Bullet Constraints Builder Tutorial

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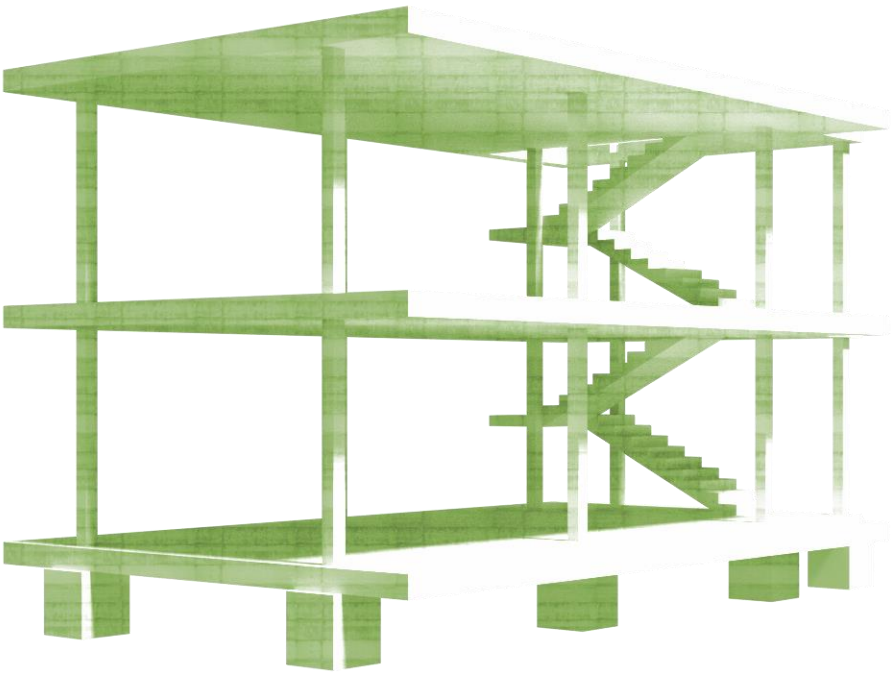
BCB Installation & Simple Collapse Simulation



Laurea University of Applied Sciences

Kai Kostack & Oliver Walter

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1. Introduction

The Bullet Constraints Builder (BCB) was developed from scratch during the three yearlong R&D project INACHUS (1) at LAUREA, University of Applied Sciences (2). The focus during this time was on improving the software, its accuracy and speed, therefore tutorials were time and again postponed. Due to the growing interest and requests from universities and engineers around the world, tutorials became indispensable. This tutorial is the first of three that have been written to gradually introduce the BCB basics:

BCB Tutorials:

1. Guide for BCB Installation & Simple Collapse Simulation
- installation instruction and introduction into a simple collapse simulation

2. Guide to Simulate a Multi-Family House with Standard Blender
- Introduction of the BCB fundamentals with standard Blender

3. Guide to Simulate a Multi-Family House with Fracture Modifier
- Introduction into a speed optimized variant with the FM

To follow this tutorial no Blender knowledge is required.

2. What is the BCB?

The BCB is a software that is installed as an add-on from within Blender. It extends Blender´s basic physics functionality with a sophisticated toolset to simulate load dynamics in building structures. It establishes constraining connections between loose rigid bodies that incorporate real world parameters.

At this stage the BCB is first and foremost suitable to simulate the effects of major structural deficiency in composite reinforced concrete structures such as incapacitated load bearing elements e.g. beams or pillars. While the BCB´s formulas for the strength evaluation of reinforced concrete (RC) elements have been approved by civil engineers the formulas for the strength of steel members are not yet approved.

It has been validated by comparison in a few collapse cases (3; 4) in which the simulation results showed a good affinity with the real-world collapse shapes. However, virtual collapse simulations in general can't claim absolute authenticity and the BCB results should be used with careful consideration in critical applications.

The BCB has a rich set of functionalities that allow specialists to setup building models, define the interdependencies between the structural elements or define collapse scenarios. Nevertheless, the tool can also be used by amateurs. With a few simple steps the user can load predefined models, setup collapse scenarios and start the simulation to observe the effects.

3. Installing the software

The BCB is a set of scripts that needs to be installed as an add-on from within Blender. After the installation the full functionality of the BCB becomes available in Blender´s user interface. It is strongly recommended to use the software versions that are specifically named in this guide to avoid incompatibility or error messages. The software is open source and can be used for free.

The installation is only necessary once and it is done in the two following steps:
1. download and install Blender 2.79a
2. download and install the BCB from within Blender

3.1. Installing Blender

Blender is available for the following operating systems:
- Windows Vista, 7, 8, 10 32-bit/64-bit
- Mac OS X 10.6+ 64-bit only
- GNU Linux 32-bit/64-bit

This guide will walk you through the Windows installation. You can find descriptions for the installation on other operating systems on the internet.

1. Download the Blender software version 2.79a here: https://www.blender.org/download/ see Figure 1.

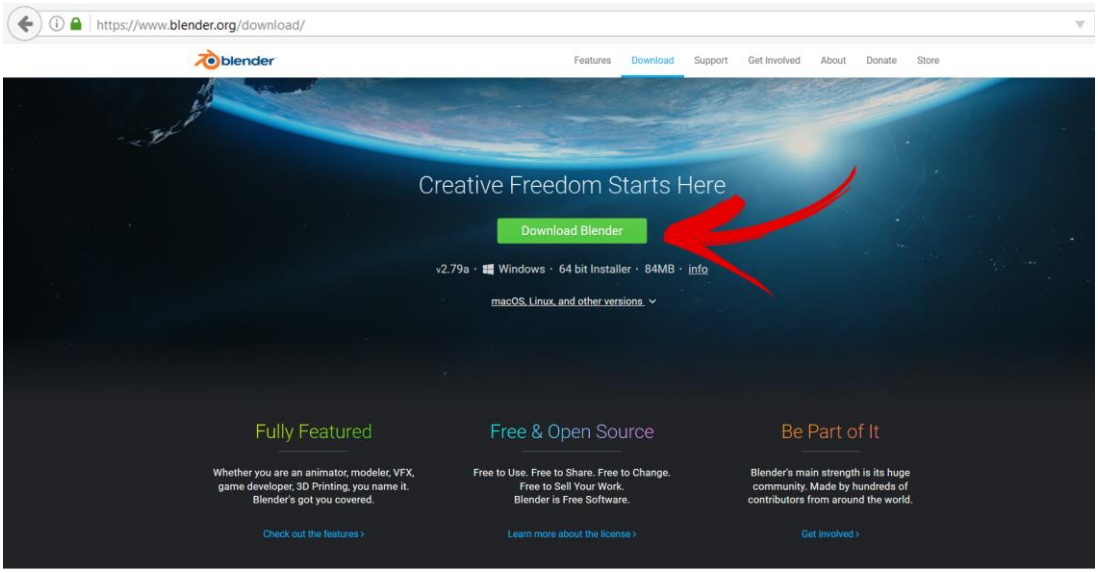

Figure 1

2. On your computer navigate to the blender-2.79a-windows(..).msi file that you just downloaded and double click it. Confirm all the following installation notifications, Figure 2. Blender is now installed on your system.

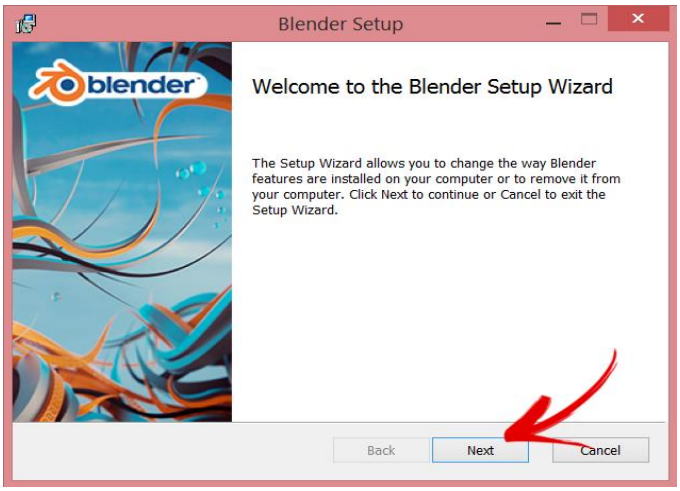

Figure 2

3.2. Installing the BCB

1. Download the BCB from this site: https://github.com/KaiKostack/bullet-constraints-builder Localize the file "**kk bullet constraints builder.zip**", click on it, Figure 3.

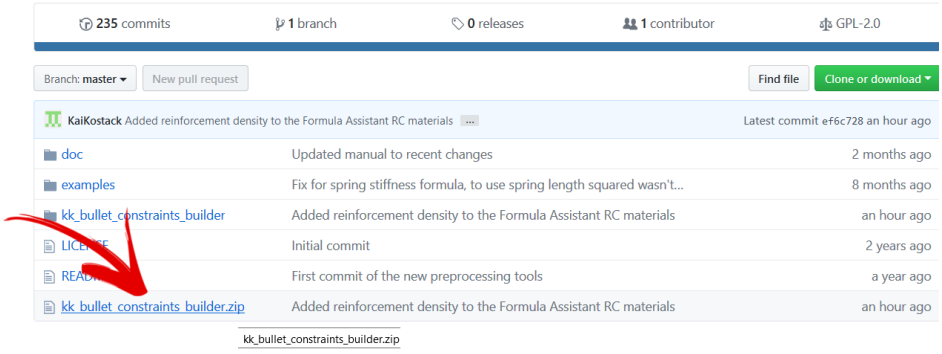

Figure 3

On the next page, Figure 4, click "**Download**" and save the file on your computer.

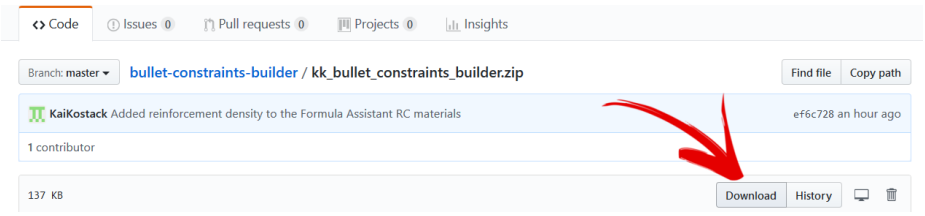

Figure 4

Note: The zipped file should not be unzipped! Blender will do this instead!

2. Start Blender and click "**File"** (Figure 4) **(**1.) on the left upper corner of the Blender interface, in the fly-out menu find "**User Preferences**" (2.) and click that as well.

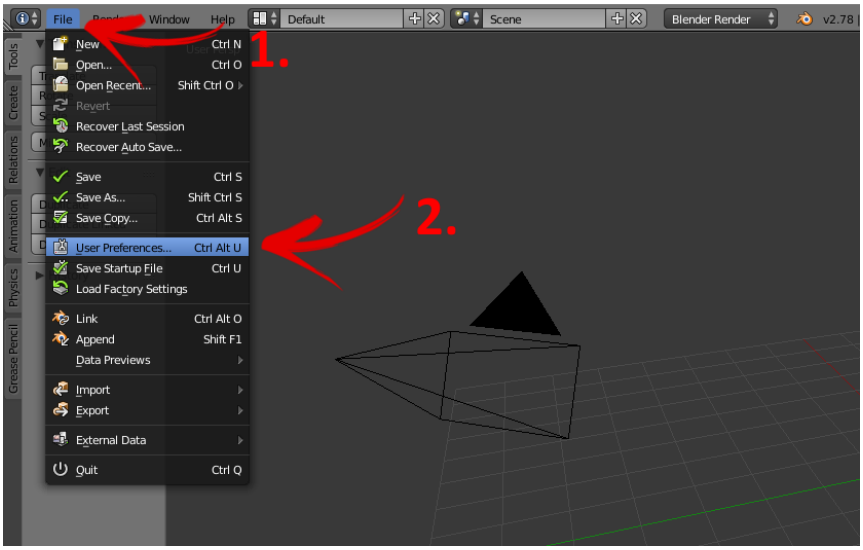

Figure 5

3. In the User Preferences window (Figure 5) activate "**Add-ons"** (1.) and then click on "**Install from File"** (2.)

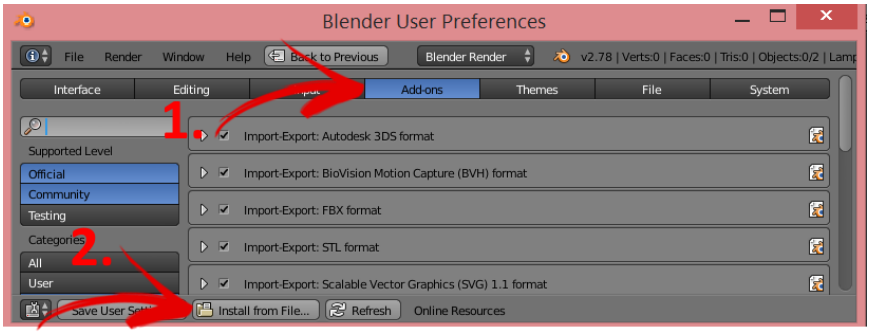

Figure 6

4. Browse to the file "**kk bullet constraints builder.zip"** (1**.)** that you just downloaded mark it and then click "**Install from File" (2.)**, Figure 7.

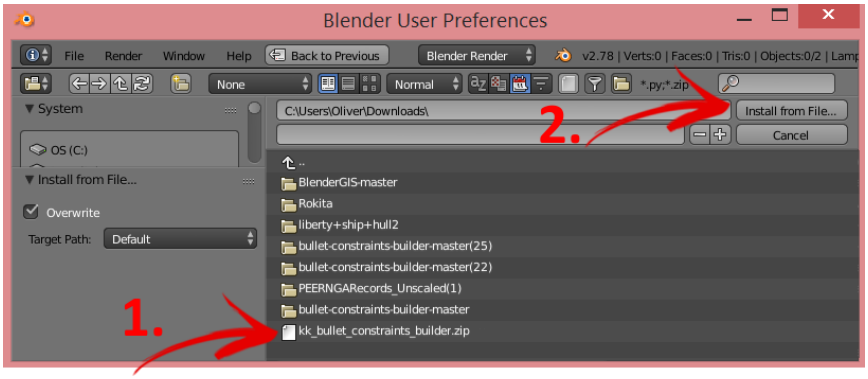

Figure 7

5. You can bring the script to the forefront by typing “Bullet” to the search field. Activate the script by checking the **check box (1)** and then click “**Save User Settings” (2)**. Close the User Preferences window, Figure 8.

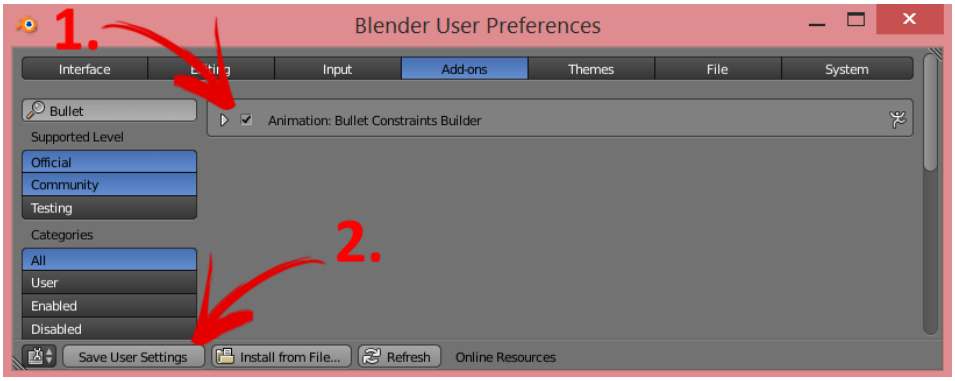

Figure 8

6. If there is now a tab named “**BCB**” on the left-hand side of Blender´s user interface, the installation was successful and you are ready to go. Activate the “**BCB**” tab and the BCB interface will open, Figure 9. From now on the BCB will automatically be loaded when starting Blender.

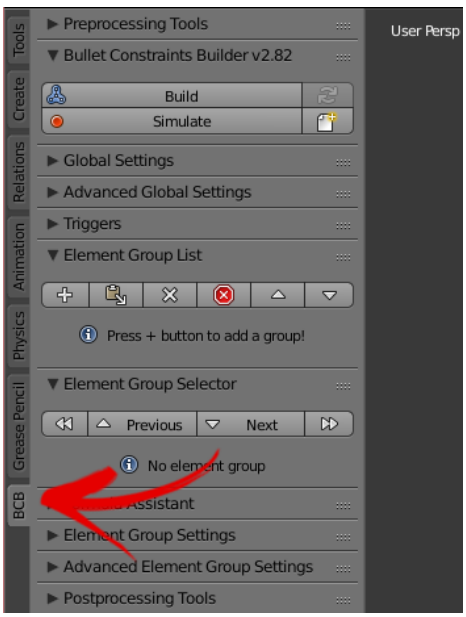

Figure 9

4. Performing a simple collapse simulation

4.1. Loading the model

- Download the sample model from here: Sample model [1]. It is a simple two storey concrete structure, the Dom-Ino house by the architect Le Corbusier. Open this model in Blender.

- Make sure the "**BCB**" tab is selected by clicking on it (red arrow in Figure 9), the BCB user interface will then show up, Figure 10. The time line displays the total length of the simulation of 250 frames. Once the simulation has been finished and by adjusting the time line slider the different stages of the simulation can be tuned into, Figure 10.

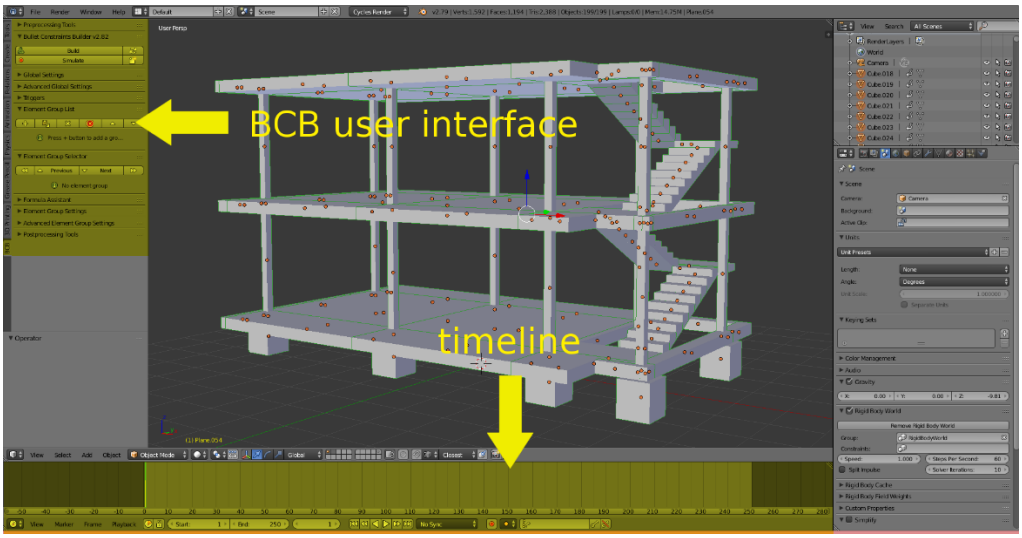

Figure 10

4.2. Prepare the model for simulation

- In the BCB- user interface **load configuration settings** (1. in Figure 11**)**, this will load the material settings for the element groups.

- Now, make sure that all elements in the scene are selected by pressing "**A**" on your keypad. The elements will be marked with a green outline.

[1] https://github.com/KaiKostack/bullet-constraints-builder/blob/master/examples/example_dom-ino_house.blend

- Press "**Build**" (2. in Figure 11), this will connect the building elements in the scene with each other. This process may take around 10 seconds.

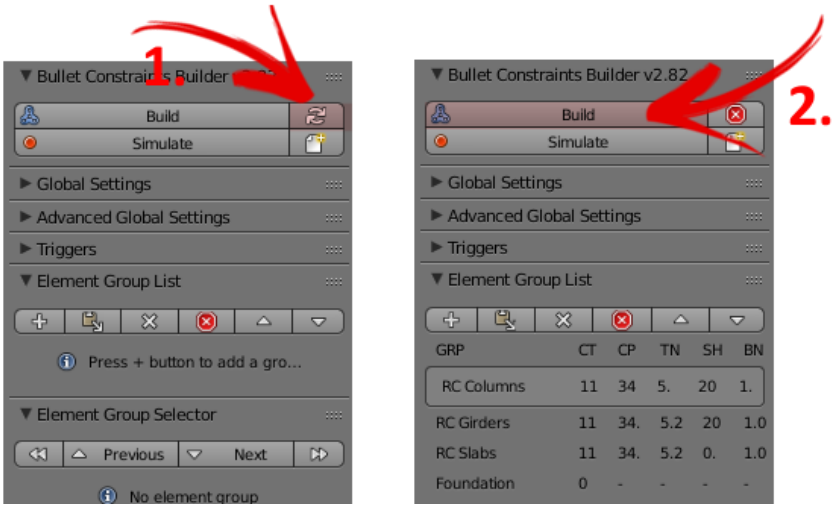

Figure 11

- Your model should look as shown in Figure 12. The connections between the building elements are represented as constraints (1. in Figure 12) which are placed on the next available free layer.

- Switch this layer off since the constraints do not concern us. To switch this layer off click on the first layer field (2. in Figure 12).

- Save this Blender model and use it for any subsequent simulation.

Figure 12

4.3. Create your own collapse scenario

- Press the right mouse button repeatedly while you move the cursor over the model. You will notice that elements will be selected one by one which is indicated by a green outline around the selected element.

- Now select any of the pillar segments, press "**delete**" on your keypad, Figure 13. You can repeat this process and delete more elements if you like.

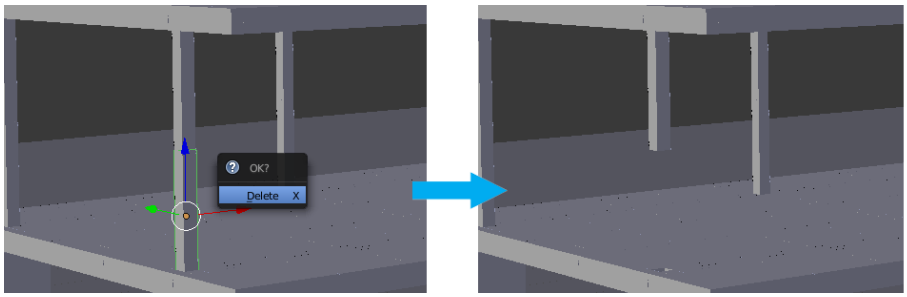

Figure 13

4.4. Start the simulation

- When you are curious to see how your structural changes affect the stability of the structure, start the simulation by pressing "**Simulate**" in the BCB user interface, Figure 14.

- The simulation progress can now be followed in real time. The program calculates a total time span of 250 frames by default, but the calculation can be shortened at any time by pressing "**esc**" on your keyboard. By moving the slider on the timeline the simulation can be scrolled back and forth.

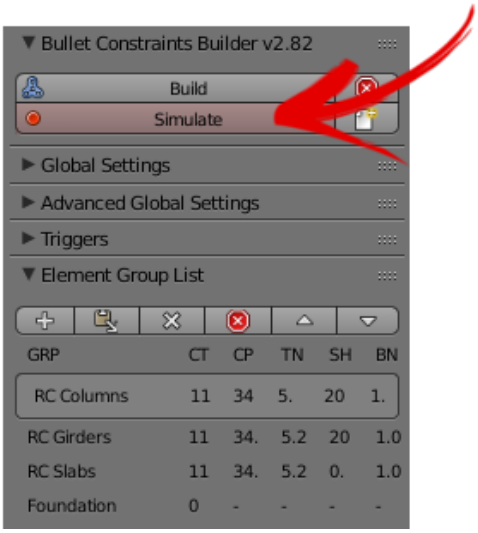

Figure 14

4.5. Change the collapse scenario

- To change the collapse scenario it is recommended to reload the previously saved model (with the ready built constraints setup). Please don´t forget to reload the configuration settings, Figure 15. Then define a new collapse scenario and start the simulation.

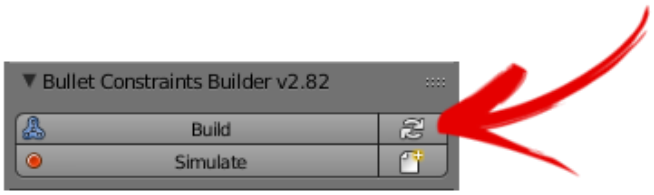

Figure 15

- Another option to restore the original condition by pressing "**CTRL+Z**" repeatedly on your keyboard until the constraints setup is deleted, continue by re- building the constraints and define a new collapse scenario afterwards.

5. A general remark concerning simulation precision

Coherent looking simulations cannot be expected from coarse building models such as presented in this exercise. We have to bear in mind that single rigid body elements are not breakable! Imagine a column in the middle of a rather large ceiling slab, this column will not be able to punch through that slab element. Breaks are only possible at the joint of two elements. To evaluate forces as authentically as possible object edges must be available close to the occurrence of the highest forces, this is increasingly the case in building models with higher discretization.

6. References

1. **INACHUS.** [Online] Institute of Communication and Computer Systems. [Cited: 02 02 2018.] https://www.inachus.eu/.
2. **Laurea University of Applied Sciences.** Inachus. *Wordpress.* [Online] [Cited: 9 1 2018.] https://inachuslaurea.wordpress.com/.
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4. **Virtual Validation Corporation.** Collapse Simulation 11-Storey Building. *Youtube.* [Online] Virtual Validation Corporation. [Cited: 18 01 2018.] https://www.youtube.com/watch?v=yu2bQtIS69g.