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I. Made Agus Ariawan, Bambang Sugeng Subagio, Bagus Hario Setiadji

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Ferry Hermawan, Tutik Rachmawati, Herry Ludiro Wahyono

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Ridwan Anas, Ofyar Z. Tamin, Sony S. Wibowo

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Pages 571-578

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Pradip Nath, Prabir Kumar Sarker, Vijaya B. Rangan
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Saloma, Amrinsyah Nasution, Iswandi Imran, Mikrajuddin Abdullah
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Gerard H.P. Hol
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Md. Aminul Islam
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Agus Maryoto
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Ali Ulvi Uzer
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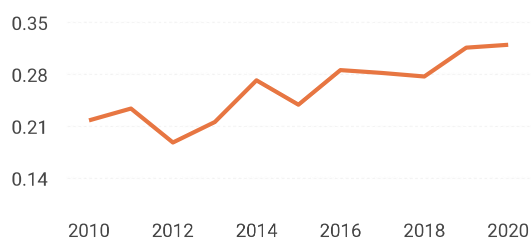

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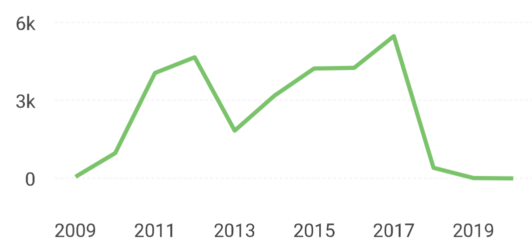

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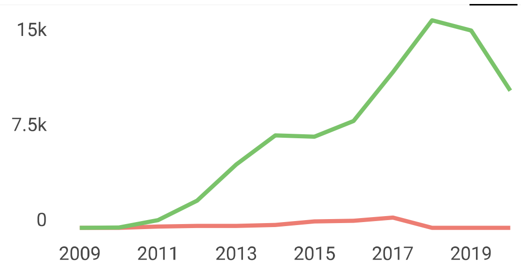

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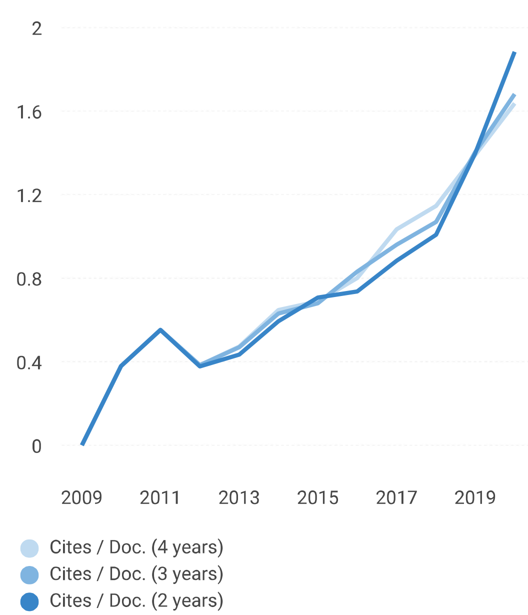

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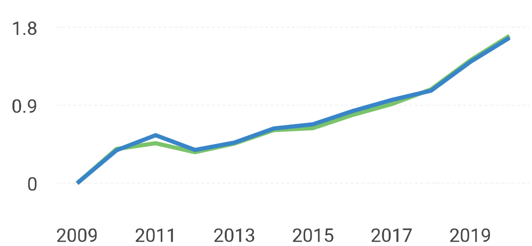

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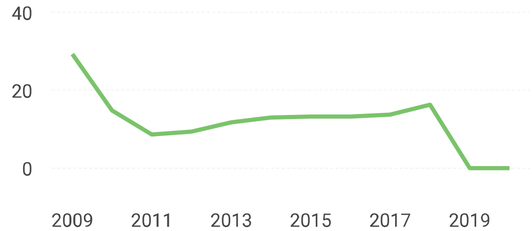

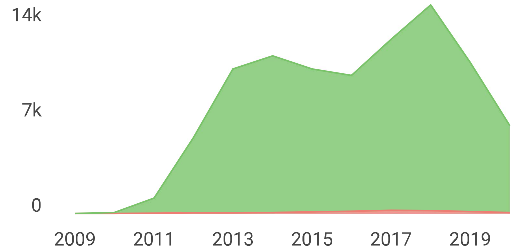

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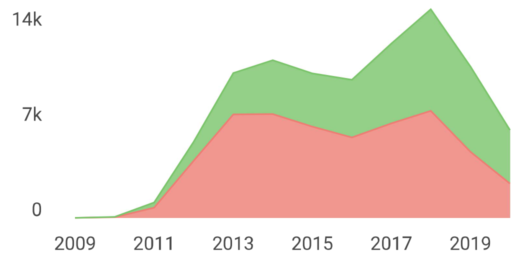

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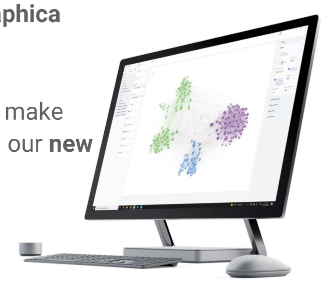

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Why does Procedia manufacturing have a quartile, but Procedia Engineering does not?
Best regards.

reply

SCImago Team

Melanie Ortiz 1 year ago

Dear Sergey,
As said previsouly, the quartile is only assigned to Journal type's publications. Best regards, SCImago Team

S

Sergey 1 year ago

Good afternoon!
Please tell me how the Procedia engineering journal was not assigned a quartile, and the Materials Science Forum was assigned Q3, although both editions publish exclusively conference proceedings? According to CITESCORE, the citation of Procedia enginering and its percentile is significantly higher.
Best regards, Sergey

reply

SCImago Team

Melanie Ortiz 1 year ago

Dear Sergey,
Thank you for contacting us. We calculate the SJR data for all the publication types, but the Quartile data are only calculated for Journal type's publications. Best regards, SCImago Team

A

Ahmad 2 years ago

Is procedia engineering can be counted as peer reviewed journal

reply

F fatima 3 years ago

Please what the price of Publishing?

reply

SCImago Team

Elena Corera 3 years ago

Dear Fatima,

thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you check author's instructions in journal website. You can find that information in SJR website https://www.scimagojr.com

Best Regards,
SCImago Team

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The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5)

Design capacity tables for structural steel based on SNI 03-1729-2002: built-up sections

Effendy Tanojo[a,*], Pamuda Pudjisuryadi[a], Billy Prawira Candra[a], Welly William[a]

[a]*Petra Christian University, Jl. Siwalankerto 121-131, Surabaya 60236, Indonesia*

Abstract

Structural steel is commonly used as construction material. In designing structural steel, practitioners typically use the steel section properties table to obtain the necessary data needed to calculate the nominal strength of the selected section. The commercially available section properties tables in Indonesia typically list the weight, section area, inertia, radius of gyration, and section modulus of the commercially available steel sections. In many cases, it is not uncommon for built-up sections to be used as structural members. The section properties of these built-up sections are not readily available in the aforementioned section properties table. A series of tables have been developed to enlist the section properties of the built-up sections that are commonly used in Indonesia. Moreover, these tables also provide the nominal strength of the built-up sections with respect to several loads, i.e. tension, compression, bending, and shear. These nominal capacities will enable the practitioners to design built-up structural steel sections more easily and efficiently.

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Keywords: structural steel; section properties; design table

1. Introduction

Steel is one of the most widely used construction materials in Indonesia. Bridges, warehouses, factories, airport terminals, office buildings, and apartments typically use structural steel. In Indonesia, steel are widely used since the 1970s. To ensure the safety of buildings constructed using structural steel, design codes have been issued by the regulators. Designing structural steel sections according to the design code requires the section properties data to

* Corresponding author. *E-mail address:* effendy@petra.ac.id

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calculate the section nominal strength with respect to the working load. Tables enlisting the section properties of commercially available structural steel sections are frequently used to help the designer obtain the required section properties such as weight, area, inertia, and radius of gyration. However, these tables do not list the section properties of the built-up sections, which are also commonly used in construction practices. The design code of structural steel in Indonesia, SNI 03-1729-2002[1], uses the Load and Resistance Factor Design (LRFD) concept. In LRFD, the factored load is compared with the nominal strength of the selected steel section. These nominal capacities can be calculated for each of the steel sections with respect to the load. In this paper, tables enlisting the section properties of built-up sections will be presented. Moreover, these tables will show the nominal strength of the built-up steel sections with respect to tension, compression, bending, and shear loads.

2. Scope of study

A literature study has been done to gather the required data for developing the design capacity tables. Data required are various design codes (especially the SNI 03-1729-2002[1]) and the list of the commercially available structural steel sections. A small research has also been done to find out which configurations of the built-up sections are most commonly used in construction practices. Double channels and double angles are among the most commonly used built-up steel sections in constructions practices in Indonesia. Design tables for single channel and single angle section will also be presented, to make it easier for designers to compare the cost/benefit of built-up sections (double channel and double angle sections) and single sections. All calculations for obtaining the nominal capacities presented were carried out using Microsoft Excel spreadsheets, based on the SNI 03-1729-2002[1] design code. Nominal capacities with respect to tension, compression, bending, and shear are calculated and presented. Figure 1 below gives the description of the geometry of the sections.

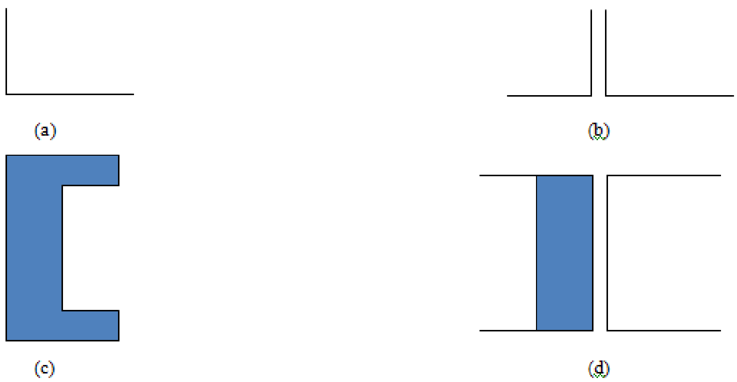

Fig. 1. (a) single angle; (b) double angle; (c) single channel; (d) double channel

3. Assumptions and analysis

All calculations and requirements used in developing these tables are based on the SNI 03-1729-2002[1] design code. All steel used are BJ37 structural steel, the most widely available in Indonesia. The weight of the sections are shown for all the sections in all the tables, to enable the practitioners to select the most economical sections among the members with adequate nominal strength. For obvious reason, the page limitation, the complete tables are not shown here. Instead, the examples of the design tables will be shown.

3.1 Nominal strength in tension

In the design tables for tension members, there are two nominal strength presented for each section. The first one, nominal yield strength, gives the nominal strength at the yielding of the gross section. While nominal fracture strength gives the nominal strength when the stress of the net section reaches the ultimate stress (f_u).
The nominal yield strength, N_n, for tension members is calculated using Equation 1,

$$N_n = A_g \times f_y \tag{1}$$

where A_g = gross section area

f_y = yield stress

while Equation 2 are used to calculate the nominal fracture strength.

$$N_n = A_e \times f_u \tag{2}$$

where $A_e = U \times A_n$ = effective section area (3)

U = reduction factor

A_n = net section area

f_u = ultimate stress

These following assumptions are made when calculating the nominal strength shown on the tables :

- A_n = 85% A_g (Using the maximum allowable hole area)
- U = 1 (other U values can be incorporated into the design by multiplying the shown nominal strength with the desired U value)

Tables 1 to 4 show examples of design tables for tension members. The nominal strength with respect to tension loads are shown on the tables for the sections.

Table 1. Nominal Strength in Tension (Single Channel)

	Weight	ϕ N_n	
		Yield	Fracture
	kg/m	(kN)	(kN)
U 30 x 33 x 5 x 7	4.36	119.84	130.87
U 40 x 35 x 5 x 7	4.97	136.69	149.27
U 50 x 38 x 5 x 7	5.69	156.56	170.97

Table 2 Nominal Strength in Tension (Single Angle)

	Weight	ϕ N_n	
		Yield	Fracture
	kg/m Yield	(kN)	(kN)
L 15 x 15 x 3	0.45	12.29	13.42
L 15 x 15 x 4	0.82	22.66	24.75
L 20 x 20 x 3	0.87	23.98	26.18

Table 3. Nominal Strength in Tension (Double Channel)

	Weight	ϕ N_n	
		Yield	Fracture
	kg/m	(kN)	(kN)
U 30 x 33 x 5 x 7	8.71	239.68	261.74
U 40 x 35 x 5 x 7	9.94	273.38	298.54
U 50 x 38 x 5 x 7	11.38	313.12	341.94

Table 4. Nominal Strength in Tension (Double Angle)

	Weight	ϕ N_n	
		Yield	Fracture
	kg/m	(kN)	(kN)
L 15 x 15 x 3	0.89	24.59	26.85
L 15 x 15 x 4	1.65	45.32	49.49
L 20 x 20 x 3	1.74	47.95	52.36

3.2 Nominal Strength in Compression

Nominal strength in compression members is heavily dependent on its effective length (L_k). The longer the effective length of the member, the more susceptible it is to buckling failure. Thus, the nominal strength for compression members are presented based on their effective length. Effective length (L_k) shown is in 1 meter (m) increment, up to 12 m (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 m).
The calculation of the nominal strength for compression members, and their dependency to the member's effective length are shown in Equations 2 to 10.

$$N_n = A_g \times f_{cr} \tag{4}$$

where $f_{cr} = \dfrac{f_y}{\omega}$ (5)

for $\lambda_c \leq 0.25$, $\omega = 1$ (6)

for $0.25 < \lambda_c < 1.2$, $\omega = \dfrac{1.43}{1.6 - 0.67\lambda_c}$ (7)

for $\lambda_c \geq 1.2$, $\omega = 1.25\lambda_c^2$ (8)

where $\lambda_c = \dfrac{L_k}{\pi r}\sqrt{\dfrac{f_y}{E}}$ (9)

These following assumptions are made when calculating the nominal strength shown on the tables :

- For double channels and double angles, the distance between the two sections is assumed to be the same value as the thickness of the single sections.
- For double channels and double angles, the recommended maximum allowable spacing of the couple plates ($L_{1\ max}$) are shown.
- Empty value cells in the nominal strength means that the section is not recommended to be used because one or more design requirements are not met.

Tables 5 to 8 show examples of design tables for compression members. The nominal strength with respect to compression loads are shown on the tables for the sections.

Table 5. Nominal Strength in Compression (Single Channel).

	ϕN_n		
	L_k = 1 m	L_k = 2 m	L_k = 3 m
	(kN)	(kN)	(kN)
U 30 x 33 x 5 x 7	68.25	-	-
U 40 x 35 x 5 x 7	81.19	23.61	-
U 50 x 38 x 5 x 7	98.98	32.13	-

Table 6. Nominal Strength in Compression (Single Angle).

	ϕN_n		
	L_k = 1 m	L_k = 2 m	L_k = 3 m
	(kN)	(kN)	(kN)
L 30 x 30 x 3	8.32	-	-
L 30 x 30 x 4	10.71	-	-
L 30 x 30 x 5	12.83	-	-

Table 7. Nominal Strength in Compression (Double Channel).

	Weight kg/m	ϕN_n			
		L_k = 1 m		L_k = 2 m	
		(kN)	L_1 max (mm)	(kN)	L_1 max (mm)
U 30 x 33 x 5 x 7	8.71	147.01	488.69	45.10	488.69
U 40 x 35 x 5 x 7	9.94	194.00	514.48	99.36	514.48
U 50 x 38 x 5 x 7	11.38	231.06	489.79	159.59	560.86

Table 8. Nominal Strength in Compression (Double Angle).

	Weight kg/m	ϕN_n			
		L_k = 1 m		L_k = 2 m	
		(kN)	L_1 max (mm)	(kN)	L_1 max (mm)
L 30 x 30 x 5	4.36	60.89	440.98	-	-
L 35 x 35 x 4	4.19	69.67	526.76	20.86	526.76
L 35 x 35 x 6	6.07	99.65	517.36	29.17	517.36

3.3 Nominal Strength in Bending (Local Buckling)

The design tables for flexural members in bending present the nominal strength in both x and y axis of the sections. The nominal strength values shown are the most critical ones, obtained from local flange buckling and local web buckling limit states. According to local flange buckling and local web buckling limit states, there are three categories of sections: compact, non-compact, and slender. Compact sections are the least susceptible ones to local buckling failure, while slender sections are the most susceptible ones. Different range of slenderness ratio (λ)

values separates each categories. Equations 10 to 12 shows how to obtain the nominal strength values in local buckling for compact, non-compact, and slender sections.

$$\text{for } \lambda \le \lambda_p \qquad , M_n = M_p = Z \times f_y \quad \text{(compact)} \tag{10}$$

$$\text{for } \lambda_p < \lambda \le \lambda_r \quad , M_n = M_r + (M_p - M_r)\frac{(\lambda_r - \lambda)}{(\lambda_r - \lambda_p)} \quad \text{(non-compact)} \tag{11}$$

$$\text{for } \lambda > \lambda_r \qquad , M_n = M_r \left(\frac{\lambda_r}{\lambda}\right)^2 \quad \text{(slender)} \tag{12}$$

where $M_r = S(f_y - f_r)$
Z = plastic section modulus
S = elastic section modulus
f_r = residual stress

Tables 9 to 12 show examples of design tables for local buckling limit state. The nominal strength are shown on the tables for the sections.

Table 9. Nominal Strength in Local Buckling (Single Channel).

	Weight	ϕ Mn	
		ϕ Mn_x	ϕ M_{ny}
	(kg/m)	(kNm)	(kNm)
U 30 x 33 x 5 x 7	4.36	1.22	1.04
U 40 x 35 x 5 x 7	4.97	1.93	1.29
U 50 x 38 x 5 x 7	5.69	2.82	1.66

Table 10. Nominal Strength in Local Buckling (Single Angle).

	Weight	ϕ Mn
		ϕ M_{nx} = ϕ M_{ny}
	(kg/m)	(kNm)
L 15 x 15 x 3	0.45	0.04
L 15 x 15 x 4	0.82	0.08
L 20 x 20 x 3	0.87	0.11

Table 11. Nominal Strength in Local Buckling (Double Channel).

	Weight	ϕ Mn	
		ϕ M_{nx}	ϕ M_{ny}
	(kg/m)	(kNm)	(kNm)
U 30 x 33 x 5 x 7	8.71	2.43	3.74
U 40 x 35 x 5 x 7	9.94	3.86	4.32
U 50 x 38 x 5 x 7	11.38	5.64	5.07

Table 12. Nominal Strength in Local Buckling (Double Angle).

	Weight	ϕ Mn	
		ϕ M_{nx}	ϕ M_{ny}
	(kg/m)	(kNm)	(kNm)
L 15 x 15 x 3	0.89	0.09	0.14
L 15 x 15 x 4	1.65	0.15	0.32
L 20 x 20 x 3	1.74	0.23	0.36

3.4 Nominal Strength in Bending (Lateral Torsional Buckling)

For flexural members in bending without continuous lateral support, the lateral torsional buckling limit state applies. The nominal strength due to lateral torsional buckling limit state is heavily dependent on the distance between lateral supports. The longer the distance between lateral supports the more susceptible the flexural members to lateral torsional buckling. Thus, the design tables for flexural members without continuous lateral support are presented based on the distance between their lateral supports. Distance between lateral supports (L) are shown in 1 meter (m) increment, up to 12 m (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 m). Based on its L value, members are categorized into three categories: short span, medium span, and long span. Members with short span are the least susceptible ones to lateral torsional buckling, while members with long span are the most susceptible ones. Equations 13 to 15 shows how to obtain the nominal strength values in lateral torsional buckling for members with short, medium, and long span.

$$\text{for } L \le L_p \qquad , M_n = M_p = Z \times f_y \quad \text{(short span)} \tag{13}$$

$$\text{for } L_p < L \le L_r \quad , M_n = C_b\left[M_r + (M_p - M_r)\frac{(L_r - L)}{(L_r - L_p)}\right] \quad \text{(medium span)} \tag{14}$$

for $L > L_r$ $\quad , M_n = C_b \dfrac{\pi}{L}\sqrt{EI_y GJ + \left(\dfrac{\pi E}{L}\right)^2 I_y I_w}$ (long span) (15)

where $C_b = \dfrac{12M_{\max}}{2{,}5M_{\max} + 3M_A + 4M_B + 3M_C}$ (16)

G = shear modulus

J = twist constant

$I_w = \dfrac{I_y h^2}{4}$

Tables 13 to 16 show examples of design tables for lateral torsional buckling limit state. The nominal strength are shown on the tables for the sections.

Table 13. Nominal Strength in Lateral Torsional Buckling. (Single Channel)

	ϕ M_n	
	L = 1 m	L = 2 m
	(kNm)	(kNm)
U 30 x 33 x 5 x 7	1.19	1.14
U 40 x 35 x 5 x 7	1.88	1.77
U 50 x 38 x 5 x 7	2.74	2.55

Table 14. Nominal Strength in Lateral Torsional Buckling (Single Angle).

	ϕ M_n	
	L = 1 m	L = 2 m
	(kNm)	(kNm)
L 15 x 15 x 3	0.09	0.05
L 15 x 15 x 4	0.19	0.16
L 20 x 20 x 3	0.27	0.20

Table 15. Nominal Strength in Lateral Torsional Buckling (Double Channel).

	ϕ M_n	
	L = 1 m	L = 2 m
	(kNm)	(kNm)
U 30 x 33 x 5 x 7	3.64	3.43
U 40 x 35 x 5 x 7	4.28	4.10
U 50 x 38 x 5 x 7	5.07	4.90

Table 16. Nominal Strength in Lateral Torsional Buckling (Double Angle).

	ϕ M_n	
	L = 1 m	L = 2 m
	(kNm)	(kNm)
L 15 x 15 x 3	0.13	0.10
L 15 x 15 x 4	0.30	0.26
L 20 x 20 x 3	0.33	0.29

3.5 Nominal Strength in Shear

In steel sections under shear, the web will completely yield long before the flanges begin to yield. Thus, yielding of the web is the most important shear limit states. The shear yield stress is typically taken as 60% of the tensile yield stress, thus:

$$f_v = \frac{V_n}{A_w} = 0.6 f_y \tag{17}$$

$$V_n = 0.6 f_y A_w \tag{18}$$

The Equation 18 above is the nominal strength in shear provided that there is no shear buckling of the web. Shear buckling of the web depends on its h/t_w ratio. If the ratio is too large, the web will buckle elastically or inelastically in shear.

Tables 17 to 20 show examples of design tables for flexural members in shear. The nominal strength with respect to shear loads are shown on the tables for the sections.

Table 17. Nominal Strength in Shear (Single Channel).

	Weight (kg/m)	ϕ V_n (kN)
U 30 x 33 x 5 x 7	4.36	19.44
U 40 x 35 x 5 x 7	4.97	25.92
U 50 x 38 x 5 x 7	5.69	32.40

Table 18. Nominal Strength in Shear (Single Angle).

	Weight (kg/m)	ϕ V_n (kN)
L 15 x 15 x 3	0.45	3.89
L 15 x 15 x 4	0.82	7.78
L 20 x 20 x 3	0.87	7.78

Table 19. Nominal Strength in Shear (Double Channel).

	Weight (kg/m)	ϕ V_n (kN)
U 30 x 33 x 5 x 7	8.71	38.88
U 40 x 35 x 5 x 7	9.94	51.84
U 50 x 38 x 5 x 7	11.38	64.80

Table 20. Nominal Strength in Shear (Double Angle).

	Weight (kg/m)	ϕ V_n (kN)
L 15 x 15 x 3	0.89	7.78
L 15 x 15 x 4	1.65	15.55
L 20 x 20 x 3	1.74	15.55

4. Concluding remarks

Examples of the developed design capacity tables for built-up sections have been presented. The selected built-up sections are double channels, double angles, and castellated beam sections. Nominal capacities, based on SNI 03-1729-2002[1], for these sections are presented, with respect to tension, compression, bending, and shear loads.

Design capacity tables for single channels and single angles sections are also presented as they are required to make it easier for the designer to weigh the cost/benefit of using built-up sections (double channels and double angles sections) compared to single sections. The tables also provide additional information as compared to the commercially available section properties table because they not only showing the section properties values, but also shows the nominal strength values of the sections with respect to tension, compression, bending, and shear loads.

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