AUTODESK **UNIVERSITY** 2015

U.S.-Style Scheduled Rebar: A Concrete Tale of Design and Fabrication in Revit

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Code MSF10008

Learning Objectives

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

- Discover the Autodesk code checking framework and identify key benefits
- Discover how to configure customized reinforcing schemas in RConcrete
- Discover how to increase design efficiency by automating design scheduling with RConcrete
- Learn how you can achieve accurate quantity takeoffs in Revit based on U.S.-style concrete reinforcing schedules

Description

This class presents the inventive new technology RConcrete for automation of reinforced concrete design directly in Revit software. U.S.-style reinforced concrete design is a unique workflow that currently has no direct support in Revit software. In the class you will learn how you can accomplish a full U.S.-style concrete design workflow without leaving the Revit environment. Learn how you can capitalize on analysis information and Autodesk's Code Checking Framework to drive calculation of required reinforcing per ACI 318. Harness new technologies to drive schedule-based design of reinforced concrete members according to a layout schema that you can customize to your own company standards.

Your AU Experts

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Lin Gallant *Lin is a senior forensic structural engineer at the Vertex Companies based in Weymouth, MA. Lin is a professional structural engineer with 10 years of experience in the design and evaluation of buildings and other structures. He has been using Autodesk products (AutoCAD, Revit, Robot Structural Analysis Professional) for over 10 years. Lin has a passion for blending engineering and technology to improve efficiency and foster innovative design. He has authored white papers on AISC's Direct Analysis Method and wind simulation, and has lectured on these subjects and BIM. He provides technical guidance, user experience review, and workflow analysis to software developers to enhance engineering analysis and design software. Lin received his B.S. and M.S. degrees in Civil Engineering (structural focus).*

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Revit as a true design to fabrication platform

It's no secret that Revit is a revolutionary, not to mention disruptive technology that is fundamentally changing the way we approach the design, fabrication, construction, and building management process. Not only is it forcing us to reconsider how we do our work, it's creating a massively adaptive platform upon which we can build out more powerful solutions and workflows: if only we harness it.

When we talk in particular about reinforced concrete modeling, detailing, and fabrication, Revit natively provides some very powerful modeling tools for not only modeling structure but also the reinforcing that lives within. Recent advances in Revit reinforcing modeling functionality has significantly reduced the footprint of rebar in a Revit model making possible the vision of fully reinforcing a real Revit model. If a fully reinforced model is a realistic possibility then full and accurate quantity takeoffs leave the realm of fantasy and become a realizable vision.

Just because the vision becomes realizable doesn't mean that it's easy or necessarily within easy reach. While Revit provides modeling and scheduling capabilities which form the backbone of what we want to achieve, the process of modeling is still very manual and the prospect of actually modeling and entire structure's worth of reinforcing is still a very daunting task.

US specific challenges in the reinforcement to fabrication workflow

While infinite customizability and automation tools are being developed on top of Revit, they all suggest a workflow where each beam would be reinforced in a unique pattern driven directly by the design calculations. In a country where labor isn't necessarily the driving force of construction cost, individually unique framing elements may be desirable. In the US, engineers have to cope with the relatively high cost of labor, lack of full time construction Quality Control oversight, and look to achieve efficiencies of scale and reduced inspection burden through design consistency.

Traditionally US engineers have managed this process by standardizing reinforcement layouts by means of a three-span continuous bar layout schema which is used in conjunction with a schedule mapping real bar quantities to bar groups in the layout schema. While this is an excellent method (and the prevailing method) for achieving design efficiency, it is a workflow not directly supported by Revit. Revit schedules are intended to quantify individual elements whereas this schema driven workflow is about scheduling abstract organizational units regardless of the fact that the organizational units ultimately are comprised of individual rebar.

Additionally this schema-based approach transcends individual elements: we're not necessarily scheduling beam by beam but really beam-line by beam-line. An individual beam-line might have many "middle" spans whereby a schedule of abstract organizational units is insufficient to adequately describe the full quantity of reinforcing required to service a particular construction project. What is needed is an additional set of tools to bridge the gap between this abstract organization and individual rebar.

Basic challenges from the fabricator's perspective

Given the traditional schema based rebar specification on contract documents there is a significant amount of work involved in mapping the schedule of abstract quantities (bar groups) to the actual beam lines, calculating all the actual lengths of bars and then tallying them all up. Because the schema is

generic, lengths of bars are typically relative to the actual length of beams and often referenced off the face of columns adding yet another calculation step in the process.

Harnessing Revit

While Revit may not provide native capabilities to automate either end of this process, Revit and the Autodesk team have provided some incredibly powerful platforms which can be harnessed to automate this entire process from either or both ends.

Key Revit Technologies that enable a full concrete design to fabrication workflow in Revit

Revit began, of course, as primarily a modeling tool. When development began on a differentiated product for structural engineering, Autodesk began incorporating tools not only for modeling the physical structure but also for providing a workflow for engineers to idealize the structure to feed the structural analysis and design chain. All of these upstream technologies feed the downstream

Revit Analytical Model

The basis for enabling the structural engineering workflow in Revit. All major structural elements in Revit also support a highly manipulate-able analytical idealization of that element. Linear elements for beams and columns, surface elements for floors and walls all feed the finite element analysis of the structure.

Revit works hard to give you a well-connected and analyzable analytical model based on the elements you have created in the physical model but realizing that idealization of a structure is reasonably idiosyncratic and open to interpretation, Revit analytical models have lots of options for adjustment including a dedicated environment for manipulating the analytical model alone. This is a huge benefit to our industry where a significantly split workflow between modeling and engineering staff still exists and probably will for a long time to come.

In addition Revit provides other necessary features for controlling member end releases, defining supports, and specifying loads on the structure.

Revit API

The Revit API is an amazing toolkit which forms the foundation for so much of what we want to accomplish with Revit, in terms of structural engineering that it should get a lot more respect than it probably does. The opening of the Revit database to external manipulation affords us the ability to read the analytical model, update members based on design, create reinforcing programmatically, populate element data parameters, store analysis results, and create advanced solutions drawing on information contained and/or stored in the model.

Originally Revit Structure had an analytical model but provided no capability for structural analysis. In order to facilitate analysis the Revit API offered third party structural analysis software providers the ability to craft link products which could read analytical information from Revit and write back results, design data, and update member sizes based on design performed in those third party software.

Revit Results Storage

Directly related to the Revit API but what I will consider a separate enabling technology is the structural analysis result storage system. As of Revit 2014, the Revit API affords the opportunity for analysis

software to store the full results of structural analysis directly inside Revit. Now Revit is truly becoming a central database for the structural engineering workflow! Having access to finite element analysis results in Revit enables visualization, exploration, and full integration of analysis to Revit. No longer is the result of analysis disconnected from and kept at "arm's length" from your Revit model.

Bringing analysis results into Revit reconnects the engineer with the analysis in a way that has never before been achievable: One Model which marries both physical model/documentation with analysis results.

The true advantage of results storage in Revit is that we can now drive fully integrated downstream design routines built either as plug-ins on top of Revit or, even as links to third party design software. This really breaks down the barriers to more localized design routines, custom design routines, and just democratized the whole engineering and design workflow: there's nothing stopping you from creating your own fully integrated design routines in Revit!

It is also worth noting that Revit Results Storage can handle almost any type of data you want to store and visualize. Not only can forces, moments, shears, stresses, etc. be returned, you could also return and store other related design data such as required areas of steel reinforcing, shear stud requirements, numbers of bars, spacing of stirrups, etc.

Analysis Visualization Framework

This is a key piece of technology developed and embedded in Revit somewhere around Revit 2012. The Analysis visualization framework provides the foundation of analysis visualization in Revit by enabling API tools to paint results into Revit, results on both surfaces as well as results on linear elements, vector fields (e.g. reactions), and displaced shapes are supported.

The "results" which can be visualized with the framework are boundless. We can use it to visualize structural analysis results in terms of forces, moments as well as deflections and deflected shapes. We can also use it to visualize almost any type of analysis data which can be painted on a surface, drawn as a diagram along a line/curve or shown as a vector or vector field. For example, heat loss data, current temperature data, proximity data, etc. The API can even be used to drive visualization of data in "real-time" or analysis results which respond to user actions in the model (floor moments resulting from the location of a piece of equipment in the model, or heat transmission to surfaces nearby a heat generating piece of equipment). It's pretty fun and exciting stuff and it's barely utilized… yet. Results Explorer is one tool which takes advantage of this technology and is discussed below.

Structural Analysis Toolkit

This is not really a technology but a collection of tools/technology which facilitate several of the things we will need to have a fully integrated workflow: In order to make results storage in Revit available to the user – to create this sense of integration, the structural analysis toolkit provides some key functionality.

Results Manager: Results of any kind can be stored in the model alongside your Revit data. They are stored by the Results Builder technology developed by Autodesk and are represented as result packages in Revit Results Manager. The Results Manager gives you access to see what packages are stored in Revit, which packages are remote cloud based result packages, and the ability to manage them by deleting them, downloading, and launching exploration/visualization of those results.

Results Explorer: Result packages stored in Revit are all available to the Results Explorer tool which enables you to visualize the results using the Analysis Visualization Framework to paint one or more results in a view. As long as results are stored in a results package, the Results Explorer tool can provide access to them for visualization and inspection.

Analyze in Cloud: This is the main integrator that facilitates standalone analysis directly in Revit without a third party analysis software. This analysis is powered by A360 Structural Analysis Cloud Services and is the beginning of fully integrated, full-featured analysis directly inside Revit. We will discuss the capabilities more fully later on in this document.

Autodesk Revit Code Checking Framework

The final piece of the big puzzle for enabling true structural engineering workflows in Revit is the Code Checking Framework. This awesome piece of technology is a set of API functionalities which facilitate assigning design code parameters to analytical elements, setting up general code parameters to guide design, and providing a uniform set of interface tools to allow the user access to results sets, and load cases/combinations to be run in design of materials.

This is a slightly more advanced set of technology but it is not out of reach for reasonably accomplished developers. In particular, the concrete code checking portion of the framework is very well developed providing automated setup of cross sections for design, where forces are readily available and you can generate your own calculations for required and/or provided reinforcing.

The Code Checking Framework isn't only for concrete, you could add design/code check routines for steel members as well. Currently supported element types are analytical beams, analytical columns, analytical floors, analytical walls, analytical foundation slabs. You can provide design/code-checking for any type of material you wish. The framework just makes it much more accessible to get coding on important stuff and takes care of a lot of the background stuff for you.

Autodesk has, in the past few years, begun truly embracing the concept of democratizing software. The Code Checking Framework is a testament to that idea: never before has customization of design routines been nearly as accessible as Excel and never before has this level of tight integration with BIM and structural engineering been possible. It is now completely within the realm of possibilities that you could implement completely custom design routines for structural elements in your own company to your own company standards and in a way that you believe the design code should be interpreted. Not only that but you could conceivably directly hook up any custom Excel tools you have created via the code-checking framework or even just by directly utilizing the Revit API.

The possibilities afforded by the Code-Checking Framework are truly remarkable and I would strongly encourage anyone to investigate these capabilities further to not only accelerate your design workflows but to allow you to make or integrate the tools you may have written yourself and trust.

Rebar Tools

This is kind of obvious in a sense but, I think it's worth mentioning in terms of how much development effort and new technology went into the currently available tools. I suppose it's also worth mentioning that, while these tools are really amazing for what they do, they are valued differently in different parts of the world.

The most important advancement in Revit reinforcing tools is the creation of the Rebar Container object. One of the biggest challenges to modeling reinforcing in Revit was the massive impact that

adding full reinforcing to a model had. For each rebar element that was added the tree of potential changes Revit had to manage and keep track of would grow. The impact would eventually become so harmful to performance that users quickly started adopting protocols for managing the impact on model performance by reducing the number of actual modeled rebar in the model. With the Rebar Container element, many rebars can be "contained" in the container and thereby significantly reduce the performance impact on the model. The Rebar Container is a Revit API accessible functionality as the API would ultimately be responsible for creating the rebars to be contained and managing any updates required due to model changes.

The beauty of the Rebar Container is that it makes the possibility of fully reinforcing a model a realizable task. Basically for each element which will be reinforced, only one new Revit "Element" will be added to the model. That Rebar Container element will contain many individual rebar as a "Rebar Container Item". Rebar container items do not have the same kind of negative impact on model performance yet still provide all the necessary functionality of schedulable rebar.

Bridging the Gap

RConcrete is a research project which aims to fill this gap and provide a fluid workflow bridging the gap between analysis and fabrication. RConcrete addresses three major areas:

1. Fully Integrated Required Reinforcing Analysis per ACI 318.
2. Automated detection of beam-lines and scheduling per layout schema
3. Automated population of model reinforcing based on layout schema.

With these three steps a fully automated workflow directly within Revit can be achieved for not only engineering to fabrication but even each sub-workflow engineering to Contract Documents and Contract Documents to fabrication information/detailing.

Required Reinforcing Analysis

Taking advantage of the Autodesk Revit Code Checking Framework, RConcrete provides an implementation of ACI318 calculations for required reinforcing. It currently works with analysis results returned from Robot Structural Analysis, A360 Cloud analysis, or other structural analysis package which can store results in Revit via Autodesk Revit Results Builder technology. Once results of analysis are stored in Revit, RConcrete can utilize them to drive calculation of required reinforcing at a number of sections along the length of each member. These calculations are presented in a very thorough manner facilitating exploration, investigation, and validation by the engineer. Verbose calculation information delivers on the promise of removing the black box and involving the engineer in the details of the calculations.

Driving a downstream workflow requires a measurement of required reinforcing and once provided downstream operations can then almost fall out of the original analysis.

Beam Layout Schema Support

New organizational methods are currently being researched to facilitate customizable specification of traditional US engineering three span continuous type layout schema. Creating a usable interface which allows the user to specify all required information is a big undertaking but is critical to the success of this

type of strategy. If the layout is not customizable then the engineer cannot be involved in the process and is once again at the mercy of their design tool.

Driving the process in "Reverse"

Whereas Engineers are typically interested in working from analysis to beam reinforcing "scheduling" as we've discussed, the next step in the workflow is to work from the engineer's schedule to actually determine the magnitude of rebar in the model to quantify it as well as to facilitate the process shop fabrication. If we know how the bar schema lays out, we can pretty easily drive the process backward from the schedule to populate a model with all be bars specified by the engineer in an automated fashion.

How Revit's Analytical Model drives downstream design

When I was a budding structural engineering intern back in the early 1990s I had the distinct honor of working with Tom Tyson out in Rochester, NY at the then Sear-Brown Company. He shared his PhD research with me thinking that I might be interested and ironically enough, looking back, his PhD research was about a fully integrated analysis, design, and documentation system based on a central database. I truly believe that BIM is the fruit of these types of ideas, Tom was obviously not the only

one who had these ideas as they applied to structural engineering but I always think of him when I think about how far we've come in this industry.

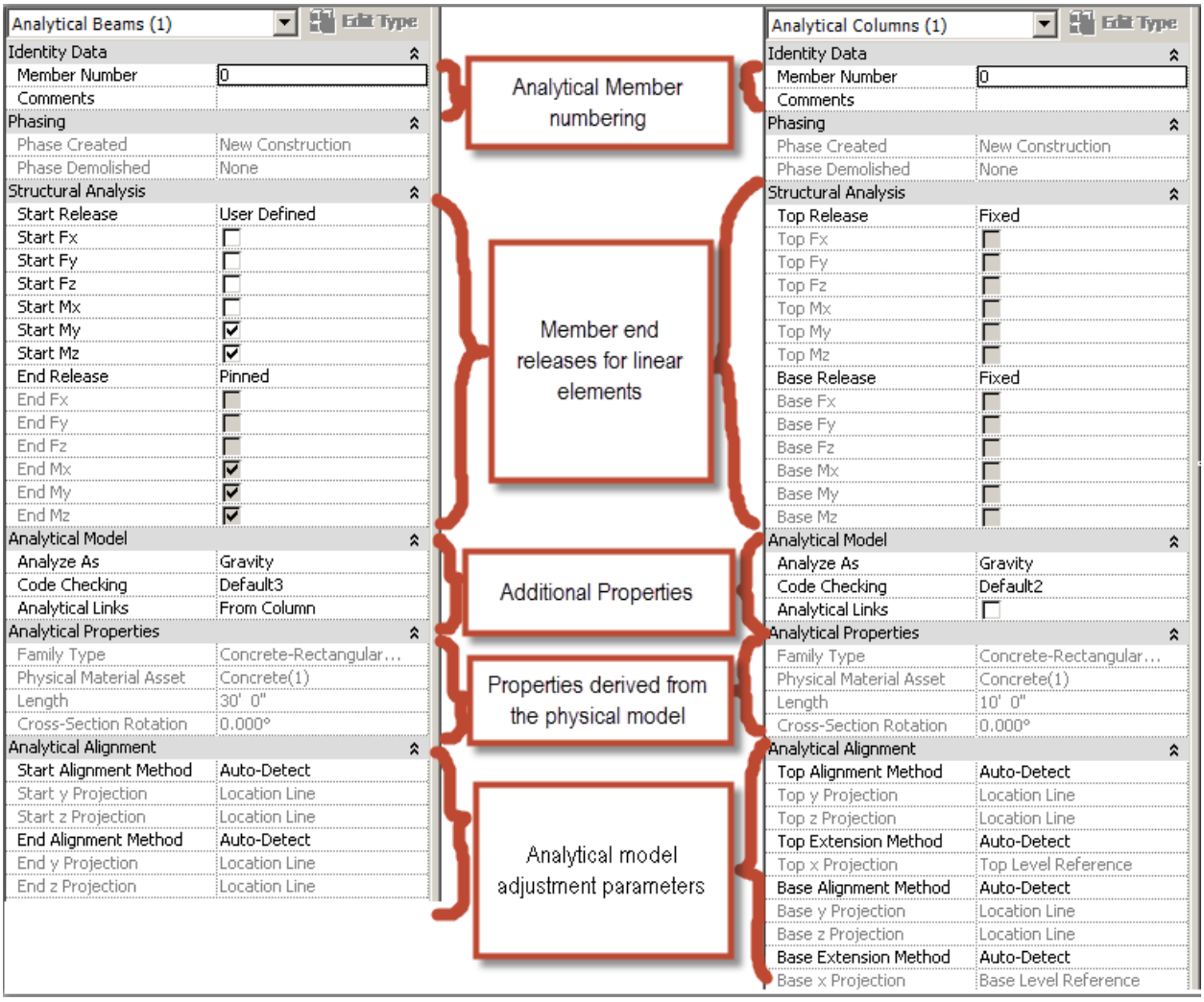
In order to support a full workflow in Revit, we have to have analysis integrated in some way. Autodesk made a bold plunge into full analysis integration in Revit by offering the A360 Cloud based structural analysis service. You can, without a third party analysis package, create model in Revit, apply loading, add boundary conditions, configure member end releases, specify load combinations, then send it directly to the cloud for analysis. Alternatively you can send your analytical model directly to Robot Structural Analysis, perform any kind of structural analysis you like.

Structural analysis results from cloud analysis or from Robot Structural Analysis can be retruned to the Revit model for exploration and visualization right inside your model. Let's take a look at how this process works:

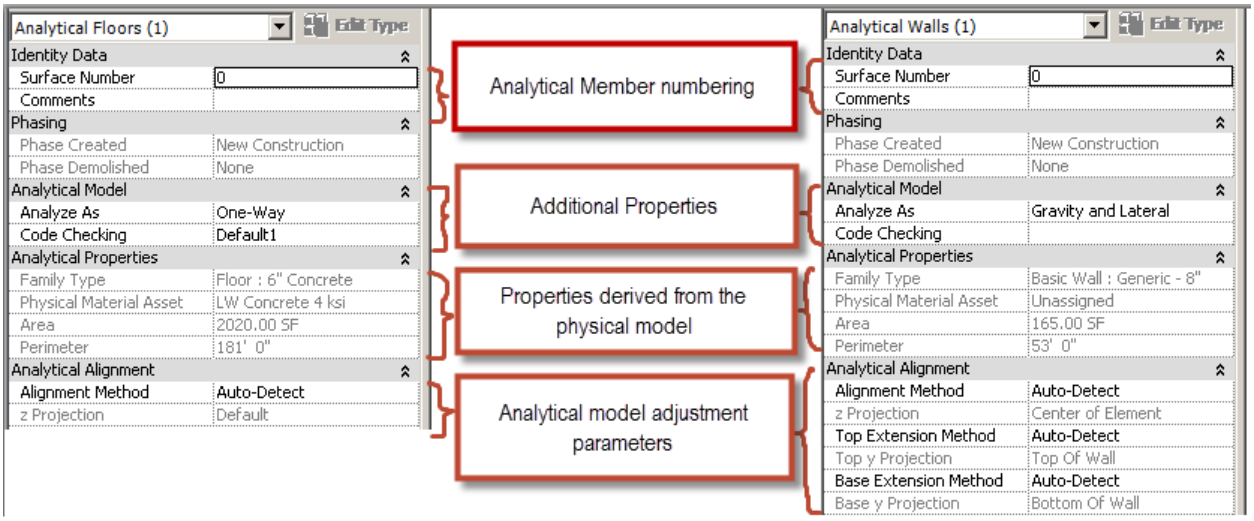
Analytical Modeling

Beams, columns, floors, walls, and foundation slabs have viable analytical models which can be used for structure idealization. These analytical elements live and die with their physical elements so we no longer have to worry about the analytical model being out of date with our physical model. One key to making this analytical model work is that the analytical model can be manipulated independently of the physical model. Allowing engineers to configure the idealized analytical model while physical modeling and documentation are unaffected, is essential to a combined workflow in one overall data model.

For beams and columns Revit provides parameters you might typically expect to be able to set for analysis such as member number, member end releases, analytical properties derived from the associated physical model as well as parameters which can control the location of the analytical model relative to the physical model. Finer control over the analytical model is available in analytical edit mode.



Floors, foundation slabs, and walls have slightly different sets of parameters but afford similar control and reporting as beams and columns;

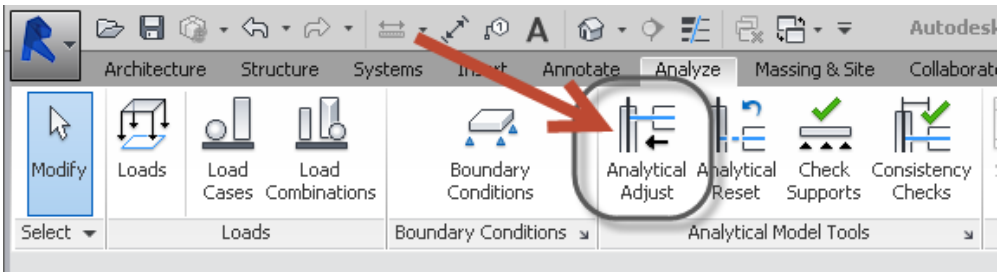


These sets of parameters form the basis for analytical model definition in Revit.

Analytical Adjust Mode:

Something that perhaps few people are aware of is the powerful analytical edit mode which was introduced in Revit 2012. The edit mode allows you to intuitively manipulate the model with node and element grips to help you create exactly the model you want, aligned the way you want it.

Accessed from the Analyze tab, the Analytical Adjust button launches the analytical adjust mode:



Once in this mode, nodes at the ends of members become visible, selectable, and have grips when selected that enable full custom manipulation of the model. In the case that Revit does not give you what you want, and the parametric adjustment for elements also does not give you quite what you want, this edit mode gives you almost total freedom.

Additional tools in the adjust mode allow you to ignore openings in floors/walls to reduce model complexity and a rigid link tool to allow you to make connections and model eccentricities.

Loads and Boundary Conditions

You can specify load cases, make manual load combinations, apply loads to your model, as well as boundary conditions. These tools together allow you to create a model which is ready for analysis directly in Revit, no need to move to a third party software.

Loading Capabilities:

- Point loads in global or local coordinates both hosted an unhosted

- Line loads in global or local coordinates both hosted and unhosted, projected or not
- Planar loads in global or local coordinates both hosted and unhosted including the option to have load projected. Unhosted surface loads can also be sloped
- All loads contain a load case property so that they may be collected together into load cases

Boundary Condition Capabilities:

- Standard options: Pinned, Roller, fixed
- Six degrees of fixity available for point (nodal) boundary conditions (three translations and three rotations)
- Four degrees of fixity available for linear (edge) boundary conditions (three translations, one rotation)
- Three degrees of fixity for surface (area) boundary conditions. (three translations)
- All boundary conditions may be oriented to the project global coordinate system or the member local coordinate system
- All boundary condition degrees of fixity can be fixed, free, or have a spring constant specified to model elastic supports.
- Boundary conditions have awesome graphics.

Results Explorer in Revit

As we have discussed, the real key for facilitating engineering workflows inside of Revit is results storage in Revit. Being able to visualize your analytical model performance directly in Revit is a powerful tool and gives you an unprecedented level of confidence that your analysis is truly connected to your model and not at arm's length as it always has been in the past.

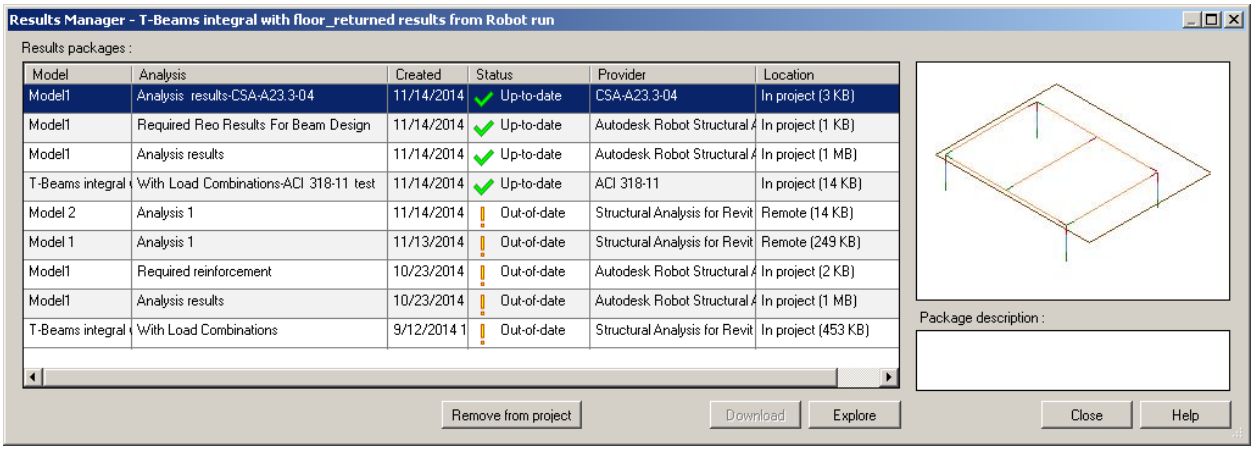
Getting Results Into Revit

Results can be stored by any 3rd party analysis application if they have added that functionality. The Structural Analysis SDK includes functionality specifically for storing and retrieving results packages in/from the Revit model. Autodesk A360 Structural Analysis provides this functionality as well as Robot Structural Analysis.

Downloading Cloud Results: Once a cloud analysis is complete, the results are still on the cloud servers. You will need to download them into your Revit model by using the Results Manager:



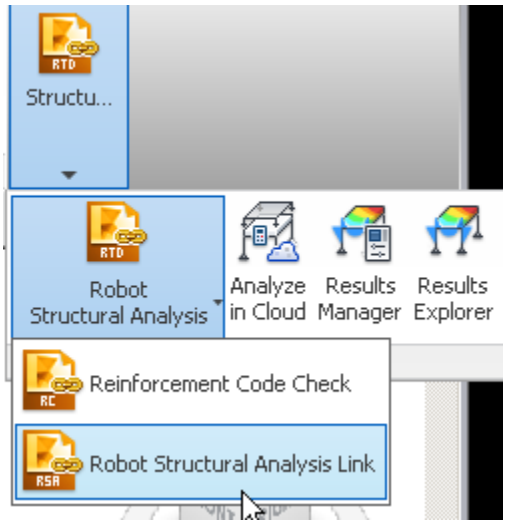
This tool provides visibility into all analysis result packages stored in, or available to the current Revit model:



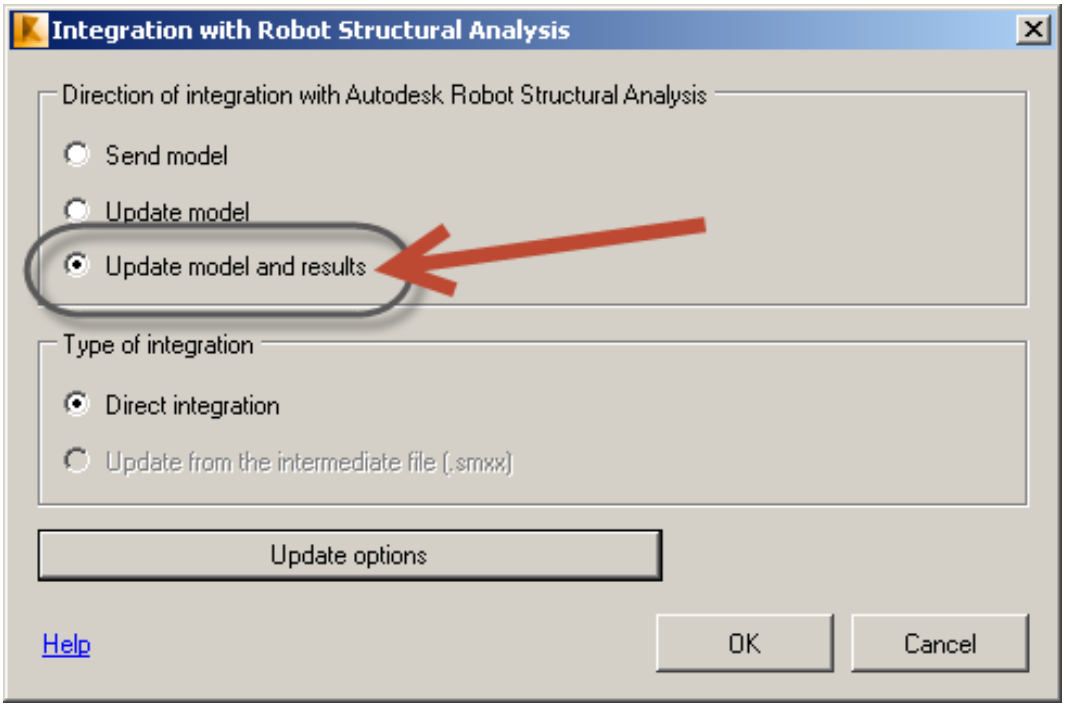
From here you can clean up old packages by deleting them if you wish, for packages with results currently in the project you can launch “Exploration” from here by using the “Explore” button and for results still in the cloud, you can download them to the project with the “Download” button.

The results will increase the size of your model but not in a way that is bad for Revit performance. The largest factors in Revit performance are number of elements in the model, this data lives alongside the element data and does not tend to impact performance in my experience.

You can also have results returned to Revit from the link with Robot Structural Analysis which you will still need to use for analyses beyond linear static analysis. Robot integration is available also on the “Structural Analysis” panel of the Analyze Tab:



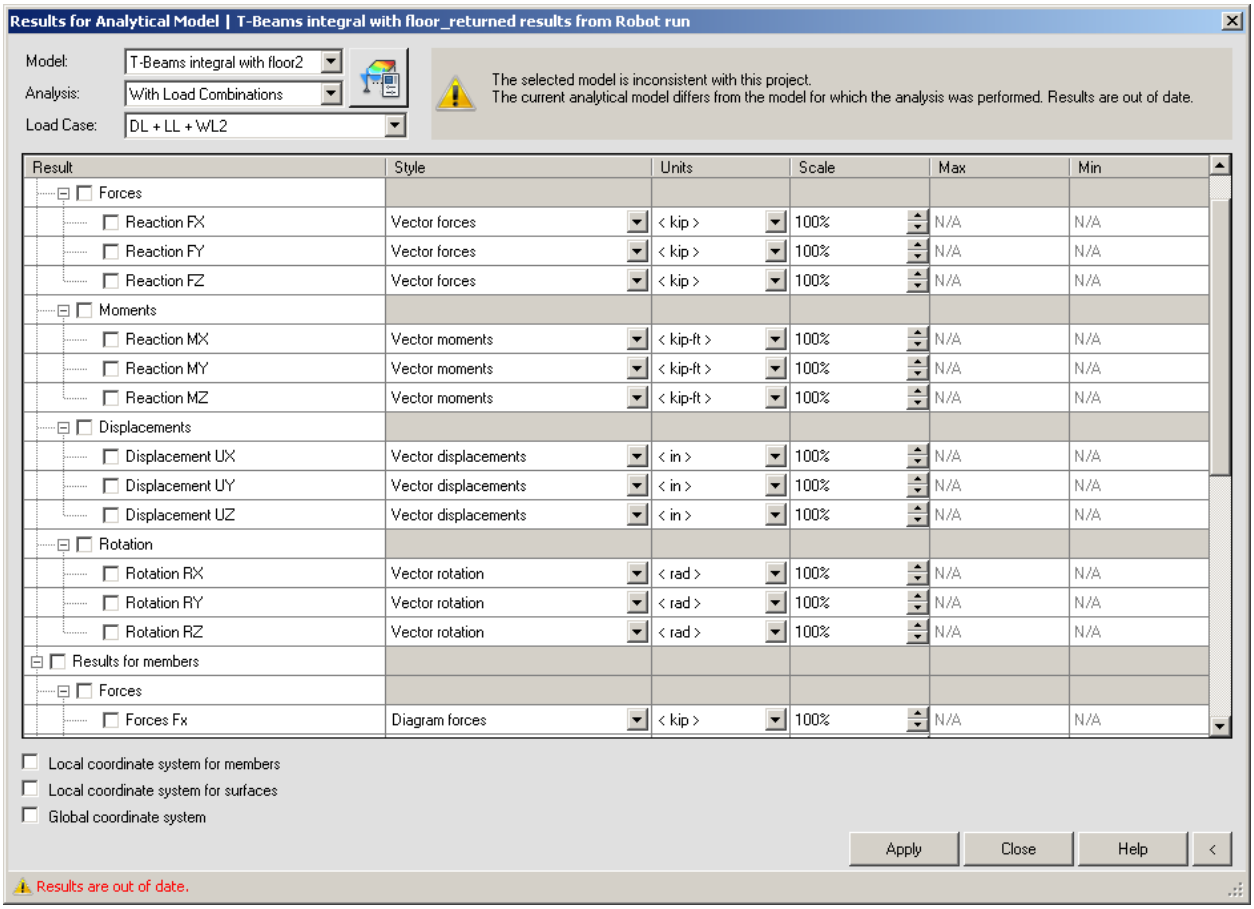
In the “Robot Structural Analysis Link” you have the options to “Update model and results” which will import results for elements analyzed in Robot Structural Analysis back into the Revit model for both exploration as well as driving downstream analysis, design, and code-checking applications. The key is getting results from analysis into the model, where they come from, is somewhat arbitrary as long as the source is a legitimate structural analysis of course.



Exploring Results

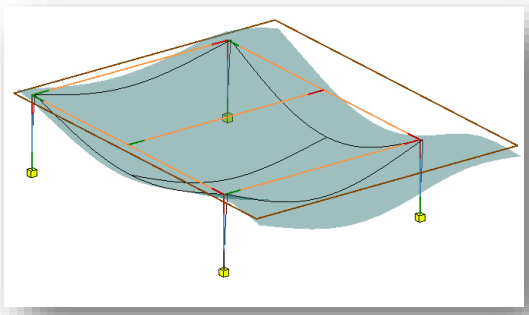
You can either launch Results Explorer from the Structural Analysis panel on the Analyze tab or from the Results Manager with the "Explore" button. Results Explorer will give you the ability to view all results contained in a result package including by load case/combination and results for linear elements as well as maps of calculated quantities on surfaces.

The explorer dialog offers you the options to switch between analysis packages and the currently displayed load case/combination. You can also select which results should be displayed on the model. If you expand the dialog, you will have even more control over the display of the results including the style of result display for the quantity, the units, and the display scale:

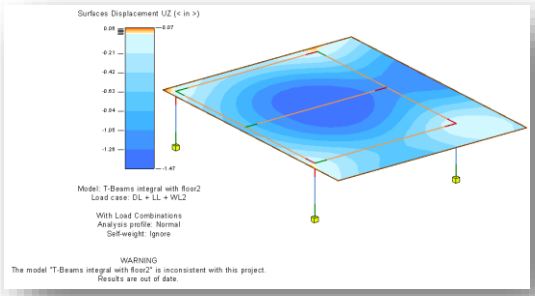


Imagine, all that functionality hiding in the Structural Analysis Toolkit! Let's take a look at some of the displays available for this simple model:

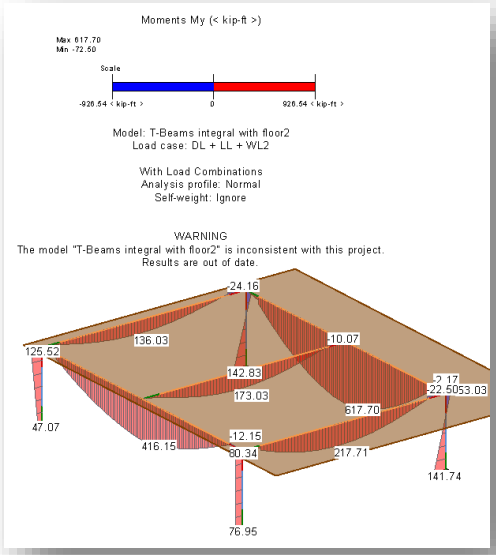
Deflected Shape:



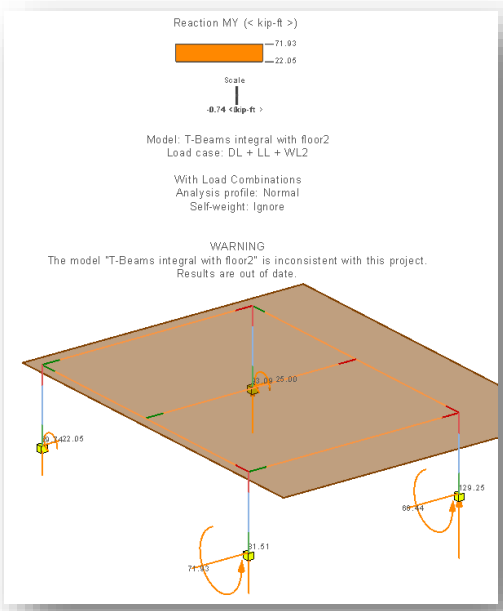
Maps on Surfaces



Diagrams on Linear Elements:



Reaction at Supports:



The Results Explorer is a user-friendly interface to display results stored in results packages in Revit. In terms of the display of the results themselves, you have a surprising amount of control over the display of each type of result. If you take a look at the parameters of the view in which you are displaying results you'll notice an "Analysis Display Style" and if you click the ellipsis button you will see all the currently displayed quantities in the view where you can control things like the visibility of the results in the view, the display style associated with the quantity, the units for display, as well as the scale. This is very similar to the information shown in the Results Explorer expanded view.

Integrated concrete design in Revit

Now that we have analysis results in Revit and have learned how to manage those results and visualize them, we want to take a look at some examples of applications that can (or will in the future) leverage these results for a fully integrated concrete design workflow in Revit. The first two solutions are geared towards full 3D rebar detailing based on requirements analysis and the last one is the first tool built on the Autodesk Code Checking Framework which intends to address a unique North American concrete design workflow.

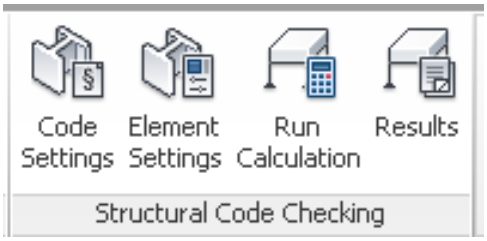
Marsh API Concrete Code Checking per ACI 318-11 and CSA-A23.3-04

The last solution is a tool that is still in the development phases and is pioneering use of the Autodesk Code Checking Framework which was published by Autodesk along with Revit 2014. As we have previously mentioned, the Code Checking Framework provides a full featured framework to facilitate per member code checking and design in Revit. We'll first look at the user interface portion of this

powerful toolkit in the way Marsh API has implemented it and then we'll look at some of the sample output and talk about future directions.

The Autodesk Code Checking Framework

Once you have installed the Structural Analysis Toolkit for Revit that there is a new panel added to the Analyze tab called "Structural Code Checking" which contains the following tools:



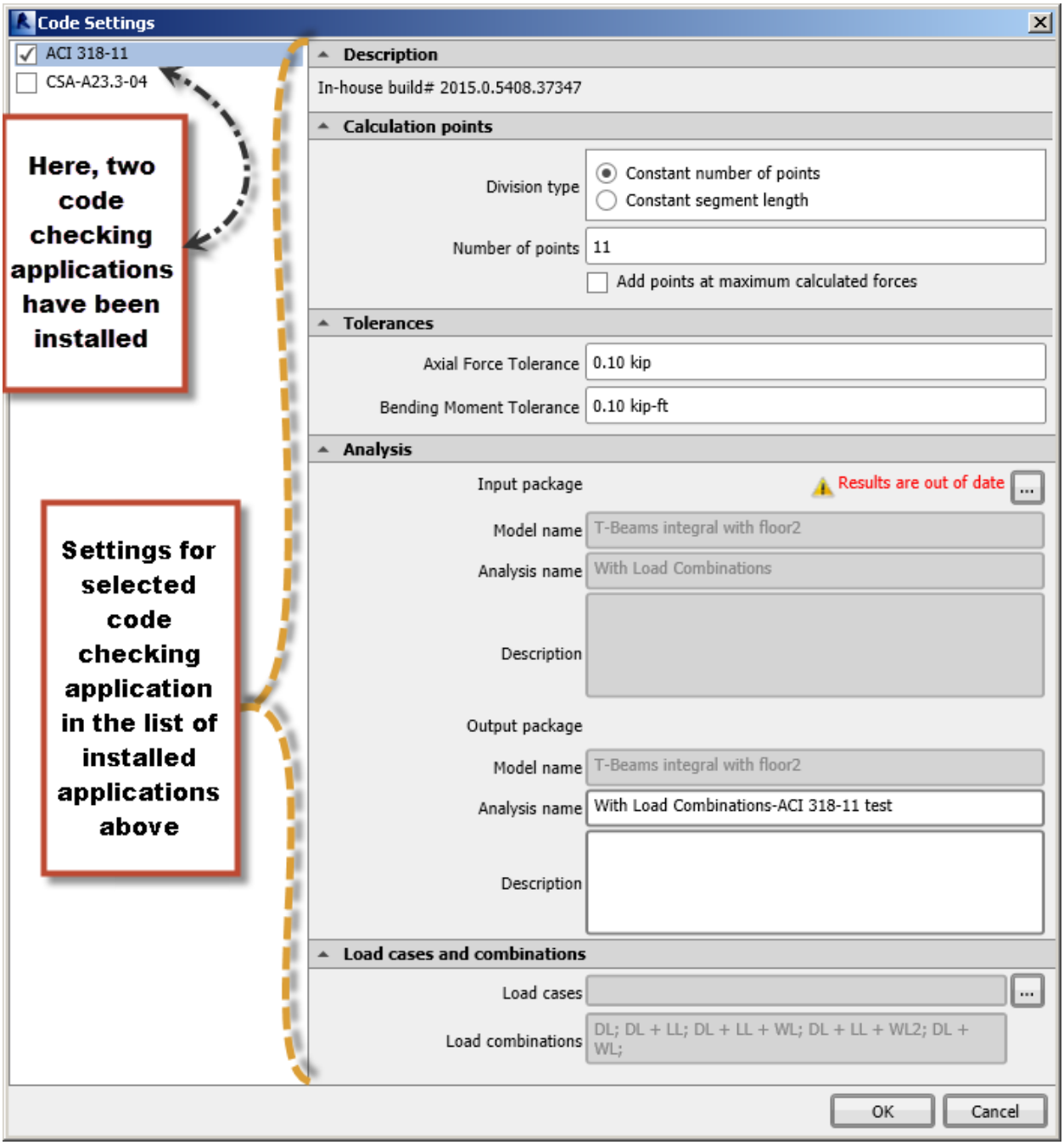
These tools work collectively to provide a consistent user experience for users of any future code checking application. Any number of code checking applications can be developed for Revit and this is the main idea of the code checking framework: Autodesk would like to encourage development of code checking utilities by experts around the world. This is a bold commitment to democratization of the code-checking and structural design workflow in Revit.

Each code checking application is installed as an external application built on the Revit API in conjunction with the Structural Analysis SDK. Each of these tools (Code Settings, Element Settings, Run Calculations, and Results) are designed to provide a common location and consistent user experience when interacting with one or more code checking applications regardless of who develops the code-checking/design functionality.

Marsh API Concrete Required Reinforcing

In order to give you an idea of how each of these tools works and provide an example of an implementation, we will look at how each of these Code Checking Framework components work together to facilitate a code checking application.

Code Settings: provides access to configure overall code parameters for any code currently installed in Revit. Clicking on Code Settings brings up the Code Settings dialog where you have access to select which, of the installed code checks, you want to enable (check boxes on the left) and to access the settings for any particular code checking application by selecting the application's entry on the left hand side of the dialog:



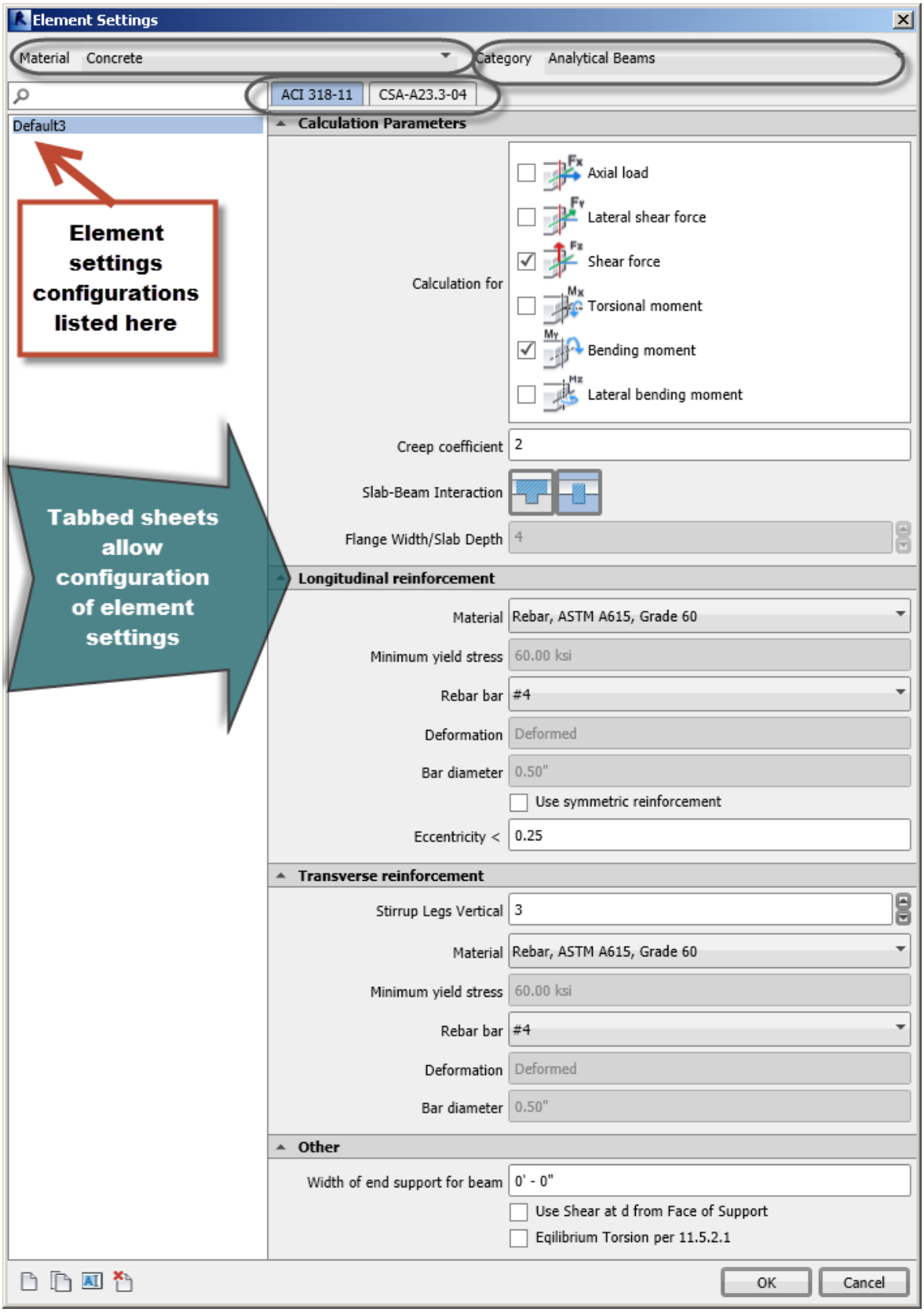
While most of the settings in this dialog are particular to the application two of the settings are provided as part of the code checking framework to facilitate selection of input package (results package) and which load cases/combinations are active for design/code-check.

As additional code checking applications are installed you would see them here in this dialog and be able to control their overall settings. Only code check/design applications checked will be executed when calculation are run. This allows the user to select multiple code checking applications to compare results or simply to design check different materials.

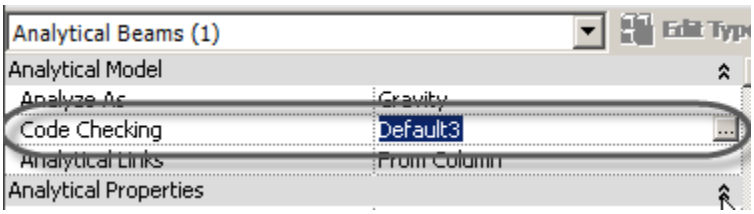
Element Settings: This is where design/code checking parameters specific to individual elements are configured and managed. For each installed code checking application there will be a tab at the top of this dialog to allow you to configure settings particular to an individual design code. As each code checking application may be unique and each code supported may have unique settings this layout is completely custom for each code checking application.

Element settings are organized by material and category. Dropdowns at the top of the dialog filter and control display of settings based on both of these items. In this example below, you see the settings for "Default3" which pertain to concrete elements of category "Analytical Beams". These settings are all part of the code checking application for ACI 318-11 and CSA-A23.3-04 that we have created. There could be as many code checking applications that implement ACI318-11 as the user is interested in obtaining. This also means that you could create your own code checking applications internally as we have previously mentioned.

Here we see the settings for Analytical Beams available. The user has control over which member forces will be considered in design, whether the beam will consider slabs above as T-Beam interaction for calculation of required reinforcing, and an initial bar size and material for the longitudinal reinforcing. There are also settings for stirrup bar/leg configuration and how the user would like to treat torsion as well as how shear should be treated near supports, all pretty standard per element controls for performing calculations of required reinforcing, and all governed by the installed code-checking application in question:


Element Settings
Material Concrete
Category Analytical Beams
ACI 318-11
CSA-A23.3-04
Default3
Element settings configurations listed here
Tabbed sheets allow configuration of element settings
Calculation Parameters
Calculation for
Axial load
Lateral shear force
Shear force
Torsional moment
Bending moment
Lateral bending moment
Creep coefficient 2
Slab-Beam Interaction
Flange Width/Slab Depth 4
Longitudinal reinforcement
Material Rebar, ASTM A615, Grade 60
Minimum yield stress 60.00 ksi
Rebar bar #4
Deformation Deformed
Bar diameter 0.50"
Use symmetric reinforcement
Eccentricity < 0.25
Transverse reinforcement
Stirrup Legs Vertical 3
Material Rebar, ASTM A615, Grade 60
Minimum yield stress 60.00 ksi
Rebar bar #4
Deformation Deformed
Bar diameter 0.50"
Other
Width of end support for beam 0' - 0"
Use Shear at d from Face of Support
Eqilibrium Torsion per 11.5.2.1
OK
Cancel

After element settings have been configured, they must be assigned to individual elements. Analytical elements in Revit have a new property as of Revit 2014 called “Code Checking” under “Analytical Model” section of the analytical element properties as shown here:

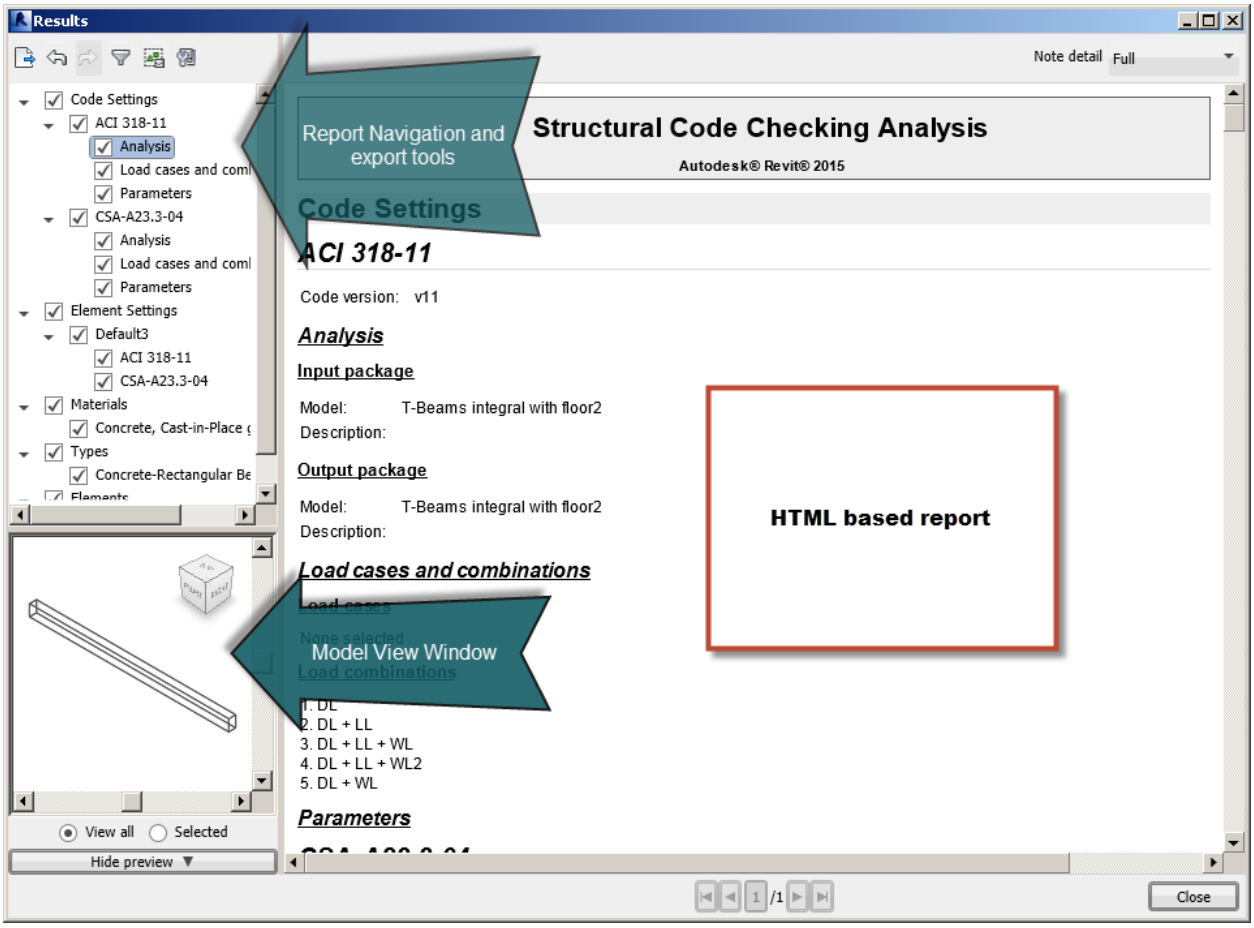


Pressing the ellipsis button will bring up the element settings dialog where you can select an element settings configuration from the list you have previously configured, or even modify or add a new element settings configuration for a particular element. All Revit analytical elements now have a “Code Checking” parameter. Note that it is the Analytical element not the physical element that hosts this parameter.

Run Calculations: Once code settings have been set, the code-checking app selected to run in Code Settings dialog, and Element settings have been configured and assigned to elements of interest, pressing “Run Calculations” will proceed to execute all code-checking applications currently configured for all elements selected by the user.

Each code checking application will perform its own calculations and prepare its own output for you to review and utilize in your documentation. The individual code checking applications may additionally store new results packages in the Revit model to facilitate further downstream analysis, design, review, or additional code-checking.

Here is a sample of the results viewer which is provided by the Code Checking Framework with results from a calculation of a beam for ACI 318-11:

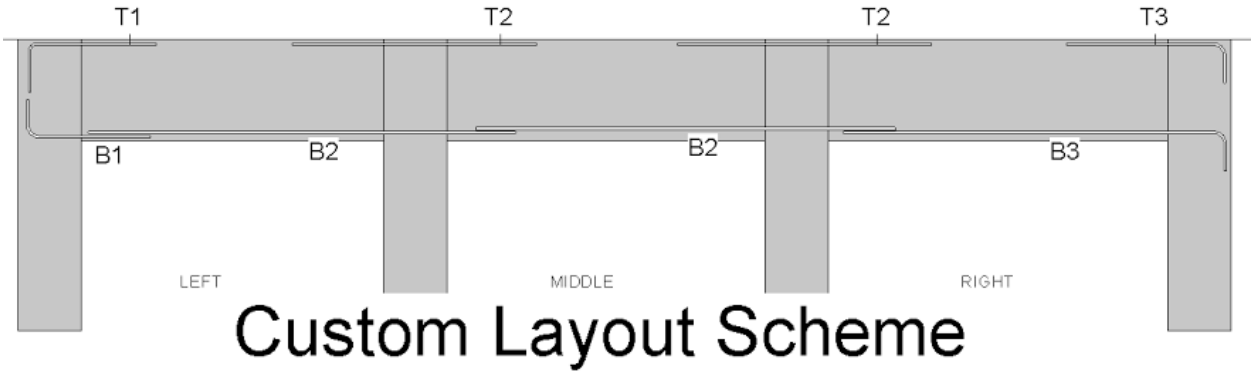


The main components of the report viewer provided by the Code Checking Framework are

1. Report Navigation and Export Tools
    a. Provide quick navigation through the report which can be somewhat lengthy
    b. Allow the user to export and save a copy of the HTML report
    c. Adjust the sorting order of the report
    d. Filter the report
2. Model View Window
    a. Elements currently displayed in the HTML report are will be highlighted in the model view area. The elements are all listed by element ID so having some visual feedback in terms of the model view is very helpful in understanding the element for which you are viewing results.
3. HTML Report area
    a. In addition to the wealth of set-up information available in the standard report, individual code-checking applications will generate their own result information for the elements.

Applying the bar layout schema

The key to this whole process is the ability to specify a customizable layout schema which can be extended to any situation in the model. This schema may have many bar "groups" (e.g., T1, T2, B1, B2) with lengths and positions all referenced to column or column face locations and relative to the actual length of the members which comprise the line in the model. This schema is critical to facilitating both workflows:



Example of potential Revit Schedule generated by RConcrete:

Beam Type	Dimensions	T1	T2	T3	B1	B2	B3
CB1	12"x24"	3#7	4#9	4#7	3#6	6#8	6#8
CB2	12"x24"	4#5	4#7	3#7	2#8	4#8	2#8