AUTODESK UNIVERSITY 2014

Structural Design inside a Family

Florian Neumayr – A2K Technologies, New Zealand

SE5004-L

The collaboration features of Revit Structure software with Structural Analysis software were widely presented and experienced over the last years. However, despite all this featured software, many structural engineers still stay with their Microsoft Excel spreadsheets and their common pencil-and-paper routine. Not all software supports all codes, and very often it is faster to use those light spreadsheets than it is to work with heavy analysis software. This workshop will demonstrate how you can implement those spreadsheets into the parameter fields of a Revit software family, making use of the formula capabilities of the Revit software parameter and of nested families in order to make Revit software tasty for engineers. We will present examples that will include a reinforced-concrete footing design, a concrete retaining wall, timber joists designs, and a timber joist cantilever design. The workshop will also cover the documentation features and possibilities.

Learning Objectives

At the end of this class, you will be able to:

- Discover the capabilities of the Revit families for structural engineers
- Discover how Revit software families can simplify the workflow and kill repetition
- Implement the country code into Revit and design around clashes visually.
- Discover what Excel can do and Revit software can do

About the Speaker

Florian Neumayr received postgraduate degrees in business and engineering with majors in product lifecycle management (PLM) and controlling in Germany. He offers 15 years of outstanding industry experience in the architectural and structural business for multistory buildings and warehouses. He has lived in New Zealand for the last 9 years, and his big passion for Building Information Modeling (BIM) leads him to speak and teach internationally. He has been working for the last 4 years as consultant for a major Autodesk Reseller in Asia Pacific, teaching and consulting multiple generations regarding a diversity of projects ranging from $100k to $1 billion. His focus as an application engineer is to optimize the computer as a communications tool. His expertise is to realize workflow studies that offer the flexibility to make room for options and changes while reducing costly repetition.
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1. Let’s discover the workflow

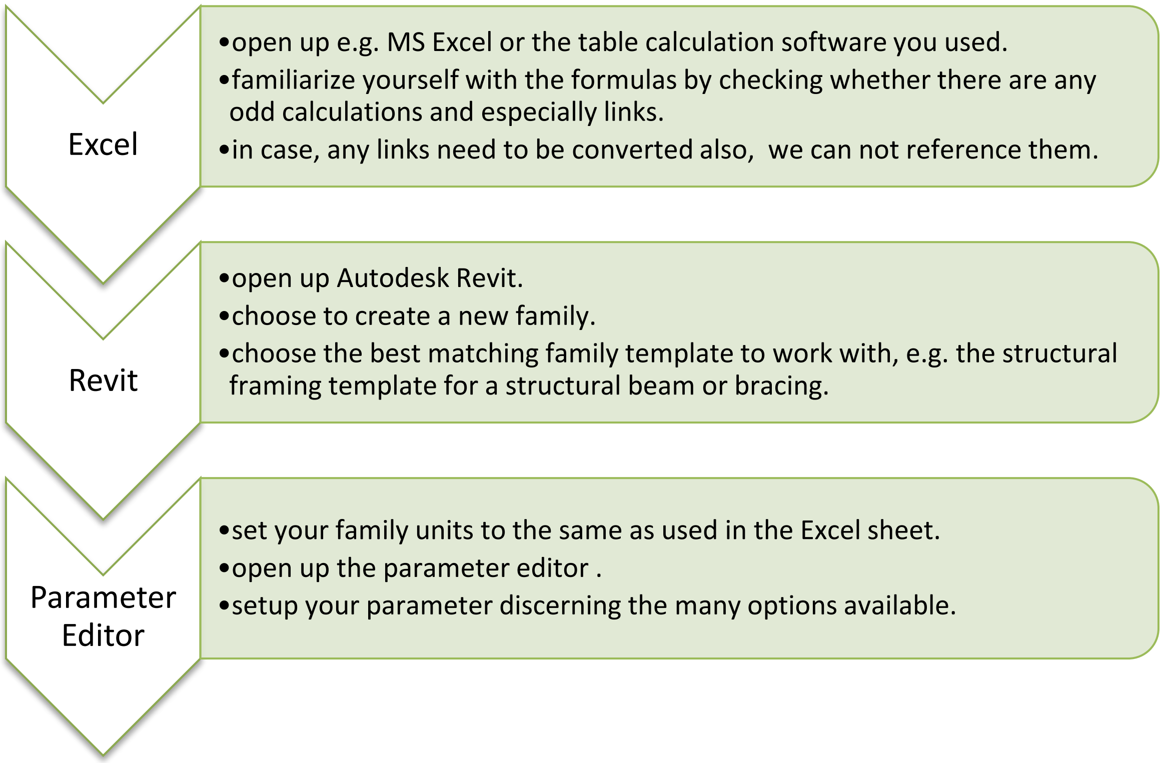
A quick note up front:

The lab will guide you through the topic through six exercises demonstrating the workflow from setting up analytical families till completing an example design of a deck. The content is multi-dimensional, allowing beginners to simply practice the adoption of an Excel formula till offering engineering enthusiasts to work with deep complex formulas. So, if you are not an engineer being familiar with similar Excel formulas on a daily basis, just simply enjoy the brain frying options and capabilities Revit offers.

Tip:

The families presented cover structural subjects. However, any engineer of any discipline can adopt the process discussed hence any formula can be implemented into any family. So this is not only for structural engineers but also for mechanical, electrical, plumbing, and environmental or any building engineers.

The workflow and suggested sequence:



Excel

- open up e.g. MS Excel or the table calculation software you used.
- familiarize yourself with the formulas by checking whether there are any odd calculations and especially links.
- in case, any links need to be converted also, we can not reference them.

Revit

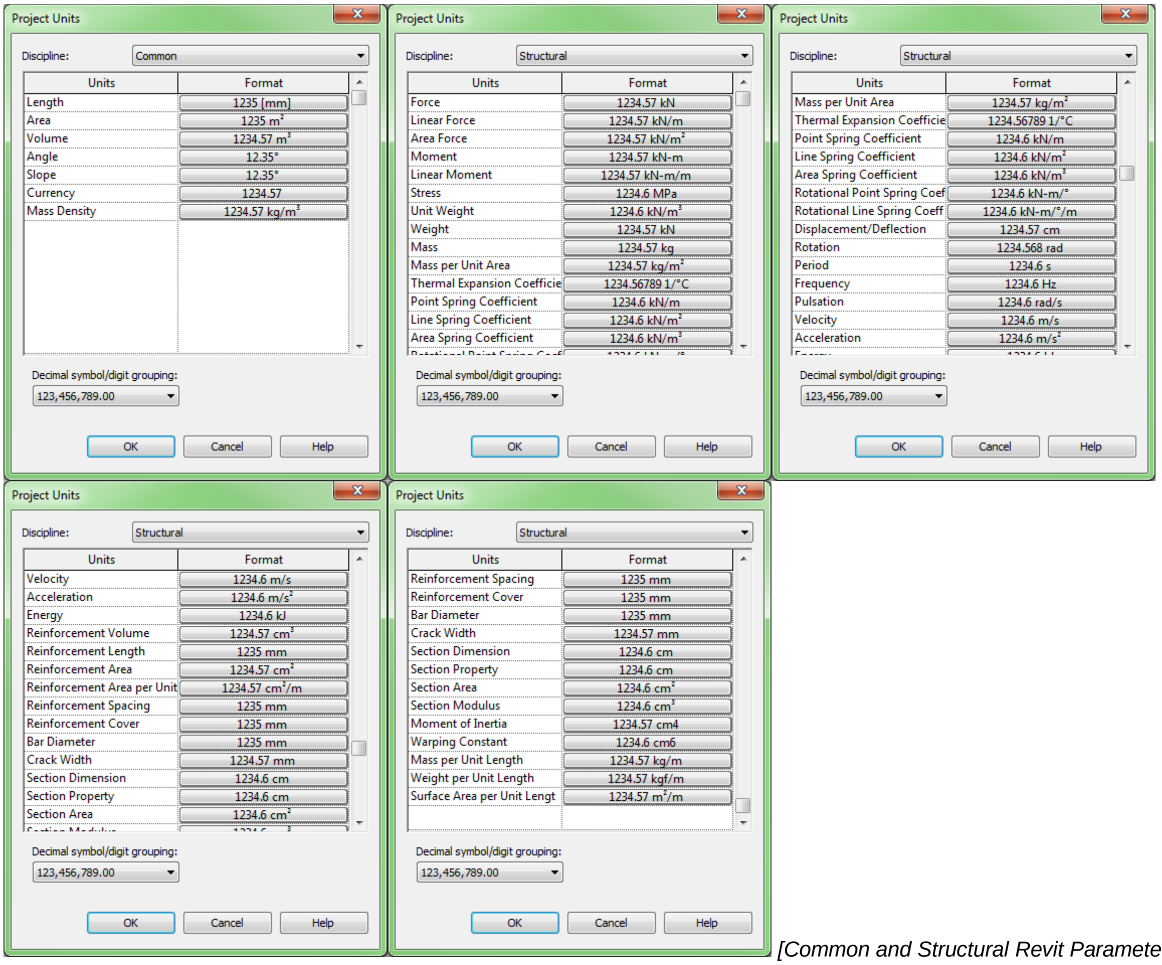
- open up Autodesk Revit.
- choose to create a new family.
- choose the best matching family template to work with, e.g. the structural framing template for a structural beam or bracing.

Parameter Editor

- set your family units to the same as used in the Excel sheet.
- open up the parameter editor .
- setup your parameter discerning the many options available.

Tip:

Revit supplies us with several units to setup. See the ‘Manage’ tab in the ribbon to access them.



Discipline: Common

Units	Format
Length	1235 [mm]
Area	1235 m^2
Volume	1234.57 m^3
Angle	12.35°
Slope	12.35°
Currency	1234.57
Mass Density	1234.57 kg/m^3

Decimal symbol/digit grouping: 123,456,789.00

Discipline: Structural

Units	Format
Force	1234.57 kN
Linear Force	1234.57 kN/m
Area Force	1234.57 kN/m^2
Moment	1234.57 kN-m
Linear Moment	1234.57 kN-m/m
Stress	1234.6 MPa
Unit Weight	1234.6 kN/m^3
Weight	1234.57 kN
Mass	1234.57 kg
Mass per Unit Area	1234.57 kg/m^2
Thermal Expansion Coefficie	1234.56789 1/°C
Point Spring Coefficient	1234.6 kN/m
Line Spring Coefficient	1234.6 kN/m^2
Area Spring Coefficient	1234.6 kN/m^3

Decimal symbol/digit grouping: 123,456,789.00

Discipline: Structural

Units	Format
Mass per Unit Area	1234.57 kg/m^2
Thermal Expansion Coefficie	1234.56789 1/°C
Point Spring Coefficient	1234.6 kN/m
Line Spring Coefficient	1234.6 kN/m^2
Area Spring Coefficient	1234.6 kN/m^3
Rotational Point Spring Coef	1234.6 kN-m/°
Rotational Line Spring Coeff	1234.6 kN-m/°/m
Displacement/Deflection	1234.57 cm
Rotation	1234.568 rad
Period	1234.6 s
Frequency	1234.6 Hz
Pulsation	1234.6 rad/s
Velocity	1234.6 m/s
Acceleration	1234.6 m/s^2

Decimal symbol/digit grouping: 123,456,789.00

Discipline: Structural

Units	Format
Velocity	1234.6 m/s
Acceleration	1234.6 m/s^2
Energy	1234.6 kJ
Reinforcement Volume	1234.57 cm^3
Reinforcement Length	1235 mm
Reinforcement Area	1234.57 cm^2
Reinforcement Area per Unit	1234.57 cm^2/m
Reinforcement Spacing	1235 mm
Reinforcement Cover	1235 mm
Bar Diameter	1235 mm
Crack Width	1234.57 mm
Section Dimension	1234.6 cm
Section Property	1234.6 cm
Section Area	1234.6 cm^2

Decimal symbol/digit grouping: 123,456,789.00

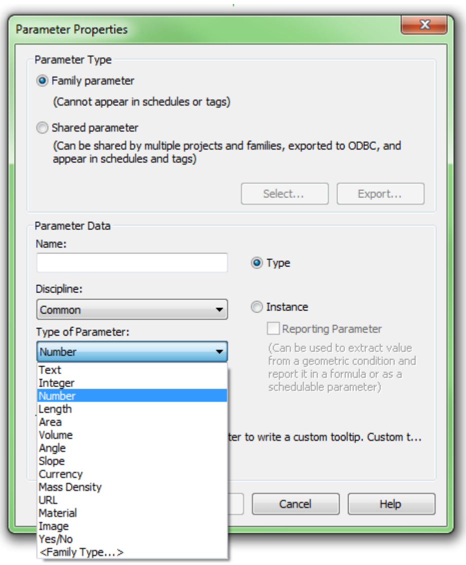
Discipline: Structural

Units	Format
Reinforcement Spacing	1235 mm
Reinforcement Cover	1235 mm
Bar Diameter	1235 mm
Crack Width	1234.57 mm
Section Dimension	1234.6 cm
Section Property	1234.6 cm
Section Area	1234.6 cm^2
Section Modulus	1234.6 cm^3
Moment of Inertia	1234.57 cm4
Warping Constant	1234.6 cm6
Mass per Unit Length	1234.57 kg/m
Weight per Unit Length	1234.57 kgf/m
Surface Area per Unit Lengt	1234.57 m^2/m

Decimal symbol/digit grouping: 123,456,789.00

[Common and Structural Revit Parameter]

Hence, Revit offers us to setup parameter several different ways. ‘Family’ parameter can be easier and faster but cannot be scheduled later. ‘Shared’ parameters require a shared parameter file to be setup prior, which can take longer. However, ‘shared’ parameter can be scheduled later. We cannot mix ‘type’ and ‘instance’ parameter in one formula; hence we need to setup all the parameter the same way. ‘Type’ parameter work globally, while ‘instance’ parameter work locally on the particular instance only. ‘Instance’ parameters offer a greater flexibility, I found so far. ‘Reporting’ parameter can be used as well to extract geometric conditions when putting the family in place. ‘Project’ parameter don’t allow to perform calculations as these are being added on at project level and work on project level only.



Parameter Properties

Parameter Type

● Family parameter

(Cannot appear in schedules or tags)

○ Shared parameter

(Can be shared by multiple projects and families, exported to ODBC, and appear in schedules and tags)

Parameter Data

Name:

● Type

Discipline: Common

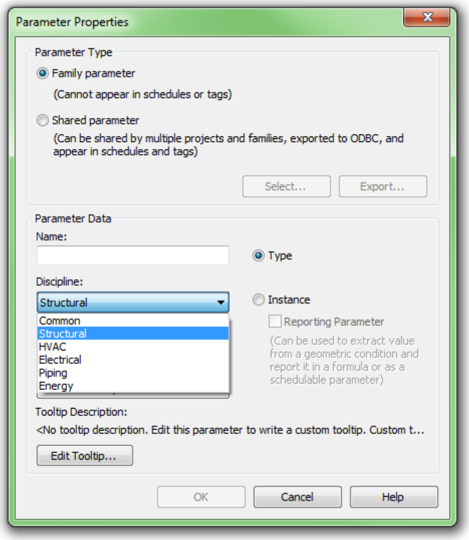
○ Instance

Type of Parameter: Number

□ Reporting Parameter

(Can be used to extract value from a geometric condition and report it in a formula or as a schedulable parameter)

ter to write a custom tooltip. Custom t...



Parameter Properties

Parameter Type

● Family parameter

(Cannot appear in schedules or tags)

○ Shared parameter

(Can be shared by multiple projects and families, exported to ODBC, and appear in schedules and tags)

Parameter Data

Name:

● Type

Discipline: Structural

○ Instance

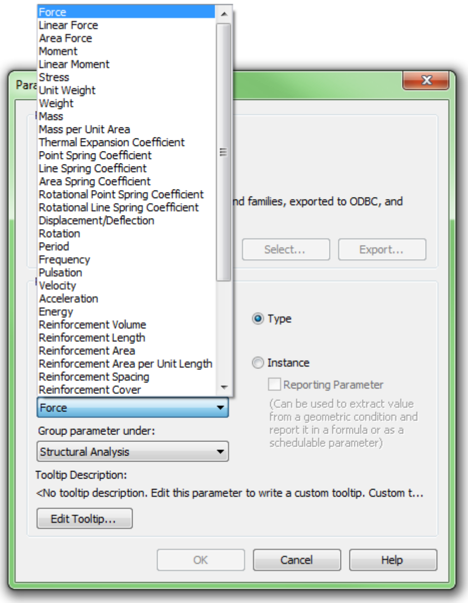
□ Reporting Parameter

(Can be used to extract value from a geometric condition and report it in a formula or as a schedulable parameter)

Tooltip Description:

<No tooltip description. Edit this parameter to write a custom tooltip. Custom t...

[The Disciplines]



Para

nd families, exported to ODBC, and

● Type

○ Instance

□ Reporting Parameter

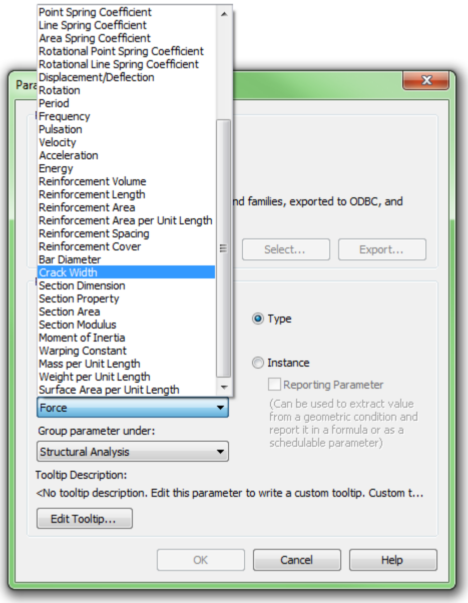
(Can be used to extract value from a geometric condition and report it in a formula or as a schedulable parameter)

Force

Group parameter under: Structural Analysis

Tooltip Description:

<No tooltip description. Edit this parameter to write a custom tooltip. Custom t...



Para

nd families, exported to ODBC, and

● Type

○ Instance

□ Reporting Parameter

(Can be used to extract value from a geometric condition and report it in a formula or as a schedulable parameter)

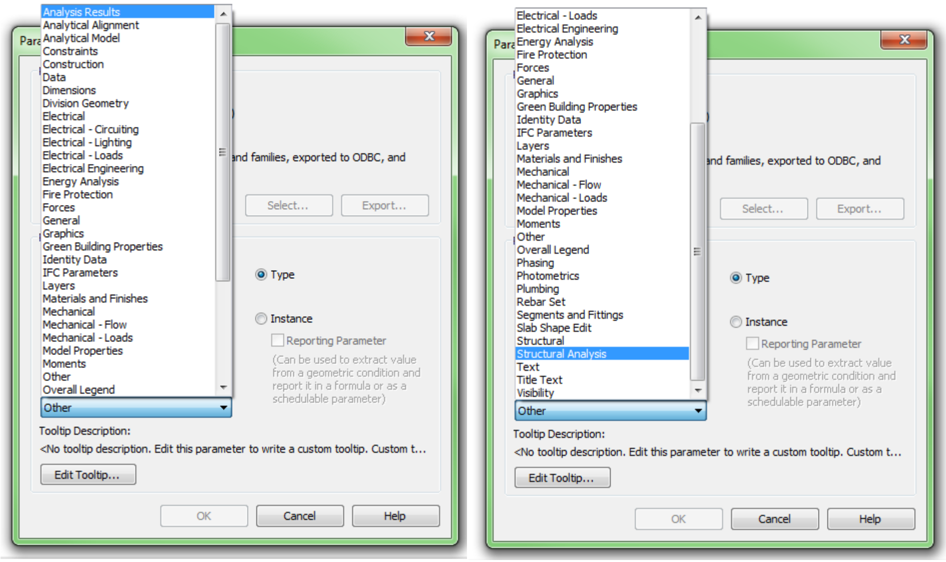
Force

Group parameter under: Structural Analysis

Tooltip Description:

<No tooltip description. Edit this parameter to write a custom tooltip. Custom t...

[The Structural Parameter]



Other

and families, exported to ODBC, and

● Type

○ Instance

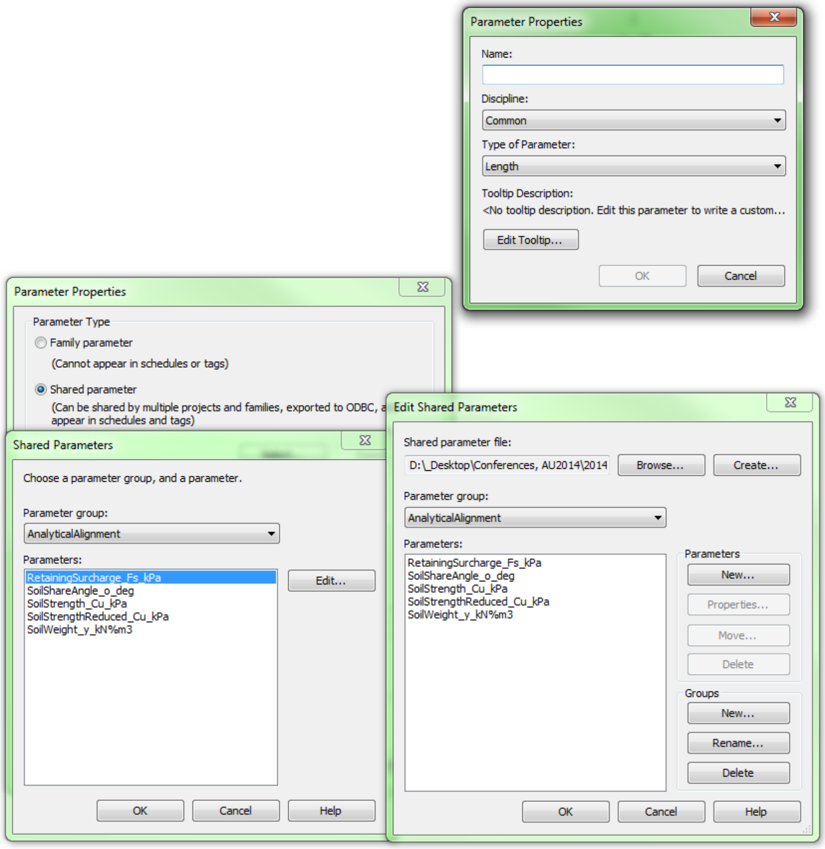
□ Reporting Parameter

(Can be used to extract value from a geometric condition and report it in a formula or as a schedulable parameter)

Tooltip Description:

<No tooltip description. Edit this parameter to write a custom t...

[The Grouping available]



Parameter Properties

Name:

Discipline: Common

Type of Parameter: Length

Tooltip Description:

<No tooltip description. Edit this parameter to write a custom...

Parameter Properties

Parameter Type

○ Family parameter

(Cannot appear in schedules or tags)

● Shared parameter

(Can be shared by multiple projects and families, exported to ODBC, a appear in schedules and tags)

Shared Parameters

Choose a parameter group, and a parameter.

Parameter group: AnalyticalAlignment

Parameters:

RetainingSurcharge_Fs_kPa
SoilShareAngle_o_deg
SoilStrength_Cu_kPa
SoilStrengthReduced_Cu_kPa
SoilWeight_y_kN%m3

Edit Shared Parameters

Shared parameter file: D:_Desktop\Conferences, AU2014\2014

Parameter group: AnalyticalAlignment

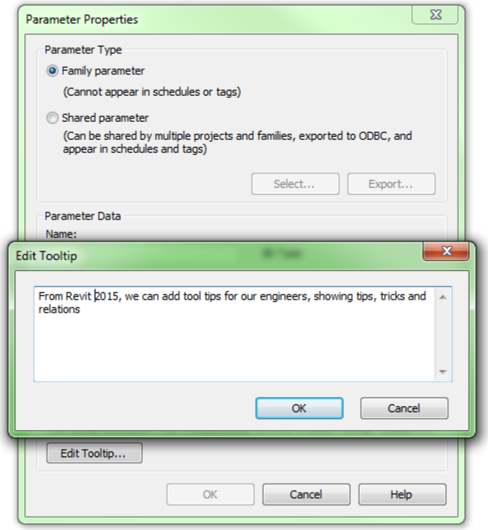
Parameters:

RetainingSurcharge_Fs_kPa
SoilShareAngle_o_deg
SoilStrength_Cu_kPa
SoilStrengthReduced_Cu_kPa
SoilWeight_y_kN%m3

Parameters

Groups

[Shared Parameter Options]



Parameter Properties

Parameter Type

● Family parameter

(Cannot appear in schedules or tags)

○ Shared parameter

(Can be shared by multiple projects and families, exported to ODBC, and appear in schedules and tags)

Parameter Data

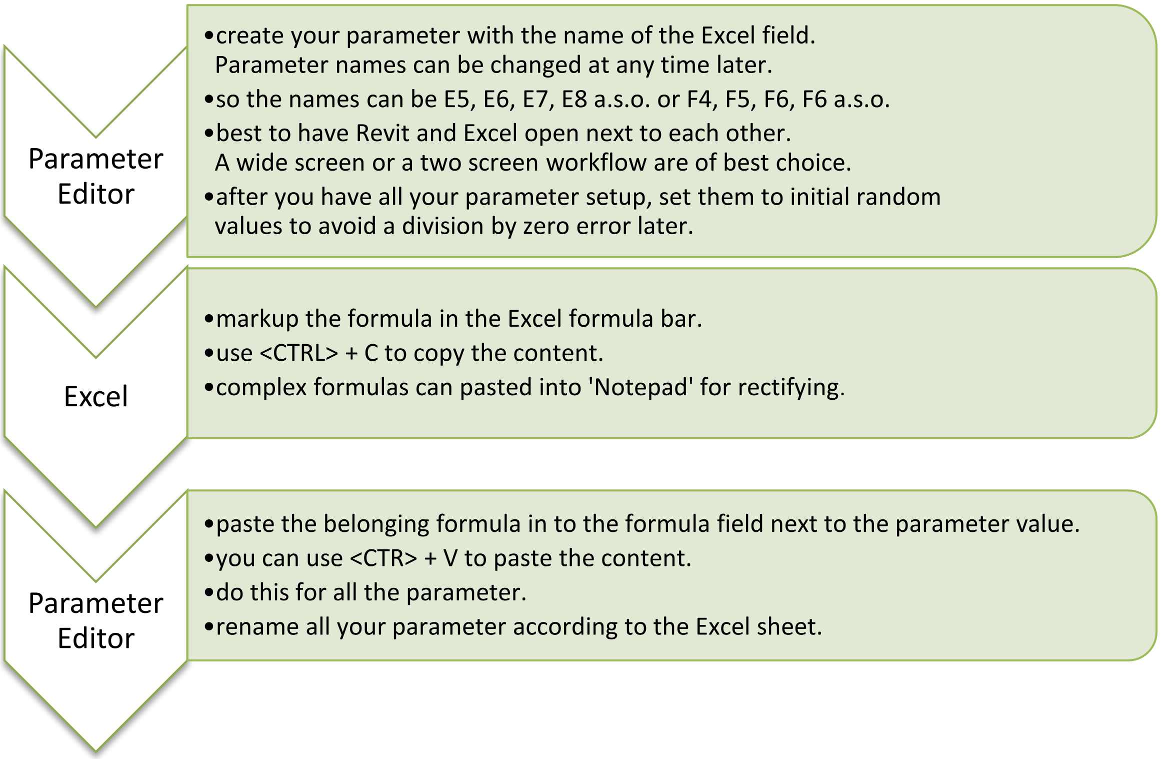
Name:

Edit Tooltip

From Revit 2015, we can add tool tips for our engineers, showing tips, tricks and relations

[The Tool Tip Feature from Revit 2015 onwards]

A fast and simply way is to limit yourself just only to the usage of the 'Common' category. Fields are for example numbers only, which don't include units. But be advised, it might be best to include the units at least in the parameter name at later stage to avoid confusion.



Parameter Editor

- create your parameter with the name of the Excel field.
  Parameter names can be changed at any time later.
- so the names can be E5, E6, E7, E8 a.s.o. or F4, F5, F6 a.s.o.
- best to have Revit and Excel open next to each other.
  A wide screen or a two screen workflow are of best choice.
- after you have all your parameter setup, set them to initial random values to avoid a division by zero error later.

Excel

- markup the formula in the Excel formula bar.
- use <CTRL> + C to copy the content.
- complex formulas can pasted into 'Notepad' for rectifying.

Parameter Editor

- paste the belonging formula in to the formula field next to the parameter value.
- you can use <CTR> + V to paste the content.
- do this for all the parameter.
- rename all your parameter according to the Excel sheet.

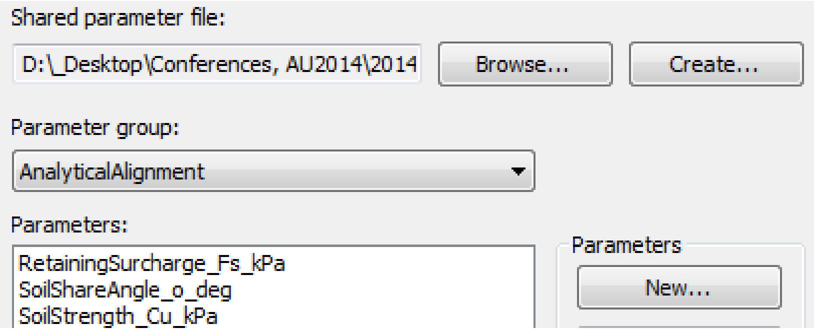
Done.

2. Let's try some hand on exercises

(Bullet points in notes form)

Step 1 – Design the retaining concrete piles

- Please check first the link to the shared parameter file, which is in the class folder.
- You find the dialog on the Manage-Tab, Settings-Panel and Shared Parameter-Icon.



Shared parameter file:

D:_Desktop\Conferences, AU2014\2014

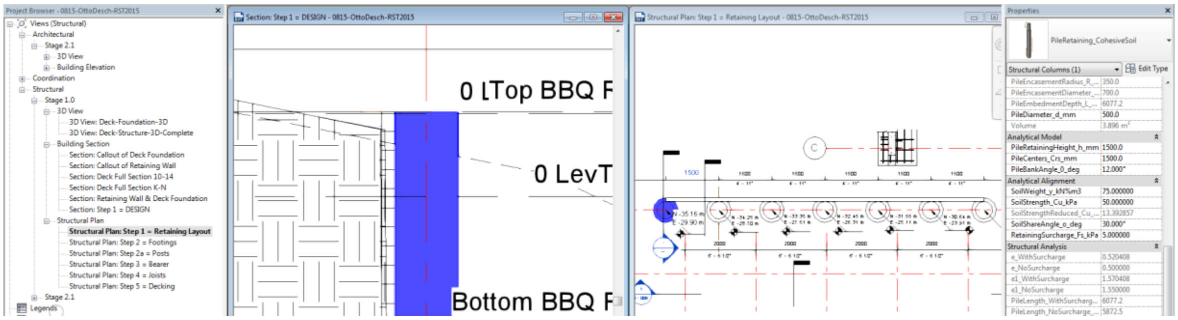
Parameter group:

AnalyticalAlignment

Parameters:

RetainingSurcharge_Fs_kPa
SoilShareAngle_o_deg
SoilStrength_Cu_kPa

- The views of 'Stage 1.0' show all relevant views for this and next stages.
- You can prepare the views like in the screen-shot below (plan' and section' using 'WT'):



Project Browser - 0815-OttoDesch-RST2015

```
Views (Structural)
  Architectural
    Stage 2.1
      3D View
      Building Elevation
  Coordination
  Structural
    Stage 1.0
      3D View
        3D View: Deck-Foundation-3D
        3D View: Deck-Structure-3D-Complete
      Building Section
        Section: Callout of Deck Foundation
        Section: Callout of Retaining Wall
        Section: Deck Full Section 10-14
        Section: Deck Full Section K-N
        Section: Retaining Wall & Deck Foundation
        Section: Step 1 = DESIGN
      Structural Plan
        Structural Plan: Step 1 = Retaining Layout
        Structural Plan: Step 2 = Footings
        Structural Plan: Step 2a = Posts
        Structural Plan: Step 3 = Bearer
        Structural Plan: Step 4 = Joists
        Structural Plan: Step 5 = Decking
    Stage 2.1
Legends
```

Section: Step 1 = DESIGN - 0815-OttoDesch-RST2015
0 [Top BBQ F
0 LevT
Bottom BBQ F
Structural Plan: Step 1 = Retaining Layout - 0815-OttoDesch-RST2015
1500
C

Properties

PileRetaining_CohesiveSoil

Structural Columns (1) — Edit Type

PileEncasementRadius_R_...	350.0
PileEncasementDiameter_...	700.0
PileEmbedmentDepth_L_...	6077.2
PileDiameter_d_mm	500.0
Volume	3.896 m³
Analytical Model	
PileRetainingHeight_h_mm	1500.0
PileCenters_Crs_mm	1500.0
PileBankAngle_0_deg	12.000°
Analytical Alignment	
SoilWeight_y_kN%m3	75.000000
SoilStrength_Cu_kPa	50.000000
SoilStrengthReduced_Cu_...	13.392857
SoilShareAngle_o_deg	30.000°
RetainingSurcharge_Fs_kPa	5.000000
Structural Analysis	
e_WithSurcharge	0.520408
e_NoSurcharge	0.500000
e1_WithSurcharge	1.570408
e1_NoSurcharge	1.550000
PileLength_WithSurcharg...	6077.2
PileLength_NoSurcharge_...	5872.5

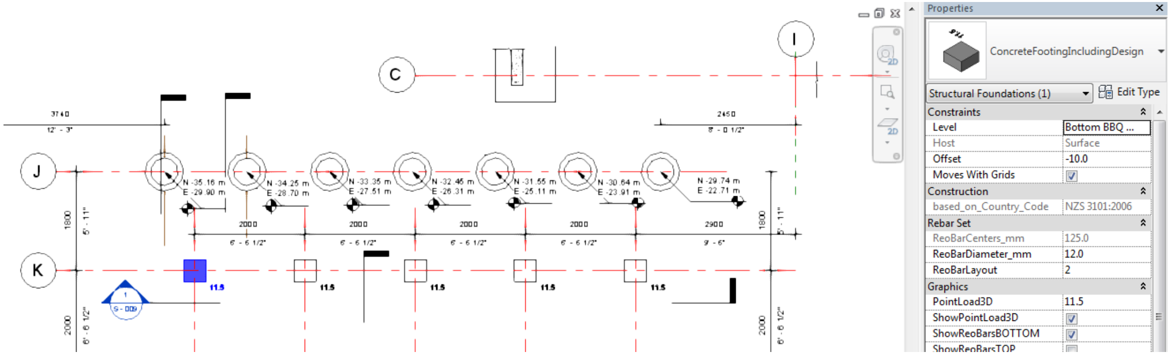
- The soil values vary unfortunately, the geotechnical engineer provided the following:

	Pile 1	**Pile 2**	**Pile 3**	**Pile 4**	**Pile 5**	**Pile 6**	**Pile 7**
Weight (kN/m^3)	75	100	150	200	150	100	75
Strength (kPa)	50	100	200	200	200	100	50
ShearAngle	30	45	60	60	60	45	30
PileBank Angle	measure	measure	measure	measure	measure	measure	measure
Pile Ø (mm)	400-600	400-600	400-600	400-600	400-600	400-600	400-600

- See how the pile length is being calculated automatically based on the situation.

Step 2 – Complete the foundation

- All the families have been created after the same principle being copied from Excel.
- In this example, we want to experience how easy or difficult it is to copy formulas across.
- See the ‘Structural Plan’: Step 2 = Footings.
- We want to create or complete this family and not design it at this stage.



Properties

ConcreteFootingIncludingDesign

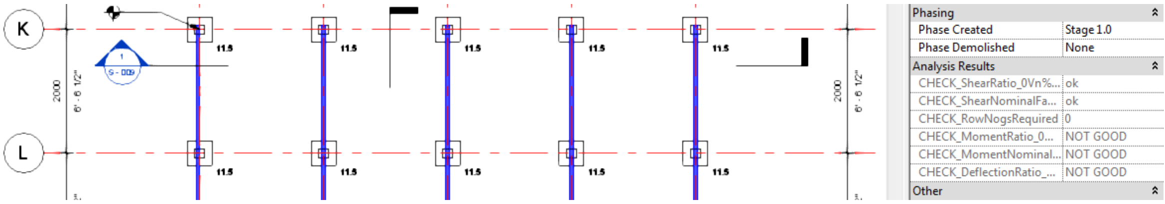
Structural Foundations (1) Edit Type

Constraints	
Level	Bottom BBQ ...
Host	Surface
Offset	-10.0
Moves With Grids	☑
Construction	
based_on_Country_Code	NZS 3101:2006
Rebar Set	
ReoBarCenters_mm	125.0
ReoBarDiameter_mm	12.0
ReoBarLayout	2
Graphics	
PointLoad3D	11.5
ShowPointLoad3D	☑
ShowReoBarsBOTTOM	☑
ShowReoBarsTOP	☐

- If you are passionate and want to experience the copy cycle, please open: ConcreteFootingIncludingDesign_StructuralVariousExcelBlank.RVT
- If you just want to go after renaming the parameter, please open: ConcreteFootingIncludingDesign_StructuralVariousExcel.RVT
- If you just want to browse and see the formulas, please open: ConcreteFootingIncludingDesign_StructuralVariousFormulas.RVT

Step 3 – Design the bearer

- The bearers have already been modelled, so only the design is required at this stage.
- The factors according NZS3603-1993 have been entered, too, already. But you are welcome to review their influence in the formulas of the used family.
- Please design the bearer for a LifeLoad_Q_kPa = 2.5 kPa.
- The SuperImposedDeadLoad_SDL_kPa = 0.5 kPa .



Phasing	
Phase Created	Stage 1.0
Phase Demolished	None
Analysis Results	
CHECK_ShearRatio_0Vn%...	ok
CHECK_ShearNominalFa...	ok
CHECK_RowNogsRequired	0
CHECK_MomentRatio_0...	NOT GOOD
CHECK_MomentNominal...	NOT GOOD
CHECK_DeflectionRatio_...	NOT GOOD
Other	

- Which is the governing bearer? (You can cheat and see ‘Step 4’, Grid 14, because of the cantilever; hence we can just check it by increasing the ‘JoistCentersMax’ to 3000mm.)
- Watch the video in the ‘Step 3’ folder, how the ‘Revit Extensions’ can help in the situation determining the actions.
- At this stage, now, the concrete footings can be updated.

Step 4 – Complete the cantilever

- Again, let's go after the development of a family, and let's explore it a bit deeper.
- We want to compare now the influence of the nature of the parameter.
- Revit does handle units extremely well.
- A unit divided by itself turns to a 'Number": e.g. 10mm / 10mm = 1;
- A unit multiplied with a another unit becomes the result of the multiplication: e.g. 10mm x 10mm = 100mm^2;
- Revit does rectify units itself: e.g. angles when just entered as number, or when the unit is represented through a division e.g. kN/m;
- All required files are found in the folder 'Step4'.
- I you want to complete a family having parameter of the 'Common' category, please complete: TimberJoistCantilever_CommonNumberEmpty.RVT
- For anybody how wants to copy formulas across using parameter of the 'Structural' category, please open: TimberJoistCantilever_StructuralVariousExcelBlank.RVT The parameter have been created already. We want to focus on the 'Revit – Excel' copy interaction. This can take a bit a concentration.
- I found it useful to review the copied content, prior copying into Revit, in 'MS Notepad'. It helps to double and triple check the copied content from Excel.
- Excel acts sometimes a bit funny when copying.
- If you are confident renaming the parameter, please open: TimberJoistCantilever_StructuralVariousExcel.RVT
- If you just want to browse and have a play with the formulas, please consider: TimberJoistCantilever_StructuralVariousFormulas.RVT
- Design the joists following the bearer design from 'Step 3'.

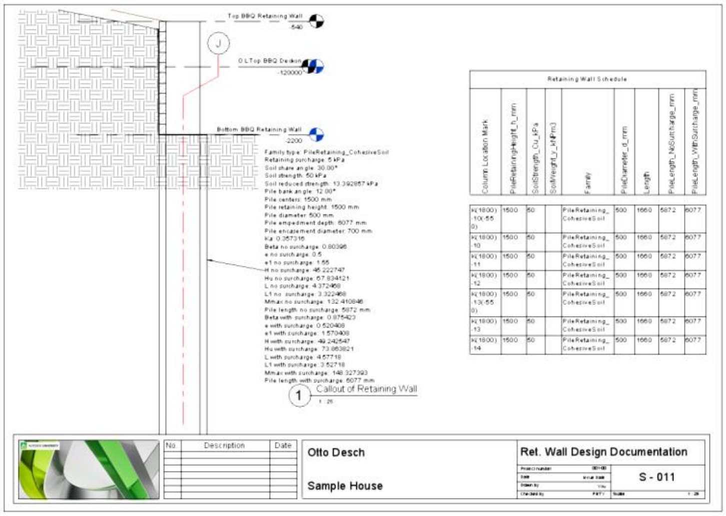
Step 5 –Finish the deck

- Switch to any view considering 'Step 5'.
- The hardware supplier has a special offer: 75mm wide battens, 25/35/45mm deep.
- Design the battens for a LifeLoad_Q_kPa of 2.5 kPa floor load.
- We can assume the SuperImposedDeadLoad_SDL_kPa = 0.25 kPa.
- What type of battens shall we buy?
- Update the battens across the joists.

Step 6 – Document the design

- Switch to the sheet views.
- We can use family parameter or shared parameter in our families.
- Shared parameters allow us to create specific tags.

- Shared parameters enable also scheduling the results.



Family type: PileRetaining_CohesiveSoil
Retaining surcharge: 5 kPa
Soil share angle: 30.00°
Soil strength: 50 kPa
Soil reduced strength: 13.392857 kPa
Pile bank angle: 12.00°
Pile centers: 1500 mm
Pile retaining height: 1500 mm
Pile diameter: 500 mm
Pile empedment depth: 6077 mm
Pile encasement diameter: 700 mm
Ka: 0.357316
Beta no surcharge: 0.80396
e no surcharge: 0.5
e1 no surcharge: 1.55
H no surcharge: 46.222747
Hu no surcharge: 67.834121
L no surcharge: 4.372468
L1 no surcharge: 3.322468
Mmax no surcharge: 132.410846
Pile length no surcharge: 5872 mm
Beta with surcharge: 0.875423
e with surcharge: 0.520408
e1 with surcharge: 1.570408
H with surcharge: 49.242547
Hu with surcharge: 73.863821
L with surcharge: 4.57718
L1 with surcharge: 3.52718
Mmax with surcharge: 148.327393
Pile length with surcharge: 6077 mm

1 Callout of Retaining Wall
1 : 25

Retaining Wall Schedule

Column Location Mark	PileRetainingHeight_h_mm	SoilStrength_Cu_kPa	SoilWeight_y_kNPm3	Family	PileDiameter_d_mm	Length	PileLength_NoSurcharge_mm	PileLength_WithSurcharge_mm
K(1800)-10(-550)	1500	50		PileRetaining_CohesiveSoil	500	1660	5872	6077
K(1800)-10	1500	50		PileRetaining_CohesiveSoil	500	1660	5872	6077
K(1800)-11	1500	50		PileRetaining_CohesiveSoil	500	1660	5872	6077
K(1800)-12	1500	50		PileRetaining_CohesiveSoil	500	1660	5872	6077
K(1800)-13(-550)	1500	50		PileRetaining_CohesiveSoil	500	1660	5872	6077
K(1800)-13	1500	50		PileRetaining_CohesiveSoil	500	1660	5872	6077
K(1800)-14	1500	50		PileRetaining_CohesiveSoil	500	1660	5872	6077

No	Description	Date

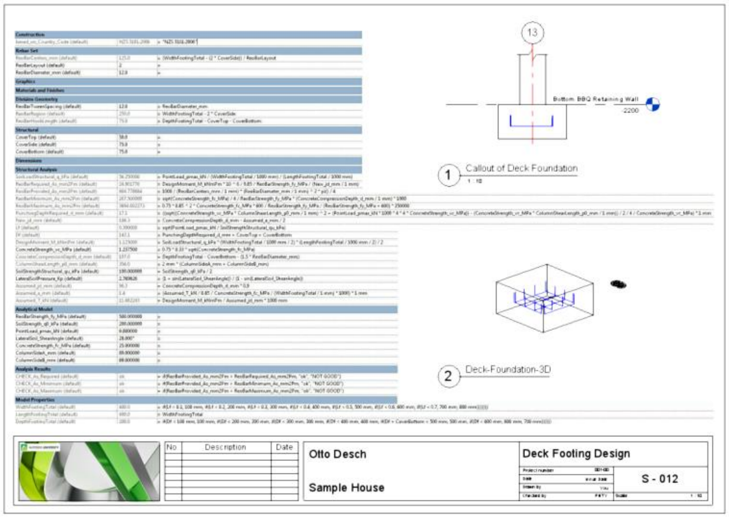
Otto Desch

Sample House

Ret. Wall Design Documentation

Project number 001-00
Date Issue Date
Drawn by You
Checked by PETT
S - 011
Scale 1 : 25

- Another way to protect the design is to "rasterize" the formulas using screen-shots.



Construction		
Issued_on_Country_Code (default)	NZS 3101-2006	= "NZS 3101-2006"
Rebar Set		
RebarCenters_mm (default)	125.0	= (WidthFootingTotal - (2 * CoverSide)) / RebarLayout
RebarLayout (default)	2	=
RebarDiameter_mm (default)	12.0	=
Graphics		
Materials and Finishes		
Division Geometry		
RebarTowerSpacing (default)	12.0	= RebarDiameter_mm
RebarRegion (default)	250.0	= WidthFootingTotal - 2 * CoverSide
RebarHookLength (default)	75.0	= DepthFootingTotal - CoverTop - CoverBottom
Structural		
CoverTop (default)	50.0	=
CoverSide (default)	75.0	=
CoverBottom (default)	75.0	=
Dimensions		
Structural Analysis		
SoilLoadStructural_q_kPa (default)	56.250000	= PointLoad_pmax_kN / (WidthFootingTotal / 1000 mm) / (LengthFootingTotal / 1000 mm)
RebarRequired_As_mm2Pm (default)	24.903770	= DesignMoment_M_kNmPm * 10 ^ 6 / 0.85 / RebarStrength_fy_MPa / (Nav_jd_mm / 1 mm)
RebarProvided_As_mm2Pm (default)	904.778684	= 1000 / (RebarCenters_mm / 1 mm) * (RebarDiameter_mm / 1 mm) ^ 2 * pi() / 4
RebarMinimum_As_mm2Pm (default)	287.500000	= sqrt(ConcreteStrength_fc_MPa) / 4 / RebarStrength_fy_MPa * (ConcreteCompressionDepth_d_mm / 1 mm) * 1000
RebarMaximum_As_mm2Pm (default)	3684.002273	= 0.75 * 0.85 * 2 * ConcreteStrength_fc_MPa * 600 / RebarStrength_fy_MPa / (RebarStrength_fy_MPa + 600) * 250000
PunchingDepthRequired_d_mm (default)	17.1	= ((sqrt((ConcreteStrength_vc_MPa * ColumnShearLength_p0_mm / 1 mm) ^ 2 + (PointLoad_pmax_kN * 1000 * 4 * 4 * ConcreteStrength_vc_MPa)) - (ConcreteStrength_vc_MPa * ColumnShearLength_p0_mm / 1 mm)) / 2 / 4 / ConcreteStrength_vc_MPa) * 1 mm
Nav_jd_mm (default)	106.3	= ConcreteCompressionDepth_d_mm - Assumed_a_mm / 2
Lf (default)	0.300000	= sqrt(PointLoad_pmax_kN / SoilStrengthStructural_qu_kPa)
Df (default)	142.1	= PunchingDepthRequired_d_mm + CoverTop + CoverBottom
DesignMoment_M_kNmPm (default)	1.125000	= SoilLoadStructural_q_kPa * (WidthFootingTotal / 1000 mm / 2) * (LengthFootingTotal / 1000 mm / 2) / 2
ConcreteStrength_vc_MPa (default)	1.237500	= 0.75 * 0.33 * sqrt(ConcreteStrength_fc_MPa)
ConcreteCompressionDepth_d_mm (default)	107.0	= DepthFootingTotal - CoverBottom - (1.5 * RebarDiameter_mm)
ColumnShearLength_p0_mm (default)	356.0	= 2 mm * (ColumnSideA_mm + ColumnSideB_mm)
SoilStrengthStructural_qu_kPa (default)	100.000000	= SoilStrength_q0_kPa / 2
LateralSoilPressure_Kp (default)	2.769826	= (1 + sin(LateralSoil_ShearAngle)) / (1 - sin(LateralSoil_ShearAngle))
Assumed_jd_mm (default)	96.3	= ConcreteCompressionDepth_d_mm * 0.9
Assumed_a_mm (default)	1.4	= (Assumed_T_kN / 0.85 / ConcreteStrength_fc_MPa / (WidthFootingTotal / 1 mm) * 1000) * 1 mm
Assumed_T_kN (default)	11.682241	= DesignMoment_M_kNmPm / Assumed_jd_mm * 1000 mm
Analytical Model		
RebarStrength_fy_MPa (default)	500.000000	=
SoilStrength_q0_kPa (default)	200.000000	=
PointLoad_pmax_kN (default)	9.000000	=
LateralSoil_ShearAngle (default)	28.000°	=
ConcreteStrength_fc_MPa (default)	25.000000	=
ColumnSideA_mm (default)	89.000000	=
ColumnSideB_mm (default)	89.000000	=
Analysis Results		
CHECK_As_Required (default)	ok	= if(RebarProvided_As_mm2Pm > RebarRequired_As_mm2Pm, "ok", "NOT GOOD")
CHECK_As_Minimum (default)	ok	= if(RebarProvided_As_mm2Pm > RebarMinimum_As_mm2Pm, "ok", "NOT GOOD")
CHECK_As_Maximum (default)	ok	= if(RebarProvided_As_mm2Pm < RebarMaximum_As_mm2Pm, "ok", "NOT GOOD")
Model Properties		
WidthFootingTotal (default)	400.0	= if(Lf < 0.1, 100 mm, if(Lf < 0.2, 200 mm, if(Lf < 0.3, 300 mm, if(Lf < 0.4, 400 mm, if(Lf < 0.5, 500 mm, if(Lf < 0.6, 600 mm, if(Lf < 0.7, 700 mm, 800 mm)))))))
LengthFootingTotal (default)	400.0	= WidthFootingTotal
DepthFootingTotal (default)	200.0	= if(Df < 100 mm, 100 mm, if(Df < 200 mm, 200 mm, if(Df < 300 mm, 300 mm, if(Df < 400 mm, 400 mm, if(Df + CoverBottom < 500 mm, 500 mm, if(Df < 600 mm, 600 mm, 700 mm))))))

1 Callout of Deck Foundation
1 : 10

2 Deck-Foundation-3D

No	Description	Date

Otto Desch

Sample House

Deck Footing Design

Project number 001-00
Date Issue Date
Drawn by You
Checked by PETT
S - 012
Scale 1 : 10

- You can also consider not relinquished work-sets when using a central file.
- To protect changes, we can toast the file on a read only CD, DVD, BD.
- CD's, DVD's, BD's have unique numbers; you can also sign them, like plans.
- Autodesk 360 documents every activity, too and would be my choice.

3. For more information go to or write to:

- http://www.bim2.tv
- contact@bim2.tv

Appendix

Exponentiation

X raised to the power of Y = X ^ Y

Circles with pi π

Usage in Revit = pi()

*Circumference = pi() * (Radius * 2)*

*Circumference = pi() * Diameter*

*Circle Area = pi() * Radius ^ 2*

Square Root (watch the units!)

Fixed value = sqrt(123)

Parameter = sqrt(Width)

Formula = sqrt(Width + Height)

Logarithm

The logarithm of a number to a given base is the exponent to which the base must be raised in order to produce that number. For example, the logarithm of 1000 to base 10 is 3, because three factors of 10 must be multiplied to yield a thousand: 10 × 10 × 10 equals 1000

Revit usage = log(1000)

Force yes/no parameters to be checked or unchecked

Force checked = 1 < 2

Force unchecked = 1 > 2

Conditional statements

Conditional statement uses this structure:

IF (<condition>, <result-if-true>, <result-if-false>)

Supported Conditional Operators

< Less than

> Greater than

= Equal

/ Divide

AND both statements are true

OR one of the statements is true

NOT statement is false

Conditional statements can contain numeric values, numeric parameter names, and Yes/No parameters.

Currently, <= and >= are not implemented. To express such a comparison, you can use a logical NOT. For example, a<=b can be entered as NOT(a>b)

Simple IF Statement

IF (Length < 900, <true>, <false>)

Formula That Returns Strings

IF (Length < 900, “Opening too narrow”, “Opening OK”)

Using logical AND

IF (AND (x = 1 , y = 2), <true>, <false>)

Returns <true> if both x=1 and y=2, else <false>

Using logical OR

IF (OR (x = 1 , y = 2) , <true>, <false>)

Returns <true> if either x=1 or y=2, else <false>

Nested IF statements

IF (Length < 500 , 100 , IF (Length < 750 , 200 , IF (Length < 1000 , 300 , 400)))

Returns 100 if Length<500, 200 if Length<750, 300 if Length<1000 and 400 if Length>1000

IF with Yes/No condition

Length > 40

Returns checked box (<true>) if Length > 40

NOT with Yes/No condition

not(Viz)

Returns checked box (<true>) if Yes/No parameter "Viz" is unchecked, and returns unchecked box (<false>) if Yes/No parameter "Viz" is checked.

IF, AND & OR returning the greatest of three values

Say you have these 3 length parameters, and want a fourth parameter to return the greater value/length of the 3:

Return Length = (Returns the greatest of the three length parameters):

Length A, Length B, Length C

Option (1)

Return Length = if(and(or(Length A > Length B, Length A = Length B), or(Length A > Length C, Length A = Length C)), Length A, if(and(or(Length B > Length A, Length B = Length A), or(Length B > Length C, Length B = Length C)), Length B, if(and(or(Length C > Length A, Length C = Length A), or(Length C > Length B, Length C = Length B)), Length C, 0 mm)))

Option (2)

Another option is to use an extra "Calc" parameter, which is a bit more clumsy but also way easier and more manageable for us mortals.

Calc = if(Length A > Length B, Length A, Length B)

Return Length = if(Calc > Length C, Calc, Length C)

Option (3)

Return Length = if(A > D, if(A > C, if(A > B, A, B), if(B > C, B, C)), if(B > D, if(B > C, B, C), if(C > D, C, D)))

Trigonometry for right triangles:

Known: a+b

c = sqrt(a ^ 2 + b ^ 2)

A = atan(a / b)

B = atan(b / a)

Known: a+c

b = sqrt(c ^ 2 - a ^ 2)

A = asin(a / c)

B = acos(a / c)

Known: b+c

a = sqrt(c ^ 2 - b ^ 2)

A = acos(b / c)

B = asin(b / c)

Known: c + A

a = c * sin(A)

b = c * cos(A)

B = 90° - A

Known: c + B

a = c * cos(B)

b = c * sin(B)

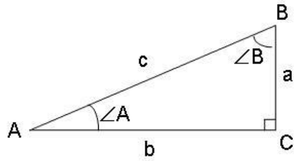
A = 90° - B

Known: a + B

b = a * tan(B)

c = a / cos(B)

A = 90° - B



Known: b + A

a = b * tan(A)

c = b / cos(A)

B = 90° - A

Known: a + A

b = a / tan(A)

c = a / sin(A)

B = 90° - A

Known: b + B

a = b / tan(B)

c = b / sin(B)

A = 90° - B

Range of Values

Given the following parameters:

user_value:

min_value:

max_value:

actual_value: = if (user_value < min_value, min_value, if (user_value > max_value, max_value, user_value))

Specify a range of valid entries, with the min_value and max_value parameters; then, use the actual value if it is within the range; otherwise, use your minimum or maximum values.

Round Function in Formulas

Values in formulas can be now rounded up or down. For example, when riser height is calculated, one needs the function “round” to find the appropriate value.

ROUND(x)

The round function returns a number rounded nearest to a whole number. It doesn’t take into consideration rounding direction (round up or down). If the number is (for example) from 24.5 to 24.9, the function rounds it to 25. If it is from 23.1 to 23.4, the function rounds it to 23.

Examples:

round (23.4) = 23

Round (23.5) = 24

Round (23.6) = 24

Round (-23.4) = -23

Round (-23.5) = -23

Round (-23.6) = -24

Syntax

The syntax for the round function is: round(number)

number is the number to round.

ROUNDDOWN(x)

“x” is a unit less value that should return the smallest integral value less than or equal to x.

For example:

rounddown (23.0) = 23

rounddown (23.5) = 23

rounddown (23.9) = 23

rounddown (-23.0) = -23

rounddown (-23.5) = -24

rounddown (-23.9) = -24

The syntax for the rounddown function is: rounddown (number)

number is the number to round down.

ROUNDUP(x)

“x” is a unit less value that should return the largest integral value greater than or equal to x.

For example:

roundup (23.0) = 23

roundup (23.5) = 24

roundup (23.9) = 24

roundup (-23.0) = -23

roundup (-23.5) = -23

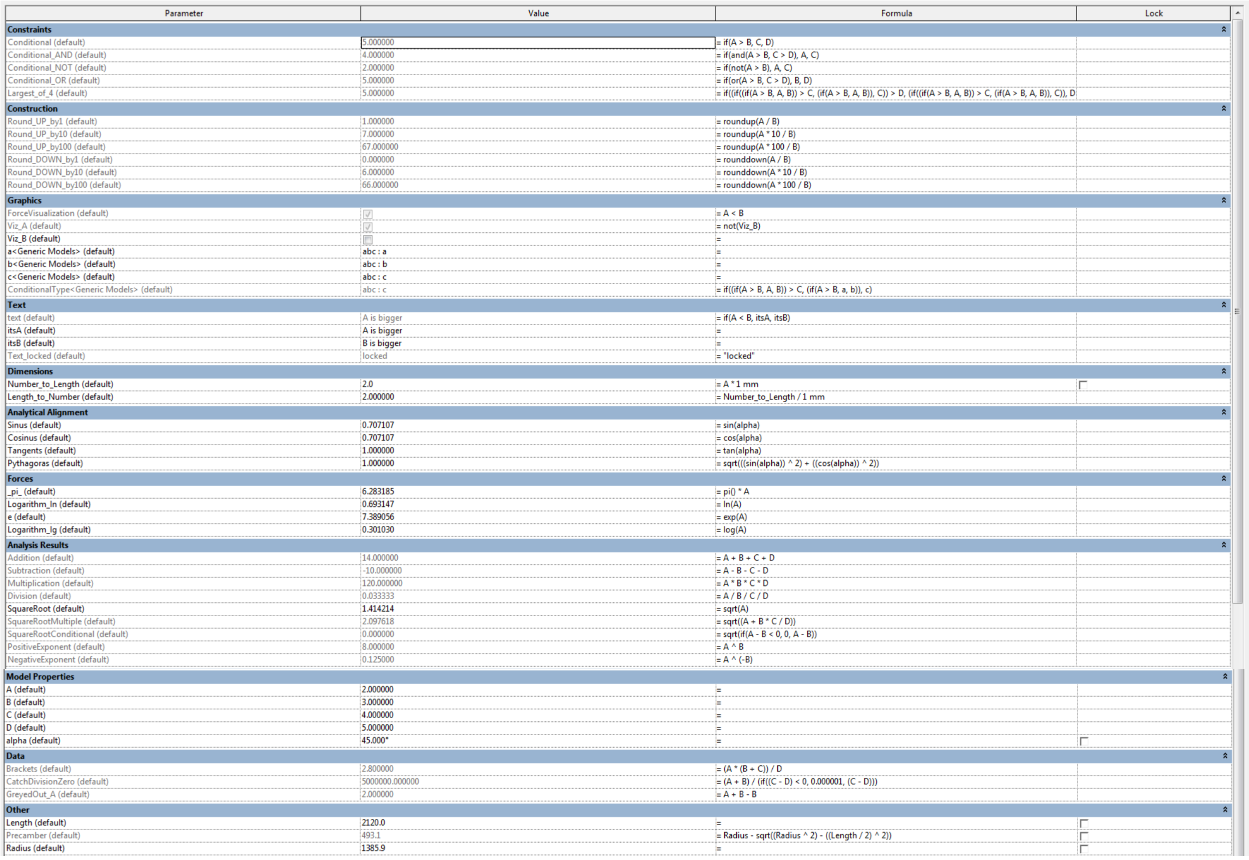
roundup (-23.9) = -23

The syntax for the roundup function is: roundup (number)

number is the number to round up.

Note that when numbers such as 23.5 are rounded, they can result in either 23 or 24. To produce a stable result, for all the .5 cases, we round to the larger integer. That means that 23.5 is rounded to 24, while -23.5 to -23

(http://www.revitforum.org/tutorials-tips-tricks/1046-revit-formulas-everyday-usage.html)



Parameter	Value	Formula	Lock
Constraints			
Conditional (default)	5.000000	= if(A > B, C, D)	
Conditional_AND (default)	4.000000	= if(and(A > B, C > D), A, C)	
Conditional_NOT (default)	2.000000	= if(not(A > B), A, C)	
Conditional_OR (default)	5.000000	= if(or(A > B, C > D), B, D)	
Largest_of_4 (default)	5.000000	= if((if((if(A > B, A, B)) > C, (if(A > B, A, B)), C)) > D, (if((if(A > B, A, B)) > C, (if(A > B, A, B)), C)), D	
Construction			
Round_UP_by1 (default)	1.000000	= roundup(A / B)	
Round_UP_by10 (default)	7.000000	= roundup(A * 10 / B)	
Round_UP_by100 (default)	67.000000	= roundup(A * 100 / B)	
Round_DOWN_by1 (default)	0.000000	= rounddown(A / B)	
Round_DOWN_by10 (default)	6.000000	= rounddown(A * 10 / B)	
Round_DOWN_by100 (default)	66.000000	= rounddown(A * 100 / B)	
Graphics			
ForceVisualization (default)	☑	= A < B	
Viz_A (default)	☑	= not(Viz_B)	
Viz_B (default)	☐	=	
a<Generic Models> (default)	abc : a	=	
b<Generic Models> (default)	abc : b	=	
c<Generic Models> (default)	abc : c	=	
ConditionalType<Generic Models> (default)	abc : c	= if((if(A > B, A, B)) > C, (if(A > B, a, b)), c)	
Text			
text (default)	A is bigger	= if(A < B, itsA, itsB)	
itsA (default)	A is bigger	=	
itsB (default)	B is bigger	=	
Text_locked (default)	locked	= "locked"	
Dimensions			
Number_to_Length (default)	2.0	= A * 1 mm	☐
Length_to_Number (default)	2.000000	= Number_to_Length / 1 mm	
Analytical Alignment			
Sinus (default)	0.707107	= sin(alpha)	
Cosinus (default)	0.707107	= cos(alpha)	
Tangents (default)	1.000000	= tan(alpha)	
Pythagoras (default)	1.000000	= sqrt(((sin(alpha)) ^ 2) + ((cos(alpha)) ^ 2))	
Forces			
_pi_ (default)	6.283185	= pi() * A	
Logarithm_ln (default)	0.693147	= ln(A)	
e (default)	7.389056	= exp(A)	
Logarithm_lg (default)	0.301030	= log(A)	
Analysis Results			
Addition (default)	14.000000	= A + B + C + D	
Subtraction (default)	-10.000000	= A - B - C - D	
Multiplication (default)	120.000000	= A * B * C * D	
Division (default)	0.033333	= A / B / C / D	
SquareRoot (default)	1.414214	= sqrt(A)	
SquareRootMultiple (default)	2.097618	= sqrt((A + B * C / D))	
SquareRootConditional (default)	0.000000	= sqrt(if(A - B < 0, 0, A - B))	
PositiveExponent (default)	8.000000	= A ^ B	
NegativeExponent (default)	0.125000	= A ^ (-B)	
Model Properties			
A (default)	2.000000	=	
B (default)	3.000000	=	
C (default)	4.000000	=	
D (default)	5.000000	=	
alpha (default)	45.000°	=	☐
Data			
Brackets (default)	2.800000	= (A * (B + C)) / D	
CatchDivisionZero (default)	5000000.000000	= (A + B) / (if((C - D) < 0, 0.000001, (C - D)))	
GreyedOut_A (default)	2.000000	= A + B - B	
Other			
Length (default)	2120.0	=	☐
Precamber (default)	493.1	= Radius - sqrt((Radius ^ 2) - ((Length / 2) ^ 2))	☐
Radius (default)	1385.9	=	☐

[See the example family: ExampleFormulaTrials.RVT]

Tip:

Zoom into the electronic copy of this document to create a cheat-sheet and stick it to your screen.