Prediction of moment resistance of steel connection with Macro Excel using Eurocode standard

by Anis Saggaf

Journal of Physics: Conference Series

Prediction of moment resistance of steel connection with Macro Excel using Eurocode standard

Prediction of moment resistance of steel connection with Macro Excel using Eurocode standard

M Firdaus[1], A Saggaff[2*], M Md Tahir[3], S P Ngian[4] and A Sulaiman[4]

[1]Civil Engineering Department, Faculty of Engineering, Universitas PGRI Palembang, 30116, Indonesia
[2]Civil Engineering Department, Faculty of Engineering, Universitas Sriwijaya, Inderalaya, 30862, Indonesia
[3]UTM Construction Research Centre, Professor, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor Bahru, Malaysia
[4]UTM Construction Research Centre, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor Bahru, Malaysia

*anissaggaf@yahoo.com

Abstract. To date, the use of information technology has become part of the human lifestyle. The existence of the demands of fast, precise and accurate design is a common standard that must be met which has significant advantage to compete with practitioners who are working with conventional method. In civil engineering, the use of information technology cannot be avoided, whether you like or not engineers must be able to adapt. This is a logical consequence because the analysis involves considerable calculations, iterative, or trial and error. The solution is to create a program application using Fortran, Pascal, or C ++ which sometimes frustrates engineers who are accustomed to manual methods. This paper presents one solution that bridges the existence of a 'gap' to information technology in the form of short programs as a mediator between conventional and automatic calculations. Eurocode standard was used for design steel connection because this code already established and using metric units that commonly used in Indonesia. The parametric analysis was conducted by means of Excel combine with Visual Basic Application (VBA), the calculation performed iteratively for different dimensions and summarized in the form of a table.

1. Introduction

Microsoft Excel is one of the products of Microsoft Corporation based on operating data using a grid of cells arranged in numbered rows and letter-named columns. Excel not only can be implemented for numerical operation data but can also be operated for data text, logical, database and Lookup & References. The final data presentation can also be presented in the form of diagrams or graphs. Therefore, it is not surprising that Excel is very popular and widely used in many applications, academics, researchers, and professionals. Excel was originally developed in 1985 and always increases in terms of performance and supporting features. The built-in Visual Basic Application (VBA) was included in a Microsoft package in Excel 5.0 in 1993. This feature is a development of the Visual Basic programming language, the end-users can create his own commands or add some special functions (User define functions) that can be combined with Excel. As with other program languages, this feature enables iterative operations and can solve the complicated calculation. This is a unique combination

between a spreadsheet and VBA [1]. Almost everyone uses Excel and automatically has a built-in VBA and hence no purchase of expensive software is needed. This is one of the benefits for the end user. Worksheet applications are widely used not only for academic purposes, but also used in the offices, research, consultants, and contractors. Many studies have been conducted to show spreadsheets applications in the civil engineering field, among others, used to solve numerical problems, to facilitate data entry, efficiency in the analysis, as a user interface and presentation of analysis in the form of diagrams [2-10]. Cost optimization of composite connections using Excel VBA was developed by Fernando et. al [11]. The purpose of the study is to propose an efficient design solution in terms of the time required for the design of composite and steel semi-rigid endplate joints, at the same time cost savings by considering the moment resistance and initial stiffness of the connection.

Excel has existed for approximately 33 years. For old Excel users, most feel more comfortable and quite satisfied by applying classic features without involving advance tools like VBA, macros oradd-ins. Excel VBA offers better performance, however, it still requires basic programming skills and knowledge, among others variable definition, **if** or **else** statements or other commands that might be considered complicated because of age reasons or no programming talent.

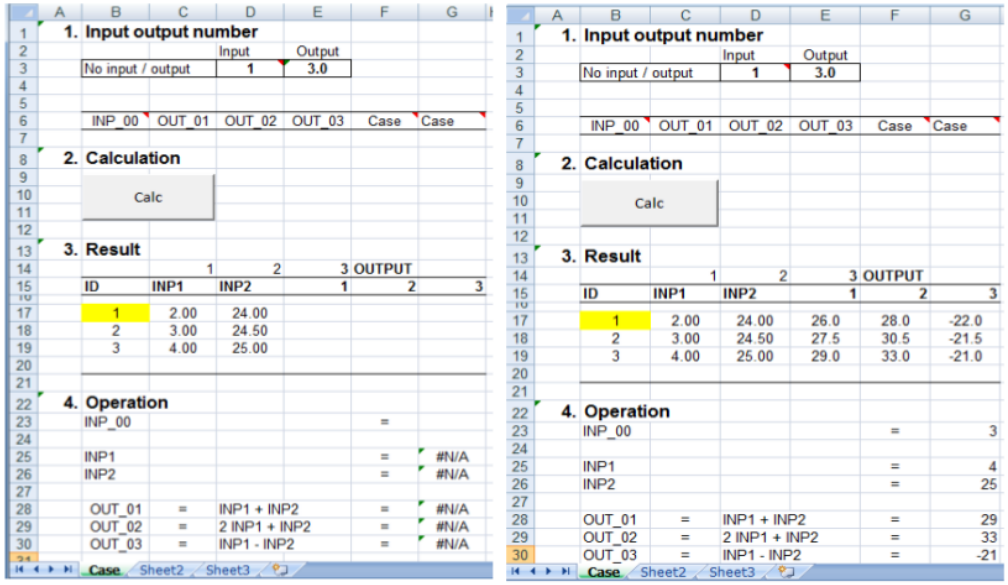
This paper presents the combination of VBA and Excel to predict the moment resistance of connection with gusset plate connected to beam-to-column connection of cold-formed steel section. A short program was created where the end-user is no longer needs to mess around with the program codes that must be made. This method can also be used by anyone while being able to use Microsoft Excel. In this paper, the use of this program for steel connection design with Eurocode Standard was introduced.

2. Method and procedure

The basic concept of this programming is very simple. Select the single cell containing the formula and paste special value at the cell location that has been defined by using the name manager command. This program is able to calculate by involving more than 1 sheet. For convenience, a very simple example was used to illustrate this procedure. In Figure 1(a), simple mathematical operations are used to obtain OUT_01, OUT_02, and OUT_03 which are the functions of INP1 and INP2. Cell G28: G30 contains the formula that's typed in the usual way. The INP1 and INP2 are the input data typed on the same line as ID data (Cell B17: B19). After the Calc button is pressed, Excel will automatically calculate as shown Figure 1(b), for the 3rd data the input is INP1 = 4, INP2 = 25, and the results are OUT_01 = 29, OUT_02 = 33, and OUT_03 = -21. Those values are then automatically copied and paste special value to Cell E19:G19. Before executing the application, the sheet template must be prepared as shown in Figure 1(a). The steps are as follows:

- Select cell D3 and define a cell name with NO_INPUT.
- Repeat step 1 for E3(dmyCol), B6:G6(INP_A), B17(CELL_01), G23(INP_00), G28(OUT_01), G29 (OUT_02), and G30 (OUT_03).
- Select cell NO_INPUT and fill with 1 because range B17: B19 has only one column.
- Select cell dmyCol and then type 3 which means the output will start to be placed in the third column, cell E17.
- Select range INP_A and type INP_00, OUT_1, OUT_2, OUT_3.
- Select cell F6 and type "Case" (sheet input name) and also cell G6 with "Case" (sheet output name), means the output will be printed on the same sheet.
- Select CELL_01 and fill with a value of 1 indicating the first data.
- Furthermore, select cell B18 and B19 and fill with 2 and 3 as the second and third data.
- Fill range 17:C19 with the first input data, e.g. 2.3, and 4.
- Fill range D17:D19 with the second input data, e.g. 24, 24.5 and 2.5.
- Range E17: G19 are left blank, and will be filled in by the program.
- Select G25 and type formula = VLOOKUP (INP_00, B17: G19, 2, FALSE).
- Repeat step 12 for G26 = VLOOKUP (INP_00, B17: G19, 3, FALSE).
- Repeat step 12 for OUT_01 = G25 + G26.

- Repeat step 12 for OUT_02 = 2*G25 + G26.
- Repeat step 12 for OUT_03 = G25-G26.



(a) (b)

Figure 1. Calculation example (a) Before calculated (b) After calculated.

From the above procedure, it can be seen that steps 12 to 16 are definitely familiar for spreadsheet users. Furthermore, VBA code must be created as presented in Figure 2 and Figure 3.
The program is executed by just clicking one button. Initial identification of data and command will be processed in line with the steps outlined below:

- Row 1-14, defines the variable NI = "NO_INPUT", INP_01 = "INP_A", myCell_00 = "CELL_01".
- Row 17-18, select and read cell name NI, the result is NI = 1.
- Row 21, select and read cell name dmyCol = 3.
- Row 22, calculate DeltamyCol = 3 - 1 = 2.
- Row 25, select the INP_01 range.
- Row 26, read and store in array myArray1 = [INP_00, OUT_01, OUT_02, OUT_03, Case, Case], array dimension is 1x6.
- Row 29, compute y = Number of columns myArray1 - 1 = 6 - 1 = 5.
- Row 30, select and read myArray (1,5) = "Case" and store in SHEET_INP.
- Row 33, compute y = Number of columns myArray1= 6.
- Row 34, select and read myArray (1,6) = "Case" and store in SHEET_OUT.
- Row 37, select myCell_00, then cell B17(CELL_01) will be selected.
- Row 38-39, is the instruction for Excel to select the range starting with CELL_01, the result is the region B17: G19 and store in myArray2.
- Row 40, read the row position of myCell_00 located in B17, the result is myRow=17.
- Row 41, read the column position of myCell_00, the result is myCol=2.

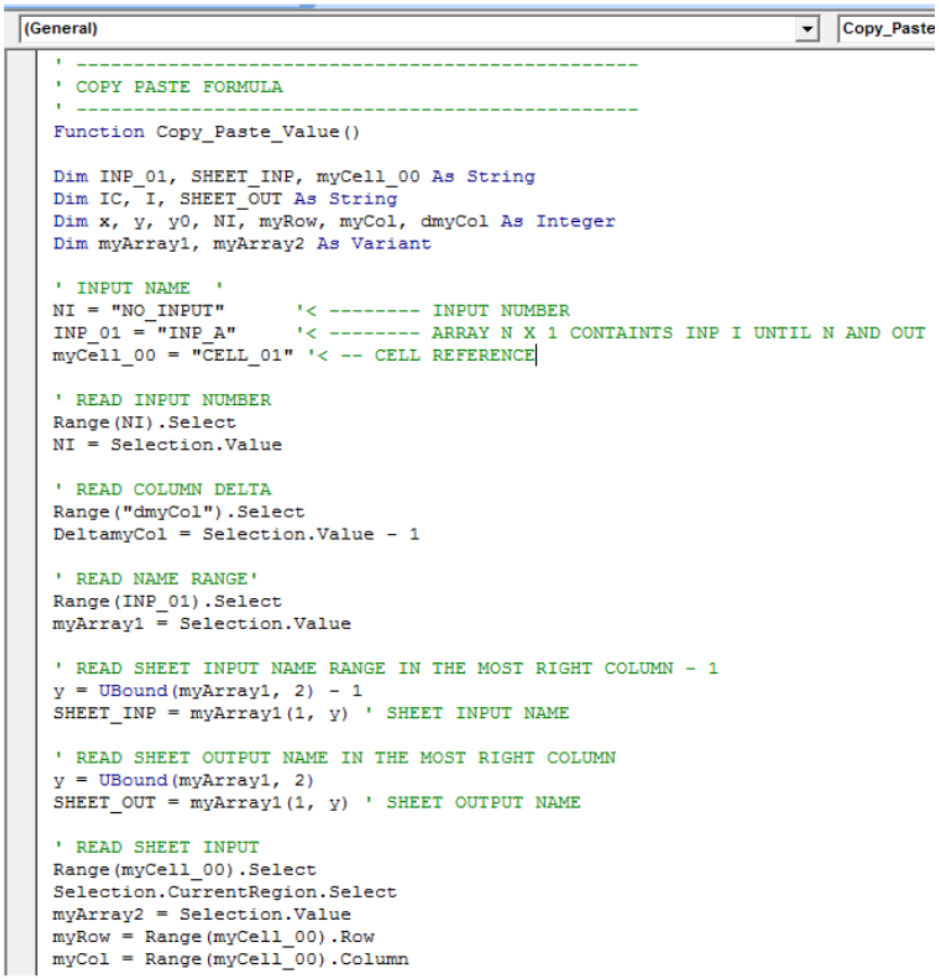
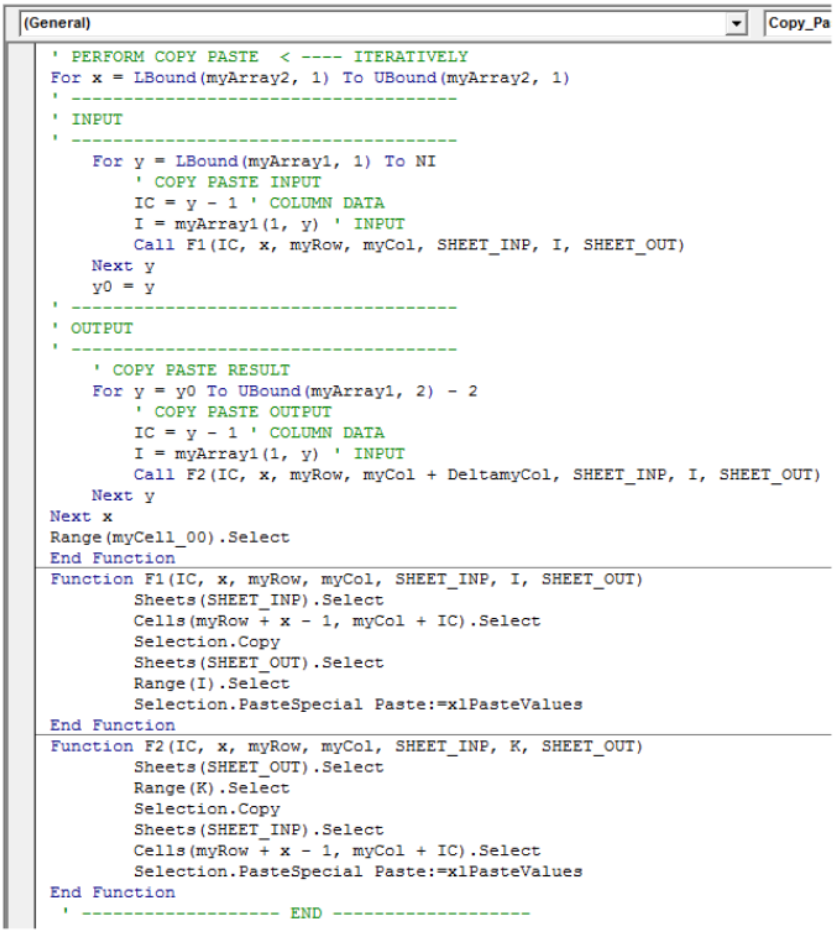


Figure 2. List of VBA program Row 1-41.

The next steps are the repeating operation of read and write data input/output (Figure 3)

- Row 43, the looping operation starts on this line, the statements **for...next** will be executed repeatedly over all the elements, in this case, myArray 2 (3x6).
- Row 47-52, is a command to copy paste Input data to the specific range (Range_00) by involving F1 function (line 67-74). For the first loop, Range_00 with ID = 1, automatically the input data will be INP1 = 2, INP2 = 24, afterwards, the output calculated directly and stored in variable OUT_1 = 26, OUT_2 = 28, OUT_3 = -22, respectively.
- Row 58-63, containing the command to writing the output from step 2 (OUT_1, OUT_2, OUT_3) to the specific sheet and specific range, according to myRow and myCol.
  For convenience, the list command is collected inside the F2 function (line 75-83).
- Row 66 returns the cursor to its original position with the purpose the results can be seen immediately.



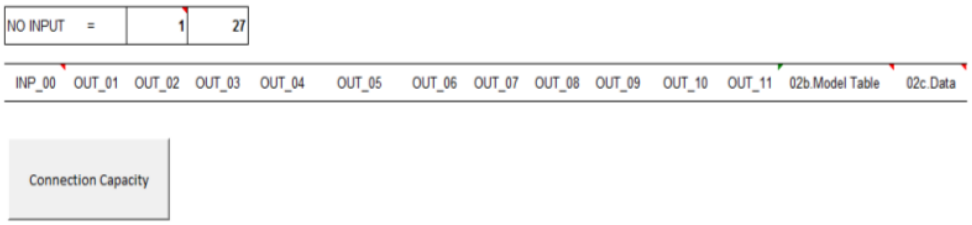
```
(General)                                                    Copy_Pa

' PERFORM COPY PASTE  < ---- ITERATIVELY
For x = LBound(myArray2, 1) To UBound(myArray2, 1)
' ------------------------------------
' INPUT
' ------------------------------------
    For y = LBound(myArray1, 1) To NI
        ' COPY PASTE INPUT
        IC = y - 1 ' COLUMN DATA
        I = myArray1(1, y) ' INPUT
        Call F1(IC, x, myRow, myCol, SHEET_INP, I, SHEET_OUT)
    Next y
    y0 = y
' ------------------------------------
' OUTPUT
' ------------------------------------
    ' COPY PASTE RESULT
    For y = y0 To UBound(myArray1, 2) - 2
        ' COPY PASTE OUTPUT
        IC = y - 1 ' COLUMN DATA
        I = myArray1(1, y) ' INPUT
        Call F2(IC, x, myRow, myCol + DeltamyCol, SHEET_INP, I, SHEET_OUT)
    Next y
Next x
Range(myCell_00).Select
End Function
Function F1(IC, x, myRow, myCol, SHEET_INP, I, SHEET_OUT)
        Sheets(SHEET_INP).Select
        Cells(myRow + x - 1, myCol + IC).Select
        Selection.Copy
        Sheets(SHEET_OUT).Select
        Range(I).Select
        Selection.PasteSpecial Paste:=xlPasteValues
End Function
Function F2(IC, x, myRow, myCol, SHEET_INP, K, SHEET_OUT)
        Sheets(SHEET_OUT).Select
        Range(K).Select
        Selection.Copy
        Sheets(SHEET_INP).Select
        Cells(myRow + x - 1, myCol + IC).Select
        Selection.PasteSpecial Paste:=xlPasteValues
End Function
 ' ------------------- END -------------------
```

Figure 3. List of VBA program Row 42-84.

3. Results and discussion

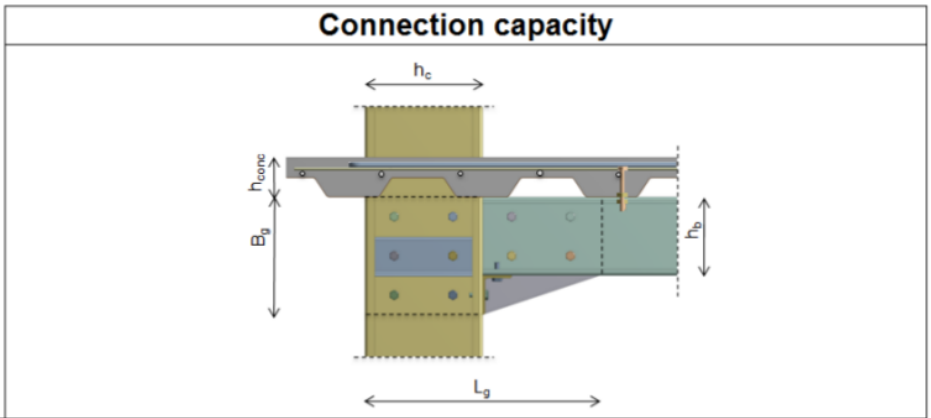
In this paper, the Excel VBA programs were applied to design steel connection. Until now, the steel connections have many configurations and depend upon the type of connecting elements. To choose the connection type, the engineer must consider the force transfer mechanism. Therefore, this paper presents the parametric analysis limited by only one type of the connection, namely gusset plate steel connection, where the calculation has been described elsewhere [12]. The connection design is carried out in accordance with the procedure in Eurocode 3 and 4 [13,14]. As it involves detailed calculation, it will be easier and debugging will be faster if the analysis made on a separate sheet. The group of sheets was made by considering the same functions, including: Material Database, Database Model, Table Model, Data, Bolt resistance, CFS effective for bending, Composite beam, Hogging moment resistance, Lever arm, Column web in compression, Reinforcement bar, Gusset plate-buckling moment, Gusset bolt plate resistance group, Beam flange & angle comp, Shear resistance, Web shear panel, Bolt under shear and torsion, Joint stiffness, Equivalent stiffness, Stiffness of web column, Stiffness classification, Summary and Standard Table.



No	Code	ID	Name	Beam Grade	Beam Size	Column Grade	Column Size	Plate Grade	Plate thk mm	Plate Coord	Bolts Class	Bolts Dia mm	Bolts Coord
1	IJT	01	IJT-01	Test-1	SC20024	Test-1	SC30024	S275	10	IJT_01_GP	8.8	12	IJT_01_Bolt
2	IJT	02	IJT-02	Test-1	SC25024	Test-1	SC30024	S275	10	IJT_02_GP	8.8	12	IJT_02_Bolt
3	IJT	03	IJT-03	Test-1	SC30024	Test-1	SC30024	S275	10	IJT_03_GP	8.8	12	IJT_03_Bolt
4	IJT	04	IJT-04	Test-1	SC20024	Test-1	SC30024	S275	10	IJT_04_GP	8.8	12	IJT_04_Bolt
5	IJT	05	IJT-05	Test-1	SC25024	Test-1	SC30024	S275	10	IJT_05_GP	8.8	12	IJT_05_Bolt
6	IJT	06	IJT-06	Test-1	SC30024	Test-1	SC30024	S275	10	IJT_06_GP	8.8	12	IJT_06_Bolt

Figure 4. Program application for steel connection analysis.

Figure 4 demonstrates the interface of the input data. It is clearly the application can be used for more than one input and output. After analysis, the calculation results are presented in the form of a standard table as indicated in Figure 5. The moment capacity of the connection increase as long as the depth of the beam, increase. While for shear capacity, theoretically for all configurations is equal because of the same number of bolts.



No	Beam size: Size	b_b mm	h_b mm	$t_{fb} = t_{wb}$ mm	f_y Mpa	Slip in plate: B_g mm	L_g mm	Thk mm	f_y Mpa	Reinforcement: n_{rebar}	f_y Mpa	M_j Kn m	F_v Kn
1	SC20024	75	200	2.4	545	300	600	10	275	2D12	450	49	259
2	SC25024	75	250	2.4	545	400	600	10	275	2D12	450	58	259
3	SC30024	100	300	2.4	545	450	600	10	275	2D12	450	63	259
4	SC20024	75	200	2.4	545	300	600	10	275	2D12	450	50	259
5	SC25024	75	250	2.4	545	400	600	10	275	2D12	450	59	259
6	SC30024	100	300	2.4	545	450	600	10	275	2D12	450	64	259

Figure 5. Summary of connection capacity.

4. Conclusion

In this paper, the successful application of complicated civil engineering problems in Excel VBA exhibits the potential of this programs for engineering purposes. The use of spreadsheet manually combines with VBA have been introduced, furthermore, the example demonstrating use for steel connection analysis have been given. The powerful and ease of use of spreadsheets can be promoted as design tools in engineering fields. Furthermore, the full-scale test should be done as the validation and comparison of parametric analysis.

Acknowledgments

The authors would like to acknowledge the support provided by Structure and Construction Laboratory, Faculty of Engineering, Universitas Sriwijaya and Universiti Teknologi Malaysia Construction Research Centre (UTM-CRC) with grant number 4B235. We would like to express the deepest appreciation to Professor Anis and Professor Mahmood from UTM for valuable assistance.

References

[1] Pangaribuan G 2016 *An Introduction to Excel for Civil Engineers: From Engineering Theory to Excel Practice* (Jakarta: CreateSpace Independent Publishing Platform)
[2] Abdelkarim A E 2017 Excel Visual Basic Application 'VBA'for Beam problems Calculation *J. of Basic and App. Sci.* **2**(1)
[3] Agel P and A Lokaj 2014 Semi-rigid joint of timber-concrete composite beams with steel plates and convex nails *Wood res.* **59**(3) p 491-498
[4] Danavandi V S and S K Ahmed 2017 Developing civil engineering design software using MS Excel *Int. J. of Current Eng. And Sci. Res.* **4**(5) p 37-41
[5] Jesumi A and M Rajendran 2013 Optimal Bracing system for steel Towers *International Journal of Engineering Research and Applications* **3**(2) p 729-732
[6] Niazkar M and S H Afzali 2017 Analysis of water distribution networks using MATLAB and Excel spreadsheet: Q-based methods *Comp. App. in Eng. Ed* **25**(2) p 277-289
[7] Rosmanit M and P Pařenica 2013 Capacity of composite steel-concrete columns *Proc.Eng.* **65** p 428-433
[8] Sil B S et al. 2013 Use of excel-solver as an optimization tool in design of pipe network *Int. j. of hydraulic engineering* **2**(4) p 59-63
[9] Wagh S A and U Waghe 2014 Comparative study of RCC and steel concrete composite structures *J. of Eng. R. and App.* **4**(4) p 2248-9622
[10] Wang J P and D Huang 2012 RosenPoint: A Microsoft Excel-based program for the Rosenblueth point estimate method and an application in slope stability analysis *Comp. & geosci.* **48** p 239-243
[11] Ramires F B et al. 2012 Genetic algorithm optimization of composite and steel endplate semi-rigid joints *Eng. Struc.* **45** p 177-191
[12] Firdaus M, Saggaff A and M.M. Tahir 2017 Finite element analysis of composite beam-to-column connection with cold-formed steel section *AIP Conf. Proc.*
[13] Eurocode 3 2005 *BS EN 1993-1-8:2005 - Eurocode 3: Design of steel structures . Part 1-8: Design of joints* (Brussels: European Committee for Standardization)
[14] Eurocode 4 2005 *BS EN 1994-1-1:2004 - Eurocode 4: Design of composite steel and concrete structures:Part 1-1: General rules and rules for buildings* (Brussels: European Committee for Standardization)

Prediction of moment resistance of steel connection with Macro Excel using Eurocode standard

ORIGINALITY REPORT

15%	10%	5%	13%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universitas Pendidikan Indonesia Student Paper	8%
2	www.er-c.org Internet Source	2%
3	Muhammad Firdaus, Anis Saggaff, Mahmod Tahir, Shek Poi Ngian, Arizu Sulaiman, Musab Nimir Salih. "Experimental and analytical study on composite connection with cold-formed steel of double channel sections", IOP Conference Series: Materials Science and Engineering, 2019 Publication	2%
4	Submitted to University of Liverpool Student Paper	1%
5	aip.scitation.org Internet Source	1%
6	Submitted to American Intercontinental University Online Student Paper	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		