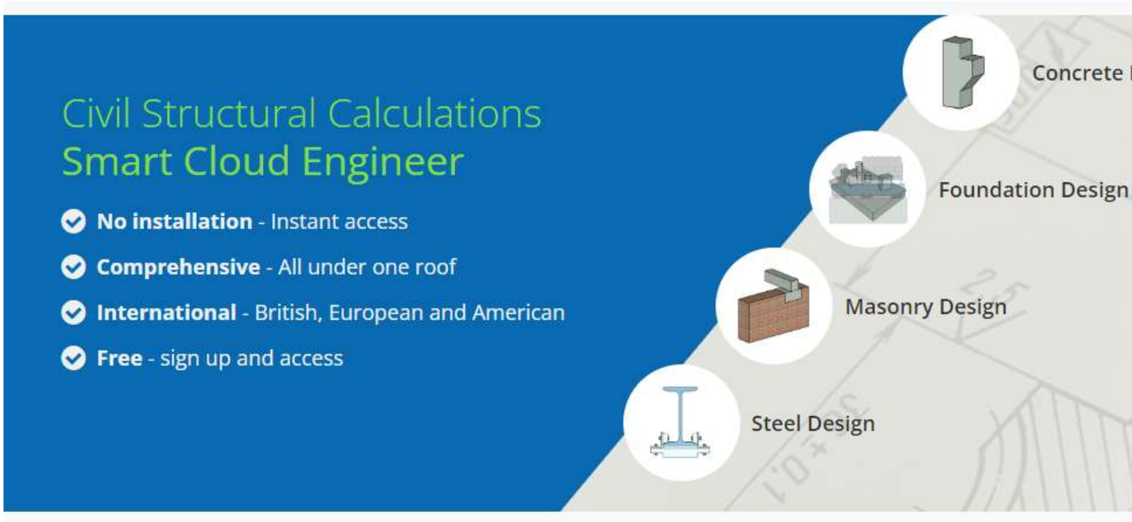


ECPLUS DESIGN CLOUD BASED CIVIL STRUCTURAL SOFTWARE VALIDATION REPORT

ECPLUS DESIGN SOFTWARE IS DEVELOPED AND MARKETED BY

HAPVAS TECHNOLOGIES PRIVATE LIMITED.

www.ecplusdesign.com

TABLE OF CONTENTS

EXAMPLES

INTRODUCTION:

This software verification report provides example problems used to test various features and capabilities of the ECPLUS Design Software and the key results are compared to give confidence to the users.

METHODOLOGY:

A series of test problems are generated to compare with textbook examples and manual calculation to test/verify the various elements and analysis/design features of ECPLUS Design Programs. The comparison of key results with various samples obtained from independent source and manual calculations are provided in tabular form.

ACCEPTANCE CRITERIA

The comparison of the ECPLUS Design Software validation and verification example results are classified under following categories.

- **Exact:** There is no major difference between the ECPLUS Design Modules and the independent results. The difference is less than one percent (1%).
- **Acceptable:** The difference between the ECPLUS Design Software results and the independent design results is less than five percent (5%).
- **Unacceptable:** The difference between the ECPLUS Design Software results and the independent design results is greater than five percent (5%).

VALIDATION SUMMARY

Based on the above criteria, All the ECPLUS modules were tested and listed below the accuracy levels.

Sl. No	MODULE DESCRIPTION	VALIDATION WITH	ACCURACY LEVEL
Example: 1.1	Mat Foundation	Manual Calculation	Exact
Example: 2.1	Dynamic Foundation	Design of Structures and Foundations for Vibrating Machines - Suresh Arya Michael O'Neill George Pincus	Exact
Example: 2.2	Dynamic Foundation	Handbook of Machine Foundations - P.Srinivasulu & C.V.Vaidyanathan	Exact
Example: 3.1	Storage Tank Design	Manual Calculation	Exact
Example: 3.2	Storage Tank Design	Saudi Aramco Best Practice SABP005 (2002)	Exact
Example: 3.3	Storage Tank Design	Saudi Aramco Best Practice SABP-Q-005 (2008)	Acceptable
Example: 3.4	Storage Tank Design – Seismic Calculation	Manual Calculation	Acceptable
Example: 3.5	Storage Tank Design – Wind Calculation	Manual Calculation	Exact
Example: 4.1	Horizontal Equipment Foundation Design	PIP Document (PIP STE03360)	Exact

Example: 4.2	Horizontal Equipment Foundation Design – Wind and Seismic	Manual Calculation	Exact
Example: 5.1	Vertical Vessel Foundation Design	PIP Document (PIP STE03350)	Exact
Example: 5.2	Vertical Vessel Foundation Design – wind and Seismic	Manual Calculation	Exact
Example: 6.1	Monorail – British	SANDS Program	Exact
Example: 7.1	Monorail – European	SANDS Program	Exact
Example: 8.1	Isolated Foundation Design	Manual Calculation	Exact
Example: 9.1	Lintel Analysis	Manual Calculation	Acceptable
Example: 10.1	Crane Gantry Girder Design	Manual Calculation	Acceptable
Example: 11.1	Retaining Wall Design	Design of Structural Elements - Chanakya Arya	Acceptable
Example: 12.1	Column Design – British	Reinforced Concrete Analysis and Design by S.S. Ray	Exact
Example: 13.1	Column Design – European	Worked Examples to Eurocode2 by CH Goodchild	Acceptable
Example: 14.1	Masonry Bearing	Design of Structural Elements by Chanakya Arya	Exact
Example: 15.1	Concrete Pit Design	Rectangular Concrete Tanks by Javeed A. Munshi	Acceptable
Example: 16.1	Corbel Design – British	Reinforced Concrete Analysis and Design by S.S. Ray	Exact
Example: 17.1	Corbel Design – European	Manual Calculation	Exact
Example: 18.1	Corbel Design – American (SI)	Manual Calculation	Exact
Example: 19.1	Corbel Design – American (Imperial)	Manual Calculation	Exact
Example: 20.1	Masonry Column	Manual Calculation	Exact
Example: 21.1	Pile Cap with 2 Piles	Manual Calculation	Exact
Example: 22.1	Pile Cap with 3 Piles	Manual Calculation	Exact
Example: 23.1	Pile Cap with 4 Piles	Manual Calculation	Exact
Example: 24.1	Rectangular Concrete Beam Design – British	Reinforced Concrete Analysis and Design by S.S. Ray	Exact
Example: 25.1	Rectangular Concrete Beam Design – European	Worked Examples to Eurocode2 by CH Goodchild	Acceptable
Example: 26.1	Rectangular Concrete Beam Design – American (SI)	Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer	Exact
Example: 26.2	Rectangular Concrete Beam Design – American (SI) - Shear	Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer	Acceptable
Example: 27.1	Rectangular Concrete Beam Design –	Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer	Exact

	American (Imperial) – Reinforcement		
Example: 27.2	Rectangular Concrete Beam Design – American (Imperial) - Shear	Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer	Exact
Example: 28.1	Rectangular Concrete Flanged Beam Design– Reinforcement – British	Reinforced Concrete Analysis and Design by S.S. Ray	Exact
Example: 28.2	Rectangular Concrete Flanged Beam Design - Shear - British	Reinforced Concrete Analysis and Design by S.S. Ray	Exact
Example: 29.1	Rectangular Concrete Flanged Beam Design – European	Worked Examples to Eurocode2 by CH Goodchild	Exact
Example: 30.1	Rectangular Concrete Flanged Beam Design – American (SI)	Manual Calculation	Exact
Example: 31.1	Rectangular Concrete Flanged Beam Design - Reinforcement – American (Imperial)	Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer	Acceptable
Example: 31.2	Rectangular Concrete Flanged Beam Design- Shear – American (Imperial)	Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer	Exact
Example: 32.1	Staircase Design - British	Manual Calculation	Exact
Example: 33.1	Staircase Design - European	Manual Calculation	Exact
Example: 34.1	Slab Design – British	Reinforced Concrete Analysis and Design by S.S. Ray	Exact
Example: 35.1	Slab Design – European	Worked Examples to Eurocode2 by CH Goodchild	Exact
Example: 36.1	Baseplate British - Fixed	Joints in Steel Connection Moment Connection - BCSA	Acceptable
Example: 37.1	Baseplate British - Pinned	Joints in Steel Connection Simple Connection - BCSA	Exact
Example: 38.1	Baseplate Fixed New Version – ACI (Imperial) LRFD	Base Plate and Anchor Rod Design by James M. Fisher and Lawrence A. Kloiber	Exact
Example: 38.2	Baseplate Fixed New Version – ACI (Imperial) ASD	Base Plate and Anchor Rod Design by James M. Fisher and Lawrence A. Kloiber	Exact
Example: 39.1	Crack width – RC Beam	Reinforced Concrete Analysis and Design by S.S. Ray	Acceptable

CONCLUSION

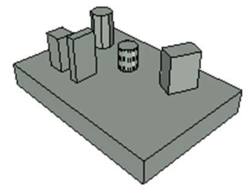
Based on this validation process, ECPLUS results are verified either with Book references or with manual calculations and found that all the module results are in the acceptable range.

EXAMPLE 1.1 Mat Foundation

MODULE NAME: MAT FOUNDATION DESIGN (ECMAT)

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION



GENERAL DESCRIPTION

Footing of length 2000mm, breadth 2000mm and thickness 600mm is modeled as a foundation pad and a square pedestal of size 700mm is modeled at the center of Pad in ECPLUS Design module. Manual calculation is performed to validate and verify the results. Foundation, Pad, Pedestal, loading details, Soil and Concrete Properties are aligned in both program and manual calculation. Key results such as Factor of safety against overturning in X and Z Directions, Maximum Bearing Pressure and Percentage of Compression Area are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

MAT FOUNDATION DESIGN – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
FOS against Overturning – X Direction	3.12	3.12	0
FOS against Overturning – Z Direction	3.12	3.12	0
Maximum Bearing Pressure (kN/m^2)	94.72	94.72	0
Percentage of Compression Area (%)	82.6	82.63	0

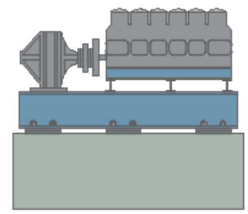
CONCLUSION

The ECPLUS results are exactly matching with themanually calculated results.

EXAMPLE 2.1 Dynamic Foundation

MODULE NAME: DYNAMIC FOUNDATION DESIGN (ECDYN)

REFERENCE: DESIGN OF STRUCTURES AND FOUNDATIONS FOR VIBRATING MACHINES BY SURESH ARYA MICHAEL O'NEILL GEORGE PINCUS



GENERAL DESCRIPTION

The Example problem given in "Design of Structures and Foundations for Vibrating Machines by Suresh Arya Michael O'Neill George Pincus" book, page no: 93 is used to validate and verify the results of ECPLUS.

Foundation of size 27'-6" x 15'-9" and 5' thick is modeled as a Block element. Loadings and soil parameters are applied as given in the example problem. The results of all the ECPLUS design parameters have been validated with Book results. In addition, Key results such as Natural Frequencies, Resonance Frequencies and Amplitudes are presented below to compare with Book results.

RESULTS COMPARISON

The comparison of ECPLUS with book results are provided in the below table.

NATURAL FREQUENCY - WITH BOOK EXAMPLE

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Vertical Excitation (rpm)	1089.3	1082.8	0.6
Horizontal Excitation (rpm)	1033.3	1017.7	1.5
Rocking Oscillation (rpm)	1677.1	1677.6	0
Pitching Oscillation (rpm)	1665.3	1661.2	0.2

RESONANCE FREQUENCY - WITH BOOK EXAMPLE

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Vertical Excitation (rpm)	No Resonance	No Resonance	0
Horizontal Excitation (rpm)	No Resonance	No Resonance	0
Rocking Oscillation (rpm)	1934.2	1934.3	0
Pitching Oscillation (rpm)	1775.9	1770.9	0.3

AMPLITUDE - WITH BOOK EXAMPLE

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Amplitude – X Direction (µin)	130.971	133	1.5
Amplitude – Y Direction (µin)	433.028	443.2	2.3 *
Amplitude – Z Direction (µin)	605.022	717	15.6 *

*** Calculation assumption in the book**

As per the foot note given in book page no: 96, Out of phase loads such as Vertical forces & Moments and Horizontal forces & Moments are considered together to obtain the conservative results. Thereby, Amplitudes of book results are slightly on the higher side.

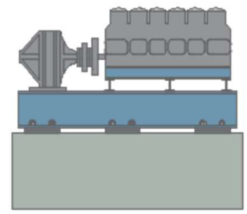
CONCLUSION

The ECPLUS results are exactly matching with “Design of Structures and Foundations for Vibrating Machines by Suresh Arya Michael O’Neill George Pincus” book results.

EXAMPLE 2.2 Dynamic Foundation

MODULE NAME: DYNAMIC FOUNDATION DESIGN (ECDYN)

REFERENCE: HANDBOOK OF MACHINE FOUNDATIONS – P.SRINIVASULU& C.V.VAIDYANATHAN



GENERAL DESCRIPTION

The Example problem given in “Handbook of Machine Foundations–P.Srinivasulu and C.V.Vaidyanathan” book, page no: 85 is used to validate and verify the results of ECPLUS.

Foundation of size 9.5 x 7.5 and 0.6 m thick is modeled as a Block element and other machine supporting blocks are modeled as Pedestals. Loadings and Soil parameters are applied as given in the example problem. The results of all the ECPLUS design parameters have been validated with Book results. In addition, Key results such as Natural Frequencies and Amplitudes are compared with Book results, and conclusion is presented.

RESULTS COMPARISON

The comparison of ECPLUS with book results are provided in the below table.

NATURAL FREQUENCY - WITH BOOK EXAMPLE

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Coupled Natural Frequencies, Horizontal (Fx) and Rocking (My) (rad/s)	163.653	163.363	0.2
Coupled Natural Frequencies, Horizontal (Fx) and Rocking (My) (rad/s)	69.546	69.304	0.4

AMPLITUDE - WITH BOOK EXAMPLE

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Horizontal Amplitude at Top of the Foundation (µm)	94.935	95.1	0.2
Horizontal Amplitude at Base Level (µm)	79.701	79.2	0.6

CONCLUSION

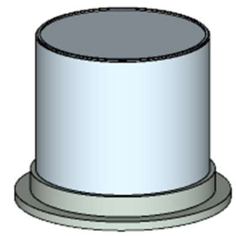
The ECPLUS results are exactly matching with the “Handbook of Machine Foundations – P.Srinivasulu & C.V.Vaidyanathan” book results.

EXAMPLE 3.1 Storage Tank Design

MODULE NAME: STORAGE TANK FOUNDATION DESIGN (ECTANK)

STANDARD: MULTI STANDARD

REFERENCE: MANUAL CALCULATION



GENERAL DESCRIPTION

Storage Tank of inner diameter 20m and Shell height of 15m is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Tank details, Foundation data, Soil, Concrete Properties and Factors are aligned in both program and manual calculation. Key results such as Stability Checks and Ring Beam Capacity are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

STABILITY CHECKS – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Uplift – SLS3	9.22	9.216	0
Sliding – SLS3	21.08	21.078	0
Overturning – SLS3	19.45	19.451	0
Base Pressure Under Tank at Foundation Level– SLS1 (kN/m^2)	189.9	189.920	0
Allowable Base Pressure – SLS9 (kN/m^2)	218.5	218.5	0

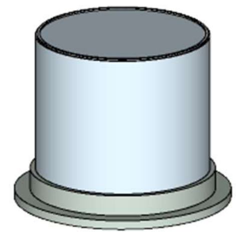
RING BEAM CAPACITY – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Hoop Tension – ULS2 (kN)	2110.5	2110.469	0
Equivalent Bending Moment – ULS22 (kN.m)	1140.7	1140.675	0

CONCLUSION

The ECPLUS results are exactly matching with the manual calculation results.

EXAMPLE 3.2 Storage Tank Design



MODULE NAME: STORAGE TANK FOUNDATION DESIGN (ECTANK)

STANDARD: MULTI STANDARD

REFERENCE: SAUDI ARAMCO BEST PRACTICE SABP-005 2002

GENERAL DESCRIPTION

The Example problem given in “Saudi Aramco Best Practice SABP-005 2002”, Example 1 (page no: 13) is used to validate and verify the results of ECPLUS.

Storage Tank of inner diameter 4320in and Shell height of 720in is modeled in ECPLUS Design module. Foundation Data, Loading, Soil and Concrete properties are applied as given in the example problem. The Key result Maximum Base Pressure under Ring Beam / Footing and Hoop Tension are computed and validated with the Saudi Aramco example.

RESULTS COMPARISON

STORAGE TANK FOUNDATION DESIGN– SAUDI ARAMCO

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Max. Base Pressure Under Ring Beam / Footing (ksf)	3.65	3.675	0.7
Hoop Tension (kips)	1488.8	1482.4	0.4

CONCLUSION

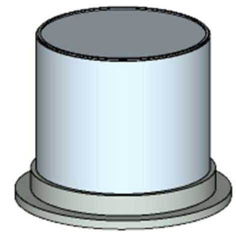
The ECPLUS results are exactly matching with the “Saudi Aramco” results.

EXAMPLE 3.3 Storage Tank Design

MODULE NAME: STORAGE TANK FOUNDATION DESIGN (ECTANK)

STANDARD: MULTI STANDARD

REFERENCE: SAUDI ARAMCO BEST PRACTICE SABP-Q-005 2008



GENERAL DESCRIPTION

The Example problem given in "Saudi Aramco Best Practice SABP-Q-005 2008", Example 2 (page no: 29) is used to validate and verify the results of ECPLUS.

Storage Tank of inner diameter 1440 in and Shell height of 468 in is modeled. Foundation Data, Loading, Soil and Concrete properties are applied as given in the example problem. Hoop Tension is computed and validated with the Saudi Aramco example.

RESULTS COMPARISON

STORAGE TANK FOUNDATION DESIGN– SAUDI ARAMCO

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Hoop Tension (kips)	287.8	289.872	0.7
Twisting Moment (kips.ft/ft)	1.3	0.8701	49.4

*** Calculation assumption**

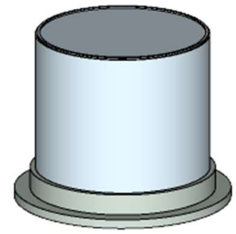
In SABP example, the Twisting moment calculation is underestimated as the effect of soil pressure was not considered. However, in ECPLUS, the same effect is accounted in order to have actual effect as well as to have equilibrium of all forces. Thereby, twisting moment in SABP is slightly on the lower side.

Similarly, the minimum reinforcement criteria are not reflected in SABP examples and the same has been taken care in the ECPLUS examples.

CONCLUSION

The ECPLUS result is within acceptable range with the "Saudi Aramco" results.

EXAMPLE 3.4 Storage Tank Design – Seismic Calculation



MODULE NAME: STORAGE TANK FOUNDATION DESIGN (ECTANK)

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

The Seismic load calculation is performed automatically by the Storage Tank Foundation program based on API 650 Appendix-E. The same input is used to verify using manual calculation as well as third party software. The Seismic load effects key results such as seismic shear (Vs), ring wall/beam moment (Mrw) and slab moment (sloshing) (Ms) are computed and compared based on API 650-2013 (Annex E) procedure using the same site seismic design parameters.

RESULTS COMPARISON

WITH API 650 EXAMPLE

Output Parameter	ECPLUS	API 650	DIFFERENCE abs (%)
Seismic Ringwall Moment (kips.ft)	22519.6	22888.4	1.6

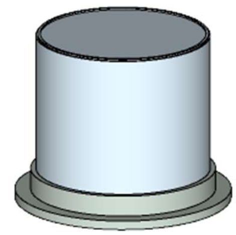
WITH MANUAL COMPUTATION

KEY RESULTS	ECPLUS	MANUAL COMPUTATION	DIFFERENCE abs (%)
Seismic Shear (Vs) (kips)	1434.3	1470.832	2.5
Seismic Ring Wall Moment (Mrw) (kips.ft)	22519.6	22753.345	1.0
Seismic Slab Moment (Ms) (kips.ft)	54650	55241.255	1.1

CONCLUSION

The ECPLUS results are within acceptable comparison with API 650-Appendix-Eand manually computed results.

EXAMPLE 3.5 Storage Tank Design – Wind Calculation



MODULE NAME: STORAGE TANK FOUNDATION DESIGN (ECTANK)

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

The Wind load calculation is performed automatically by the Storage Tank Foundation program based on BS 6399.The same input is used to verify using manual calculation. The Wind load effects key results such as Wind Uplift Pressure, Wind Shear and Wind Moment are computed and compared based on code procedure using the same wind design parameters.

RESULTS COMPARISON

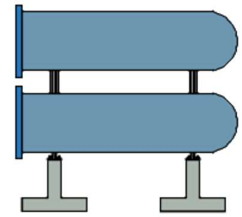
WITH MANUAL COMPUTATION

KEY RESULTS	ECPLUS	MANUAL COMPUTATION	DIFFERENCE (%)
Wind Uplift Pressure (ksf)	0.046	0.0464	0.8
Wind Shear (kips)	89.12	89.14	0
Wind Moment (kips-ft)	2190.9	2191.374	0

CONCLUSION

The ECPLUS results are exactly matching with the manually computed results.

EXAMPLE 4.1 Horizontal Equipment Foundation Design



MODULE NAME: HORIZONTAL EQUIPMENT FOUNDATION DESIGN (ECHORVES)

STANDARD: BRITISH

REFERENCE: PIP DOCUMENT(PIP STE03360)

GENERAL DESCRIPTION

The Example problem given in "PIP Document (PIP STE03360)" report, page no.18, is used to validate and verify the results of ECPLUS.

Horizontal Equipment with two exchangers is modeled in ECPLUS design module. Equipment, Foundation, Load data and Combinations, Soil and Concrete Properties are applied as per PIP Document. Thermal Load and Bearing Pressure are computed and validated with the PIP Document example.

RESULTS COMPARISON

HORIZONTAL EQUIPMENT FOUNDATION DESIGN – PIP Document

Output Parameter	ECPLUS	PIP DOCUMENT	DIFFERENCE abs (%)
Thermal Load (kips)	22.2	22.2	0
Bearing Pressure(ksf)	5.77	5.79	0.3

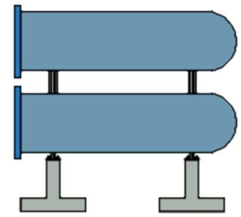
Note:

Analysis and Design of Pad and Pedestal follow Mat Foundation Calculation.

CONCLUSION

The ECPLUS results are exactly matching with the "PIP Document" results.

EXAMPLE 4.2 Horizontal Equipment Foundation Design – Wind and Seismic



MODULE NAME: HORIZONTAL EQUIPMENT FOUNDATION DESIGN (ECHORVES)

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

The Wind and Seismic load calculation are performed automatically by the Horizontal Equipment Foundation Design. The same input is used to verify using manual calculation. The key results such as Wind Pressure and Total Base Shear are computed and compared based on code procedure using the same wind design parameters.

RESULTS COMPARISON

WIND CALCULATION

KEY RESULTS	ECPLUS	MANUAL COMPUTATION	DIFFERENCE (%)
Wind Pressure (N/m^2)	836.1	836.7	0.01

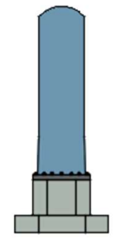
SEISMIC CALCULATION

KEY RESULTS	ECPLUS	MANUAL COMPUTATION	DIFFERENCE (%)
Total Base Shear (kN)	25.650	25.65	0

CONCLUSION

The ECPLUS results are exactly matching with the manually computed results.

EXAMPLE 5.1 Vertical Vessel Foundation Design



MODULE NAME: VERTICAL VESSEL FOUNDATION DESIGN (ECVERVES)

STANDARD: BRITISH

REFERENCE: PIP DOCUMENT (PIP STE03350)

GENERAL DESCRIPTION

The Example problem given “PIP Document (PIP STE03350)” report, page no.22, is used to validate and verify the results of ECPLUS.

Vertical Vessel of Diameter 173.04 in is modeled in ECPLUS design module. Foundation, Pad, Pedestal details, Load data and Combinations, Soil and Concrete Properties are applied as per PIP Document. Bearing Pressure is computed and validated with the PIP Document example.

RESULTS COMPARISON

VERTICAL VESSEL FOUNDATION DESIGN – PIP Document

Output Parameter	ECPLUS	PIP DOCUMENT	DIFFERENCE abs (%)
Bearing Pressure (ksf)	3.11	3.13	0.6

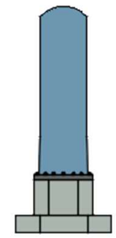
Note:

Analysis and Design of Pad and Pedestal follow Mat Foundation Calculation.

CONCLUSION

The ECPLUS result is exactly matching with the “PIP Document” results.

EXAMPLE 5.2 Vertical Vessel Foundation Design – wind and Seismic



MODULE NAME: VERTICAL VESSEL FOUNDATION DESIGN (ECVERVES)

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

The Wind and Seismic load calculation are performed automatically by the Vertical Vessel Foundation Design based on BS6399 and ASCE-7 2005 codes. The same input is used to verify using manual calculation. The key results such as Wind Pressure and Total Base Shear are computed and compared based on code procedure using the same wind design parameters.

RESULTS COMPARISON

WIND CALCULATION

KEY RESULTS	ECPLUS	MANUAL COMPUTATION	DIFFERENCE (%)
Wind Pressure (N/m^2)	1495.3	1502.003	0.4

SEISMIC CALCULATION

KEY RESULTS	ECPLUS	MANUAL COMPUTATION	DIFFERENCE (%)
Total Base Shear (kN)	6.080	6.08	0

CONCLUSION

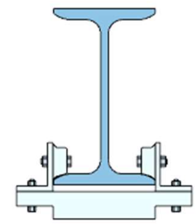
The ECPLUS results are exactly matching with the manually computed results.

EXAMPLE 6.1 Monorail – British

MODULE NAME: MONORAIL BEAM DESIGN (ECMONO)

STANDARD: BRITISH

REFERENCE: SANDS PROGRAM



GENERAL DESCRIPTION

The Example problem given in “SANDS Program” report, Example: 2.1 is used to validate and verify the results of ECPLUS.

Monorail Beam of section UB 254 x 102 x 28 is modeled in ECPLUS design. Section size, Support and Monorail properties are applied as per SANDS Program. The Key result such as Shear Stress, Transverse Stress and Allowable Transverse Stress are computed and validated with the program data.

RESULTS COMPARISON

MONORAIL BEAM DESIGN – SANDS PROGRAM

Output Parameter	ECPLUS	SANDS PROGRAM	DIFFERENCE abs (%)
Total Shear Stress (N/mm^2)	10.303	10.3	0.3
Transverse Stress – Remote from end of the beam(N/mm^2)	72.678	72.72	0.1
Transverse Stress – At the end of the beam(N/mm^2)	116.576	116.6	0
Allowable Transverse Stress (N/mm^2)	223.88	223	0.4
Stress due to vertical Moment (N/mm^2)	81.285	81.37	0.1
Allowable Stress (N/mm^2)	111.801	112.2	0.3
Deflection (mm)	1.167	1.165	0.2

CONCLUSION

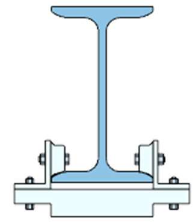
The ECPLUS results are exactly matching with the “SANDS Program” results.

EXAMPLE 7.1 Monorail – European

MODULE NAME: MONORAIL BEAM DESIGN (ECMONO)

STANDARD: EUROPEAN

REFERENCE: SANDS PROGRAM



GENERAL DESCRIPTION

The Example problem given "SANDS Program" report, is used to validate and verify the results of ECPLUS.

Monorail Beam of section UB 254 x 102 x 28 is modeled in ECPULS design module. Section sizes, Support and Monorail properties are applied as per SANDS Program. The Key result such as Deflection, Vibration Check, Combined Bending and Torsion check, Serviceability Limit State check, Torsional Buckling Moment, Vertical Moment, Shear Force and Vertical Crane Load are computed and validated with the program data.

RESULTS COMPARISON

MONORAIL BEAM DESIGN – SANDS PROGRAM

Output Parameter	ECPLUS	SANDS PROGRAM	DIFFERENCE abs (%)
Slenderness of Bottom Flange	50.7	50.688	0
Combined Bending and Torsion Check – Unity Ratio	0.85	0.85347	0.4
Global Bending Stress (N/mm^2)	121.772	121.75	0
Reversible Behavior Stresses – exp 7.2c (N/mm^2)	124.666	124.64	0
Reversible Behavior Stresses – exp 7.2e (N/mm^2)	179.27	179.25	0
Torsional Buckling Moment (kNm)	37.5	37.497	0
Allowable Torsional Buckling Moment (kNm)	68.41	68.427	0
Vertical Moment (kNm)	37.5	37.497	0
Allowable Vertical Moment (kNm)	97.1	97.075	0
Shear Force (kN)	25.3	25.28	0.8
Allowable Shear Force (kN)	282.3	282.77	0.2
Deflection (mm)	1.1	2.222	50.5 *

*** Note:**

In Sands Example, Cantilever span alone is considered for the deflection calculation whereas the effect of continuous span (both Simply Supported and Cantilever) is considered in ECPLUS. Thereby, Deflection in SANDS example is slightly on higher side.

CONCLUSION

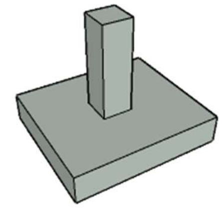
The ECPLUS results are exactly matching with the “SANDS Program” results.

EXAMPLE 8.1 Isolated Foundation Design

MODULE NAME: ISOLATED FOUNDATION DESIGN

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION



GENERAL DESCRIPTION

Isolated Foundation with a pad of size 2000mm x 2000mm and a square pedestal of size 700mm is modeled in ECPLUS Design module, and Manual calculation is performed to validate and verify the results. Foundation, Pad, Pedestal details, Loadings, Soil and Concrete Properties are aligned in both program and manual calculation. Key results such as FOS against overturning in X and Z Directions, Maximum Bearing Pressure and Percentage of Compression Area are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

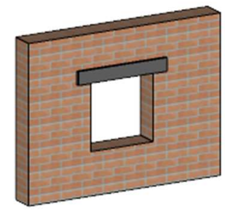
ISOLATED FOUNDATION DESIGN – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
FOS against Overturning – X Direction	3.12	3.1187	0
FOS against Overturning – Z Direction	3.12	3.1187	0
Maximum Bearing Pressure (kN/m^2)	94.7	94.716	0
Percentage of Compression Area (%)	82.63	82.63	0

CONCLUSION

The ECPLUS results are exactly matching with the manually calculated results.

EXAMPLE 9.1 Lintel Analysis



MODULE NAME: LINTEL ANALYSIS (ECLINTEL)

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Masonry Lintel of height 2600 mm is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Openings, Loading and Material Properties are aligned in both program and manual calculation. Key results such as Maximum Bending Moment and Shear are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

LINTEL ANALYSIS – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Maximum Bending Moment (kNm)	3.2	3.238	1.2
Maximum Shear Force (kN)	4.1	4.048	1.3

CONCLUSION

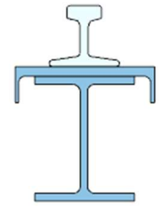
The ECPLUS results are in acceptable range with the manual calculation results.

EXAMPLE 10.1 Crane Gantry Girder Design

MODULE NAME: CRANE GANTRY GIRDER DESIGN (ECCRANE)

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION



GENERAL DESCRIPTION

Crane Gantry Girder of span 6m is modeled in ECPLUS design module. Dimensions, Restraints, Steel Properties and Loading are applied as per manual calculation. The Key result such as Shear Capacity Ratio, Moment Interaction Ratio, Bearing and Buckling Capacity, Vertical and Horizontal Deflection are computed and validated with the book example.

RESULTS COMPARISON

SHEAR CAPCAITY RATIO – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Load Case01	1.1	1.104	0.4
Load Case02	0.0252	0.025	0.8

MOMENT INTERACTION RATIO – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Load Case01	3.15	3.147	0.1
Load Case02	3.09	3.155	2.1

UNSTIFFENED WEB – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Bearing Capacity (kN)	1258	1258	0
Buckling Capacity (kN)	394.4	394.4	0

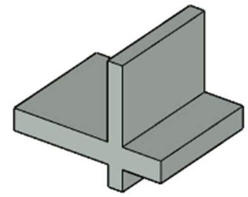
DEFLECTION – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Vertical Deflection (mm)	22.6	21.6	4.6
Horizontal Deflection (mm)	16.2	15.3	5.8

CONCLUSION

The ECPLUS results are within acceptable comparison with the manually calculated results.

EXAMPLE 11.1 Retaining Wall Design



MODULE NAME: REINFORCED CONCRETE RETAINING WALL DESIGN (ECRETAIN)

STANDARD: BRITISH

REFERENCE: DESIGN OF STRUCTURAL ELEMENTS BY CHANAKYA ARYA

GENERAL DESCRIPTION

The Example problem given in “Design of Structural Elements by Chanakya Arya” book, Example 3.16, page no: 125 is used to validate and verify the results of ECPLUS.

Reinforced Concrete Retaining wall of size as given in the book is modeled. Soil, Material properties and Loading are applied as given in the example problem. The Key result Check for Overturning, Sliding, bearing Pressure, Moment at Stem, Base Slab Top and Bottom are computed and validated with the book example.

RESULTS COMPARISON

CHECK FOR OVERTURNING, SLIDING AND BEARING PRESSURE –BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
FOS for Overturning	4.949	4.9	1
FOS for Sliding	1.568	1.56	0.5
Maximum Bearing Pressure (kN/m^2)	115.783	116	0.2
Minimum Bearing Pressure (kN/m^2)	65.167	65	0.3

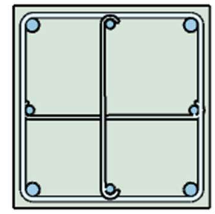
MOMENT – BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Stem (kNm)	184.721	184.7	0
Base Slab Top (kNm)	156.487	160.5	2.5
Base Slab Bottom (kNm)	35.408	36.5	3

CONCLUSION

The ECPLUS results are within acceptable comparison with the “Design of Structural Elements by Chanakya Arya” book results.

EXAMPLE 12.1 Column Design – British



MODULE NAME: REINFORCED CONCRETE COLUMN DESIGN (ECCOLUMN)

STANDARD: BRITISH

REFERENCE: REINFORCED CONCRETE ANALYSIS AND DESIGN BY S.S. RAY

GENERAL DESCRIPTION

The Example problem given in "Reinforced Concrete Analysis and Design by S.S. Ray" book, Example 4.1 (Page no: 164) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Column of size 400 x 600 mm is modeled in ECPLUS design module. Dimension, Loading and Concrete properties are applied as given in the example problem. The Key results such as Moment and Design Shear Stress in Y and Z Directions are computed and validated with the book example.

RESULTS COMPARISON

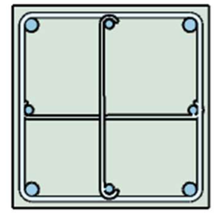
REINFORCED CONCRETE COLUMN DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Moment at Bottom – Y Direction (kNm)	575.5	573	0.4
Moment at Bottom – Z Direction (kNm)	277	276	0.4
Design Shear Stress – Y Direction (N/mm^2)	0.392	0.39	0.5
Design Shear Stress – Z Direction (N/mm^2)	0.694	0.69	0.6

CONCLUSION

The ECPLUS results are exactly matching with the "Reinforced Concrete Analysis and Design by S.S. Ray" book results.

EXAMPLE 13.1 Column Design – European



MODULE NAME: REINFORCED CONCRETE COLUMN DESIGN (ECCOLUMN)

STANDARD: EUROPEAN

REFERENCE: WORKED EXAMPLES TO EUROCODE2 BY CH GOODCHILD

GENERAL DESCRIPTION

The Example problem given in "Worked Examples to Eurocode2 by CH Goodchild" book, Example 5.2 (Page no: 139) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Column of size 300 x 300 mm is modeled in ECPLUS design module. Concrete, Reinforcement and Loading are applied as given in the example problem. Design Moment for both load cases are computed and validated with the book example.

RESULTS COMPARISON

DESIGN MOMENT –BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Design Moment (kNm) – LC1	89.6	98.5	9.0 *
Design Moment (kNm) – LC2	68.7	68.7	0

*** Calculation Difference**

In the book example, minimum eccentricity moment is added with Design moment. Thereby, Design Moment is slightly on higher side.

CONCLUSION

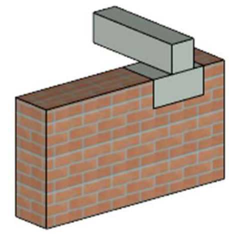
The ECPLUS results are within acceptable comparison with "Worked Examples to Eurocode2 by CH Goodchild" book results.

EXAMPLE 14.1: VALIDATION REPORT FOR ECPLUS MASONRY BEARING DESIGN

MODULE NAME: ECPLUS MASONRY BEARING DESIGN

STANDARD: BRITISH

REFERENCE: DESIGN OF STRUCTURAL ELEMENTS BY CHANAKYA ARYA



GENERAL DESCRIPTION

The Example problem given in "Design of Structural Elements by Chanakya Arya" book, Example 5.3 (page no: 256) is used to validate and verify the results of ECPLUS.

Masonry Bearing Wall of height 3500 mm is modeled in ECPLUS design module. Masonry Properties, Construction and Design Loads are applied as given in the example problem. Key results such as Characteristic Compressive Strength and Allowable Bearing Stress are computed and validated with the book example.

RESULTS COMPARISON

MASONRY BEARING WALL DESIGN – BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE (%)
Characteristic Compressive Strength (N/mm^2)	6.3	6.3	0
Allowable Bearing Stress (N/mm^2)	1.711	1.728 (371 N/mm)	0.9

*** Calculation assumption**

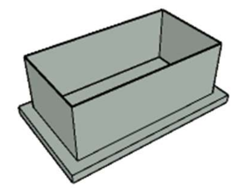
Unit of Allowable bearing stress is converted to N/mm^2 as per ECPLUS result for validation purpose.

CONCLUSION

The ECPLUS results are exactly matching with the "Design of Structural Elements by Chanakya Arya" book results.

EXAMPLE 15.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE RECTANGULAR PIT DESIGN

MODULE NAME: ECPLUS NEW REINFORCED CONCRETE RECTANGULAR PIT DESIGN



STANDARD: AMERICAN (IMPERIAL)

REFERENCE: RECTANGULAR CONCRETE TANKS BY JAVEED A. MUNSHI

GENERAL DESCRIPTION

The Example problem given in "Rectangular Concrete Tanks by Javeed A. Munshi" book, page no: 5-1, is used to validate and verify the results of ECPLUS.

Rectangular Concrete Pit of size 30 x 20 x 10 ft is modeled in ECPLUS design module. Dimensions, Coefficients and properties are applied as given in the example problem. The Key result Moment and Shear in Long and Short Wall are computed and validated with the book example.

RESULTS COMPARISON

MOMENT CALCULATION– BOOK EXAMPLE

Output Parameter	ECPLUS (kip-ft)	BOOK (kip-ft)	DIFFERENCE abs (%)
Long wall – Support	-8.8	-9.030	2.5
Long wall – Span	-6	-5.46	9.9
Short wall - Support	-5.9	-9.030	34.7
Short wall – Span	-6	-5.46	9.9

SHEAR CALCULATION – BOOK EXAMPLE

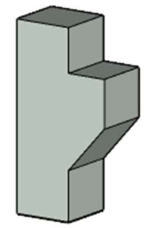
Output Parameter	ECPLUS (kips)	BOOK (kips)	DIFFERENCE abs (%)
Long wall	3.7	2.59	42.8
Short wall	2.3	1.89	21.6

*** ECPLUS uses Ultimate design factors and thereby, Moment and Shear are slightly on higher side.**

CONCLUSION

The ECPLUS resultsare within acceptable comparison with"Structural Concrete by M.Nadim Hassoun &Akthem Al-Manaseer"book results.

EXAMPLE 16.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE CORBEL DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE CORBEL DESIGN

STANDARD: BRITISH

REFERENCE: REINFORCED CONCRETE ANALYSIS AND DESIGN BY S.S. RAY

GENERAL DESCRIPTION

The Example problem given in “Reinforced Concrete Analysis and Design by S.S. Ray” book, Example 5.21, page no: 200 is used to validate and verify the results of ECPLUS.

Rectangular Concrete Corbel of size as per book is modeled. Moment, Shear, Concrete and Reinforcement properties are applied as given in the example problem. The Key result Area of Main Reinforcement, Maximum Area of Reinforcement and Area of shear reinforcement are computed and validated with the book example.

RESULTS COMPARISON

REINFORCED CONCRETE RECTANGULAR BEAM DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Main Reinforcement (mm^2)	1570	1567	0.1
Maximum Area of Reinforcement (mm^2)	12000	12000	0
Area of Shear Reinforcement(mm^2/m)	785	783.5	0.1

CONCLUSION

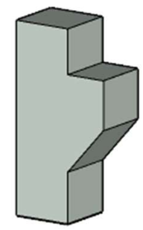
The ECPLUS results are exactly matching with the “Reinforced Concrete Analysis and Design by S.S. Ray” book results.

EXAMPLE 17.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE CORBEL DESIGN

MODULE NAME: ECPLUS REINFORCED CONCRETE CORBEL DESIGN

STANDARD: EUROPEAN

REFERENCE: MANUAL CALCULATION



GENERAL DESCRIPTION

Rectangular Concrete Corbel is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Moment, Shear, Concrete and Reinforcement properties are aligned in both program and manual calculation. Key results such as Area of Main Reinforcement, Area of One Link Provided and Crack Width are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

REINFORCED CONCRETE CORBEL DESIGN– MANUAL CALCULATION

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Main Reinforcement (mm^2)	619.1	619.098	0
Area of One Link Provided(mm^2)	113.1	113.097	0
Crack Width (mm)	4.68	4.68	0

CONCLUSION

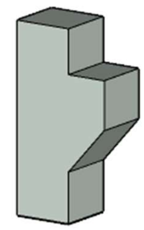
The ECPLUS results are exactly matching with the manually calculated results.

EXAMPLE 18.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE CORBEL DESIGN

MODULE NAME: ECPLUS REINFORCED CONCRETE CORBEL DESIGN

STANDARD: AMERICAN (SI)

REFERENCE: MANUAL CALCULATION



GENERAL DESCRIPTION

Rectangular Concrete Corbel is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Moment, Shear, Concrete and Reinforcement properties are aligned in both program and manual calculation. Key results such as Area of Main Reinforcement Required, Minimum Area of Reinforcement and Area of Horizontal Reinforcement Required are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

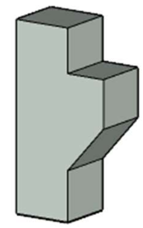
REINFORCED CONCRETE CORBEL DESIGN– MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Area of Main Reinforcement Required (mm^2)	403	405.818	0.7
Minimum Area of Reinforcement(mm^2)	270.7	270.652	0
Area of Horizontal Reinforcement Required(mm^2)	129.5	130.445	0.7

CONCLUSION

The ECPLUS results are exactly matching with the manually calculated results.

EXAMPLE 19.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE CORBEL DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE CORBEL DESIGN

STANDARD: AMERICAN (IMPERIAL)

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Rectangular Concrete Corbel is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Moment, Shear, Concrete and Reinforcement properties are aligned in both program and manual calculation. Key results such as Area of Main Reinforcement Required, Minimum Area of Reinforcement and Area of Horizontal Reinforcement Required are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

REINFORCED CONCRETE CORBEL DESIGN– MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Area of Main Reinforcement Required (in^2)	0.536	0.536	0
Minimum Area of Reinforcement(in^2)	0.536	0.536	0
Area of Horizontal Reinforcement Required(in^2)	0.241	0.241	0

CONCLUSION

The ECPLUS results are exactly matching with the manually calculated results.

EXAMPLE 20.1: VALIDATION REPORT FOR ECPLUS MASONRY COLUMN DESIGN

MODULE NAME: ECPLUS MASONRY COLUMN DESIGN

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Masonry Column of size 3000 x 500 mm is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Masonry Properties, Construction and Design Loads are aligned in both program and manual calculation. Key results such as Slenderness Limit and Allowable Load are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

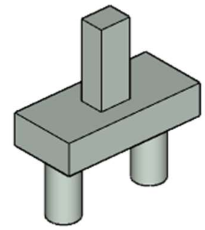
MASONRY COLUMN DESIGN – MANUAL CALCULATION

Output Parameter	ECPLUS	BOOK	DIFFERENCE (%)
Slenderness Limit	7.500	7.500	0
Allowable Load (kN)	159.700	159.677	0

CONCLUSION

The ECPLUS results are exactly matching with the manual calculations.

EXAMPLE 21.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE TWO PILES PILECAP DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE TWO PILES PILECAP DESIGN

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Reinforced Concrete Pilecap with two piles of size 2300 x 800 mm is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Design Load, Material properties and Factors are aligned in both program and manual calculation. Key results such as Area of Reinforcement and Design Concrete Shear Stress are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

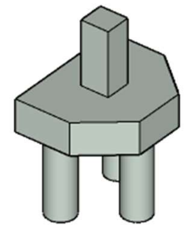
REINFORCED CONCRETE TWO PILES PILECAP DESIGN – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Area of Reinforcement Required (mm^2/m)	2093.4	2096.377	0.1
Design Concrete Shear Stress (N/mm^2)	0.463	0.463	0

CONCLUSION

The ECPLUS results are exactly matching with the manual calculation results.

EXAMPLE 22.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE THREE PILES PILECAP DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE THREE PILES PILECAP DESIGN

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Reinforced Concrete Pilecap with three piles of size 1300 x 1200 mm is modeled in ECPLUS Design module and manual calculation is performed to validate and verify the results. Design Load, Material properties and Factors are aligned in both program and manual calculation. Key results such as Area of Reinforcement and Design Concrete Shear Stress are computed with the manual calculation results and tabulated below.

RESULTS COMPARISON

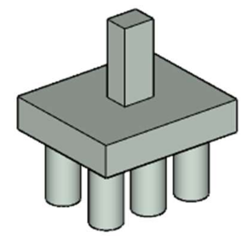
REINFORCED CONCRETE THREE PILES PILECAP DESIGN – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Area of Reinforcement Required (mm^2/m)	2079	2078.967	0
Design Concrete Shear Stress (N/mm^2)	0.672	0.672	0

CONCLUSION

The ECPLUS results are exactly matching with the manual calculation results.

EXAMPLE 23.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETEFOUR PILES PILECAP DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE FOUR PILES PILECAP DESIGN

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Reinforced Concrete Pilecap with four piles of size 2300 x 2300 mm is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Design Load, Material properties and Factors are aligned in both program and manual calculation. Key results such as Area of Reinforcement and Design Concrete Shear Stress are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

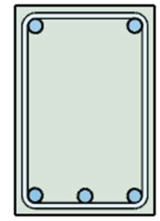
REINFORCED CONCRETE FOUR PILES PILECAP DESIGN – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Area of Reinforcement Required (mm^2/m)	2242.2	2242.152	0
Design Concrete Shear Stress (N/mm^2)	0.326	0.326	0

CONCLUSION

The ECPLUS results are exactly matching with the manual calculation results.

EXAMPLE 24.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN

STANDARD: BRITISH

REFERENCE: REINFORCED CONCRETE ANALYSIS AND DESIGN BY S.S. RAY

GENERAL DESCRIPTION

The Example problem given in “Reinforced Concrete Analysis and Design by S.S. Ray” book, Example: 2.1(Page no: 65) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size 300 x 500 mm is modeled. Concrete, Reinforcement and Loading are applied as given in the example problem. The Key result such as Area of Tension Reinforcement, Shear Resistance and Area of shear reinforcement computed and validated with the book example.

RESULTS COMPARISON

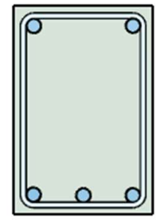
REINFORCED CONCRETE RECTANGULAR BEAM DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Tension Reinforcement (mm^2)	1415.1	1413	0.1
Shear Resistance (N/mm^2)	0.737	0.74	0.4
Area of Shear Reinforcement(mm^2/m)	300	300	0

CONCLUSION

The ECPLUS results are exactly matching with the “Reinforced Concrete Analysis and Design by S.S. Ray” book results.

EXAMPLE 25.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN

STANDARD: EUROPEAN

REFERENCE: WORKED EXAMPLES TO EUROCODE2 BY CH GOODCHILD

GENERAL DESCRIPTION

The Example problem given in "Worked Examples to Eurocode2 by CH Goodchild" book, Example 4.1 (Page no: 98) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size 300 x 450 mm is modeled. Concrete, Reinforcement and Loading are applied as given in the example problem. Area of Tension Reinforcement and Area of shear reinforcement are computed and validated with the book example.

RESULTS COMPARISON

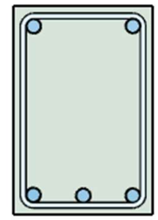
REINFORCED CONCRETE RECTANGULAR BEAM DESIGN –BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Tension Reinforcement (mm^2)	1217.4	1255	3.0
Area of Shear Reinforcement(mm^2/m)	432.7	429	0.9

CONCLUSION

The ECPLUS results are within acceptable comparison with "Worked Examples to Eurocode2 by CH Goodchild" book results.

EXAMPLE 26.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN

STANDARD: AMERICAN (SI)

REFERENCE: STRUCTURAL CONCRETE BY M.NADIM HASSOUN & AKTHEM AL-MANASEER

GENERAL DESCRIPTION

The Example problem given in "Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer" book, Example 4.13 (Page no: 162), is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size 250 x 600 mm is modeled. Moment, Concrete and Reinforcement properties are applied as given in the example problem. Area of Tension Reinforcement provided is computed and validated with the book example.

RESULTS COMPARISON

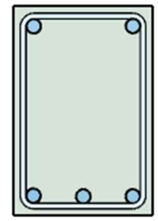
REINFORCED CONCRETE RECTANGULAR BEAM DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Tension Reinforcement (mm^2)	1753.5	1772	1.0

CONCLUSION

The ECPLUS result is exactly matching with the "Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer"book results.

EXAMPLE 26.2: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN

STANDARD: AMERICAN (SI)

REFERENCE: STRUCTURAL CONCRETE BY M.NADIM HASSOUN & AKTHEM AL-MANASEER

GENERAL DESCRIPTION

The Example problem given in "Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer" book, Example 8.7 (Page no:293), is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size 350 x 550 mm is modeled. Concrete, Reinforcement and Loading are applied as given in the example problem. Concrete and Reinforcement Shear Strength are computed and validated with the book example.

RESULTS COMPARISON

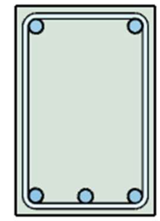
REINFORCED CONCRETE RECTANGULAR BEAM DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Concrete Shear Strength (kN)	127.3	130	2.1
Reinforcement Shear Strength (kN)	110.3	107.65	2.5

CONCLUSION

The ECPLUS results are within acceptable comparison with" Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer" results.

EXAMPLE 27.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN

STANDARD: AMERICAN (IMPERIAL)

REFERENCE: STRUCTURAL CONCRETE BY M.NADIM HASSOUN & AKTHEM AL-MANASEER

GENERAL DESCRIPTION

The Example problem given in "Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer" book, Example 4.11 (Page no: 158), is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size 20 x 30 in is modeled. Concrete, Reinforcement and Loading are applied as given in the example problem. Area of Tension Reinforcement required is computed and validated with the book example.

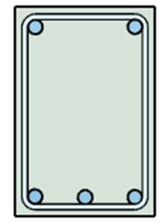
RESULTS COMPARISON

REINFORCED CONCRETE RECTANGULAR BEAM DESIGN – BOOK RESULT

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Tension Reinforcement (in^2)	7.9	7.98	1.0

CONCLUSION

The ECPLUS results are exactly matching with the"Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer"book results.



EXAMPLE 27.2: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN

MODULE NAME: ECPLUS REINFORCED CONCRETE RECTANGULAR BEAM DESIGN

STANDARD: AMERICAN (IMPERIAL)

REFERENCE: STRUCTURAL CONCRETE BY M.NADIM HASSOUN & AKTHEM AL-MANASEER

GENERAL DESCRIPTION

The Example problem given in “Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer” book, Example 8.2 (Page no: 270), is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size 14 x 25 in, is modeled. Concrete, Reinforcement and Loading are applied as given in the example problem. Concrete Shear Strength is computed and validated with the book example.

RESULTS COMPARISON

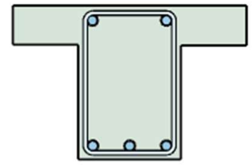
REINFORCED CONCRETE RECTANGULAR BEAM DESIGN – BOOK RESULT

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Concrete Shear Strength (kips)	25.9	25.88	0.1

CONCLUSION

The ECPLUS result is exactly matching with the “Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer”book results.

EXAMPLE 28.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN

STANDARD: BRITISH

REFERENCE: REINFORCED CONCRETE ANALYSIS AND DESIGN BY S.S. RAY

GENERAL DESCRIPTION

The Example problem given in "Reinforced Concrete Analysis and Design by S.S. Ray" book, Example 2.2 (Page no: 73) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size as per book is modeled. Moment, Shear, Concrete and Reinforcement properties are applied as given in the example problem. Area of Tension Reinforcement is computed and validated with the book example.

RESULTS COMPARISON

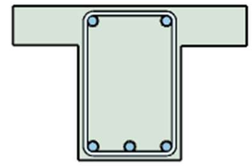
REINFORCED CONCRETE FLANGED BEAM DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Tension Reinforcement (mm^2)	3248.9	3245	0.1

CONCLUSION

The ECPLUS result is exactly matching with the "Reinforced Concrete Analysis and Design by S.S. Ray" book results.

EXAMPLE 28.2: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN

STANDARD: BRITISH

REFERENCE: REINFORCED CONCRETE ANALYSIS AND DESIGN BY S.S. RAY

GENERAL DESCRIPTION

The Example problem given in “Reinforced Concrete Analysis and Design by S.S. Ray” book, Example 2.2 (Page no: 73) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size as per book is modeled. Moment, Shear, Concrete and Reinforcement properties are applied as given in the example problem. Shear Resistance is computed and validated with the book example.

RESULTS COMPARISON

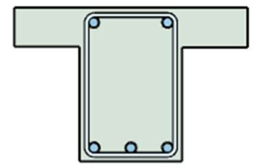
REINFORCED CONCRETE FLANGED BEAM DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Shear Resistance (N/mm^2)	2.717	2.716	0

CONCLUSION

The ECPLUS result is exactly matching with the “Reinforced Concrete Analysis and Design by S.S. Ray” book results.

EXAMPLE 29.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN

STANDARD: EUROPEAN

REFERENCE: WORKED EXAMPLES TO EUROCODE2 BY CH GOODCHILD

GENERAL DESCRIPTION

The Example problem given in “Worked Examples to Eurocode2 by CH Goodchild” book, Example 4.2(Page no: 104) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size as per book is modeled. Dimension, Moment, Shear, Concrete and Reinforcement properties are applied as given in the example problem. The Key result Area of Tension Reinforcement and Area of shear reinforcement computed and validated with the book example.

RESULTS COMPARISON

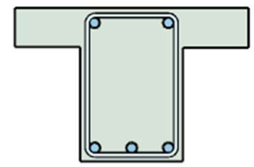
REINFORCED CONCRETE FLANGED BEAM DESIGN –BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Tension Reinforcement (mm^2)	1008.5	1012	0.3
Area of Shear Reinforcement(mm^2/m)	764.7	760	0.6

CONCLUSION

The ECPLUS results are exactly matching with the “Worked Examples to Eurocode2 by CH Goodchild” book results.

EXAMPLE 30.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN

STANDARD: AMERICAN (SI)

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Reinforced Concrete Flanged Beam of size 600 x 450 mm is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Design Load, Material properties and Factors are aligned in both program and manual calculation. Key results such as Area of Reinforcement Required, Maximum Area of Reinforcement and Area of Shear Reinforcement are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

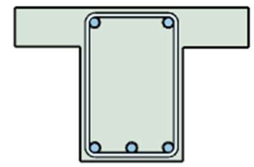
REINFORCED CONCRETE FLANGED BEAM DESIGN – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Area of Tension Reinforcement (mm^2)	951.4	955.631	0.4
Maximum Area of Reinforcement (mm^2)	3192.5	3183.954	0.3
Area of Shear Reinforcement(mm^2/m)	6.81	6.82	0.1

CONCLUSION

The ECPLUS results are exactly matching with the manual calculation results.

EXAMPLE 31.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN

STANDARD: AMERICAN (IMPERIAL)

REFERENCE: STRUCTURAL CONCRETE BY M.NADIM HASSOUN & AKTHEM AL-MANASEER

GENERAL DESCRIPTION

The Example problem given in “Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer” book, Example 4.7 (Page no: 153), is used to validate and verify the results of ECPLUS.

Reinforced Flanged Beam of size as per book example is modeled. Moment, Concrete and Reinforcement properties are applied as given in the example problem. Area of Tension Reinforcement and Maximum Area of Reinforcement are computed and validated with the book example.

RESULTS COMPARISON

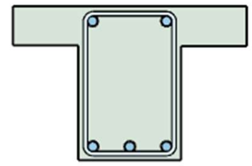
REINFORCED CONCRETE FLANGED BEAM DESIGN – BOOK RESULT

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Area of Tension Reinforcement (in^2)	4.9	4.74	3.3
Maximum Area of Reinforcement (in^2)	7.1	7.06	0.6

CONCLUSION

The ECPLUS results are within acceptable comparison with “Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer” book results.

EXAMPLE 31.2: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE FLANGED BEAM DESIGN

STANDARD: AMERICAN (IMPERIAL)

REFERENCE: STRUCTURAL CONCRETE BY M.NADIM HASSOUN & AKTHEM AL-MANASEER

GENERAL DESCRIPTION

The Example problem given in "Structural Concrete by M.Nadim Hassoun &Akthem Al-Manaseer" book, Example 8.2,(Page no: 270), is used to validate and verify the results of ECPLUS.

Reinforce Flanged Beam of size as per book example is modeled. Shear, Concrete and Reinforcement properties are applied as given in the example problem. Concrete Shear Strength is computed and validated with the book example.

RESULTS COMPARISON

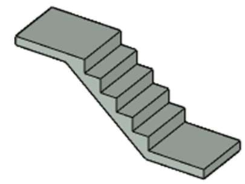
REINFORCED CONCRETE FLANGED BEAM DESIGN – BOOK RESULT

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Concrete Shear Strength (kips)	25.9	25.88	0.07

CONCLUSION

The ECPLUS result is exactly matching with the "Structural Concrete by M.Nadim Hassoun & Akthem Al-Manaseer" book results.

EXAMPLE 32.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE STAIRCASE DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE STAIRCASEDESIGN

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Reinforced Concrete Staircase of size 250mm thread and 160 mm rise is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Dimensions, Loading and Factors are aligned in both program and manual calculation. Key results such as Design Moment and Design Shear Force are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

WAIST SLAB –MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Design Moment (kNm/m)	25	25.016	0.1

UPPER LANDING – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Design Moment (kNm/m)	28.7	28.685	0.1
Design Shear Force (kN)	47.1	47.089	0

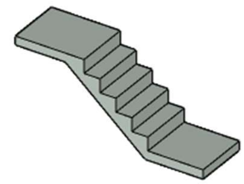
LOWER LANDING – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Design Moment (kNm/m)	13.3	13.341	0.3
Design Shear Force (kN)	36.1	36.102	0

CONCLUSION

The ECPLUS results are exactly matching with the manually calculated results.

EXAMPLE 33.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE STAIRCASE DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE STAIRCASEDESIGN

STANDARD: EUROPEAN

REFERENCE: MANUAL CALCULATION

GENERAL DESCRIPTION

Reinforced Concrete Staircase of size 250mm thread and 160 mm rise is modeled in ECPLUS Design module and Manual calculation is performed to validate and verify the results. Dimensions, Loading and Factors are aligned in both program and manual calculation. Key results such as Design Moment and Design Shear Force are compared with the manual calculation results and tabulated below.

RESULTS COMPARISON

WAIST SLAB –MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Design Moment (kNm/m)	27.71	27.709	0

UPPER LANDING – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Design Moment (kNm/m)	22.48	22.481	0
Design Shear Force (kN)	40.74	40.738	0

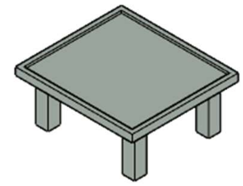
LOWER LANDING – MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Design Moment (kNm/m)	10.46	10.456	0
Design Shear Force (kN)	31.23	31.323	0.3

CONCLUSION

The ECPLUS results are exactly matching with the manually calculated results.

EXAMPLE 34.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE SLAB DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE SLAB DESIGN

STANDARD: BRITISH

REFERENCE: REINFORCED CONCRETE ANALYSIS AND DESIGN BY S.S. RAY

GENERAL DESCRIPTION

The Example problem given in "Reinforced Concrete Analysis and Design by S.S. Ray" book, Example 3.1 (page no: 120) is used to validate and verify the results of ECPLUS.

Reinforced Concrete Slab of size 6.3 x 4.3 m is modeled. Dimensions, Loading and Factors are applied as given in the example problem. The Key result Design Shear Force, Hogging & Sagging Moment in Width and Length directions are computed and validated with the book example.

RESULTS COMPARISON

WIDTH DIRECTION – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Design Moment - Sagging (kNm)	28.9	28.8	0.3
Design Moment – Hogging (kNm)	38.5	38.5	0
Design Shear Force (kN)	76.3	75.7	0.8

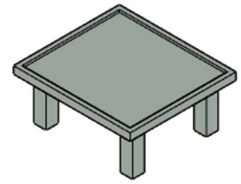
LENGTH DIRECTION – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Design Moment - Sagging (kNm)	17.8	17.8	0
Design Moment – Hogging (kNm)	23.7	23.7	0
Design Shear Force (kN)	56.8	56.8	0

CONCLUSION

The ECPLUS results are exactly matching with the "Reinforced Concrete Analysis and Design by S.S. Ray" book results.

EXAMPLE 35.1: VALIDATION REPORT FOR ECPLUS REINFORCED CONCRETE SLAB DESIGN



MODULE NAME: ECPLUS REINFORCED CONCRETE SLAB DESIGN

STANDARD: EUROPEAN

REFERENCE: WORKED EXAMPLES TO EUROCODE2 BY CH GOODCHILD

GENERAL DESCRIPTION

The Example problem given in "Worked Examples to Eurocode2 by CH Goodchild" book, Example 3.2 (Page no: 40) is used to validate and verify the results of ECPLUS.

One-way Reinforced Concrete Slab of size 5975 mm is modeled. Concrete, Reinforcement and Loading are applied as given in the example problem. Design Moment and Shear Force are computed and validated with the book example.

RESULTS COMPARISON

LENGTH DIRECTION – BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Design Moment - Sagging (kNm)	37.84	37.84	0
Design Moment – Hogging (kNm)	37.84	37.84	0

SHEAR FORCE – BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Continuous Edge (kN)	44.19	44.1	0.2

CONCLUSION

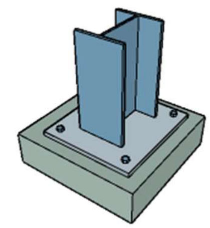
The ECPLUS results are exactly matching with "Worked Examples to Eurocode2 by CH Goodchild" book results.

EXAMPLE 36.1: VALIDATION REPORT FOR ECPLUS FIXED BASE PLATE DESIGN

MODULE NAME: ECPLUS FIXED BASE PLATE DESIGN

STANDARD: BRITISH

REFERENCE: JOINTS IN STEEL CONNECTION – MOMENT CONNECTION BY THE BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION LTD.



GENERAL DESCRIPTION

The Example problem given in "Joints in Steel Connection – Moment Connection by The British Constructional Steelwork Association Ltd." book, Example: 6.10 (Page no: 99) is used to validate and verify the results of ECPLUS.

Fixed Baseplate of section 305 x 305 x 118 is modeled. Column, Base plate, Loading and Bolt and Concrete Properties are applied as given in the example problem. The Key result such as Required Thickness of Baseplate, Force acting per bolt and Weld force are computed and validated with the book example.

RESULTS COMPARISON

FIXED BASE PLATE DESIGN –MANUAL CALCULATION

Output Parameter	ECPLUS	MANUAL CALCULATION	DIFFERENCE abs (%)
Required Thickness of Baseplate (mm)	49	48.8	0.4
Force acting per Bolt (kN)	168.844	170	0.6
Weld Force (kN/mm)	2.05	2.06	0.4

CONCLUSION

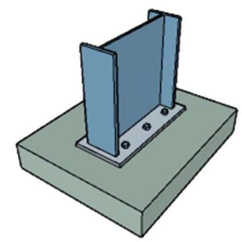
The ECPLUS results are within acceptable range with the "Joints in Steel Connection – Moment Connection by The British Constructional Steelwork Association Ltd." results.

EXAMPLE 37.1: VALIDATION REPORT FOR ECPLUS PINNED BASE PLATE DESIGN

MODULE NAME: ECPLUS PINNED BASE PLATE DESIGN

STANDARD: BRITISH

REFERENCE: MANUAL CALCULATION



GENERAL DESCRIPTION

The Example problem given in “Joints in Steel Connection – Simple Connection by The British Constructional Steelwork Association Ltd.” book, Example: 1 (Page no: 274) is used to validate and verify the results of ECPLUS.

Fixed Baseplate of section 305 x 305 x 137 is modeled. Column, Base plate, Loading and Bolt and Concrete Properties are applied as given in the example problem. Required Thickness of Baseplate is computed and validated with the book example.

RESULTS COMPARISON

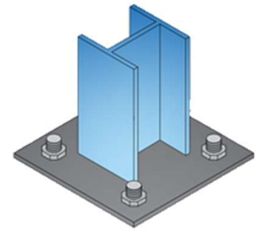
FIXED BASE PLATE DESIGN – JOINTS IN STEEL CONNECTION (SIMPLE CONNECTION)

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Required Thickness of Base plate (mm)	46	45.9	0.2

CONCLUSION

The ECPLUS results is exactly matching with “Joints in Steel Connection – Simple Connection by The British Constructional Steelwork Association Ltd.” book results.

EXAMPLE 38.1: VALIDATION REPORT FOR ECPLUS COLUMN BASE PLATE FIXED NEW VERSION



MODULE NAME: ECPLUS COLUMN BASE PLATE FIXED NEW VERSION

STANDARD: AMERICAN (IMPERIAL)

REFERENCE: BASE PLATE AND ANCHOR ROD DESIGN BY JAMES M. FISHER AND LAWRENCE A. KLOIBER

GENERAL DESCRIPTION

The Example problem given in “Base Plate and Anchor Rod Design by James M. Fisher and Lawrence A. Kloiber” book, Example: 4.6(Page no: 37), by LRFD method is used to validate and verify the results of ECPLUS.

Column Base Plate of size 19 x 19 in, is modeled. Base plate, Pedestal, Loads, Steel and Concrete Properties are applied as given in the example problem. The Key result such as Bearing Pressure per Unit Width and Required Plate Thickness are computed and validated with the book example.

RESULTS COMPARISON

COLUMN BASE PLATE FIXED NEW VERSION–BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Bearing Pressure per Unit Width (kips / in)	26.9	26.9	0
Required Plate Thickness – Compression (in)	1.36	1.36	0

CONCLUSION

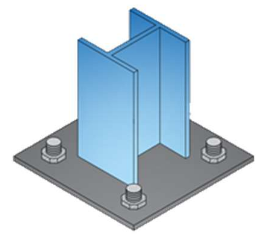
The ECPLUS results are exactly matching with the “Base Plate and Anchor Rod Design by James M. Fisher and Lawrence A. Kloiber” book results.

EXAMPLE 38.2: VALIDATION REPORT FOR ECPLUS COLUMN BASE PLATE FIXED NEW VERSION

MODULE NAME: ECPLUS COLUMN BASE PLATE FIXED NEW VERSION

STANDARD: AMERICAN (IMPERIAL)

REFERENCE: BASE PLATE AND ANCHOR ROD DESIGN BY JAMES M. FISHER AND LAWRENCE A. KLOIBER



GENERAL DESCRIPTION

The Example problem given in “Base Plate and Anchor Rod Design by James M. Fisher and Lawrence A. Kloiber” book, Example: 4.6(Page no: 37), ASD method is used to validate and verify the results of ECPLUS.

Column Base Plate of size 19 x 19 in is modeled. Base plate, Pedestal, Loads, Steel and Concrete Properties are applied as given in the example problem. The Key result such as Bearing Pressure per Unit Width and Required Plate Thickness are computed and validated with the book example.

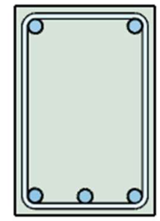
RESULTS COMPARISON

COLUMN BASE PLATE FIXED NEW VERSION–BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Bearing Pressure per Unit Width (kips / in)	18.6	18.6	0
Required Plate Thickness – Compression (in)	1.39	1.39	0

CONCLUSION

The ECPLUS results are exactly matching with the “Base Plate and Anchor Rod Design by James M. Fisher and Lawrence A. Kloiber” book results.



EXAMPLE 39.1: VALIDATION REPORT FOR ECPLUS CRACK WIDTH CALCULATION

MODULE NAME: ECPLUS CRACK WIDTH CALCULATION

STANDARD: BRITISH

REFERENCE: REINFORCED CONCRETE ANALYSIS AND DESIGN BY S.S. RAY

GENERAL DESCRIPTION

The Example problem given in “Reinforced Concrete Analysis and Design by S.S. Ray” book, Example: 2.1(Page no: 65) is used to validate and verify the results of ECPLUS.

Rectangular Concrete Beam of size 300 x 500 mm is modeled. Concrete, Reinforcement and Loading are applied as given in the example problem. Design Surface Crack Width is computed and validated with the book example.

RESULTS COMPARISON

REINFORCED CONCRETE RECTANGULAR BEAM DESIGN – S.S. RAY BOOK

Output Parameter	ECPLUS	BOOK	DIFFERENCE abs (%)
Design Surface Crack Width (mm)	0.255	0.27	5.55

Note:

In the book example, modulus of concrete is directly taken whereas, In ECPLUS we have calculated modulus of elasticity of concrete based on concrete grade. Therefore, Crack width on book is slightly on higher side.

CONCLUSION

The ECPLUS result is in allowable range with the “Reinforced Concrete Analysis and Design by S.S. Ray” book results.