DIGITAL APPROACHES TO BUILDING MEASUREMENT: STANDARDS, TOOLS AND TECHNIQUES

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Disclaimer

This Handbook provides general guidance only and is not intended as a substitute for industry standards and practices.

Deakin University recommends that users consult the latest version of available ANZSMM and/or other relevant industry standards and practices to ensure the information/measurements/methodology provided are current and correct and conform with applicable industry standards and practices.

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ABBREVIATIONS AND TERMINOLOGY

The following abbreviations are used throughout this book:

- ANZSMM: Australian and New Zealand Standard Method of Measurement
- ASMM: Australian Standard Method of Measurement
- BQ: Bill of Quantities
- CAD: Computer-aided Design
- CHS: Circular Hollow Section
- f'c: Specified compressive strength of concrete at 28 days
- MPa: Megapascal
- PDF: Portable Document Format
- PF: Pad Footing
- QS : Quantity Surveying
- RF: Raft Footing
- RHS: Rectangular Hollow Section
- SF: Strip Footing
- SHS: Square Hollow Section
- UOM: Unit of Measurement

The terms “RIB CostX” and “CostX” are used interchangeably throughout the handbook.

ACCESSIBILITY STATEMENT

This resource includes images and diagrams that contain detailed information. To ensure readability, images can be clicked to view in a larger format. For the best experience, we recommend accessing this handbook on a larger screen

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

To align the teaching and learning of building measurement with current industry practices and standards in Australia, it is essential to update traditional teaching materials[1]. Existing textbooks predominantly focus on manual measurement methods and provide limited coverage of computer-based techniques that are now widely adopted in professional practice. This handbook addresses this gap by integrating digital measurement tools, particularly RIB CostX software, which reflects contemporary industry workflows. The approach adopted in this book aligns with the principles of the Australian and New Zealand Standard Method of Measurement (ANZSMM) and industry practices.

This handbook covers key trades, namely groundworks, concrete, formwork, reinforcement, and masonry. The key goals of this handbook are to:

- increase access to high-quality, up-to-date resources that reflect current industry practices
- support students in transitioning from manual to digital measurement techniques
- promote collaborative and innovative learning through the sharing of resources within both the academic and professional communities, and
- ensure alignment with accreditation requirements and adherence to Australian industry standards.

Chapter two presents the technologies related to trades classified under groundworks. Items such as clearing the site, topsoil excavation, removal of trees, basement excavation, pit excavation, trench excavation, backfilling, disposal of surplus excavated materials, working space and paper and plastic membranes are discussed. The chapter outlines the specific measurement rules and description writing conventions for these items. The measurement process is then demonstrated using a real-world building project, with examples provided using RIB CostX software.

Chapter three focuses on concrete works. It introduces various concrete elements such as strip footings, slabs, and pad footings, as well as associated considerations like grade, thickness, and form of construction. The chapter details the rules for measurement and description of concrete works, followed by worked examples using CostX software to illustrate digital take-off procedures.

1. Gurmu, A., Kamardeen, I. and Mahmood, M.N., 2023. Blended pedagogical model for effective teaching of building measurement and estimating. International Journal of Construction Management, 23(7), pp.1138–1147.

Chapter four describes the measurement of formwork. It explains the function and types of formworks used in different structural components. The chapter clarifies the measurement principles, such as deductions, repetitions, and surface areas to be included. The use of digital tools to automate surface area measurement is demonstrated through step-by-step CostX examples.

Chapter five explains reinforcement works. It covers reinforcement types and bar sizes. Measurement conventions for reinforcement are also introduced in this chapter. The chapter then discusses the process of quantifying reinforcement from drawings using CostX software to enable users of this handbook understand the digital measurement processes of reinforcement.

Chapter six focuses on masonry, covering various types of walls (solid, veneer, and cavity), as well as piers and damp-proof membrane. It discusses typical wall construction, bond patterns, and openings, along with the measurement of wall areas and piers. Measurement rules are explained, and users are guided through how to perform take offs using CostX software to extract accurate masonry quantities from digital plans.

1.2 THE MEASUREMENT PROCESS

Figure 1.1 provides a comprehensive visual representation of the measurement process typically followed in the preparation of a Bill of Quantities (BQ) for construction projects. The flow chart in Figure 1.1 underscores the sequential and integrated nature of the measurement process. It illustrates how various information sources (drawings, standards, specifications) converge through the act of measurement,either manually or digitally,to produce outputs (BQs) essential to the financial and contractual management of construction projects. This structured process plays a critical role in construction estimation, cost planning, tendering, and contract administration, and it integrates key inputs, tools, and outputs used by quantity surveyors and cost estimators. Understanding this process is crucial to develop the technical and digital competencies expected in the contemporary construction industry.

The process begins with the analysis of drawings, which are usually produced by architects, engineers and other construction professionals. These drawings include floor plans, elevations, sections, and details that define the scope and physical dimensions of construction works. Accurate interpretation of drawings is fundamental skill, as all subsequent measurement activities are based on the information available on the drawings.

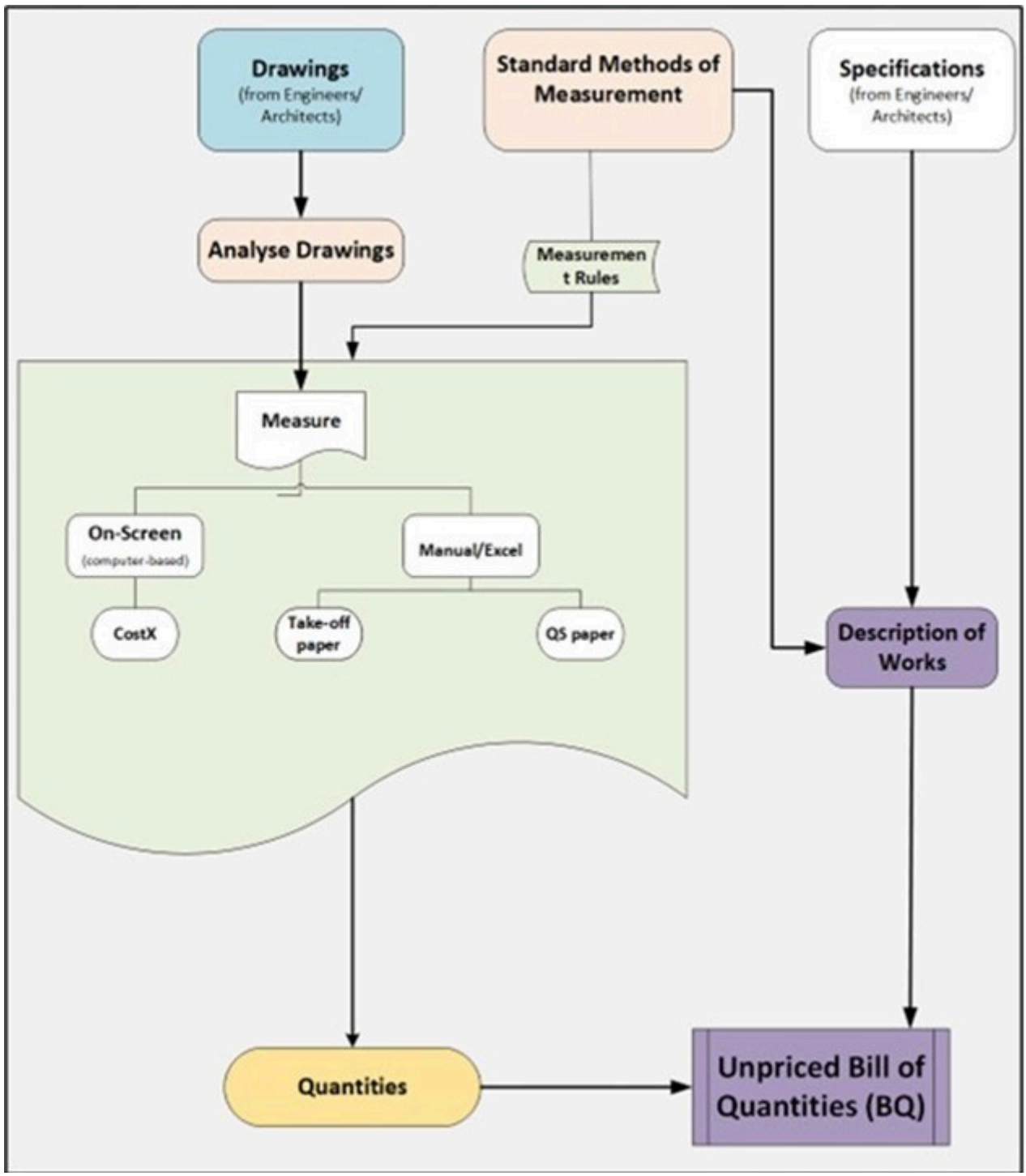


Figure 1.1: Flow chart of the measurement process (Source: Created by Authors)

As shown in Figure 1.1, the measurement process is guided by the standard methods of measurement, such as the ANZSMM. The standard provides a framework for how construction work should be described and measured. It ensures consistency in the interpretation of quantities across projects and between stakeholders.

Another key input in the measurement process is the project specification, which details the technical and qualitative requirements of materials, construction techniques, workmanship standards, and compliance

obligations. Specifications often contain information not visible on drawings, such as strength grades of concrete and reinforcement types. Therefore, specifications complement the drawings and provide useful information for writing the descriptions of works.

After gathering and analysing these inputs, the measurement task can proceed. The measurement can be performed using one of two main approaches:

- On-screen (computer-based) measurement: This involves the use of digital tools such as RIB CostX software, which allows users to upload digital plans [Portable Document Format (PDF), Computer-Aided Design (CAD) files or images], calibrate them to scale, and perform measurements on screen with tools for length, area, and volumetric take off. This method increases efficiency, accuracy, and traceability in measurement. It also enables the integration of measurement data with estimating tools and BIM models, aligning with modern digital construction practices. This method is adopted in this handbook, and the details are explained in the subsequent chapters.

- Manual or Excel-based measurement: This method comprises transferring measured dimensions from drawings to take-off paper or Quantity Surveying (QS) paper. This method, while more traditional, remains relevant for building foundational skills in measurement logic, and can still be used in practice where digital tools are not available or suitable.

Both methods produce quantities for different trades of work. These quantities are typically recorded using standard item codes and structured descriptions based on standard rules. The final outcome of the process is the preparation of an Unpriced BQ, which presents a detailed list of works, quantities, and descriptions, ready to be priced by bidders.

1.3 ON-SCREEN MEASUREMENT WORKFLOW

Figure 1.2 illustrates a detailed workflow for conducting on-screen measurement using RIB CostX software, a digital platform adopted in the construction industry for quantity take-off and cost planning. In this handbook, the terms RIB CostX and CostX are used interchangeably. This process forms the practical backbone of this handbook, guiding users through the standard industry methodology from the import of drawings to the generation of reports. The workflow begins by adding project drawings into CostX. These drawings, typically received in PDF, CAD, or image file formats, form the foundation for all subsequent measurements. Once imported, the drawings are calibrated to ensure the measurements taken within the software are accurate. This involves setting a known reference dimension on the drawing to establish the scale. Following calibration, dimension groups are created for each trade or work category (e.g. concrete, groundwork and reinforcement). These groups help organise the measurement tasks and align with how quantities are typically reported in industry. Measurements are then carried out using CostX's on-screen tools, allowing the user to trace linear or area components directly on the digital drawings. Once measurements are complete, the quantities are transferred to the CostX workbook, which serves as a digital version of the traditional Bills of Quantities spreadsheet. Each measured item is accompanied by a clear description. This ensures clarity in how work items are documented.

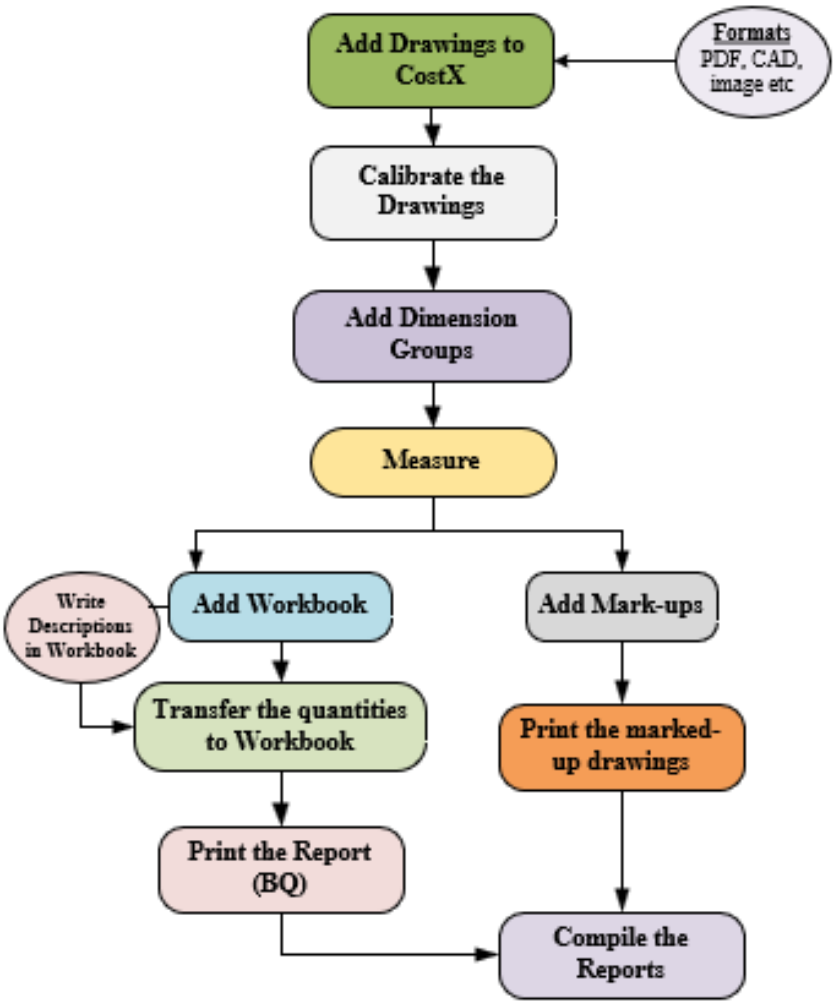


Figure 1.2 Workflow for on-screen measurement (Source Created by Authors)

After transferring quantities, users can generate reports such as the unpriced BQ. These reports list each item with its corresponding description, unit, and quantity,but exclude prices-making them ideal for tendering purposes. At the same time, users can apply markups to the drawings to visually identify measured components. These annotated drawings, when printed or exported as PDFs, provide a visual record that complements the formal quantity reports.

Screenshots can also be taken throughout the measurement process to document complex areas or support instructional use. These visual captures serve as an audit trail and can be embedded in technical documentation or shared for collaborative review. Finally, all outputs,including the BQ report, marked-up drawings, and screenshots are compiled into a cohesive report package. This comprehensive documentation reflects best practices in contemporary cost management and supports transparency in the estimation process.

Throughout this handbook, this workflow is demonstrated step by step using real-world case studies and trade-specific examples. The aim is to support users of this handbook in mastering on-screen measurement techniques that are directly aligned with current industry practices and digital construction workflows.

CHAPTER 2: MEASUREMENT OF GROUNDWORKS

2.1 OVERVIEW

Groundworks section comprises excavation, filling and hardcore, paper and plastic membranes, underpinning, and rock stabilisation. This chapter focuses on the most commonly encountered items related to excavation, filling and hardcore, as well as paper and plastic membranes, detailing their technical specifications, the relevant measurement rules, and the measurement process using CostX software.

2.2 GROUNDWORKS MEASUREMENT RULES

Section 4 of the ANZSMM sets out the measurement rules for groundworks. The sections that follow present detailed requirements for each corresponding subsection within this category. For a comprehensive understanding of the applicable measurement procedures and pricing considerations, readers are advised to refer to Section 4 of the ANZSMM.

2.2.1 Excavation

In excavation, provisions for activities such as taking samples, conducting tests, and keeping excavations free from rainwater and percolating water, using pumping or other methods, need to be allocated as preamble items.

The excavation works comprise site works, surface excavation to reduced levels, basement excavation, pit excavation, trench excavation, backfilling, disposal of surplus excavated materials, bored excavation, cuttings, tunnelling, surface preparation, working space, and designing shoring. However, this chapter focuses on the most common items encountered in building construction; bored excavation, cuttings, tunnelling, surface preparation, and designing shoring are not discussed. According to Measurement and Pricing Rule P1 of the ANZSMM, all items under the Excavation section are deemed to include associated activities such as levelling, grading, trimming, compacting, and other similar tasks.

Site works include activities such as site clearing; removal of trees completed with stumps and roots; protection and retention of existing trees and shrubs; stockpiling of turf or vegetable soil; removal of tree suckers, roots, and similar materials; and the treatment of general ground areas and the sides and bottoms of trenches. This chapter explains the measurement rules related to site clearing, tree removal, protection and retention of existing trees and shrubs, and the removal of turf or vegetable soil.

Site clearance involves removing smaller vegetation to create sufficient space for equipment and labour. This is the first step in any construction project. Figure 2.1 illustrates an example of site clearance using plant and machinery.



Figure 2.1: Example of site clearance. Photo by Bermix Studio on Unsplash used under License | Unsplash

Site clearance area must be measured in square metres (m^2) and must include the removal of trees with a girth of 0.5 metres or less, together with their stumps and roots. In accordance with standard, tree girth is to be measured at a height of 0.5 metres above ground level, as illustrated in Figure 2.2.

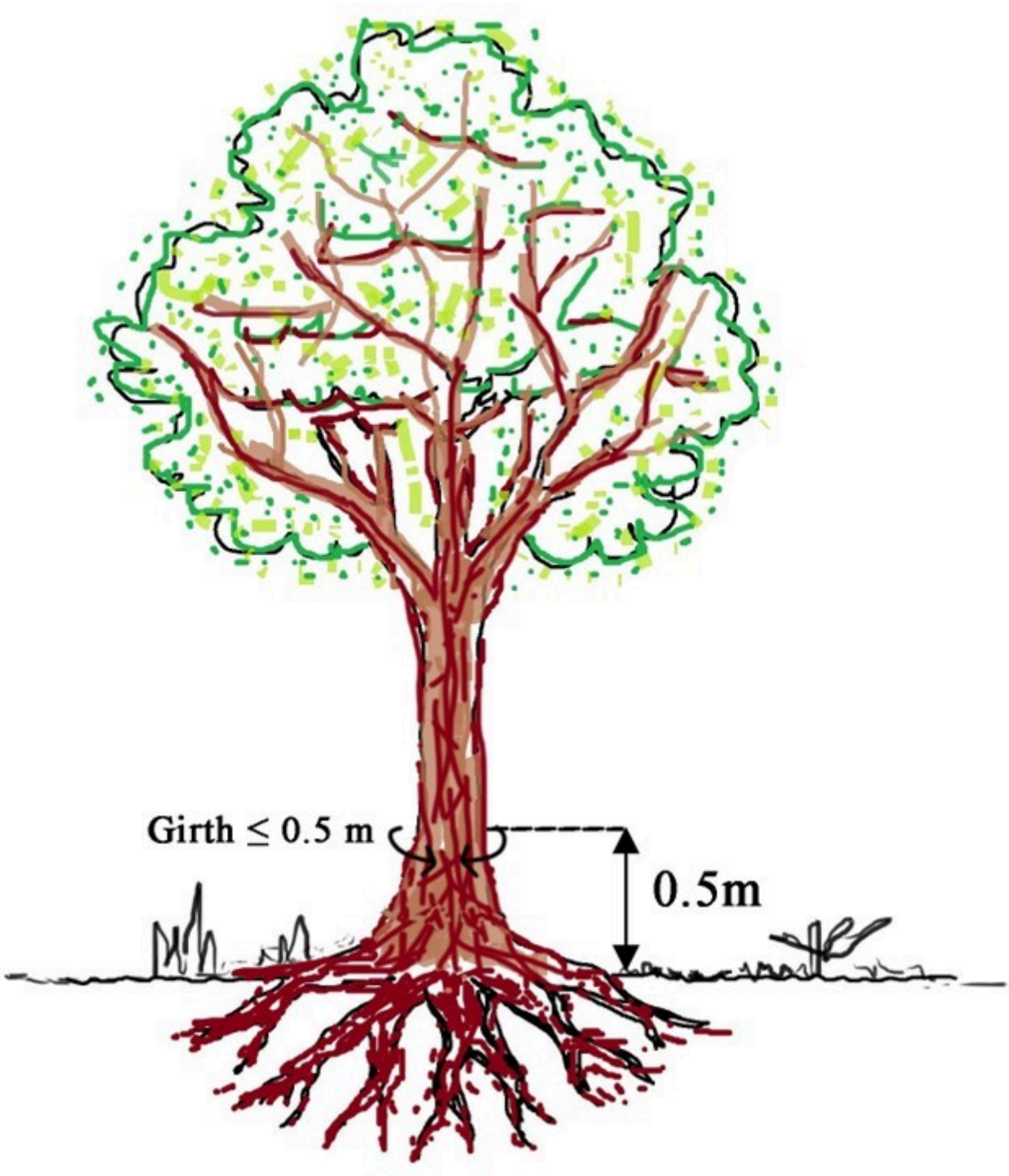


Figure 2.2: Method for measuring tree girth (Source: Created by Amirreza Aminalavije)

Trees with a girth greater than 0.5 m must be measured separately by number (no.) under the item "removal of trees complete with stumps and roots." These trees should be classified in 0.5 m girth increments. For example, a tree with a girth of 0.65 m would fall into the 0.5–1 m category. Additionally, existing trees and stumps that are to be protected and retained on site must also be measured separately, either by number (no.) or as a distinct item where required.

Turf or vegetable soil is generally soft, contains more moisture, and is readily compressible. It can often be

reused for landscaping and is therefore typically removed before any other excavation work. Consequently, the removal of topsoil is an important item on the groundwork checklist following site clearance. The Figure 2.3 shows a typical soil profile, highlighting the vegetation, topsoil, and subsoil layers (part a), as well as the removal of topsoil using machinery (part b).

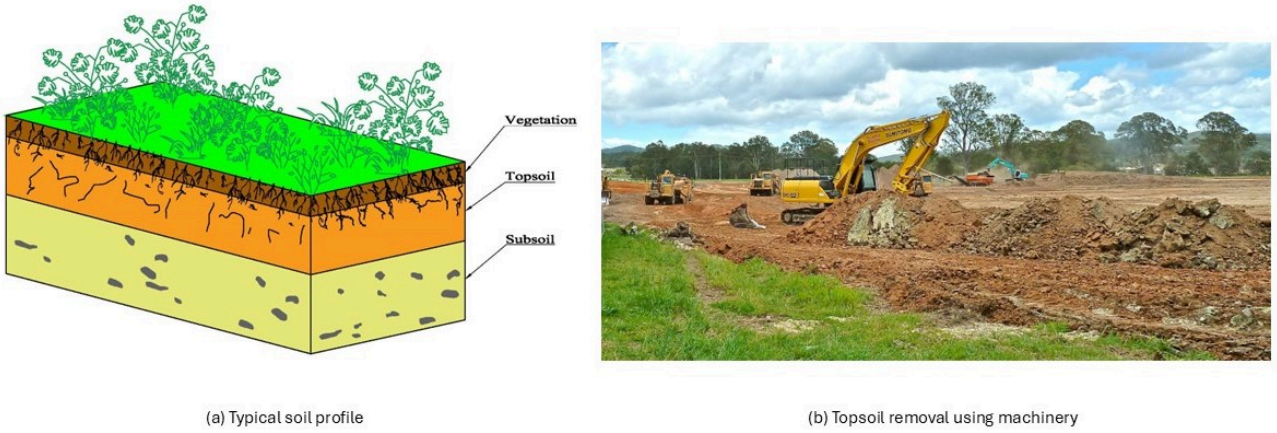


Figure 2.3: Illustration of soil profile and topsoil removal (Source of (a): Created by Amirreza Aminalavije / Source of (b): Image by Siggy Nowak from Pixabay used under the Pixabay Content License

Topsoil removal must be measured in square metres (m^2), with the average depth specified in the item description. A typical depth for topsoil removal ranges between 100 mm and 150 mm.

Figure 2.4 illustrates sample images of a basement excavation (part a), a pit excavation (part b), and a trench excavation (part c), which are commonly encountered in building construction. For all excavation types, the total depth must be identified and measured from the commencing level to the base of the excavation. Once determined, the depth should be expressed in 1 m increments within the description. For example, if the total depth is 3.5 m, the appropriate depth category would be 3 m – 4 m.

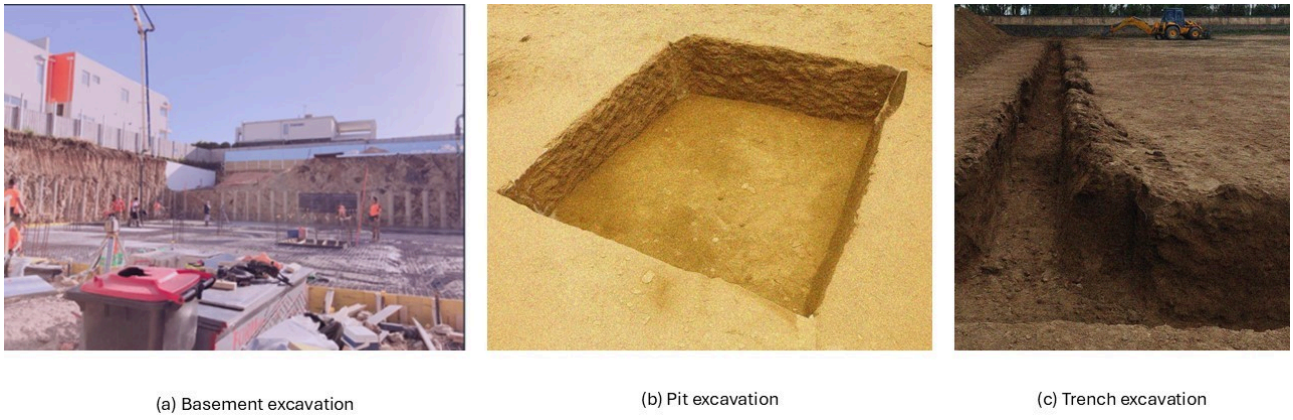


Figure 2.4 Different types of excavations (Source: a- photo taken by Dinesh Mataraarachchi, b and c Created by Amirreza Aminalavije)

Surface excavation to reduced levels, basement excavation, pit excavation, and trench excavation are

measured in cubic metres (m^3). All volumes should be measured as net areas, as outlined in the drawings. When different classes of material are encountered during excavation, each class must be measured separately. Notably, rock excavation is measured as an "extra over" item when occurring within another class of material.

It is essential to specify the commencing level of the excavation, such as the existing ground level, the bottom of topsoil excavation, the reduced level excavation, or the basement excavation. Additionally, any required working space beyond the face of the excavation must be explicitly included in the item description.

For surface excavation to reduced levels, the area must be stated in the item description. If preliminary trenches have been measured separately, this should be clearly indicated in the description for basement excavation. When measuring pit excavation, the area of each pit must be calculated. If a pit has an area of less than 1 m^2, this must be noted in the description, and the number of such pits should be indicated in brackets within the item description.

For trench excavation, it is important to specify whether the trench is intended for a strip footing, ground beam, or a similar structural element. Figure 2.5 demonstrates sections of a strip footing (part a) and a ground beam (part b), which are measured under trench excavation.

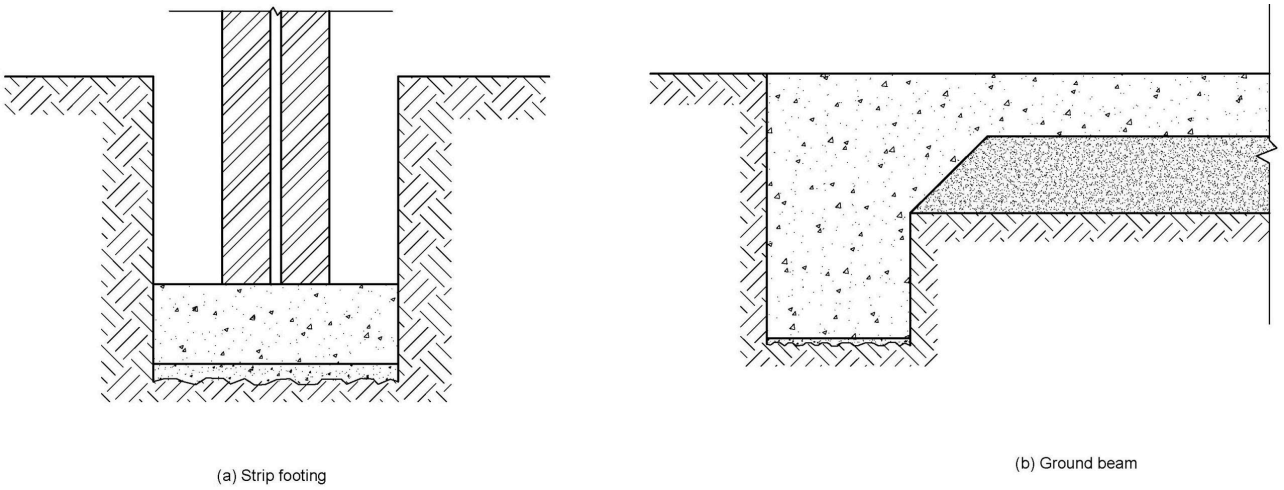


Figure 2.5 Types of trench excavations (Source: Created by Amirreza Aminalavije)

Backfilling refers to filling the excavation with excavated materials as shown in Figure 2.6. The area highlighted in grey indicates the portion that requires backfilling.

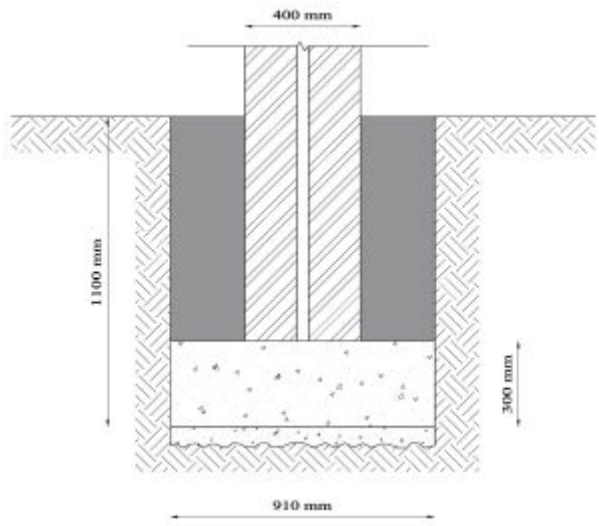


Figure 2.6: Backfilling for strip footing (Source: Created by Amirreza Aminalavije)

Backfilling is measured in cubic metres (m^3) and must be recorded separately for different applications, such as trenches. The depth of backfilling should be classified based on the total depth – up to and including 1 m, and thereafter in 1 m increments.

The disposal of surplus excavated material from all types of excavation is typically carried out at a nominated location. In accordance with the standards, the distance to the disposal site must be stated in kilometres (km).

Figure 2.7 demonstrates the provision of working space in trench excavation.

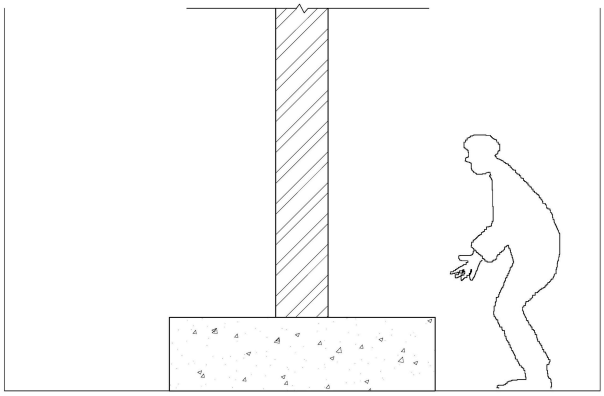


Figure 2.7: Working space in a strip footing excavation (Source: Created by Amirreza Aminalavije)

Working space must be measured in all cases, and a special note is required where excavation for working space is not possible for a given item. When measuring working space, the total depth range and purpose

must be specified in the item description. The quantity of working space is measured in square metres (m^2) by multiplying the girth along the outside line of footings by the depth of excavation.

2.2.2 Filling and hardcore

This category covers items as filling in beds, filling behind retaining walls, filling over the site, filling to slopes, filling to trenches, and surface preparation. As per the standard, all items in the filling and hardcore section are deemed to include related activities such as levelling, grading, and trimming.

In construction projects, layers of compacted material are used to create a stable base for subsequent works. These materials may include soil, crushed stone, brick, or concrete, depending on the project's stability requirements. The Figure 2.8 shows examples of sand filling (part a) and hardcore filling (part b).



(a) Sand filling

(b) Hardcore filling

Figure 2.8: Types of filling (Source: Created by Amirreza Aminalavije)

Filling in beds is measured in square metres (m^2) when the thickness is less than 250 mm, with the thickness stated in the description. When the thickness exceeds 250 mm, it is measured in cubic metres (m^3), with the corresponding area specified in the description. For filling in trenches, the total depth is categorised as less than 1 m, 1 m – 2 m, and thereafter in 1 m increments. In all cases, the description must include the type of material, the thickness of the layers, and the method of compaction.

2.2.3 Paper or plastic membranes

This category comprises items as paper, plastic, and similar membranes. All types of membranes are measured in square metres (m^2) and must specify whether they are installed horizontally, on a slope, or vertically. Measurement rules require that all measurements be taken as the net area covered, including horizontal breaks and turning ups of 500 mm or less. The description must include information on laps and joining requirements. Measurement and pricing are deemed to include dressing around and sealing all penetrations. The Figure 2.9 shows an example of laying a plastic membrane prior to slab placement.



Figure 2.9: Laying a plastic membrane (Source: Taken by Amirreza Aminalavije)

2.3 MEASUREMENT PROCESS FOR GROUNDWORKS USING COSTX SOFTWARE

2.3.1 Excavation

An early learning centre, comprising a basement, ground floor, and first floor, has been selected to demonstrate the measurement of groundworks items in this chapter. Before measuring the groundwork items, it is important to review the plans and sections of the selected project. Figure 2.10 illustrates the simplified version of the site plan of this project. The site plan is useful when measuring items such as site clearance, removal of trees, topsoil removal and topsoil disposal.

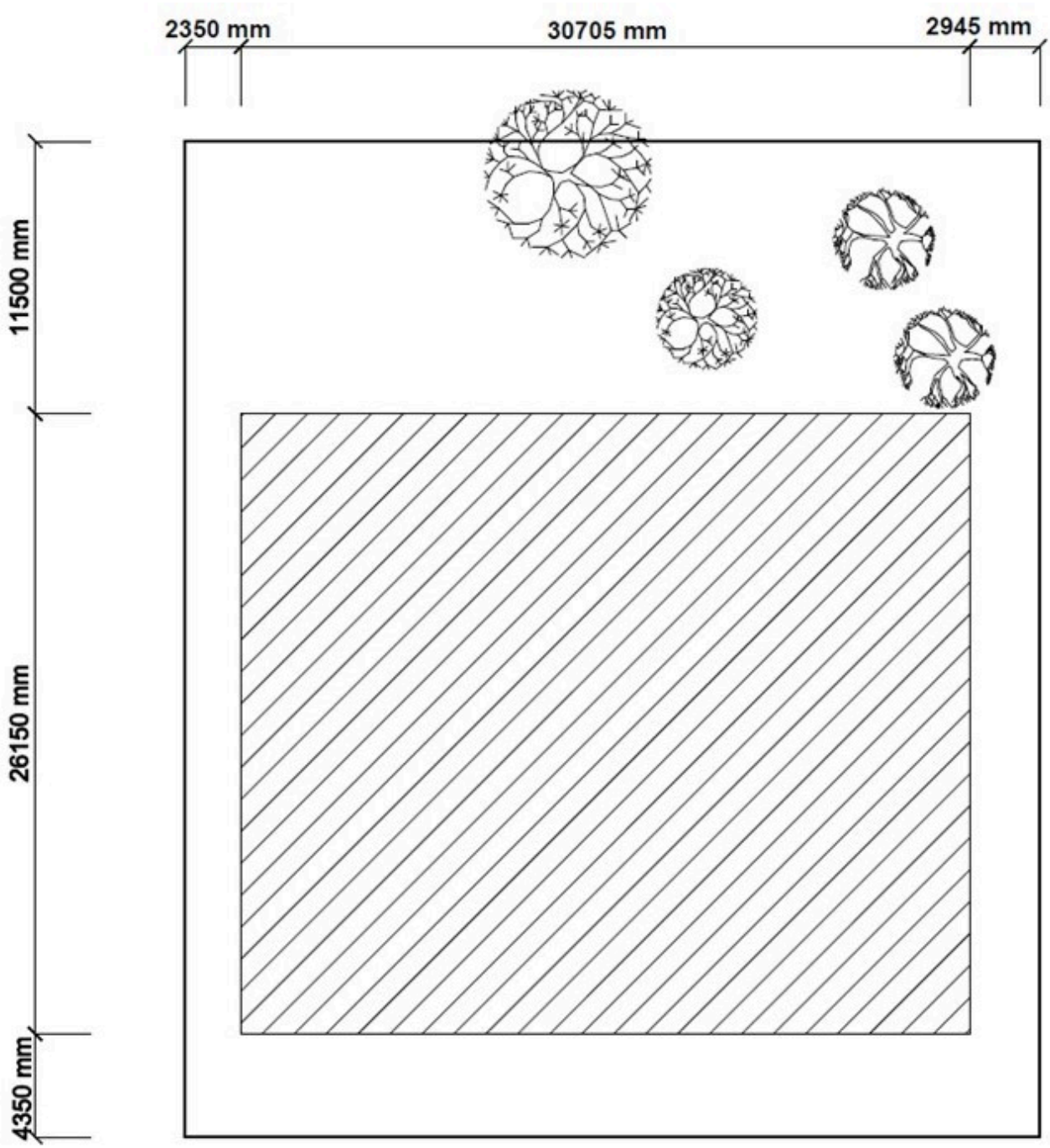


Figure 2.10: Simplified site plan of the selected project (Source: Drawn by Dinesh Mataraarachchi)

Figure 2.11 shows the basement plan of the selected project. This plan is useful for measuring basement excavation, pit excavation, and trench excavation of the selected project.

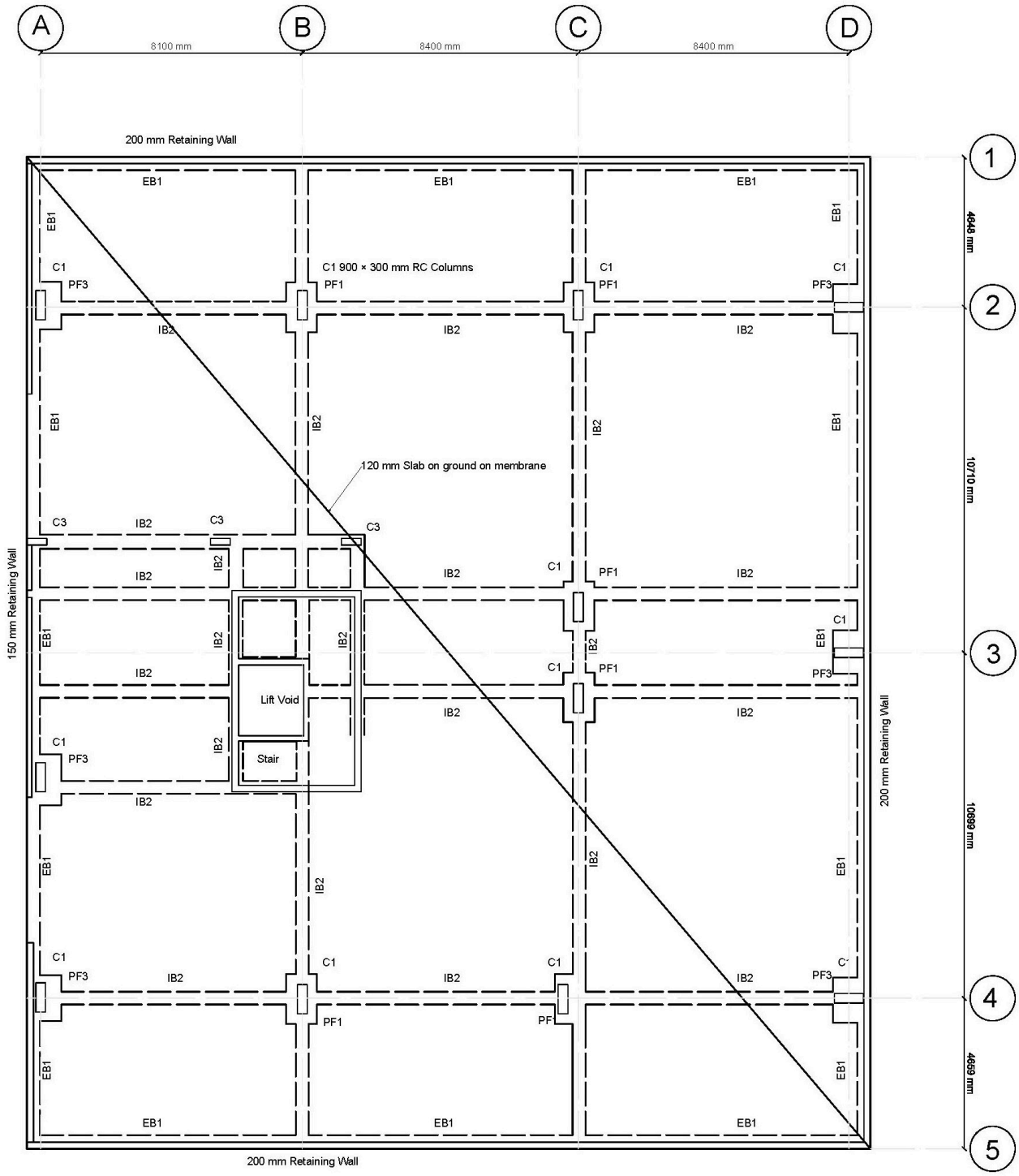


Figure 2.11: Simplified basement plan of the selected project (Source: Drawn by Dinesh Mataraarachchi)

Figure 2.12 highlights the footing details of the selected project. These are useful for identifying the depths of excavation works.

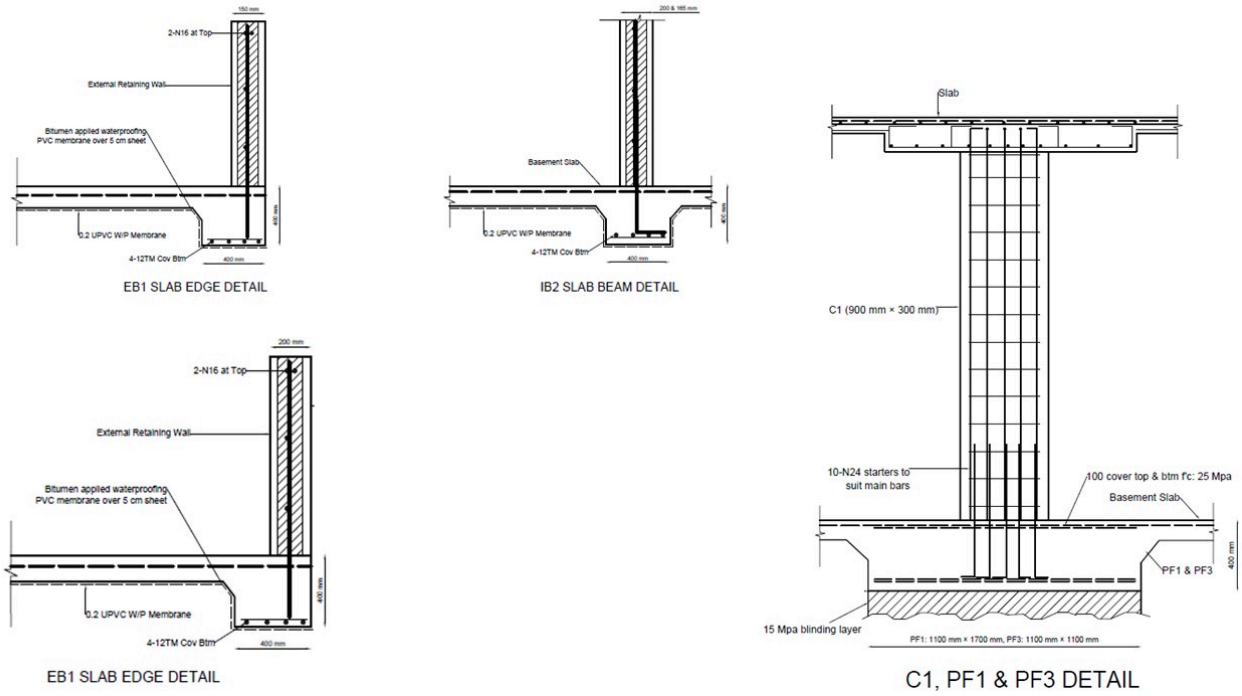
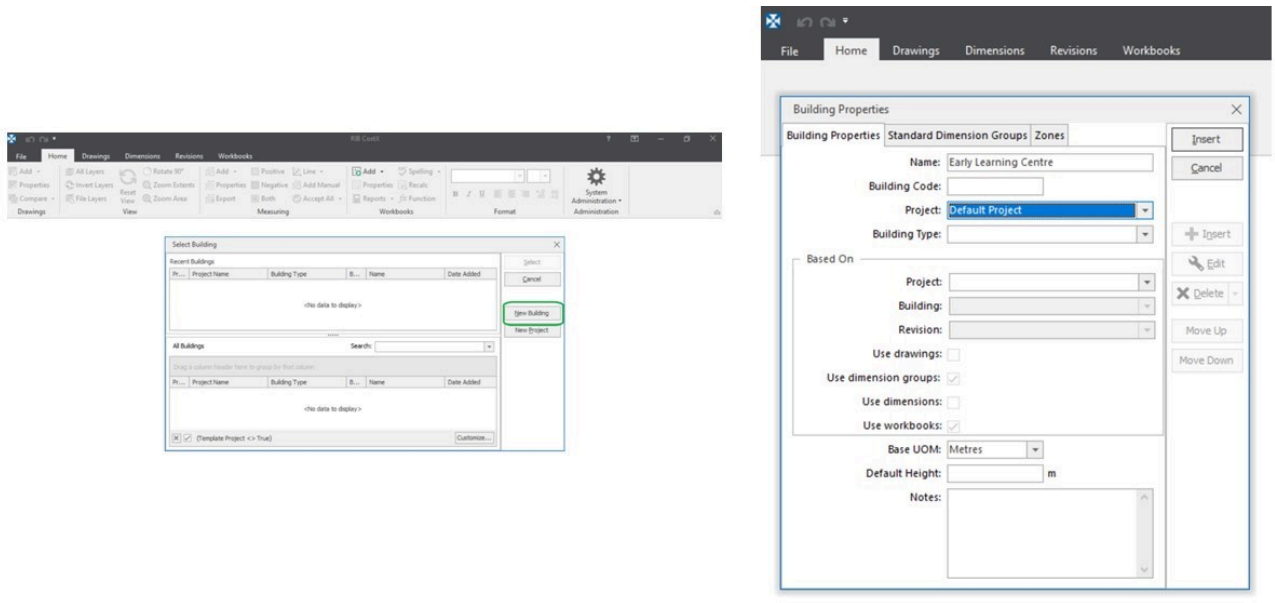


Figure 2.12: Simplified footing details of the selected project (Source: Drawn by Dinesh Mataraarachchi)

The next step is the identification of relevant groundwork items for the selected project. Items such as site clearance, tree removal, topsoil removal, topsoil disposal, basement excavation, pit excavation, trench excavation, disposal of excavated materials, working space, and plastic membrane will be demonstrated in the following section using a step-by-step approach.

Step 1: Open CostX and create a new building (part a of Figure 2.13). Name the building "Early Learning Centre". Select "Default Project" as the project and set "Meters" for Base UOM as shown in part (b) of Figure 2.13. The building code, building type, and notes can be added if required.



(a) Create a new building

(b) Complete building properties

Figure 2.13: Screenshots of creating a building using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission

Step 2: Click on the "Drawings" tab and then select "Add Drawings" to import plans into CostX, as illustrated in Figure 2.14.

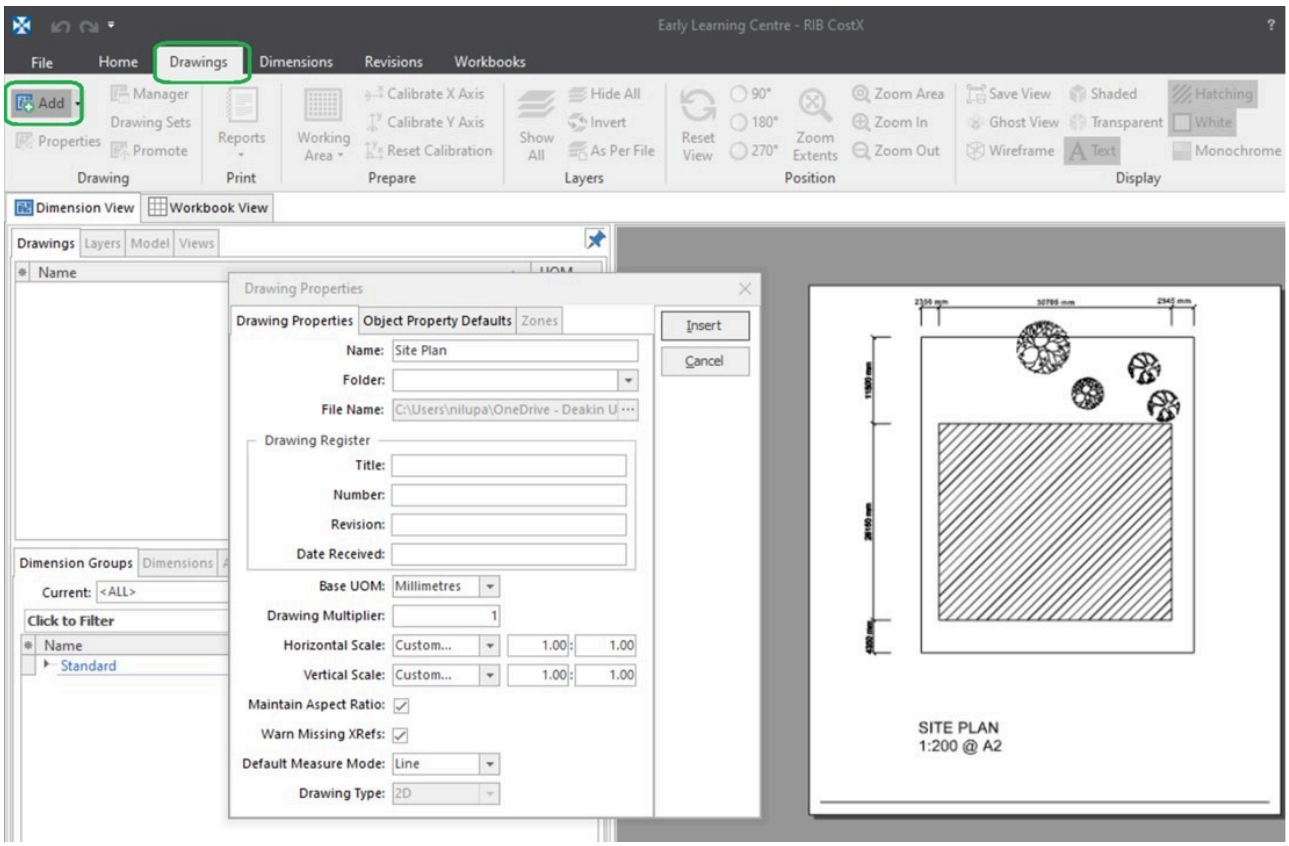
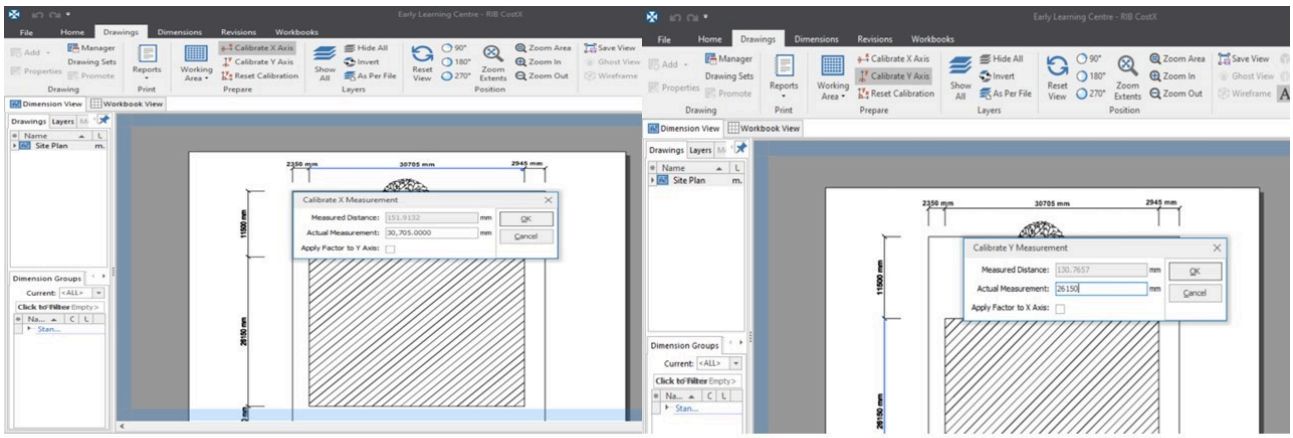


Figure 2.14: Screenshot of inserting the site plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Calibrate the drawing using the known X and Y dimensions, as illustrated in the image below. It is recommended to use the longest dimension for calibration to minimise error accumulation. The X-axis was calibrated using the 30,705 mm dimension marked on the site plan (part a), while the Y-axis was calibrated using the 26150 mm dimension indicated on the site plan drawing (part b), as shown in Figure 2.15.

To calibrate the axes separately, make sure to untick “Apply factor to Y axis”; otherwise, the X-axis calibration will also be applied to the Y-axis. Repeat the same process for the Basement Plan.



(a) Calibration of X axis

(b) Calibration of Y axis

Figure 2.15: Screenshots of calibrating the X and Y axes of the site plan in CostX software using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

After calibration, use the Measure Distance tool in CostX to check a known dimension and confirm that the drawing is calibrated correctly. If it is not, reset the calibration by clicking the Reset Calibration icon, then repeat Step 3 to calibrate the drawing again.

Step 4: Create a dimension group to measure site clearance. Add a dimension group named Site Clearance and set the folder name to Groundworks. Site clearance is measured in square meters; therefore, set both the measurement type and the default display to Area, as shown in Figure 2.16.

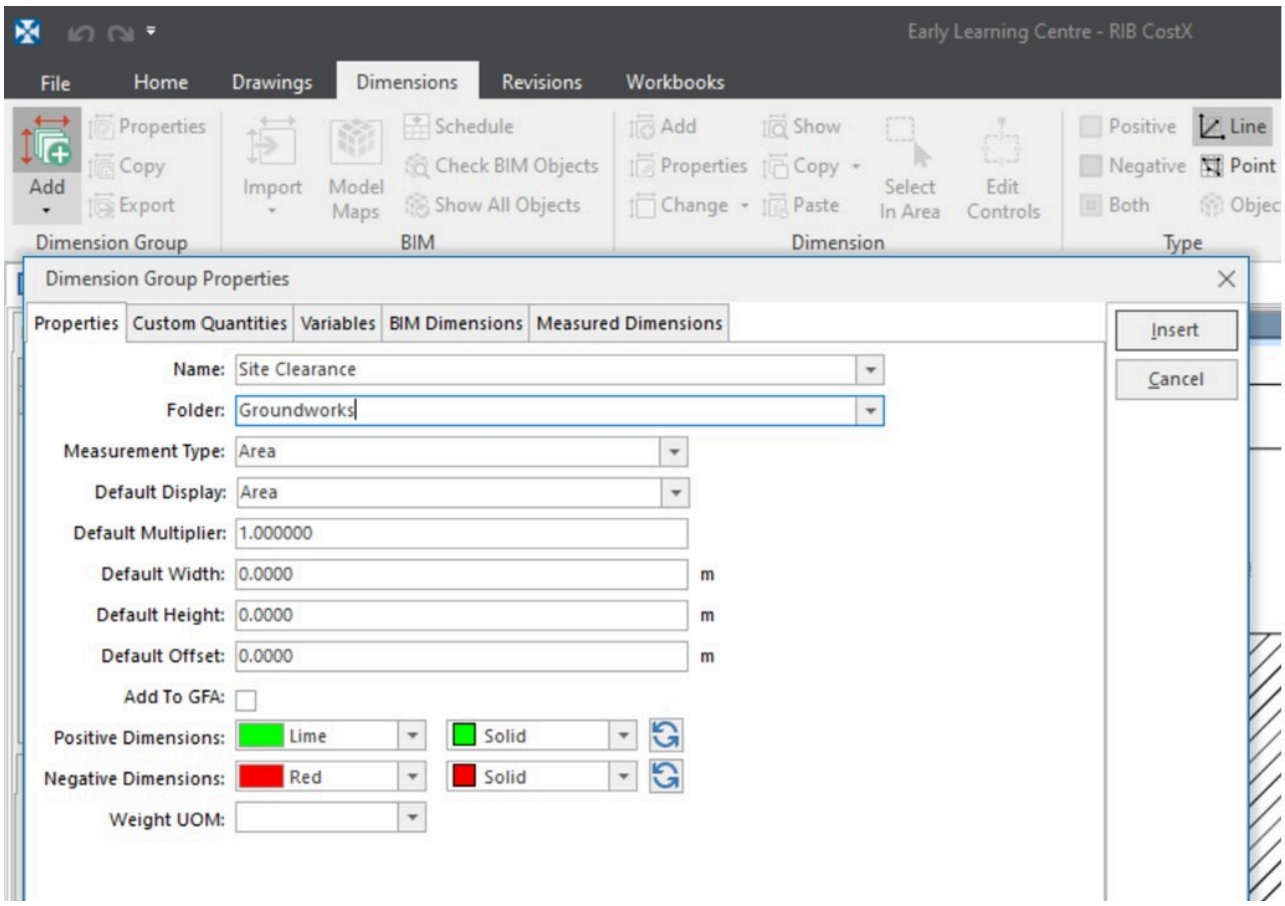


Figure 2.16: Screenshot of creating a dimension group to measure site clearance using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Using the Point method, select the boundary of the site clearance area, as illustrated in Figure 2.17.

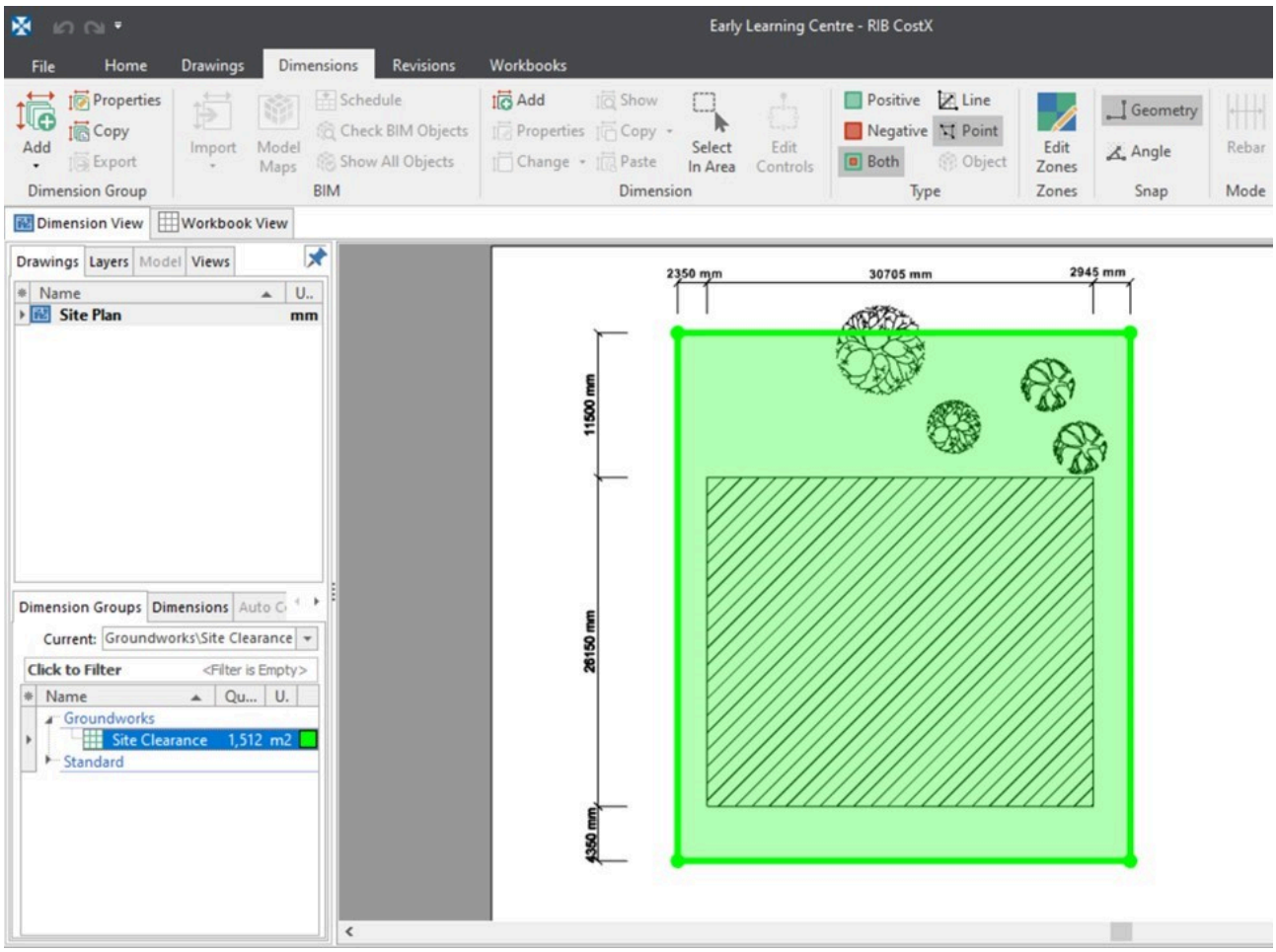


Figure 2.17: Screenshot of measurement of site clearance using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

In this project, the entire site is designated for clearance. As shown in the site plan (Figure 2.9), there are four trees on the site. For demonstration purposes, it is assumed that all four trees will be removed. The girths of the trees are 0.55 m, 0.65 m, 0.85 m, and 0.9 m. According to the standards, these trees fall into the 0.5 m – 1 m category and can be measured together under a single description.

Step 6: Create a dimension group to measure tree removal. Add a dimension group named "Removal of Trees". Tree removal is measured by number; therefore, set the measurement type and default display to count as shown in Figure 2.18.

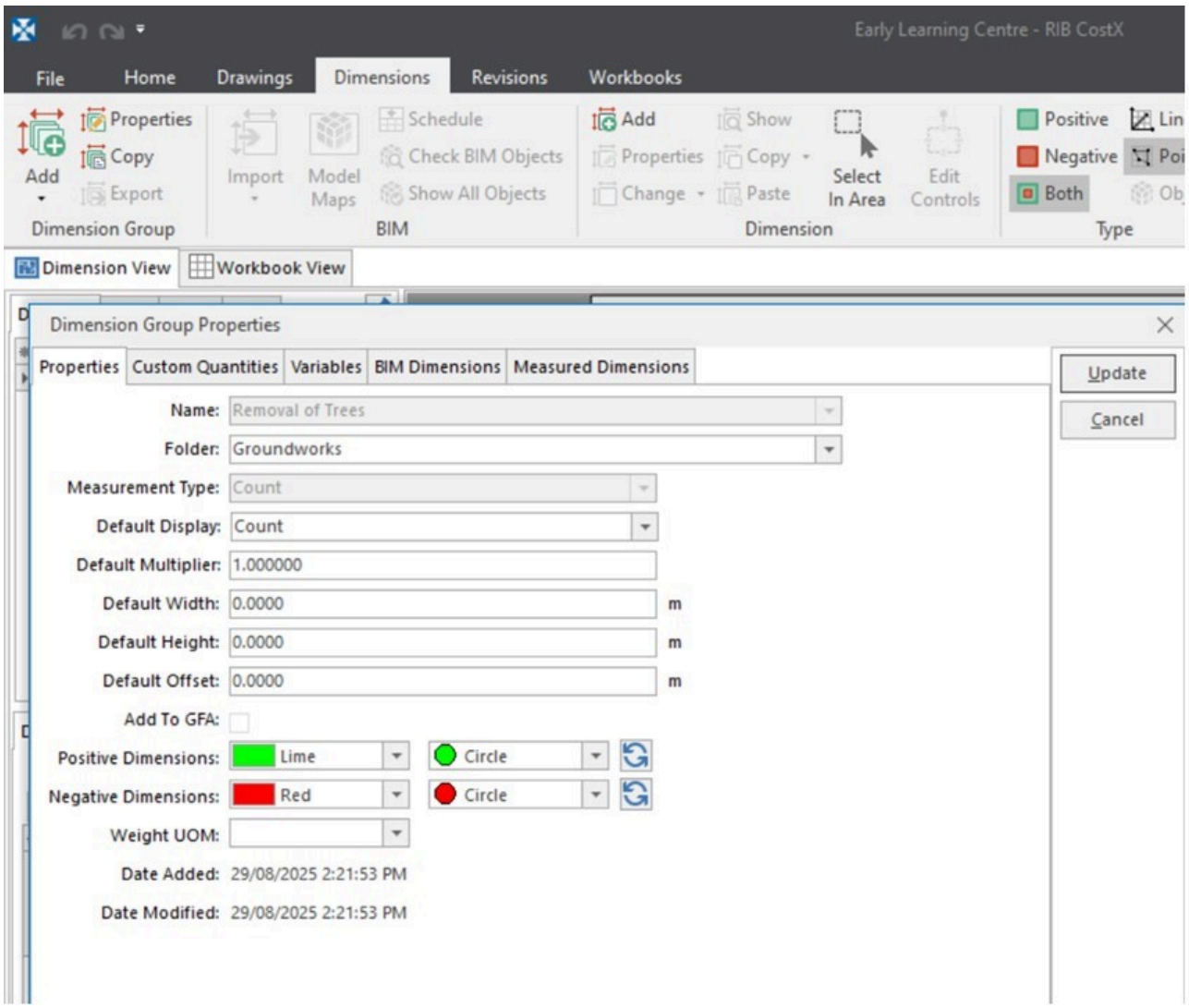


Figure 2.18: Screenshot of creating a dimension group to measure removal of trees using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 7: Using the Point method, select the trees as illustrated in Figure 2.19.

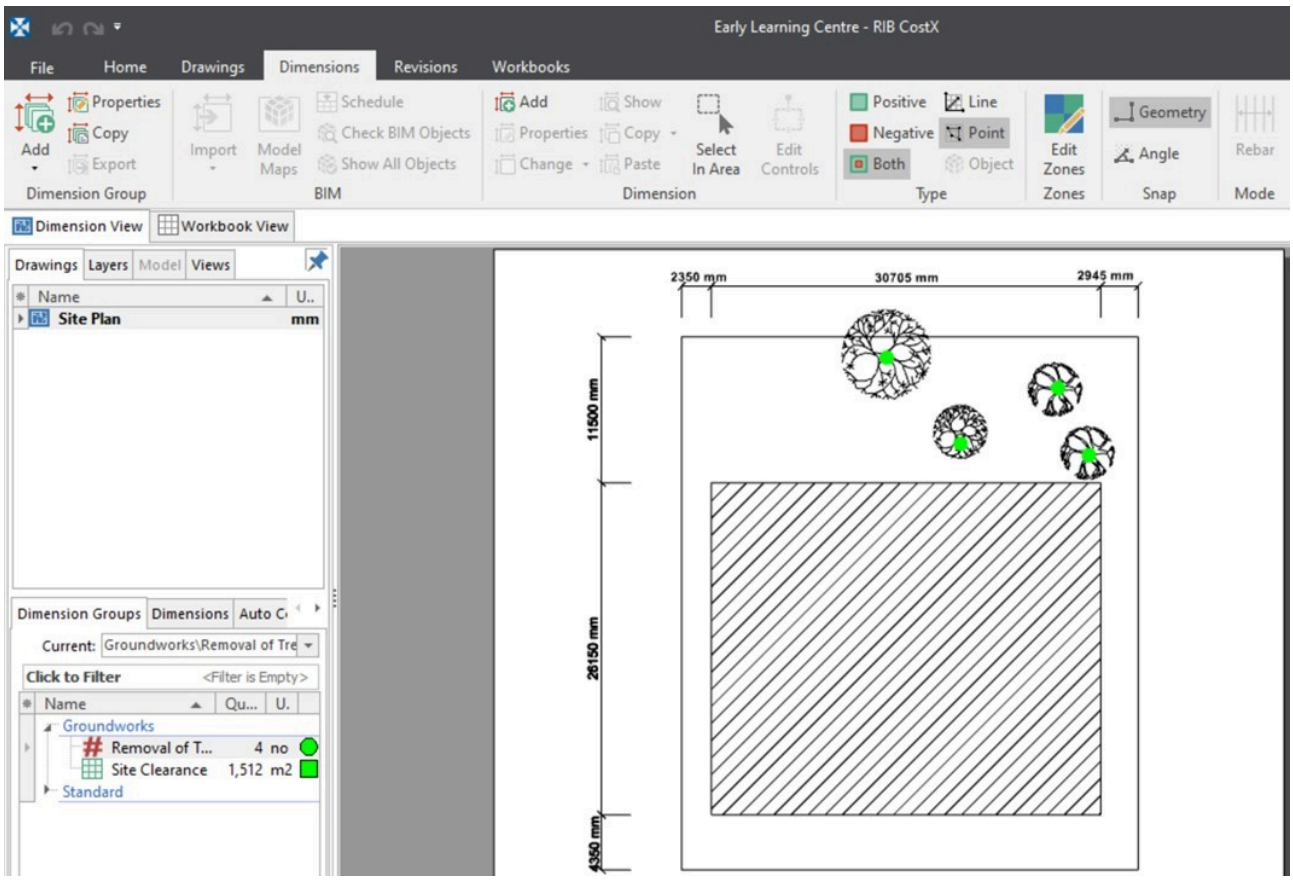


Figure 2.19: Screenshot of measurement of tree removal using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 8: Create a dimension group to measure topsoil removal. Add a dimension group named Topsoil removal and set the folder name to Groundworks. Topsoil removal is measured in square meters; therefore, set the measurement type and the default display to Area as shown in Figure 2.20.

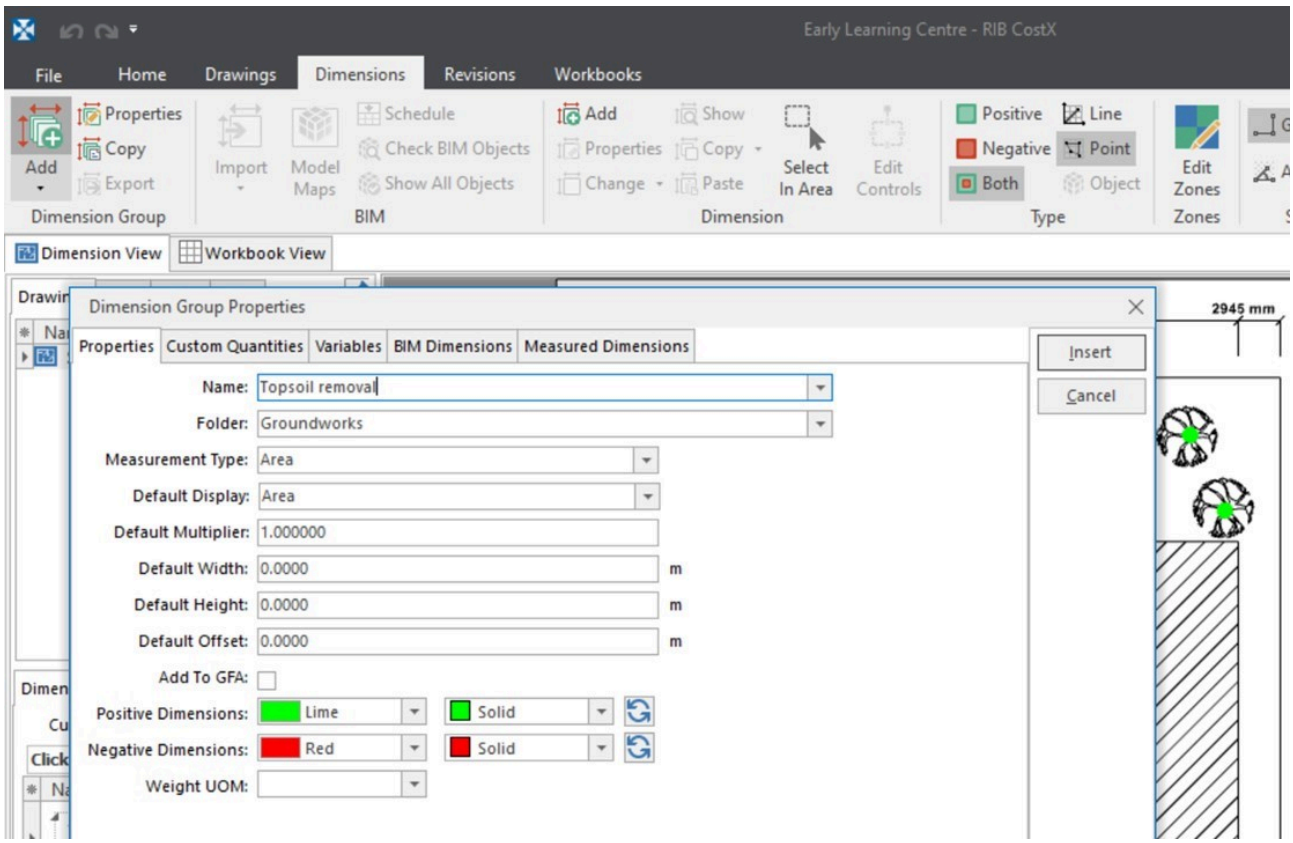


Figure 2.20: Screenshot of creating a dimension group to measure topsoil removal using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 9: Using the Point method, select the boundary of topsoil removal as illustrated in Figure 2.21.

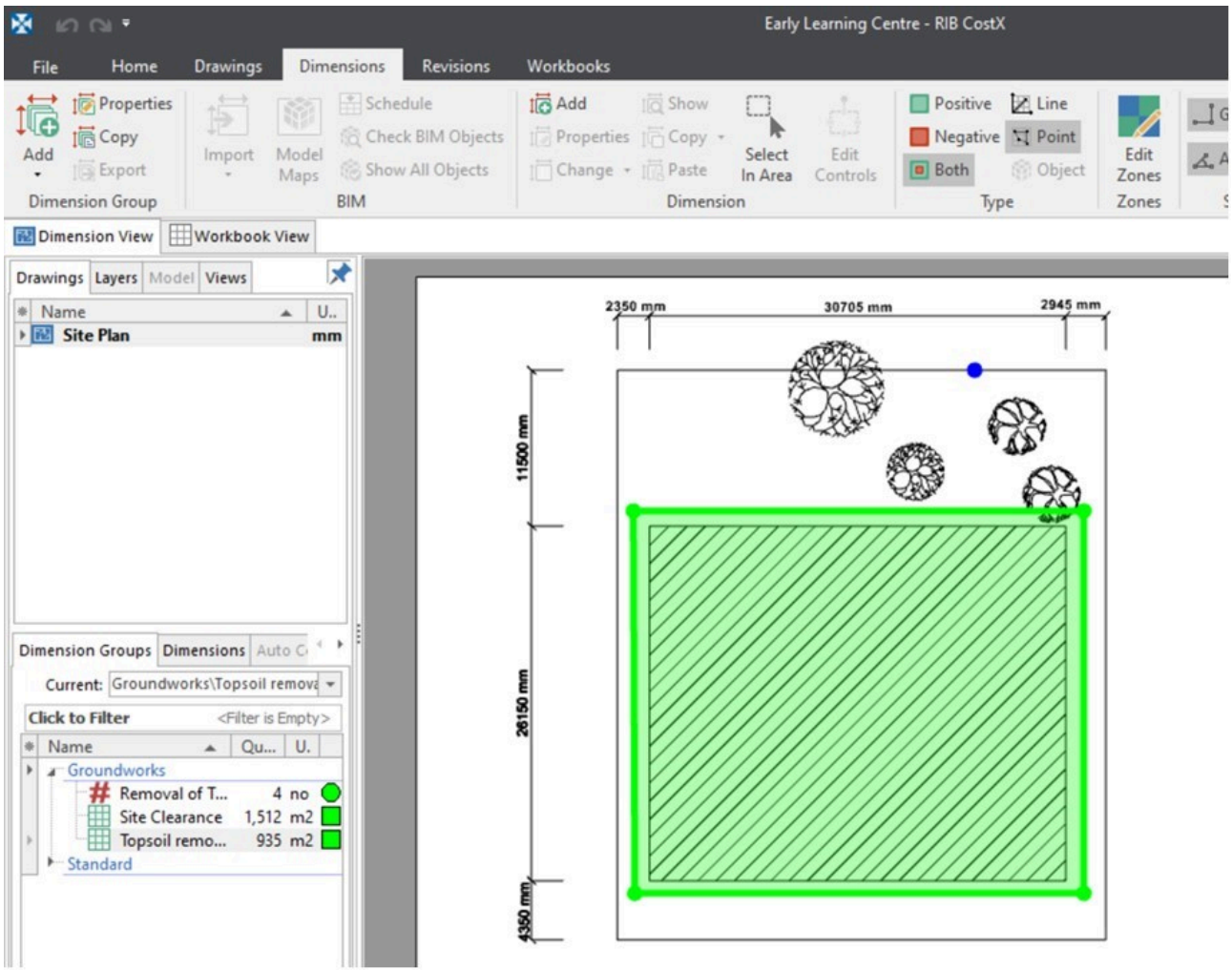


Figure 2.21: Screenshot of measurement of topsoil removal using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

When measuring the area of topsoil removal, it is important to extend the measurement beyond the building boundary to include any foundation projections that extend past the boundary.

Step 10: Create a dimension group to measure the disposal of topsoil. This can be done either by adding a new dimension group named Disposal of Topsoil or by copying the Topsoil Removal dimension group and renaming it Disposal of Topsoil, as shown in Figure 2.22. Make sure to tick the Copy Dimension box to transfer the measured quantities from the topsoil removal group to the disposal of topsoil dimension group.

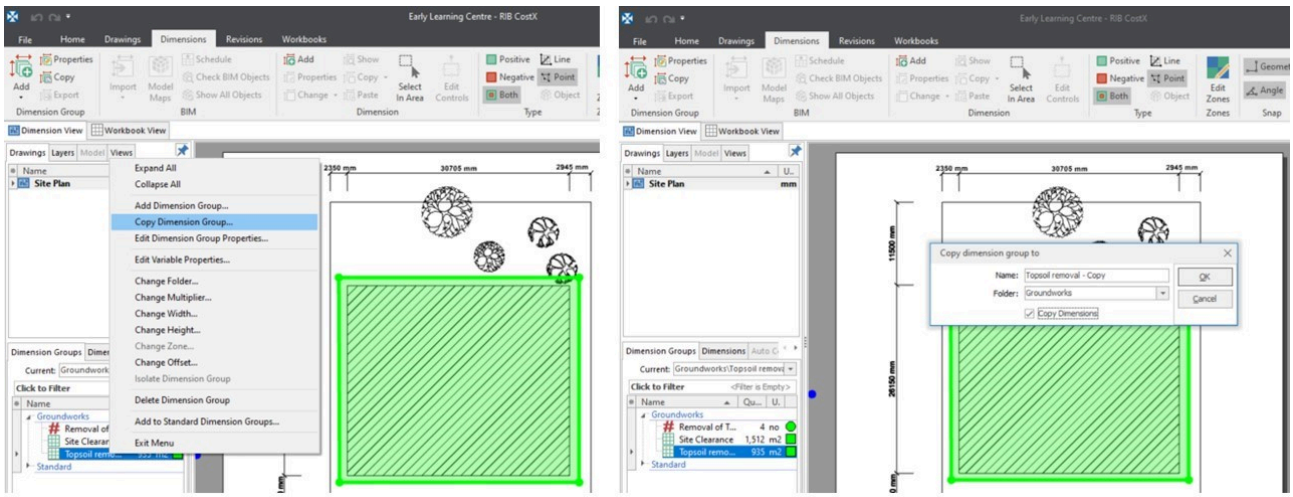
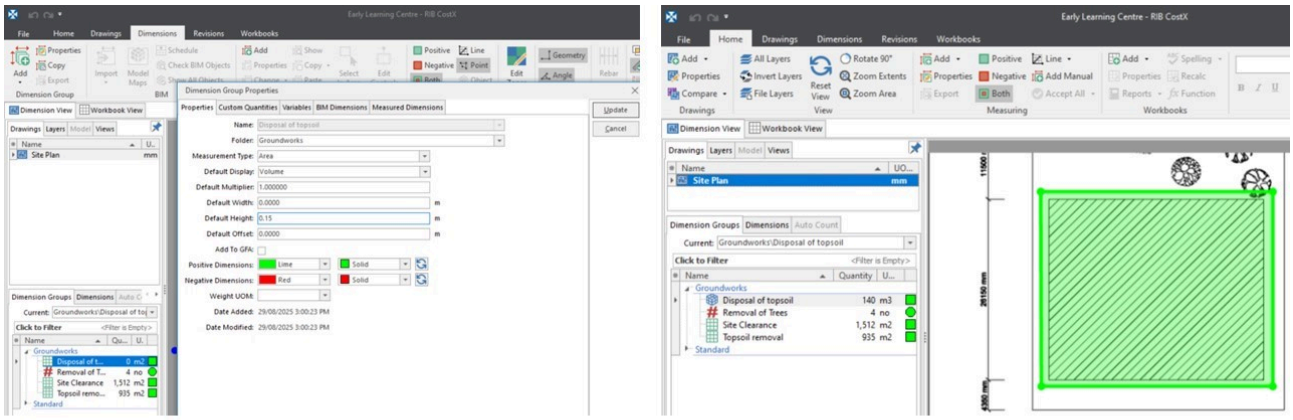


Figure 2.22: Screenshots of creating a dimension group to measure disposal of topsoil removal using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Disposal of excavated materials is measured in cubic meters. Double-click on the Disposal of Topsoil dimension group, set the measurement type to Area, and the default display to Volume. Set the height to 0.15 m, as we are considering the removal of a 150 mm topsoil layer before other excavation works, as illustrated in Figure 2.23.



(a) Updating the dimension group properties

(b) Final measured item

Figure 2.23: Screenshots of measurement of disposal of topsoil excavation using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Since the topsoil removal dimension group was copied to create the disposal of topsoil dimension group, the final quantity for topsoil disposal will be displayed in the dimension group once its properties are completed as shown in Figure 2.23.

The proposed project is located on sloping land; therefore, the average height has been used for the

basement excavation to present it in a simplified manner in this book. The bottom of the basement slab level is taken as 98.68, while the existing ground level is 101.73. Accordingly, the excavation depth is 3.05 m, calculated as the difference between these two points. Next, add the basement plan to CostX and calibrate the drawing by following the instructions in Steps 2 and 3.

Step 11: Create a dimension group to measure the basement excavation. Add a folder named "Basement Excavation". Basement excavation is measured in cubic meters; therefore, set the measurement type to Area and the default display to Volume. Enter the excavation height of 3.05 m in the Height box, as shown in Figure 2.24.

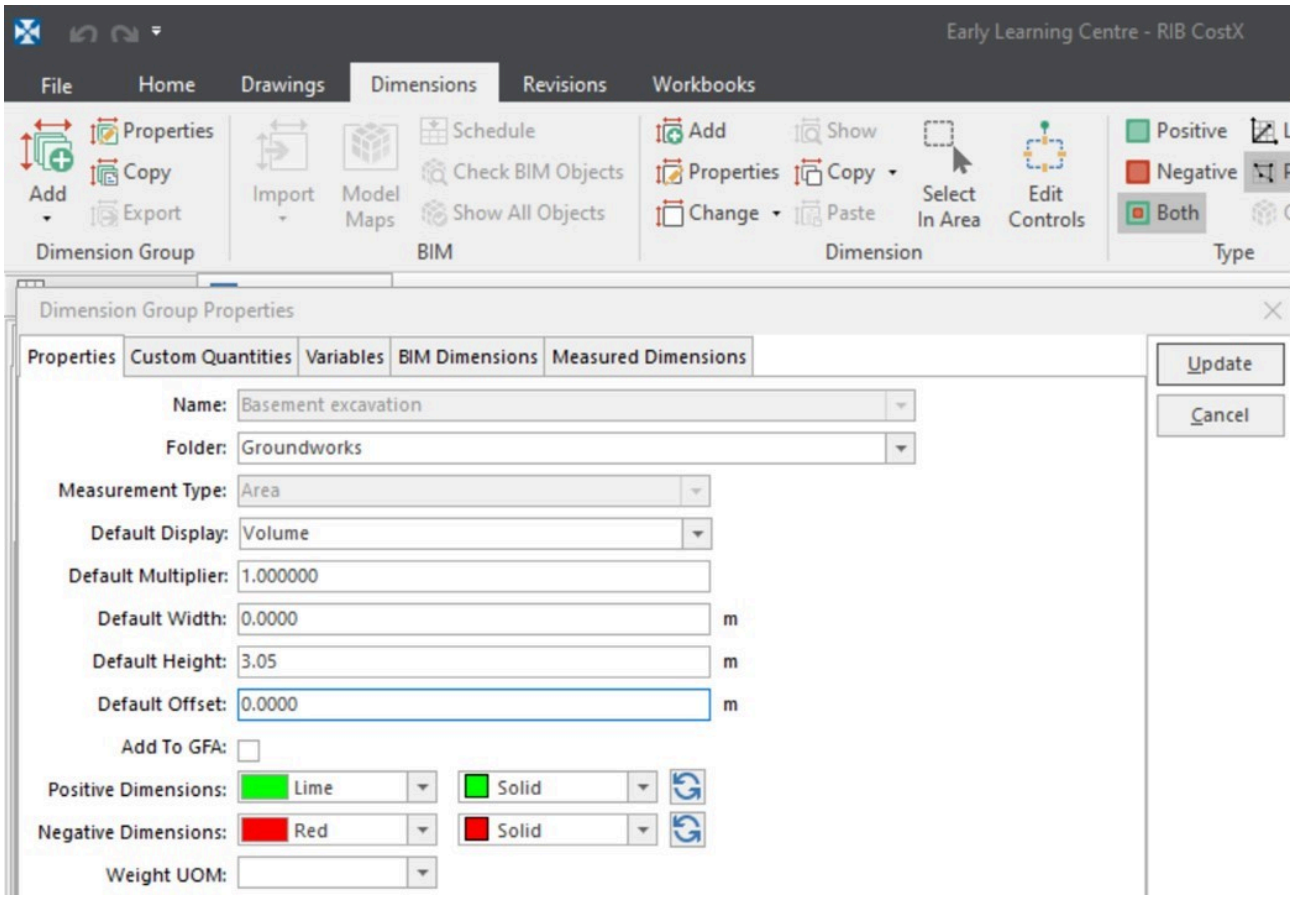


Figure 2.24: Screenshot of creating a dimension group to measure basement excavation using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 12: Using the Point method, select the boundary of the basement as illustrated in Figure 2.25.

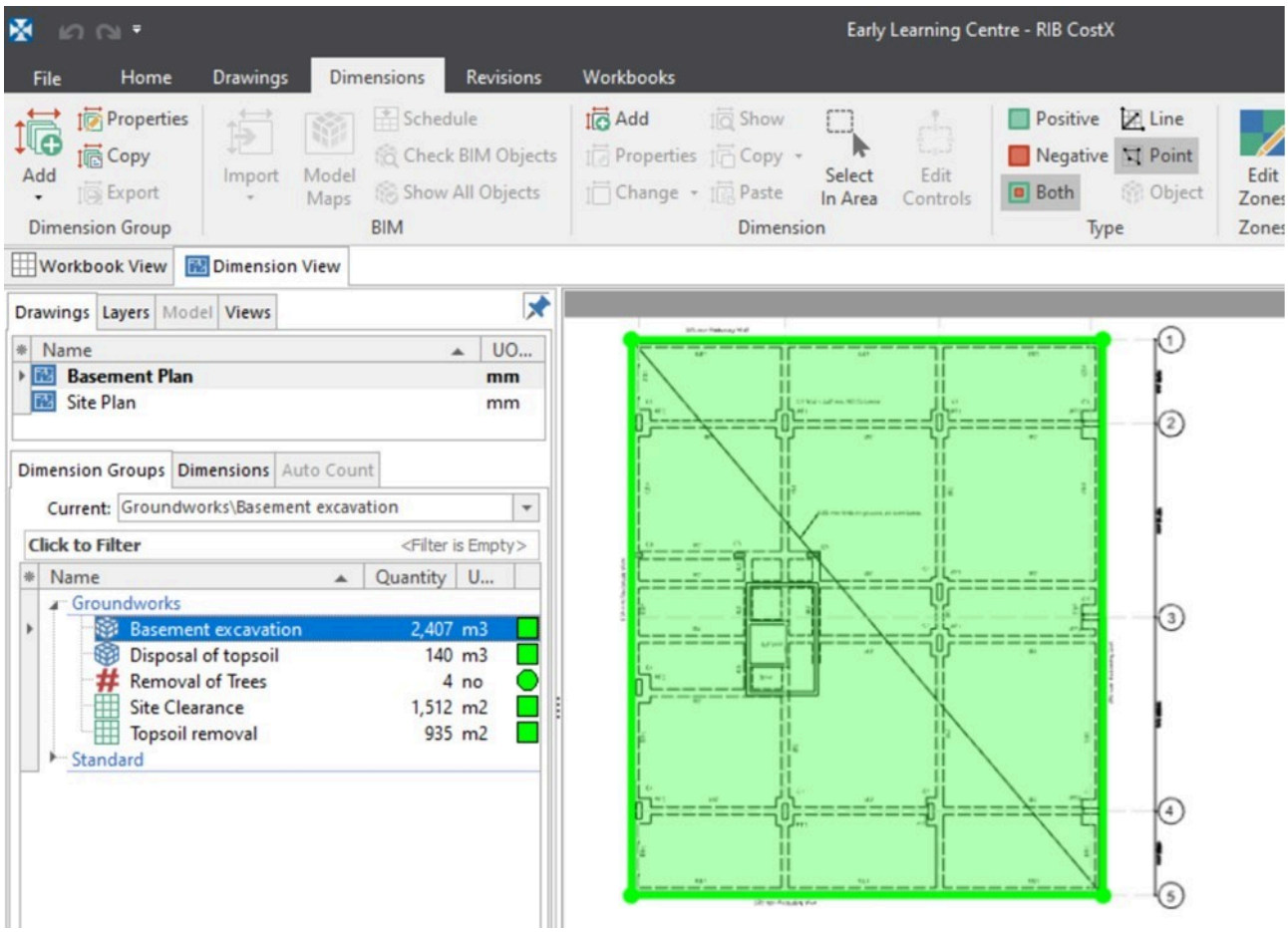


Figure 2.25: Screenshot of measurement of basement excavation using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Pit and trench excavations are carried out after the basement excavation. As shown in Figure 2.12, the height from the top of the slab to the bottom of the pad footings and ground beams is 400 mm, while the slab thickness is 120 mm, as indicated in Figure 2.11. In addition, Figure 2.12 shows a blinding concrete layer beneath the footings, taken as 50 mm. Therefore, the excavation height for both pad footings and ground beams is calculated as 400 + 50 – 120 = 330 mm.

Step 13: Create a dimension group to measure pad footing excavation. Add a folder named "Pad footing". Pad footing is measured in cubic meters; therefore, set the measurement type to Area and the default display to Volume. Enter the excavation height of 0.33 m in the Height box, as shown in Figure 2.26.

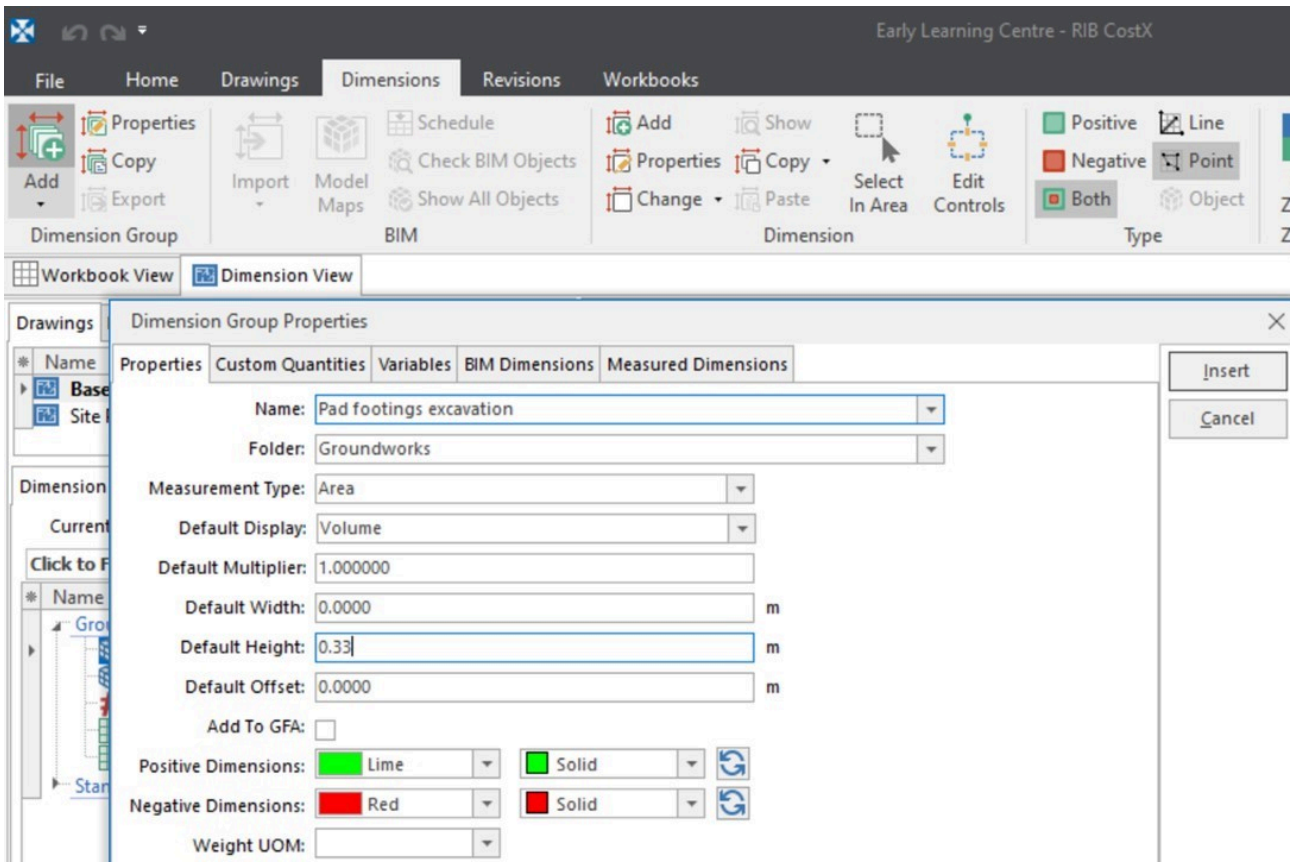


Figure 2.26: Screenshot of creating a dimension group to measure pit excavation using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 14: Using the Point method, select the boundary of pad footings as illustrated in Figure 2.27. In this example, all pad footings are measured together, as they share the same height.

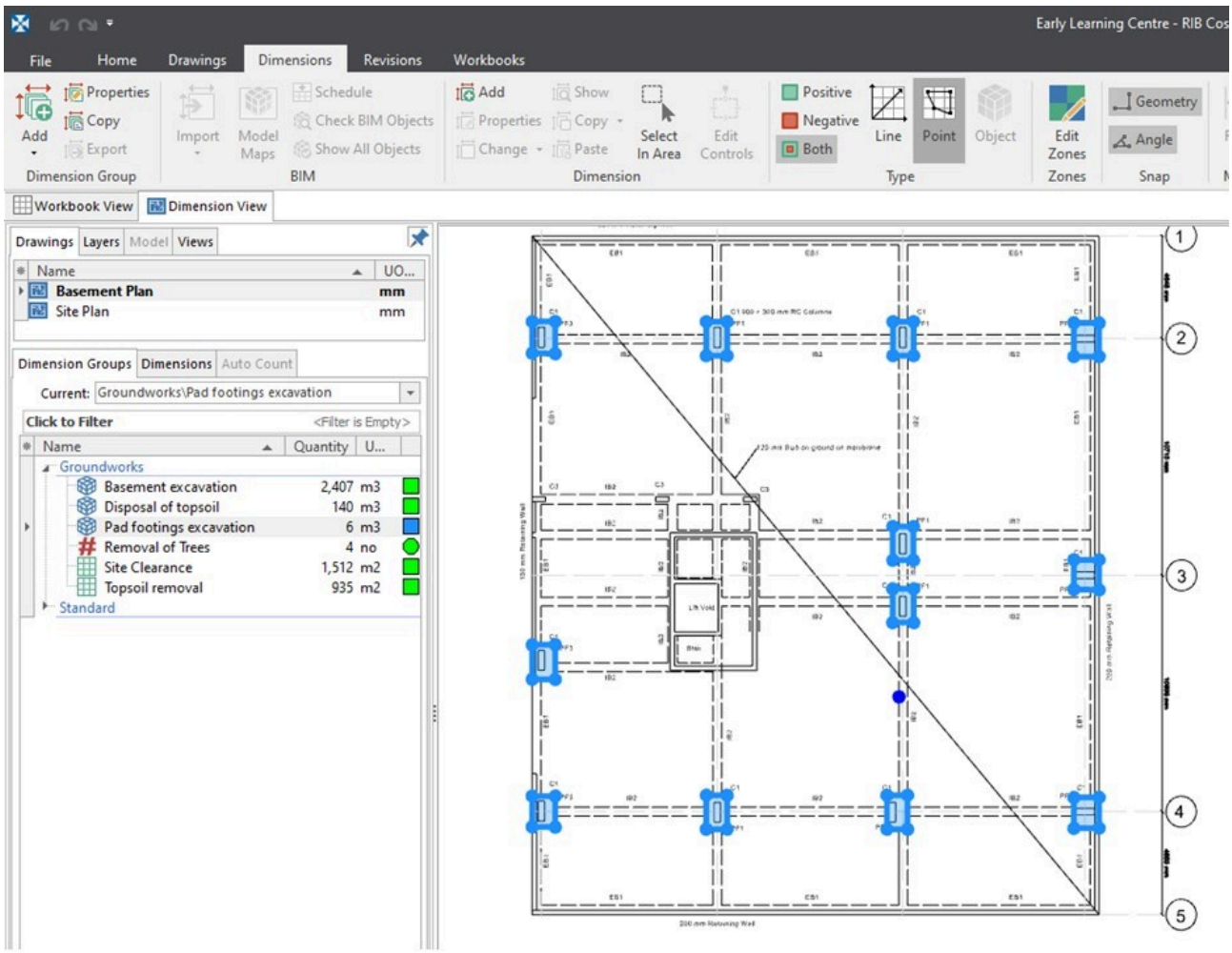


Figure 2.27: Screenshot of measurement of pad footings excavation using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 15: Create a dimension group to measure trench excavation. Add a folder named "Trench excavation for ground beams". Trench excavation is measured in cubic meters; therefore, set the measurement type to Area and the default display to Volume. Enter the excavation height of 0.33 m in the Height box, as shown in Figure 2.28.

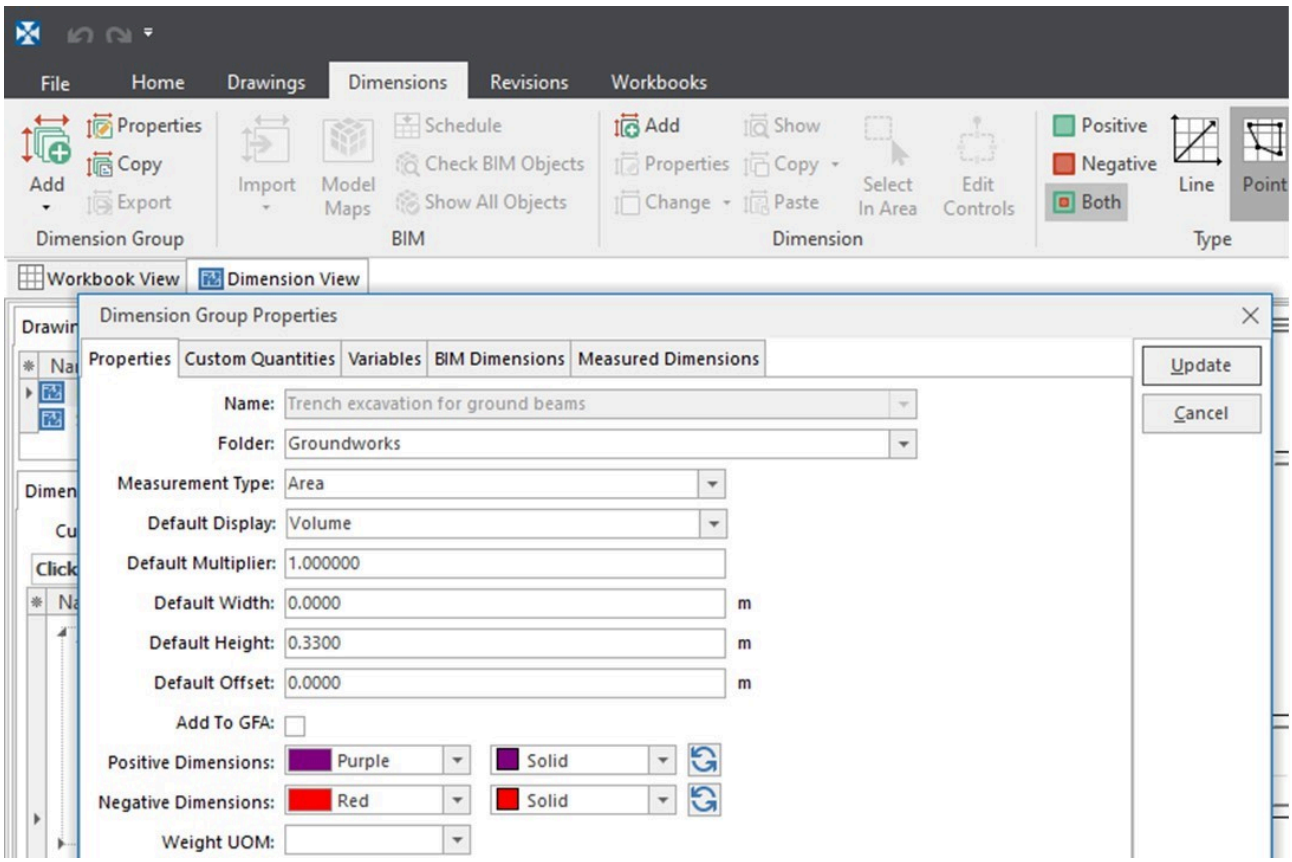


Figure 2.28: Screenshot of creating a dimension group to measure trench excavation for ground beams using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 16: Using the Point method, select the boundary of ground beams as illustrated in Figure 2.29.

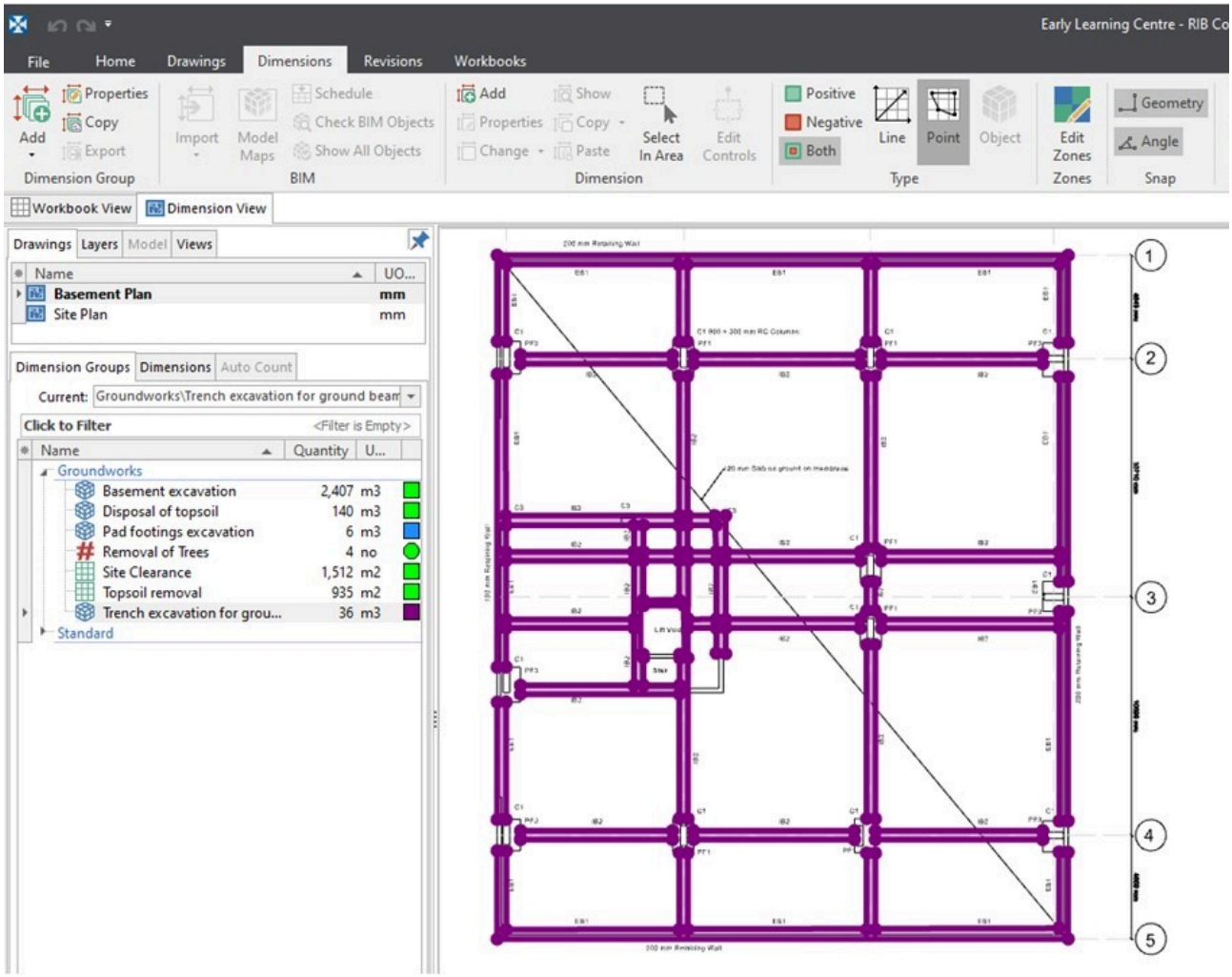


Figure 2.29: Screenshot of measurement of trench excavation for ground beams using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 17: Create a dimension group to measure the disposal of excavated materials. Add a folder named Disposal of Excavated Materials. Disposal of excavated materials is measured in cubic meters; therefore, set the measurement type to Area and the default display to Volume as shown in Figure 2.30.

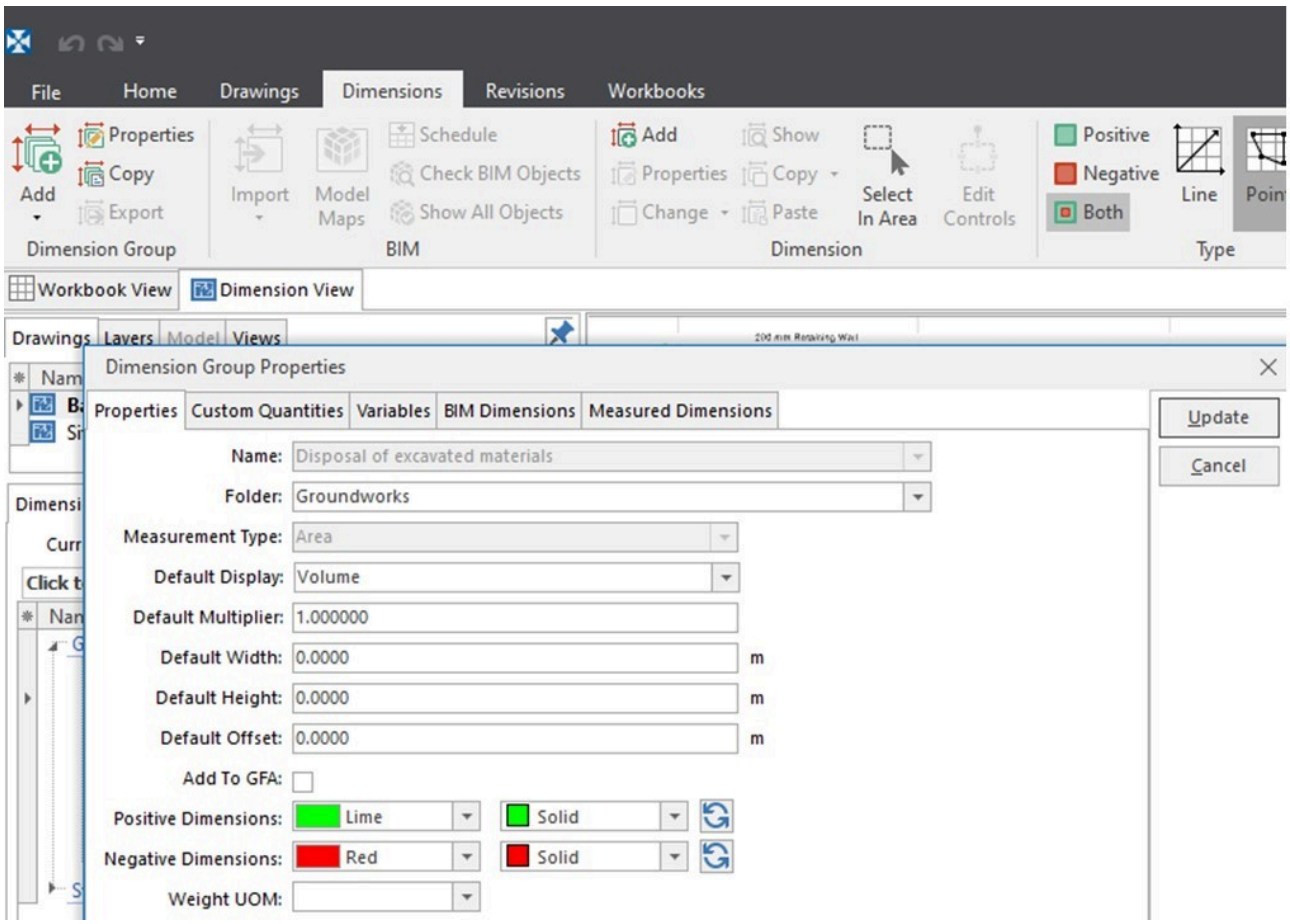


Figure 2.30: Screenshot of creating a dimension group to measure disposal of excavated materials using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

In this example, excavated materials from the basement, pad footings, and ground beams need to be disposed of. Instead of measuring them again, the already measured quantities from these three-dimension groups can be transferred to the Disposal of Excavated Materials dimension group. The following example demonstrates this process for the basement excavation; repeat the same steps for the pad footings and ground beam excavations.

Step 18: Right-click on the measured quantity of the basement excavation and select Copy Dimensions to Another Dimension Group. In the popup box, choose the Disposal of Excavated Materials folder and click OK. Then, open the dimension group, right-click on the quantity related to the basement excavation, and change the height to 3.05 m as shown in Figure 2.31.

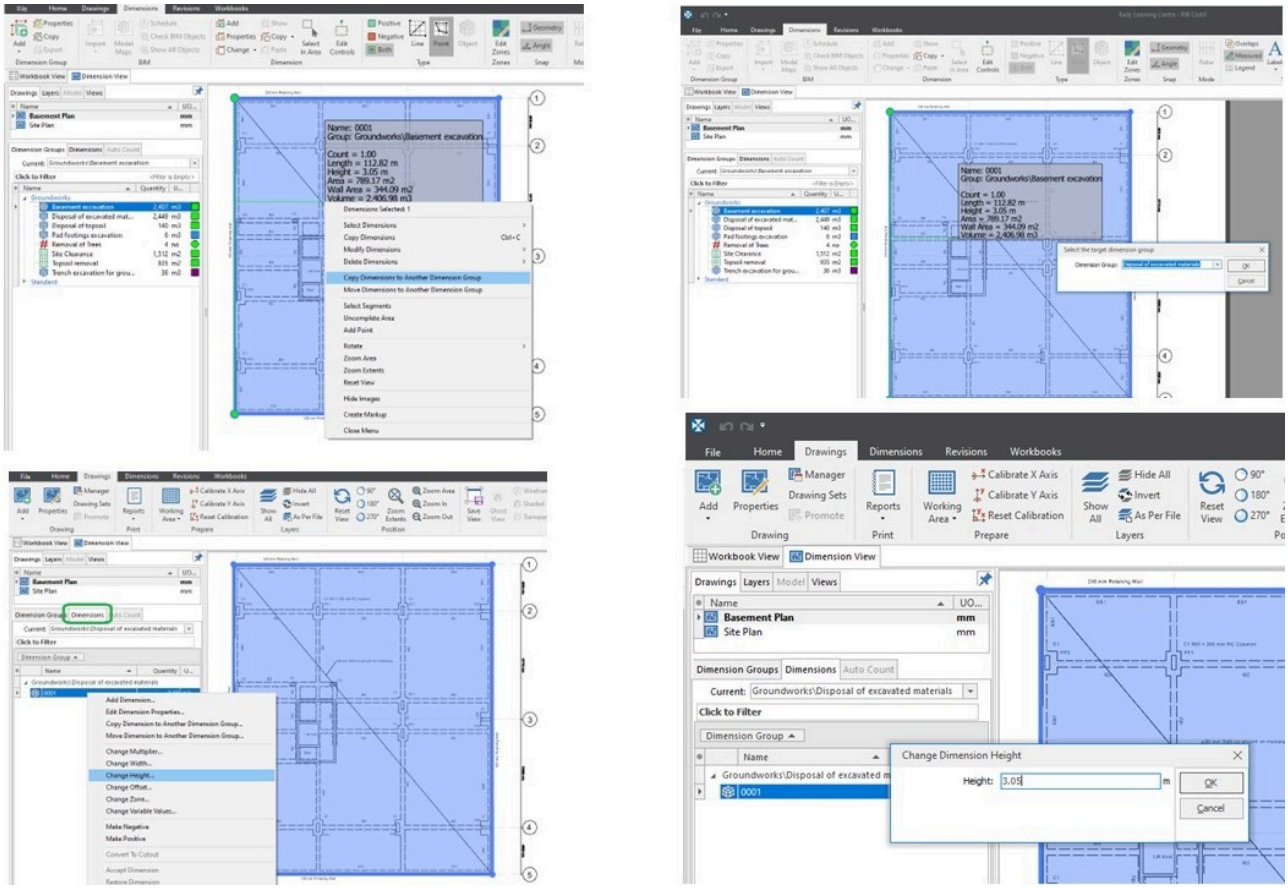


Figure 2.31: Screenshots of measurement of disposal of excavated materials using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The working space for pad footings and trenches is measured together, as their excavation heights are the same. Working space is measured in square meters by multiplying the girth on the outside line of the footing by the depth of the excavation.

Step 19: Create a dimension group to measure the working space. Add a folder named Working Space. Set the measurement type to Length and the default display to Wall Area. Enter 0.33 m in the Height box, as shown in Figure 2.32.

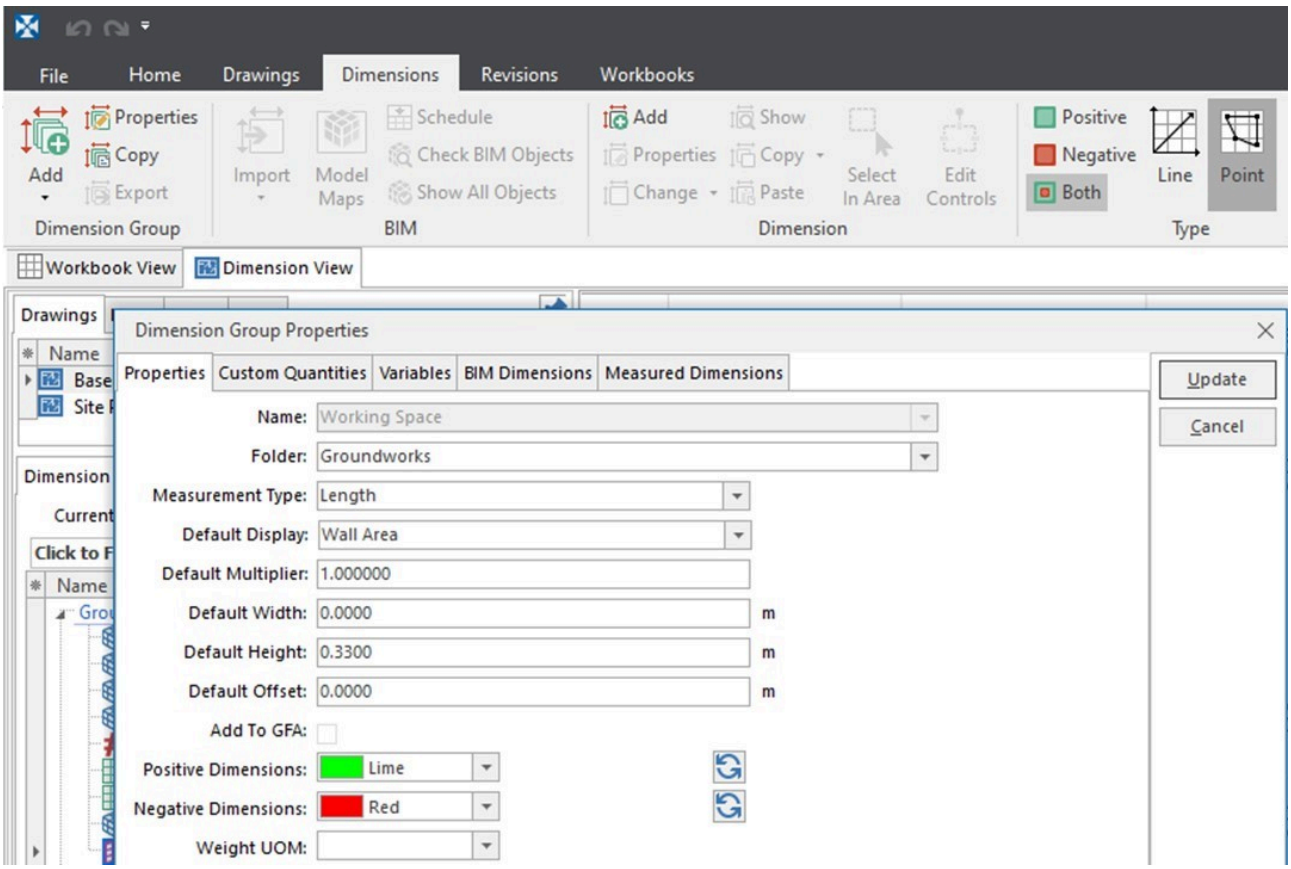


Figure 2.32: Screenshot of creating a dimension group to measure working space using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 20: Using the Point method, select the boundary of the pad footings and trenches as illustrated in Figure 2.33.

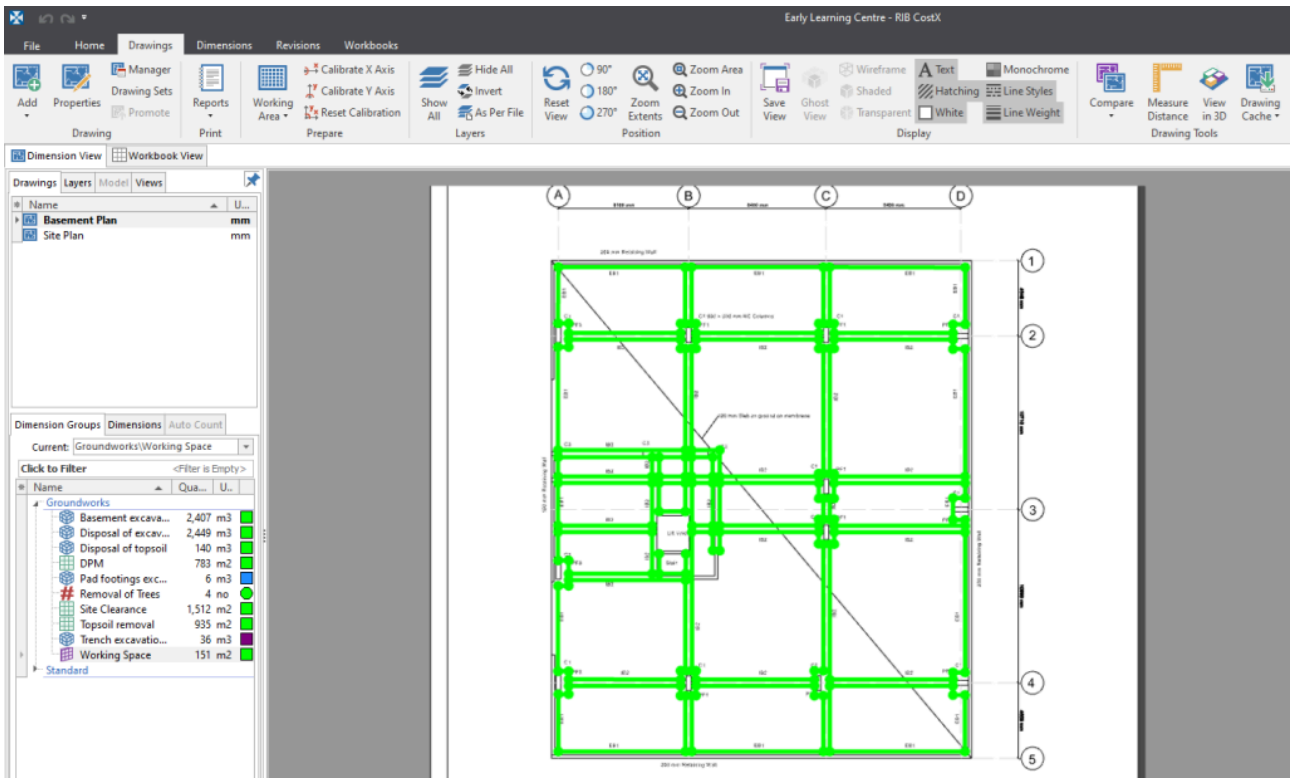


Figure 2.33: Screenshot of measurement of working space for a pad footings and ground beams using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 21: Create a dimension group to measure the damp proof membrane (DPM). Add a folder named DPM. DPM is measured in square meters. Set the measurement type and the default display to Area, as shown in Figure 2.34.

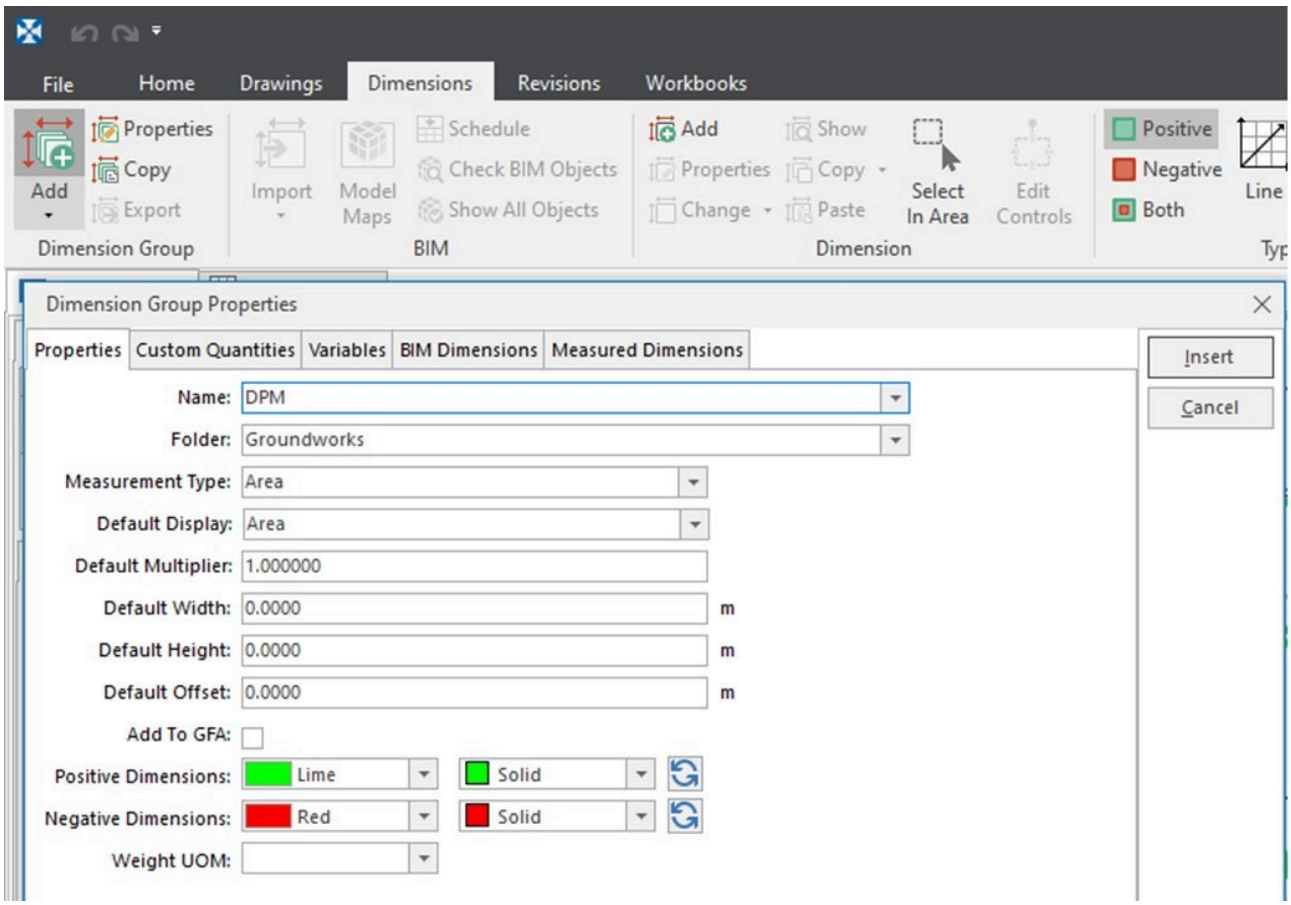


Figure 2.34: Screenshot of creating a Dimension Group to Measure DPM using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 22: Using the Point method, select the boundary of the DPM as illustrated in Figure 2.35.

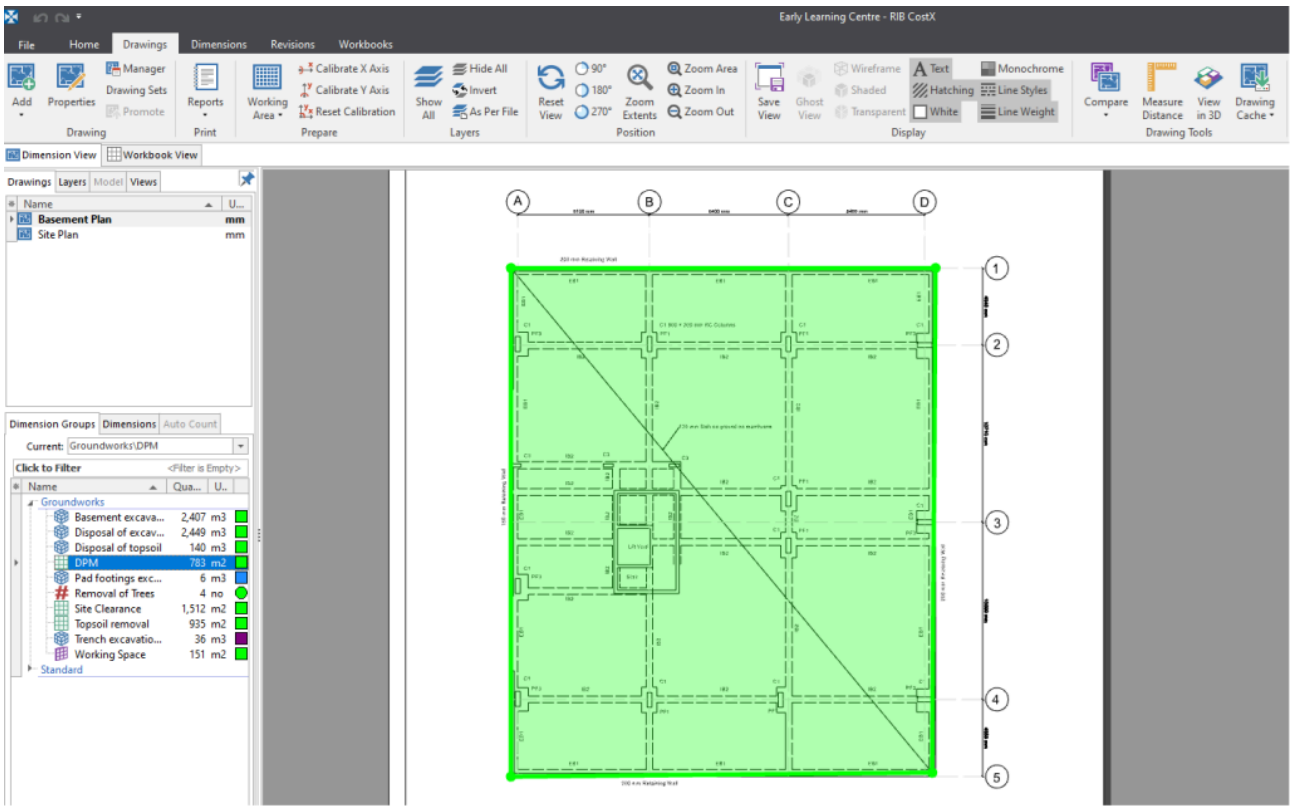
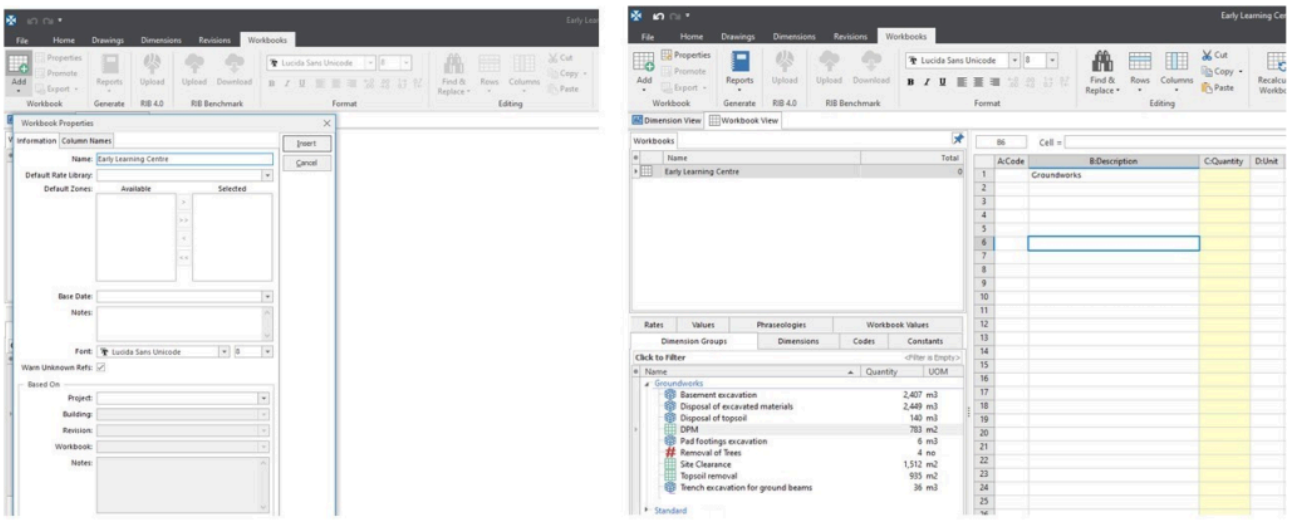


Figure 2.35: Screenshot of measurement of DPM using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 23: In CostX, create a workbook by clicking Add on the Workbook tab, and name it as Early Learning Centre (part a of Figure 2.36).

At the first level of the workbook, set the heading as “Groundworks”, as shown in part b of Figure 2.36.



(a) Creating a workbook

(b) Adding groundworks heading

Figure 2.36: Screenshots of creating a workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 24: Double-click the number associated with the "Groundworks" heading, then include the descriptions and UOM as specified in Table 2.1.

Table 2.1: Descriptions of measured groundwork items

	Item	Description	UOM	Notes
1	Preamble note	Tenderers shall refer to the Introduction, General Rules and Recommendations section of the ANZSMM.	Note	N/A
2	Preamble note	Tenderers shall refer to relevant specification sections containing particulars of groundworks.	Note	N/A
3	Preamble note	Tenderers shall refer to the measurement and prices clauses of the groundworks section in ANZSMM.	Note	N/A
4	Preamble item	Allow for samples of ground materials as specified.	Item	N/A
5	Preamble item	Allow for testing of groundwork materials and similar as required.	Item	N/A
6	Preamble item	Keeping excavations free from rain and percolating water by pumping or other means.	Item	N/A
7	Site clearance	Clearing the site, including the trees girth not exceeding 500 mm, complete with stumps and roots.	Square metres	N/A
8	Removal of trees	Removal of trees complete with stumps and roots, girth 0.5 m – 1 m.	Numbers	N/A
9	Topsoil excavation	Excavating topsoil to be stockpiled, an average depth of 150 mm from existing ground levels.	Square metres	Specify the average depth.
10	Topsoil disposal	Disposal of topsoil stockpiled offsite 1 km away from the excavation.	Cubic metres	State approximate distance from the site.
11	Basement excavation	Basement excavation commencing at bottom of topsoil excavation total depth exceeding 3m but not exceeding 4 m.	Cubic metres	State the commencing level and depth category.
12	Pit excavation for pad footings	Pit excavation for pad footings commencing at the bottom of basement excavation, total depth is less than 1 m, working space 0.5m.	Cubic metres	N/A

	Item	Description	UOM	Notes
13	Trench excavation for ground beams	Trench excavation for ground beams commencing at the bottom of basement excavation, total depth is less than 1 m, working space 0.5m	Cubic metres	N/A
14	Disposal of excavated materials	Disposal of excavated materials offsite 10 km away from the excavation.	Cubic metres	State approximate distance from the site.
15	Working space	Working space for pit and trench excavation, total depth is less than 1 m.	Square metres	State the depth range and purpose.
16	Plastic membrane	0.2 mm gauge UPVC (unplasticised polyvinyl chloride) waterproof membrane to underside of concrete floor slab, horizontal lapped 150 mm joints sealed with pressure sensitive tape, including turns-ups ≤ 500 mm.	Square metres	State the laps and jointing required. Quantity includes turnups less than or equal 500 mm.

Figure 2.37 illustrates the descriptions and units of measurement (UOM) of the groundworks items measured in the selected project.

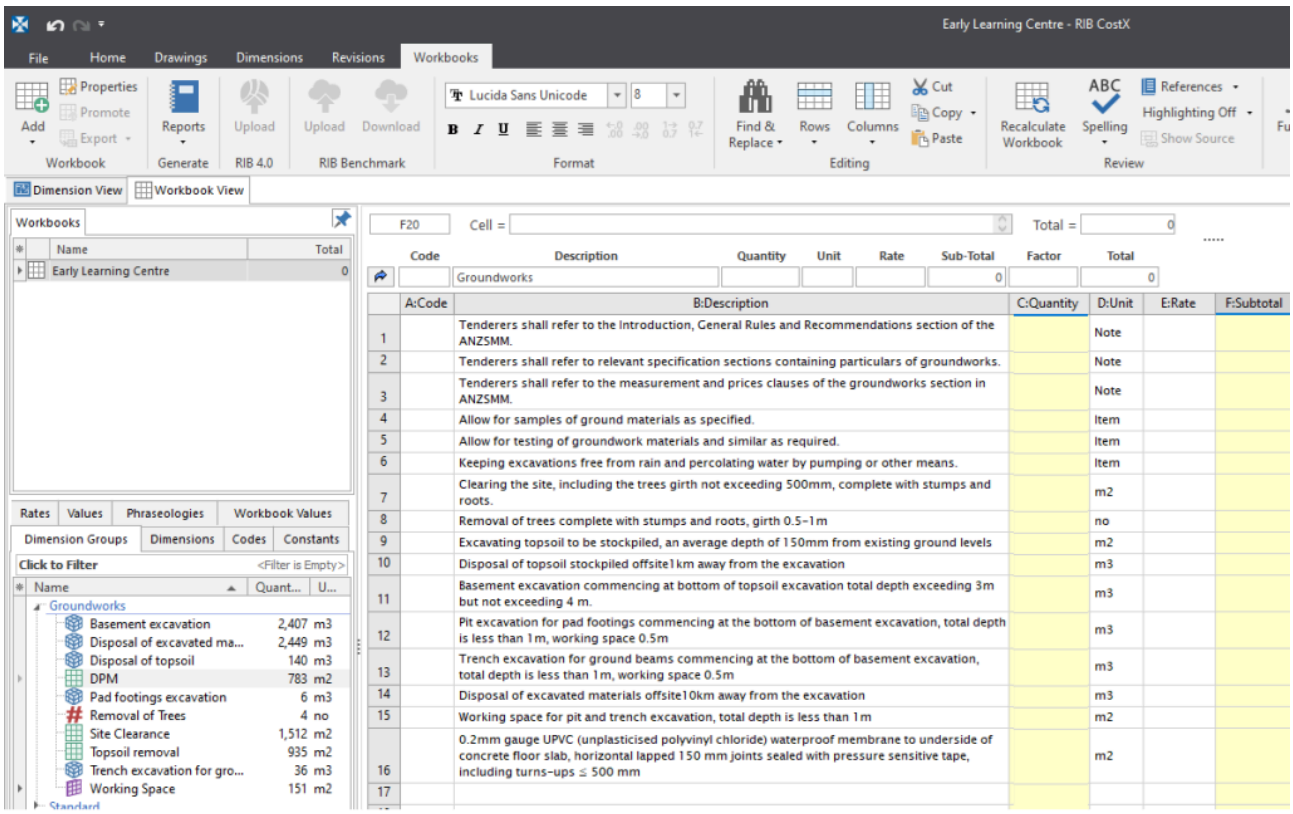


Figure 2.37: Screenshot of transferring the descriptions and UOM to the Workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 25: By double-clicking each quantity cell, transfer the measured quantities by dragging them from the dimension groups, as shown in Figure 2.38.

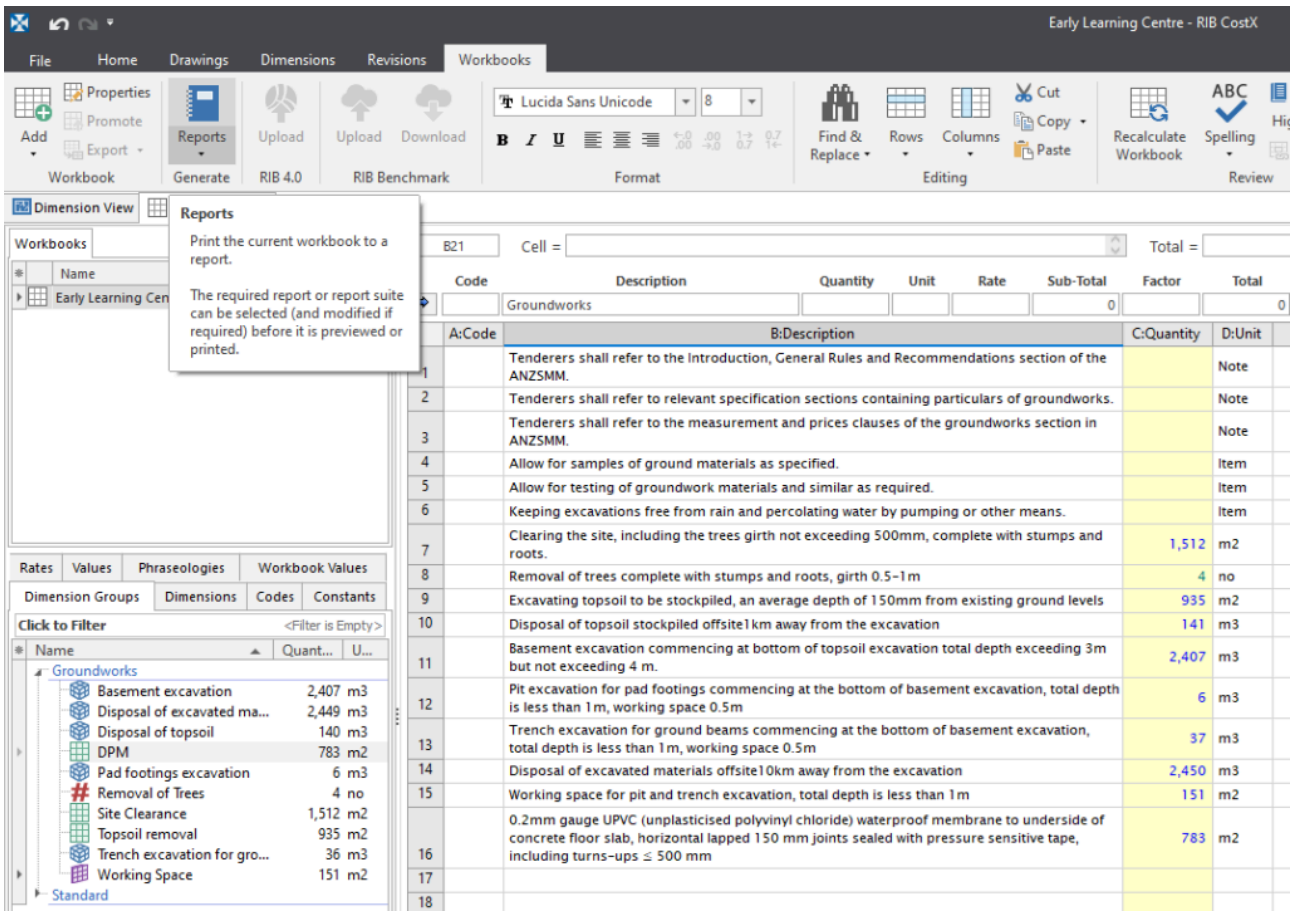


Figure 2.38: Screenshot of transferring the measured quantities to the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 26: Generate the BQs using CostX software by selecting "Report" and then clicking "Print Workbook to Report", as shown in Figure 2.39.

Default Project
Early Learning Centre
Early Learning Centre

Item	Description	Quantity	Unit	Rate	Amount
1	**Groundworks**				
A	Tenderers shall refer to the Introduction, General Rules and Recommendations section of the ANZSMM.		Note		
B	Tenderers shall refer to relevant specification sections containing particulars of groundworks.		Note		
C	Tenderers shall refer to the measurement and prices clauses of the groundworks section in ANZSMM.		Note		
D	Allow for samples of ground materials as specified.		Item		
E	Allow for testing of groundwork materials and similar as required.		Item		
F	Keeping excavations free from rain and percolating water by pumping or other means.		Item		
G	Clearing the site, including the trees girth not exceeding 500mm, complete with stumps and roots.	1,512	m2		
H	Removal of trees complete with stumps and roots, girth 0.5-1m	4	no		
J	Excavating topsoil to be stockpiled, an average depth of 150mm from existing ground levels	935	m2		
K	Disposal of topsoil stockpiled offsite1km away from the excavation	141	m3		
L	Basement excavation commencing at bottom of topsoil excavation total depth exceeding 3m but not exceeding 4 m.	2,407	m3		
M	Pit excavation for pad footings commencing at the bottom of basement excavation, total depth is less than 1m, working space 0.5m	6	m3		
N	Trench excavation for ground beams commencing at the bottom of basement excavation, total depth is less than 1m, working space 0.5m	37	m3		
P	Disposal of excavated materials offsite10km away from the excavation	2,450	m3		
Q	Working space for pit and trench excavation, total depth is less than 1m	151	m2		
R	0.2mm gauge UPVC (unplasticised polyvinyl chloride) waterproof membrane to underside of concrete floor slab, horizontal lapped 150 mm joints sealed with pressure sensitive tape, including turns-ups ≤ 500 mm	783	m2		

Figure 2.39: Screenshot of generating the BQ using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

CHAPTER 3: MEASUREMENT OF CONCRETE

3.1 OVERVIEW

This chapter focuses on the measurement of in-situ concrete for elements such as blinding, footings, slabs, walls, columns, and beams, where a distinction is made between plain and reinforced concrete. The chapter details the relevant technical specifications, applicable measurement rules, and the measurement process using CostX software.

Note: Precast concrete items are a different type of concrete and are not measured within the scope of the current chapter.

3.2 TYPES OF CONCRETE

Concrete is a construction material made by mixing cement, water, and aggregates such as sand, blue metal, gravel, or crushed rocks. When mixed, the cement reacts with the water in a chemical process called "hydration", which hardens the mixture into a strong, durable material over time. Concrete material is used in different elements of buildings.

The application of the concrete design in different elements results in different types of concrete, such as plain concrete, reinforced concrete, prestressed concrete, and precast concrete, where different requirements and considerations are required. AS3600 (concrete structures) outlined the consideration of the concrete works, including special concrete structures such as high-strength concrete and marine structures.

The composition material of plain concrete and reinforced concrete is similar, except that reinforced concrete is supported by steel bars (rebar) or steel mesh to increase the tension strength of the element. Figure 3.1 shows the placement of concrete material to be supported by the reinforcement.



Figure 3.1: The placement of concrete material for reinforced concrete elements in a building (Source: Amirreza Aminalavije)

In comparison, Figure 3.2 shows the placement of concrete without any reinforcement, representing plain concrete. The use of plain concrete is suitable when only compression of the concrete is required, such as in pavement and blinding. The use of reinforced concrete is where both tension and compression of the element are required, such as footings, slabs, columns and beams.



Figure 3.2: The placement of concrete material as a plain concrete element in a building. Image by Samuel Cruz from Unsplash under the Unsplash Content License

3.3 IN-SITU CONCRETE MEASUREMENT RULES

The complete measurement rules for concrete works are outlined in Section 6 of the ANZSMM, providing standardised guidelines for quantifying concrete works in construction projects. The information to be included table within this standard includes both preamble notes and preamble items, which serve as key references for tenderers and quantity surveyors. The preamble notes direct tenderers to the Introduction, General Rules, and Recommendations section of the standard, as well as to relevant specification sections containing concrete details, such as material properties, concrete specimens, particulars of the concrete and the concrete placement conditions. The preamble items allow for an allowance to be made for sampling of the material, conducting tests, curing and protecting after the placement.

According to the standard, the measurement of the concrete is expected to provide the net dimension of the element. Following the items in the classification table, the reinforced and plain concrete for different strengths or mixes of concrete should be measured separately. Also, the separate classification applies to different floor levels unless the consecutive levels have similar floor plans and construction methods. In this case, the levels need to be identified in the description of the item.

The description of the concrete element plays an important role in the completion of the measurements stage of the concrete works to capture the condition of the process of concrete works. As such, the method of positioning the concrete works should be included within the description, such as whether it is compacted, placed in the position, or sprayed. The material or condition of the concrete placement also plays a part in description writing, especially when the concrete is placed into formwork, steelwork or between excavated faces in footings.

The units of measurement for the in-site concrete works can be "m^2", "m^3", "m" and "no" depending on the type of elements. The unit of measurement for common elements, such as footings, is m^3. In case of measuring the volume for reinforced concrete, measurement rules outline no deduction of the reinforcement volume or structural steel unless the embedding steel element is a hollow element such as boxed, square hollow sections (SHS), rectangular hollow sections (RHS) or circular hollow sections (CHS).

As stated earlier, the measurement rules outline the net dimension of the element for the measurement of the concrete works, where the waste, making good after the removal of the formwork, joints, additional material for the tolerance of excavation and casting in all required material shall be considered within the pricing rate.

According to the standard, the measurement of concrete on different elements must follow their

classification and the corresponding measurement process. This section introduces concrete elements separately and reviews their measurement and description considerations. For a more comprehensive understanding of the measurement procedures, pricing, and definitions, the authors encourage readers to refer Section 6 of the ANZSMM.

3.3.1 Blinding concrete

Blinding is a base layer of weak concrete for other foundation elements. It is usually 10 MPa or 15 MPa plain concrete, depending on the design specification. Blinding concrete can serve different purposes within the building structure, such as providing an accurate levellingsurface for the foundation while sealing the underlying ground material. The drawings usually suggest a nominal thickness for blinding. Figure 3.3 demonstrates a blinding layer located below a pad footing in different views:

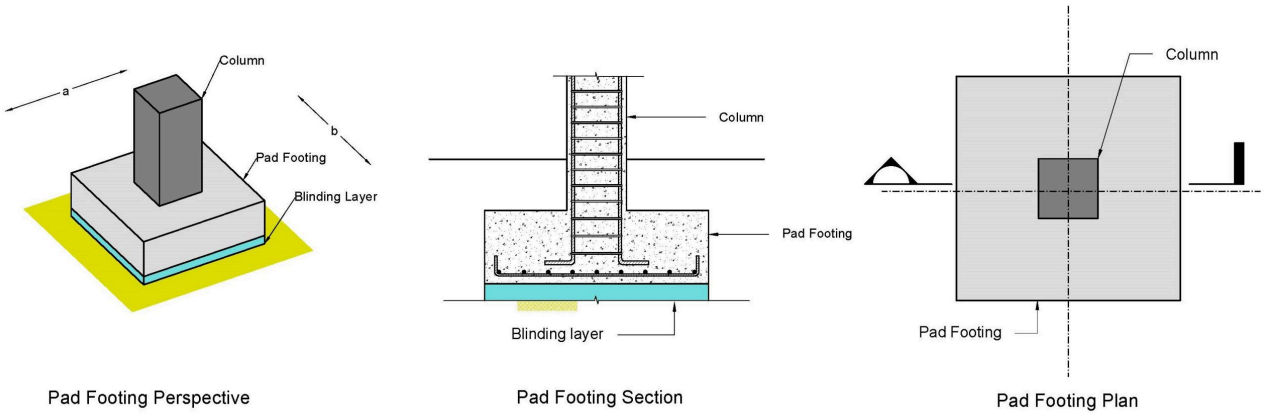


Figure 3.3: Blinding and pad footing (Source: Created by Authors)

According to the standard, the unit of measurement for blinding is square metres (m^2). The blinding needs to be classified as horizontal, sloping or vertical. It is required to state the thickness of the blinding within the description.

The horizontal blinding is commonly used in the project. When measuring the horizontal blinding, the area of the blinding on the plan can be measured.

3.3.2 Concrete for footings – pad footing and strip footing

Footings are the building elements that transfer the building load from other building elements, like columns or walls, to the ground. The size and shape of the footing depend on many factors such as the amount of the transferring load, the shape of the element above and the type of ground below (load bearing capacity of the soil), which will result in different types of footing such as pad footing, strip footing, raft footing, etc. The usual material of footings is reinforced concrete. Here are a few examples of various footings.

Pad footings are a type of footing that supports a concentrated element, such as a column. The pad footings are usually in a square or rectangular shape. They can be an isolated footing or interconnected with a linear structural element such as a ground beam, as shown in Figure 3.4.

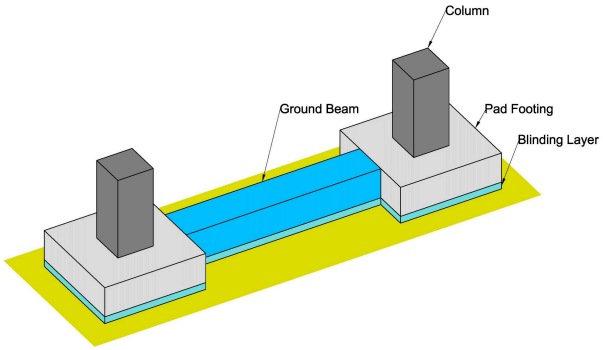


Figure 3.4: Blinding concrete layer, pad footing and ground beam illustration (Source: Created by Authors)

Strip footings are a long, narrow type of footing that supports a linear element, such as walls, as illustrated in Figure 3.5.

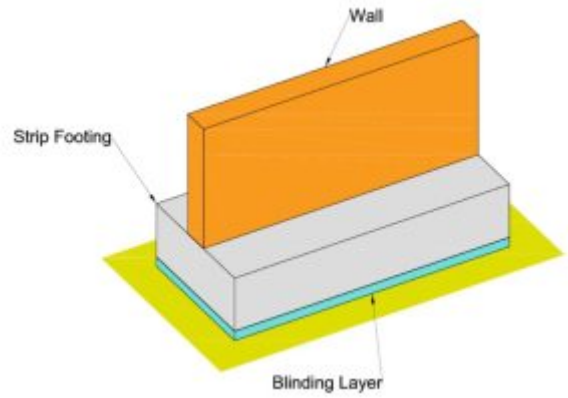


Figure 3.5: Blinding concrete and strip footing illustration (Source: Created by Authors)

Note that ground beams are very similar to strip footing but serve different purposes in buildings. Ground beams can be designed to connect other footings, such as pad footings.

According to the standard, the unit of measurement for concrete in a footing is m^3. The measurement of the footings is classified separately based on their types, such as pad footing, strip footing and ground beams. Additionally, items such as pad footings are required to be further classified if they capture less than 1 m^2 on the plan or more than 1 m^2 on the plan. It is required to state the depth of the footing within the description or mention the diameter of the footing if relevant.

3.3.3 Concrete for beam

Beams are horizontal structural elements in a building that support other structural elements, such as slabs, walls, columns, and footing elements. Also, beams may transfer loads from slabs and walls to columns or footing elements. One of the usual materials for beams is reinforced concrete. Beams can be designed to be positioned on the ground or on the upper levels. Represented in Figure 3.6, beams are usually located below a slab to support the slab loads, while upstand beams are located above the slab.

Figure 3.6 also illustrates the types of beams in reference to the slab, namely the upstand beam, the attached beam and the isolated beam. The cyan-coloured area denotes the measurement of concrete for the beams.

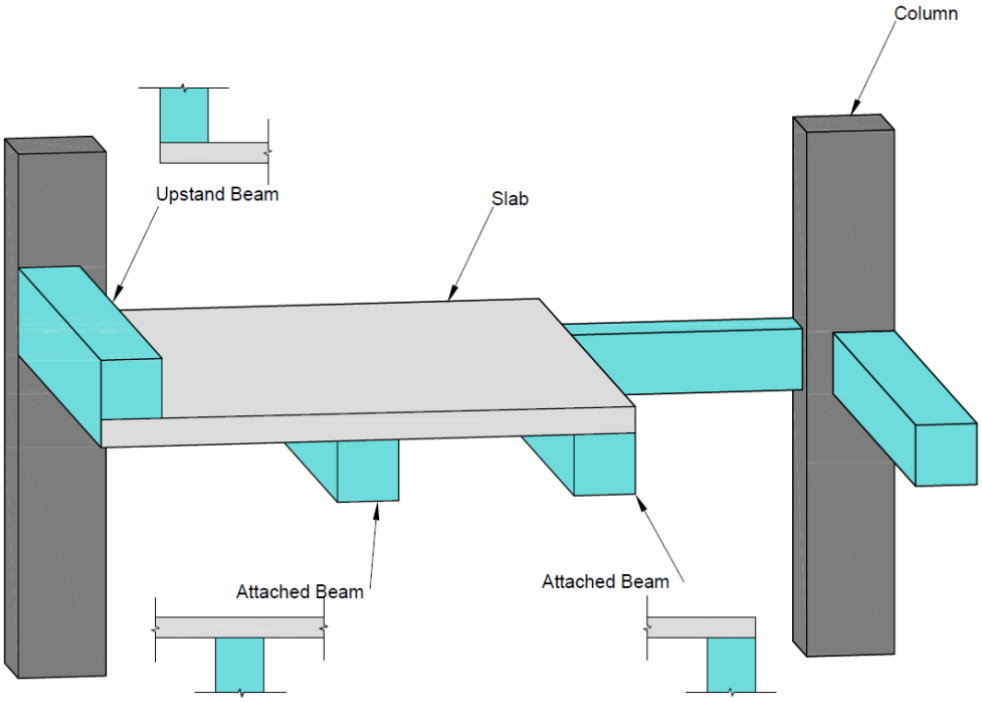


Figure 3.6: Upstand beam, attached beam and slab (Source: Created by Authors)

According to the standard, the unit of measurement for concrete in beams is in m^3. The concrete measurement of beams needs to be classified separately based on their types, such as isolated beam, attached beams and upstand beams. The concrete for the attached beams should be measured from the bottom of the slab. The concrete for the upstand beams should be measured from the top of the slab.

Ground beams are the linear structural elements that support slabs on ground, footings or walls. Ground beams are usually exposed to the soil and lie on the ground. The ground beams should be measured separately, where they are classified as a subcategory of the "footing" classification.

3.3.4 Concrete for slabs – raft slab, ground slab (slab on grade), suspended slab

The slabs are considered a flat, horizontal, or sometimes sloped layer of structural elements, usually made of reinforced concrete. The slabs are a common element used to form the floors, roofs, and foundations in buildings. Illustrated in Figure 3.7, the concrete slabs above the ground, known as suspended slabs, transfer the floor or roof load to other structural elements like beams and columns. In contrast, the slabs, which are directly on the ground, transfer the loads to the ground and can be considered structurally as a floor or foundation. The slab on ground (also known as a slab on grade) is a floor element that supports the loads directly to the ground.

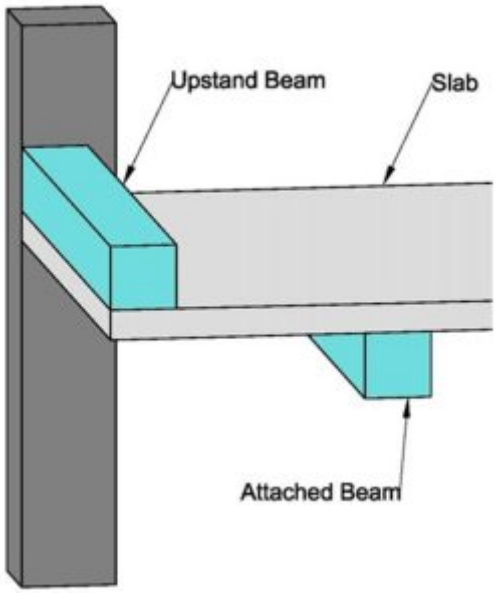


Figure 3.7: Suspended slab (Source: Created by Authors)

As illustrated in Figure 3.8, a raft slab is a foundation element that supports loads from other structural elements, such as columns, and transfers these loads to the ground.

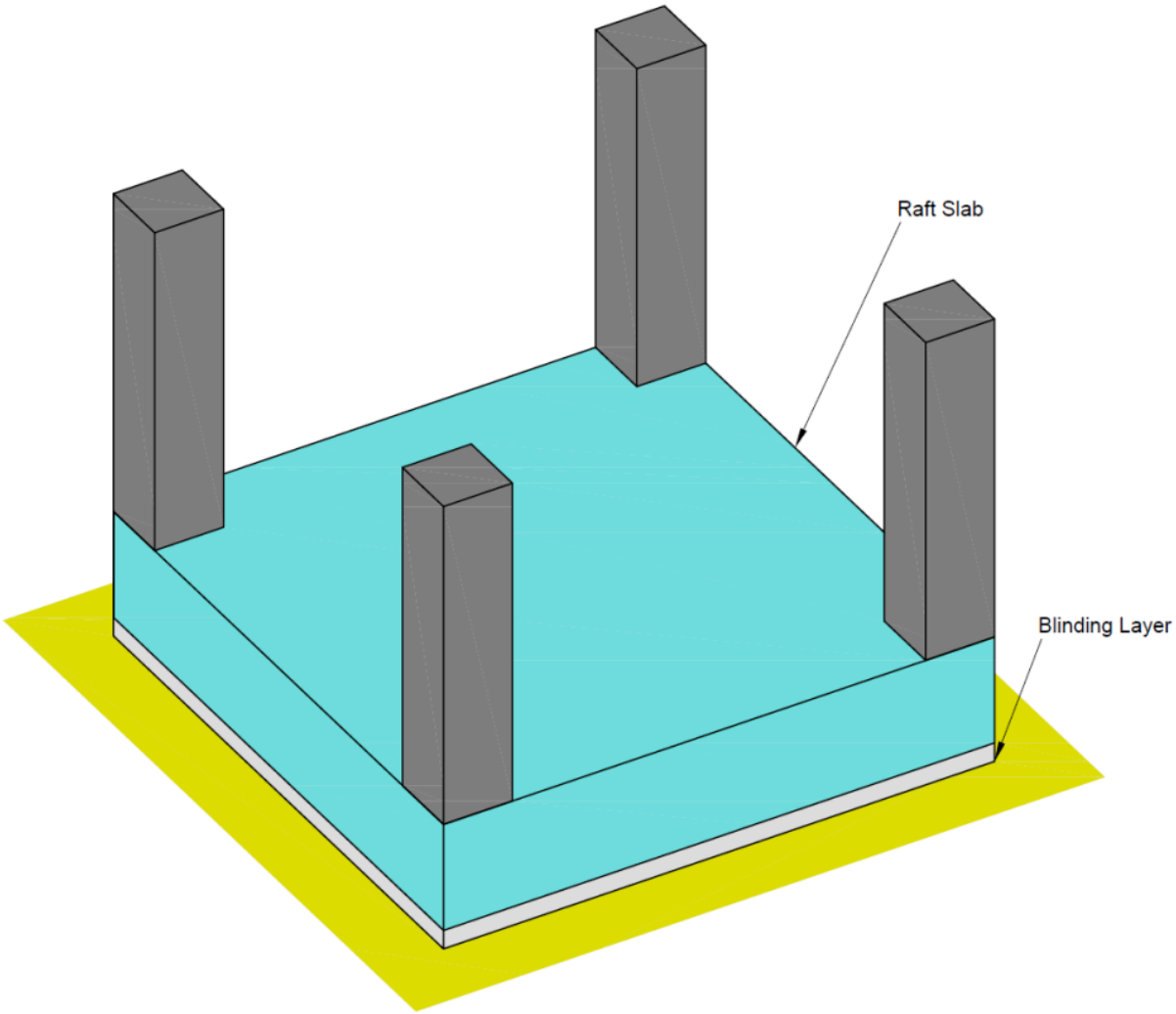


Figure 3.8: Raft slab (Source: Created by Authors)

The unit of measurement for concrete in slabs is m^3. The slabs are considered horizontal unless otherwise noted. The volume measurement of concrete slabs is classified and presented in 100 mm slab thickness intervals. The area measured for each slab classification shall be stated within the description of the item. The calculation of volume is commonly achieved by multiplying the surface area of the element by the thickness of the element. For example, the floor area of the slab multiplied by the thickness of the slab. The measurement of slabs is precise over the joining walls, beam thickenings and other concrete elements. In other words, there is no need to deduct any joining elements for the measurement of the slab area. Any slab projection, such as thickening similar items, needs to be included within the concrete slab measurement. Waffle slabs are a type of slab where waffle ribs and similar features attached to the slab need to be included in the measurement.

The sloped slabs less than 15 degrees, sloped slabs more than 15 degrees and cambered slabs are measured and categorised separately.

3.3.5 Concrete for columns

Columns are the structural elements that transfer the loads of structural elements above, such as beams and slabs, to the structure below, such as the footing system. Reinforced concrete is a common material used for columns. Columns can be designed as an isolated item or can be attached to a wall.

According to the standard, the unit of measurement for concrete in columns is m^3. The columns are classified to be measured separately based on their types, such as isolated columns and attached columns. The attached column is classified to be included within the wall take-off item to which the element is attached. For example, if a concrete column is attached to a concrete wall and the specifications of the concrete for both elements are the same, the concrete measurement of the column should be considered and presented within the concrete measurement of the wall.

3.3.6 Concrete for walls

Concrete walls are strong, durable structures made of reinforced concrete. They are commonly used as sheer walls to sustain lateral forces such as wind and earthquakes or retaining walls to keep the soil and water in the sloped landscape.

Concrete walls are constructed either cast in place (in-situ) or made precast in a factory. These two types of concrete are classified differently. The structural drawing features the detail of in-situ concrete walls and indicates the “precast” if it is expected to be one. For example, the notes or the legend of the drawing may refer to the precast nature of the walls, or the detailed section may indicate “precast panel” as the material of the wall.

The concrete in a wall is measured in m^3. The walls are classified into separate thickness stages of 50 mm. Also, the area of the wall should be expressed in the description. The attached columns or piers to the wall are classified within the concrete walls to be included within the concrete wall take-off.

3.4 MEASUREMENT PROCESS FOR CONCRETE USING COSTX SOFTWARE

This section provides a practical, step-by-step guide to measuring concrete works using CostX software. It walks through the entire process, including setting up dimension groups, applying measurement rules, and generating detailed reports. By following these instructions, readers will gain hands-on experience with CostX and learn how to accurately measure concrete elements such as footings, slabs, beams, columns and walls.

Refer to Figures 3.9 and Tables 3.1 as footing plan and footing schedules and concrete notes, measure pad footings, strip footing, raft footing, beams and concrete walls. In practice, many concrete items are measured from a floor plan. Thus, interpreting the floor plan is an essential part of measuring concrete items.

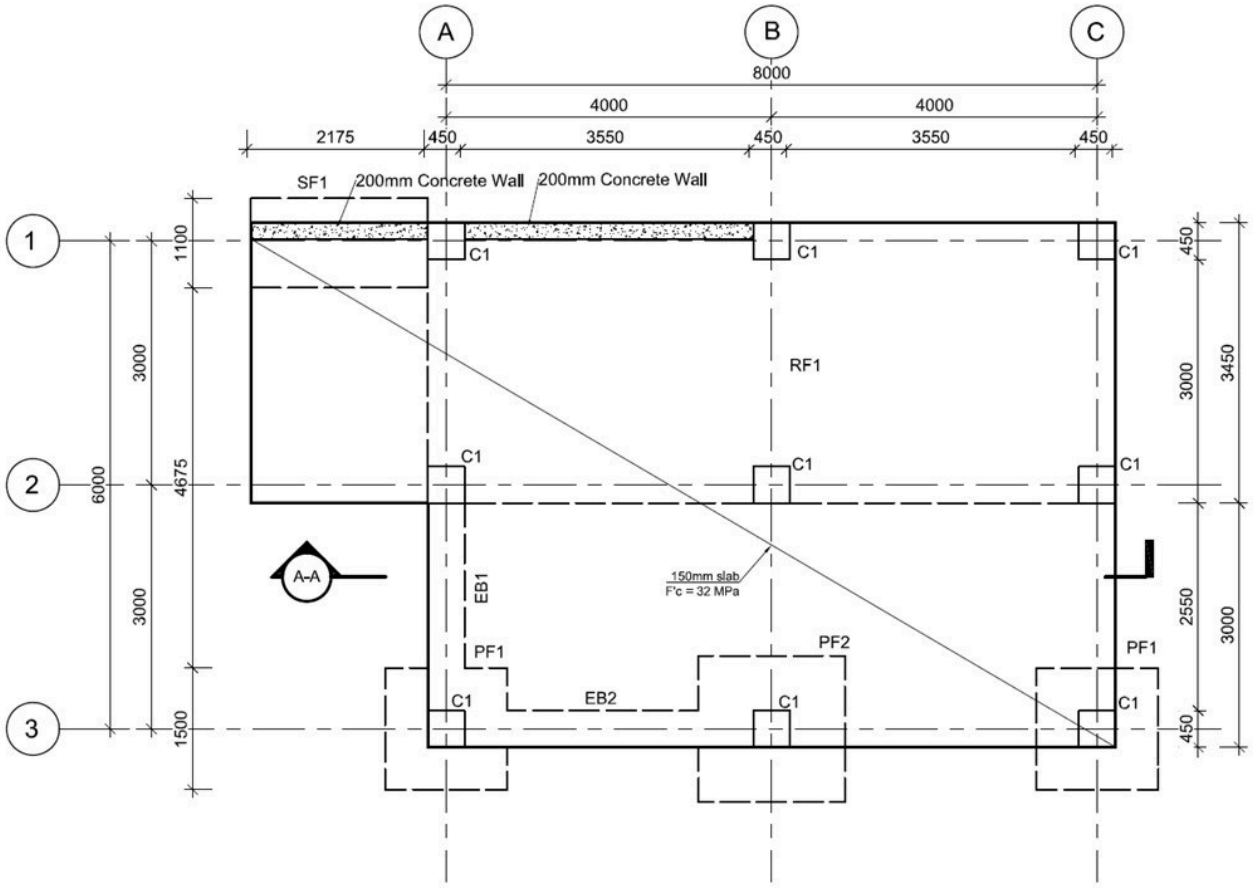


Figure 3.9: Ground Plan representing slab, footings, columns and walls (Source: Created by Authors)

Table 3.1 footing schedule indicates the height of the concrete elements. The reinforcement information

represents the combination of bars, confirming that the elements do not contain any hollow reinforcement elements within the concrete measurement.

Table 3.1: Footing schedule for concrete elements (Source: Created by Authors)

Mark	Length	Width	Depth	X-bars	Y-bars
PF1	1,500	1,500	400	N16-200 Btm	N16-200 Btm
PF2	1,800	1,800	400	N20-200 Top & Btm	N20-200 Top & Btm
SF1	N/A	1,100	300	N16-200 Top & Btm	N16-200 Top & Btm
RF1	N/A	N/A	400	2 Layers SL81 Top & Btm, Cov 60	N/A
EB1 & EB2	N/A	450	400	4-12 TM Btm, Cov 45	N/A

Table 3.2 concrete note demonstrates the strength (grade) of the concrete elements. This information guides the categorisation of the element types based on their strength. For example, the strip footings have a different concrete strength that needs to be measured and presented separately.

Table 3.2: Concrete grade notes for concrete elements (Source: Created by Authors)

Location	f'c
Pad Footings	N32
Strip Footings	N32
Raft Footings	N50
Beams	N32
Slab	N32

The details presented in Figures 3.10, 3.11, and 3.12 provide information that enhances understanding of the measured items' details and, in some cases, the nominal height of the element. For example, the thickness of the blinding can be obtained from Figure 3.11. The wall height is 2,000 mm, and the column height is 3,350 mm.

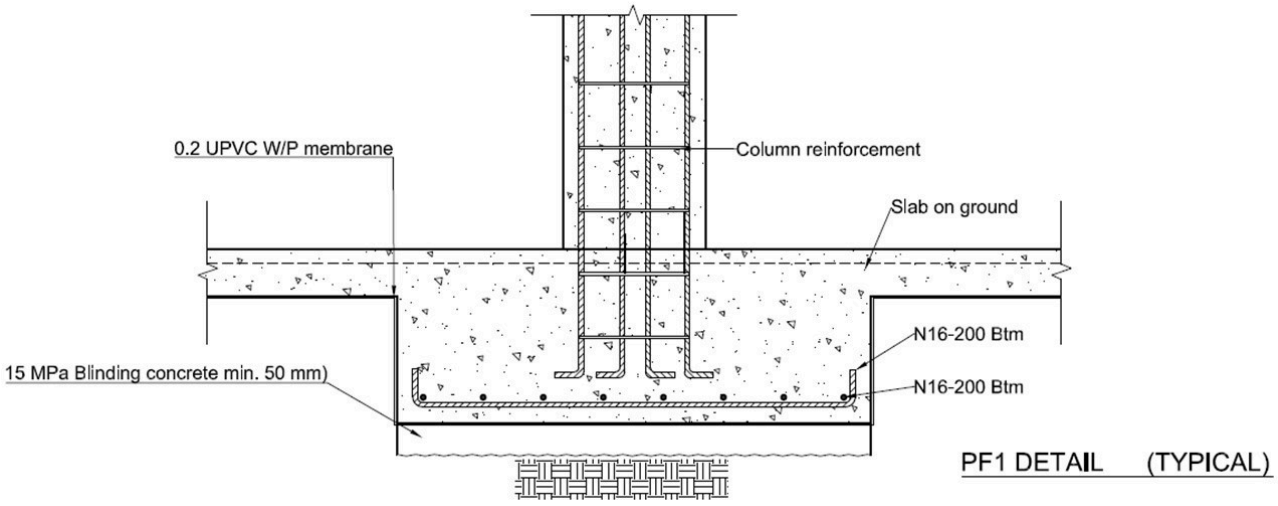


Figure 3.10: Detailed section of the concrete footing – pad footing (Source: Created by Authors)

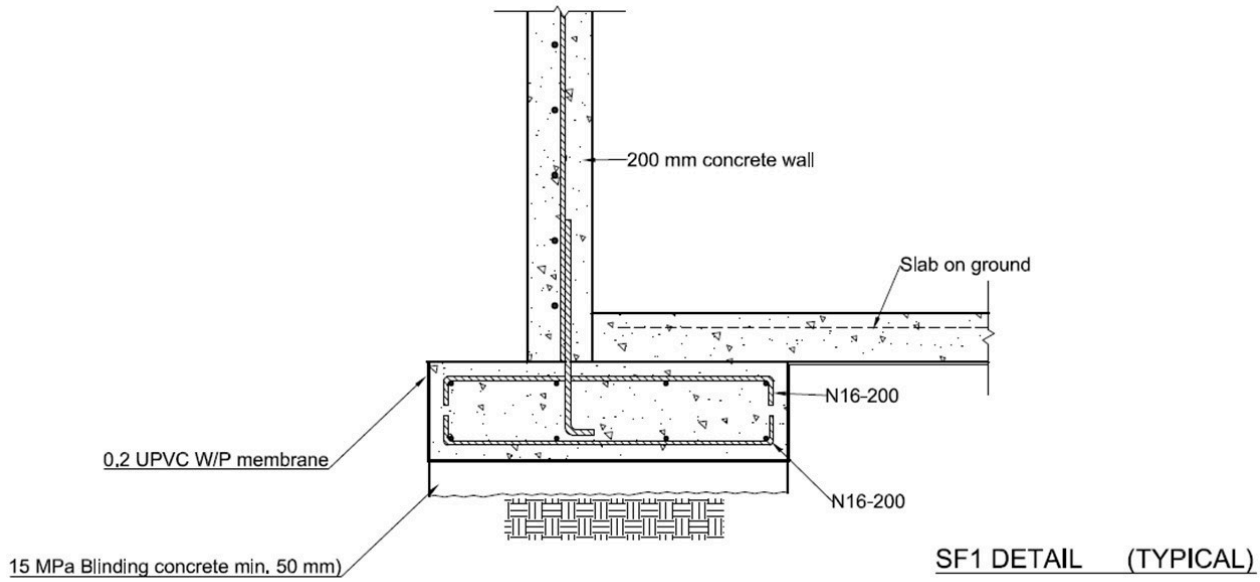


Figure 3.11: Detailed section of the concrete footing – strip footing (Source: Created by Authors)

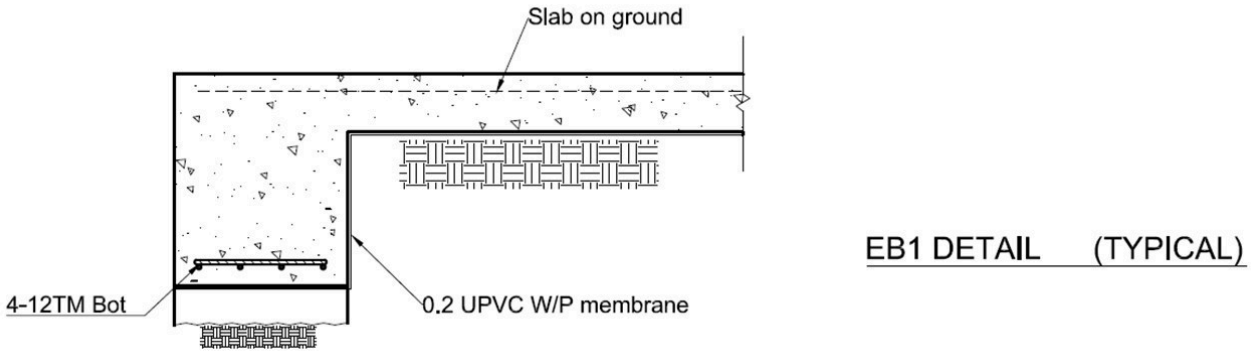


Figure 3.12: Detailed section of the concrete footing – ground (edge) beam (Source: Created by Authors)

3.4.1 Computer-based concrete measurement – iTwo CostX building set-up

Step 1: Open iTwo CostXand create a new building for measurement. The name of the building can be "Concrete Measurement". For educational purposes, select the "Default Project" as the project (Figure 3.13).

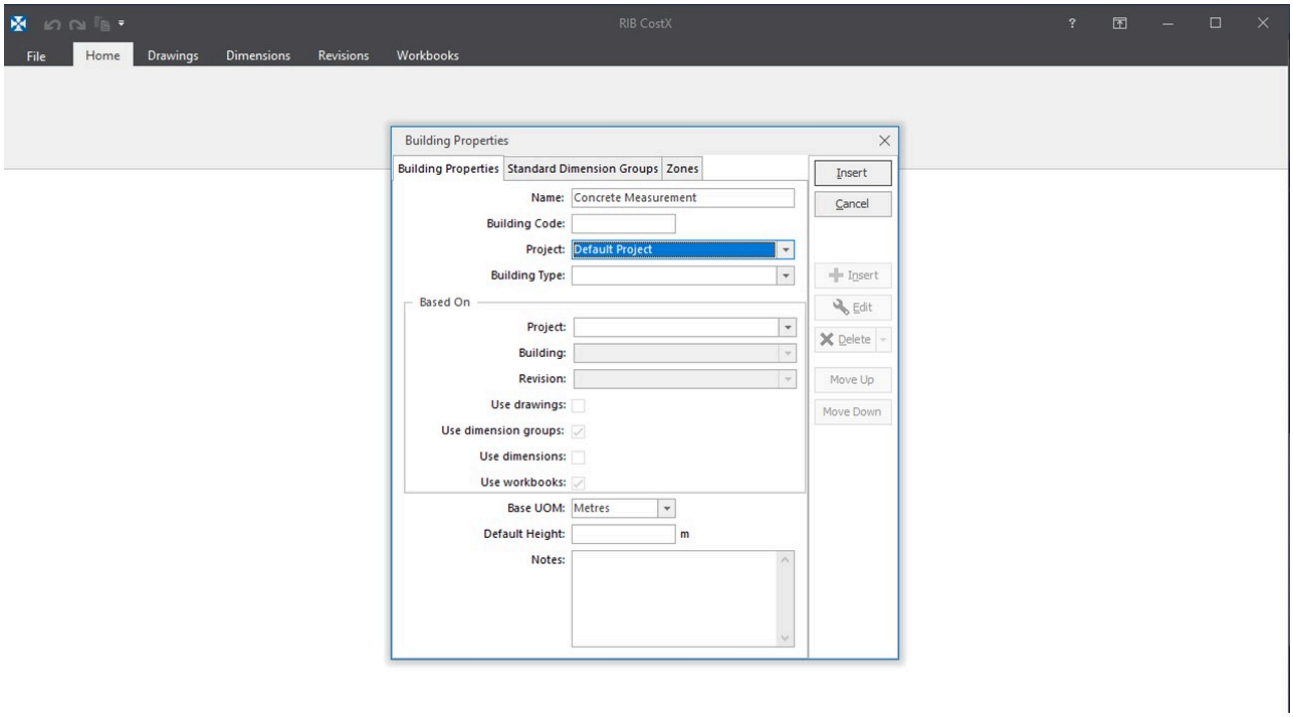


Figure 3.13: Screenshot of creating a building using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 2: Click on the Drawings tab and then select Add Drawings to import the floor plan into CostX (Figure 3.14).

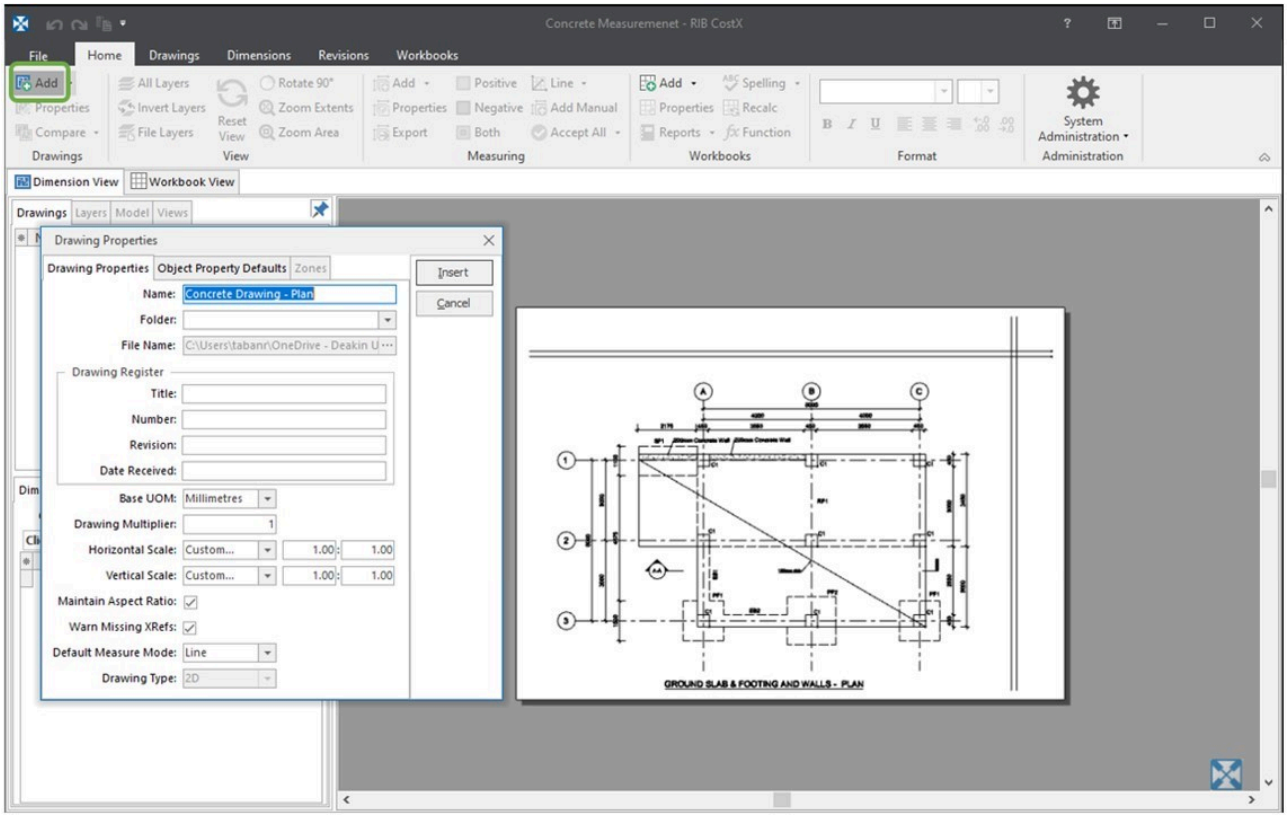


Figure 3.14: Screenshot of inserting the floor plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Calibrate the drawing using the known X and Y dimensions, as shown in Figures 3.15 and 3.16. It is recommended to use the longest dimension for calibration to minimise the accumulation of errors. The X-axis was calibrated using the 8,460 mm dimension marked on the plan, while the Y-axis was calibrated using the 6,000 mm dimension indicated on the drawings, as shown in Figures 3.15 and 3.16.

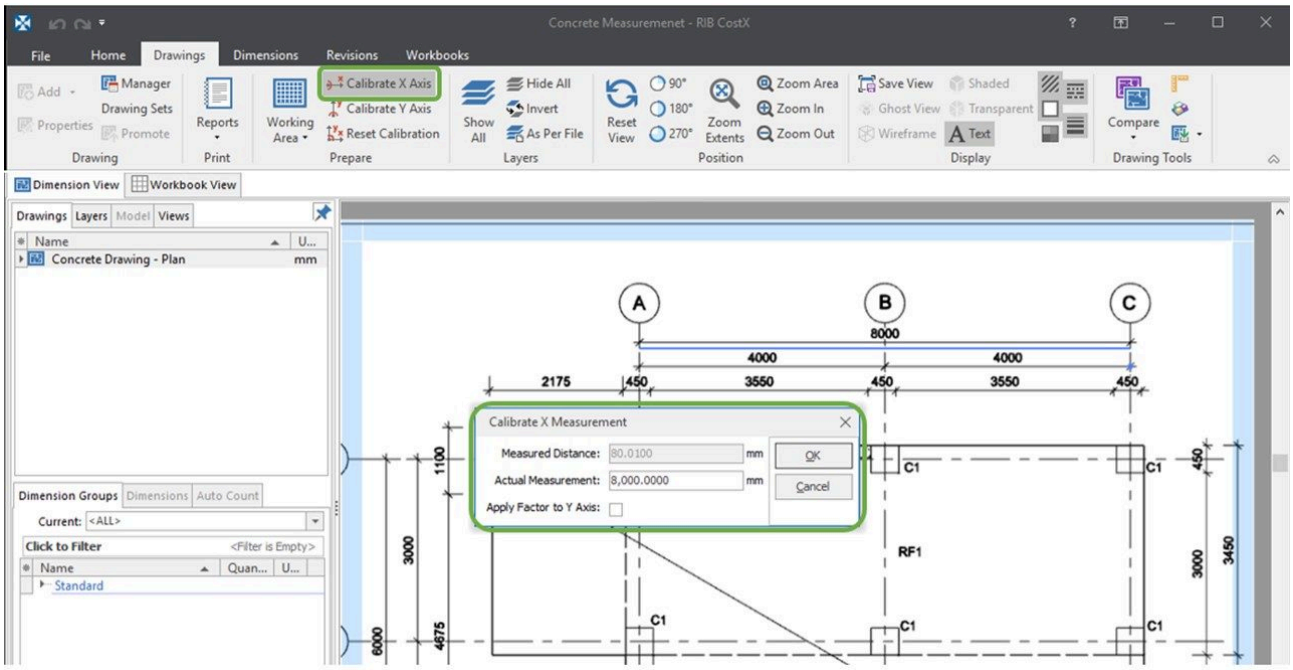


Figure 3.15: Screenshot of calibrating the X-axis from the longest horizontal dimension on the plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

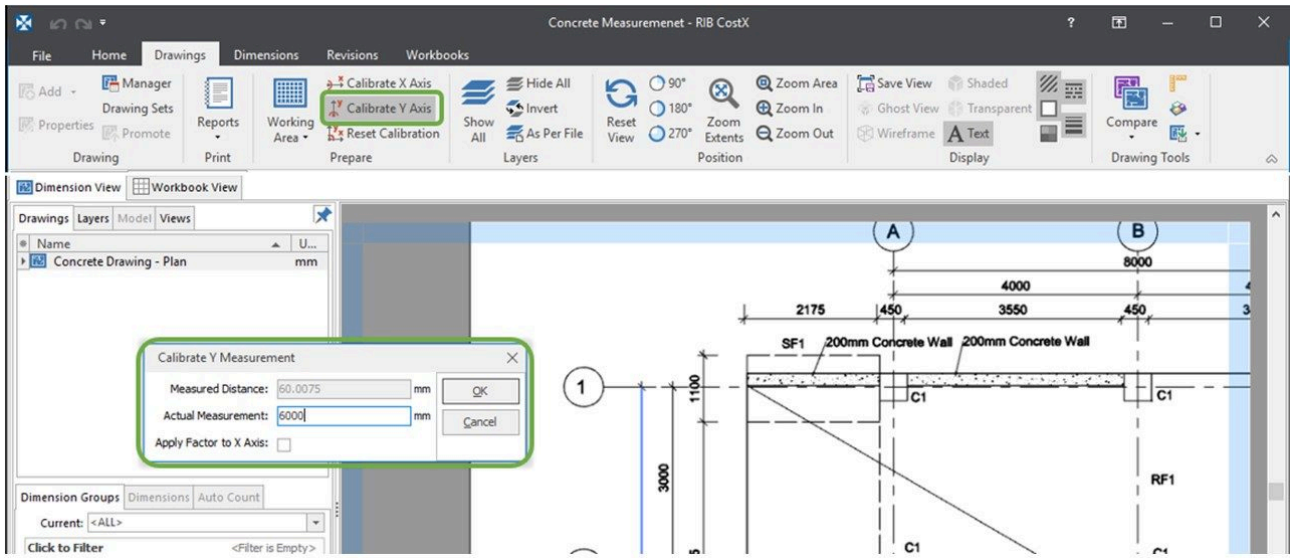


Figure 3.16: Screenshot of calibrating the Y-axis from the longest vertical dimension on the plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.2 Computer-based measurement of concrete for blinding

Step 4: Create a dimension group to measure concrete for blinding (Figure 3.17). Add a folder named "Concrete". As blinding is measured in m^2, set the "Measurement Type" and "Default Display" to

"Area". Assign the "Default height to "0.05 m". The nominal thickness of the blinding obtained from the detailed drawing is stated in "SF1 Details" and assumed for the entire project, as it is not noted anywhere else.

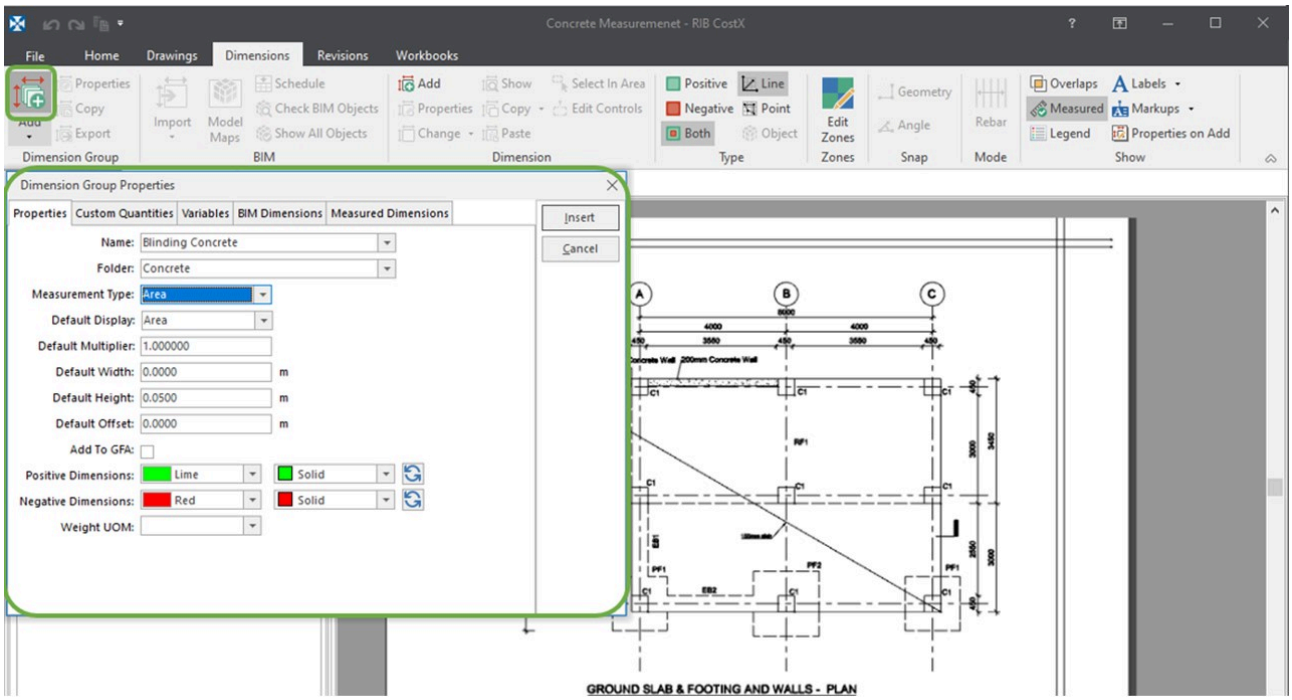


Figure 3.17: Screenshot of creating a dimension group for blinding concrete using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Trace the footprint of the items that have blinding as a base. In this example, the pad footings, strip footing, raft footing and ground beam are set to have blinding. You can choose the Point mode or Line mode for tracing the areas, whichever is more suitable.

Using the "Line" mode, then sequentially choose lines on the sides of the corresponding blinding area as illustrated in Figure 3.18. To close each area, press "enter" on the keyboard. If an unwanted item is selected mistakenly during tracing, press the "backspace" key on the keyboard to undo the selection.

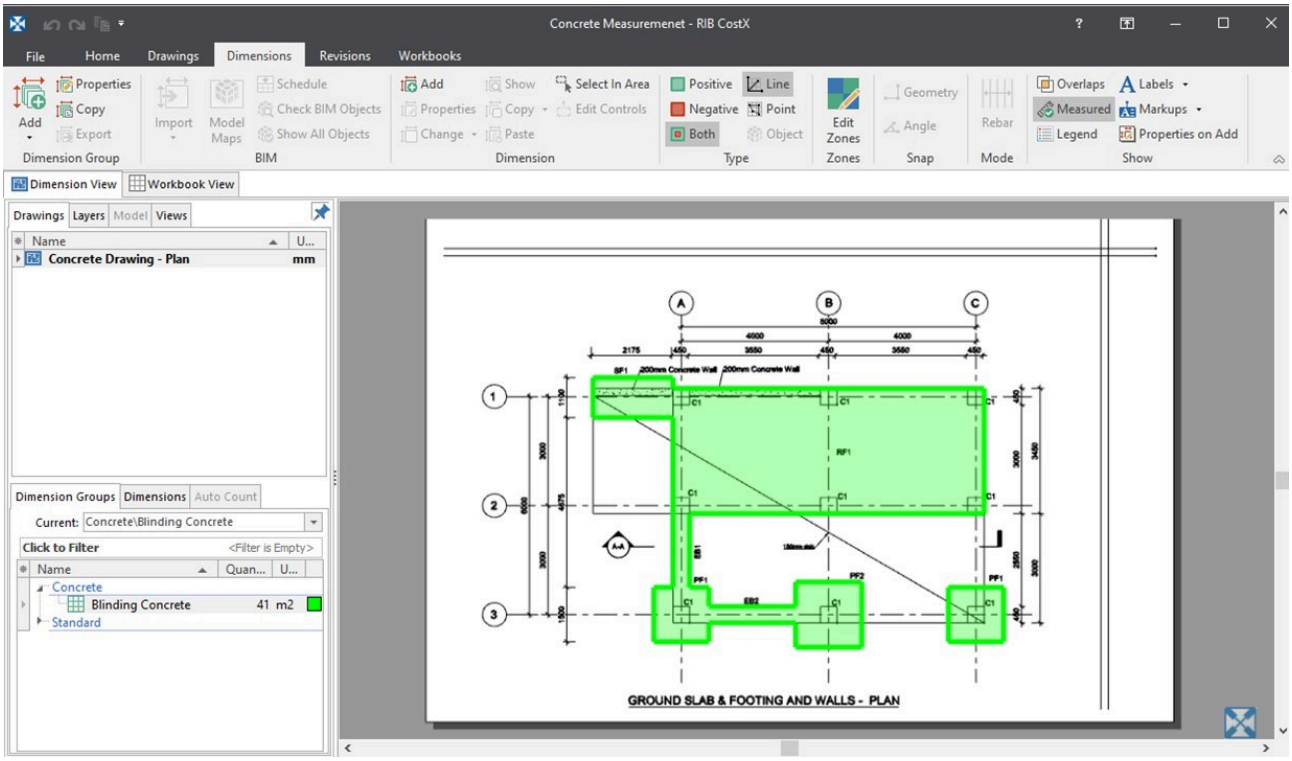


Figure 3.18: Screenshot of measuring tools using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.3 Computer-based measurement of concrete for pad footing

The drawing represents two types of pad footing: PF1 and PF2.

Dimension group for pad footing 1 (PF1)

Step 6: Create a dimension group for pad footing 1 (PF1 – Concrete 32 MPa) under the folder named "Concrete" to measure the concrete quantity. As concrete for pad footing is measured in m^3, set the "Measurement Type" to "Area" and "Default Display" to "Volume". Assign the "Default height" to "0.40" m obtained from the footing schedule (see Figure 3.19).

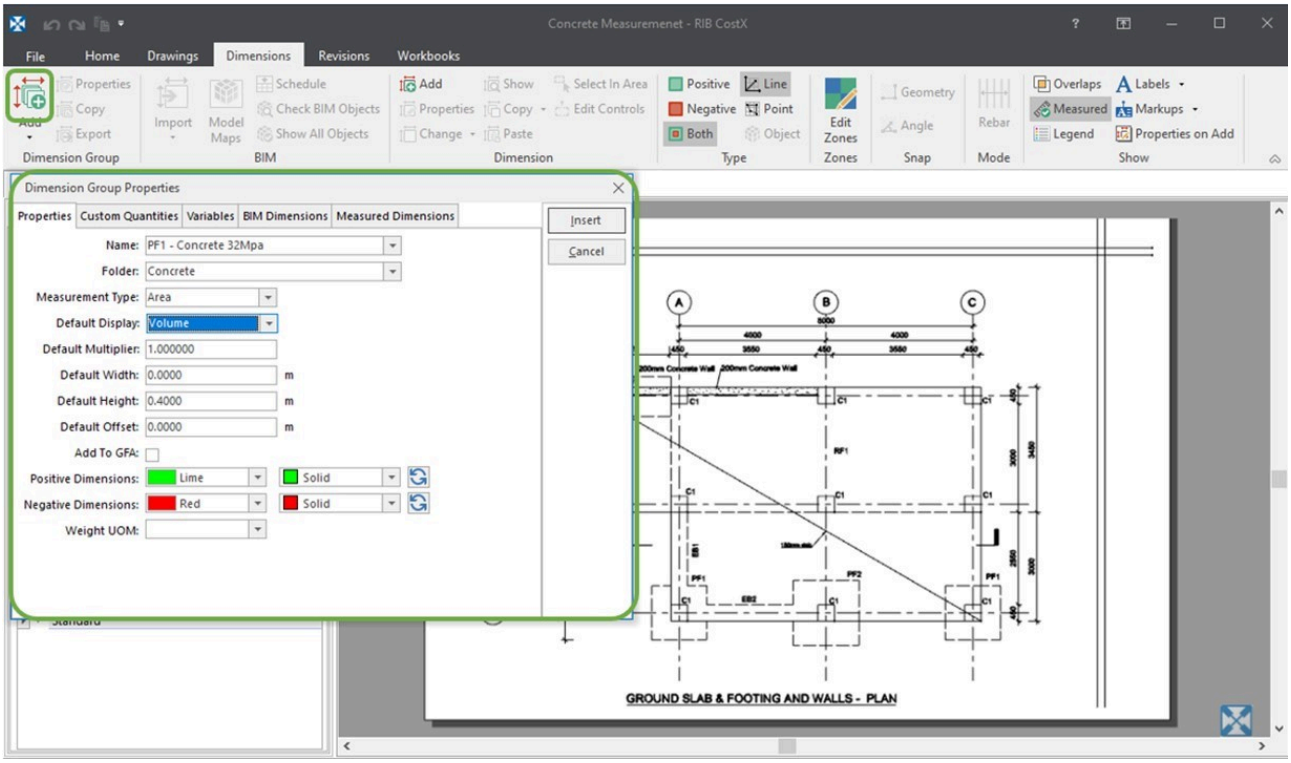


Figure 3.19: Screenshot of dimension group for pad footing using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 7: Trace the footprint of Pad footing PF1. You can choose the point mode or line mode for tracing the areas, whichever is more suitable.

Using the "Point" mode, sequentially choose the corner of the item corresponding to the pad footing footprint as illustrated in Figure 3.20. To close each area, hit "enter" on the keyboard. If an unwanted item is selected mistakenly in the middle of tracing, hit "backspace" on the keyboard to undo the selection.

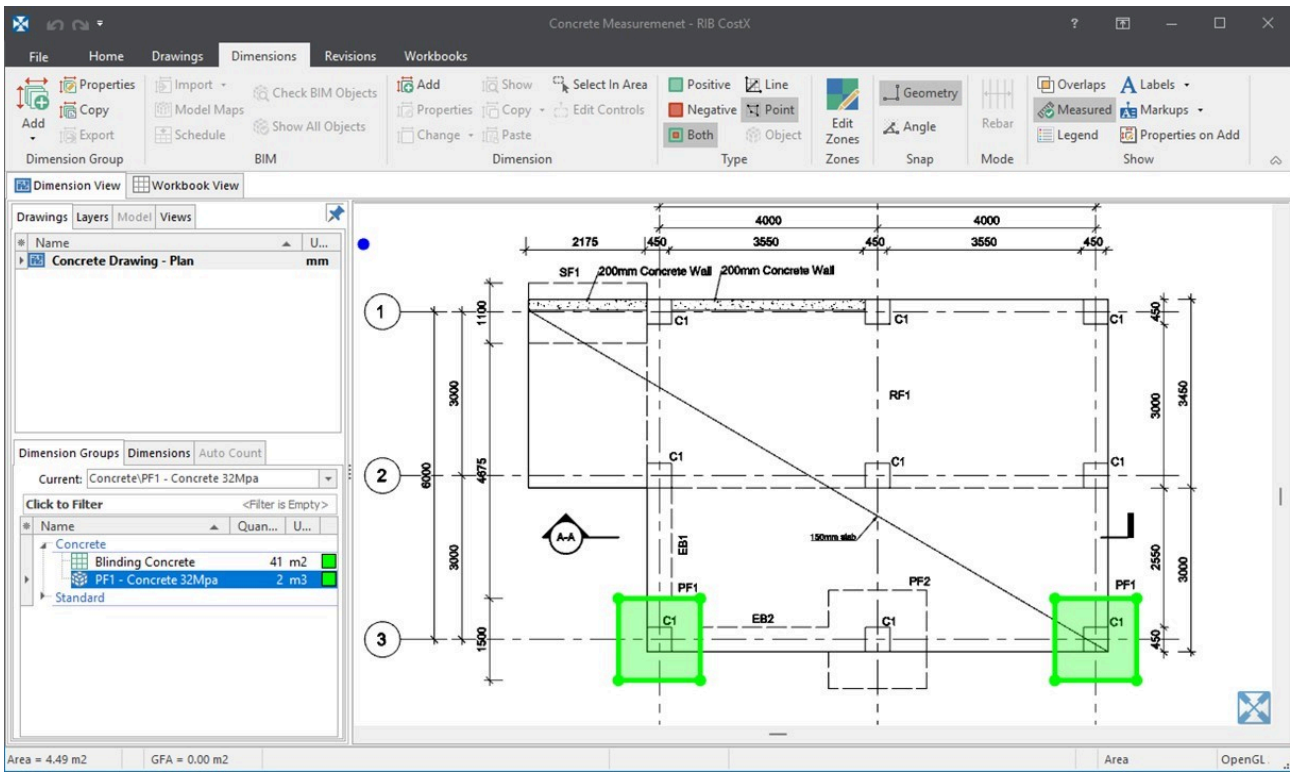


Figure 3.20: Screenshot of pad footing (PF1) measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Dimension group for pad footing 2 (PF2)

Step 8: Since the details of PF1 and PF2 are very similar, create the dimension group pad footing 2 (PF2-Concrete MPa) by copying from the PF1 dimension group. As shown in Figure 3.21, right-click on the PF1 dimension group and choose "Copy Dimension Group" and name the new dimension group as "PF2-Concrete 32 MPa". Then, leave the "Copy Dimensions" option unchecked.

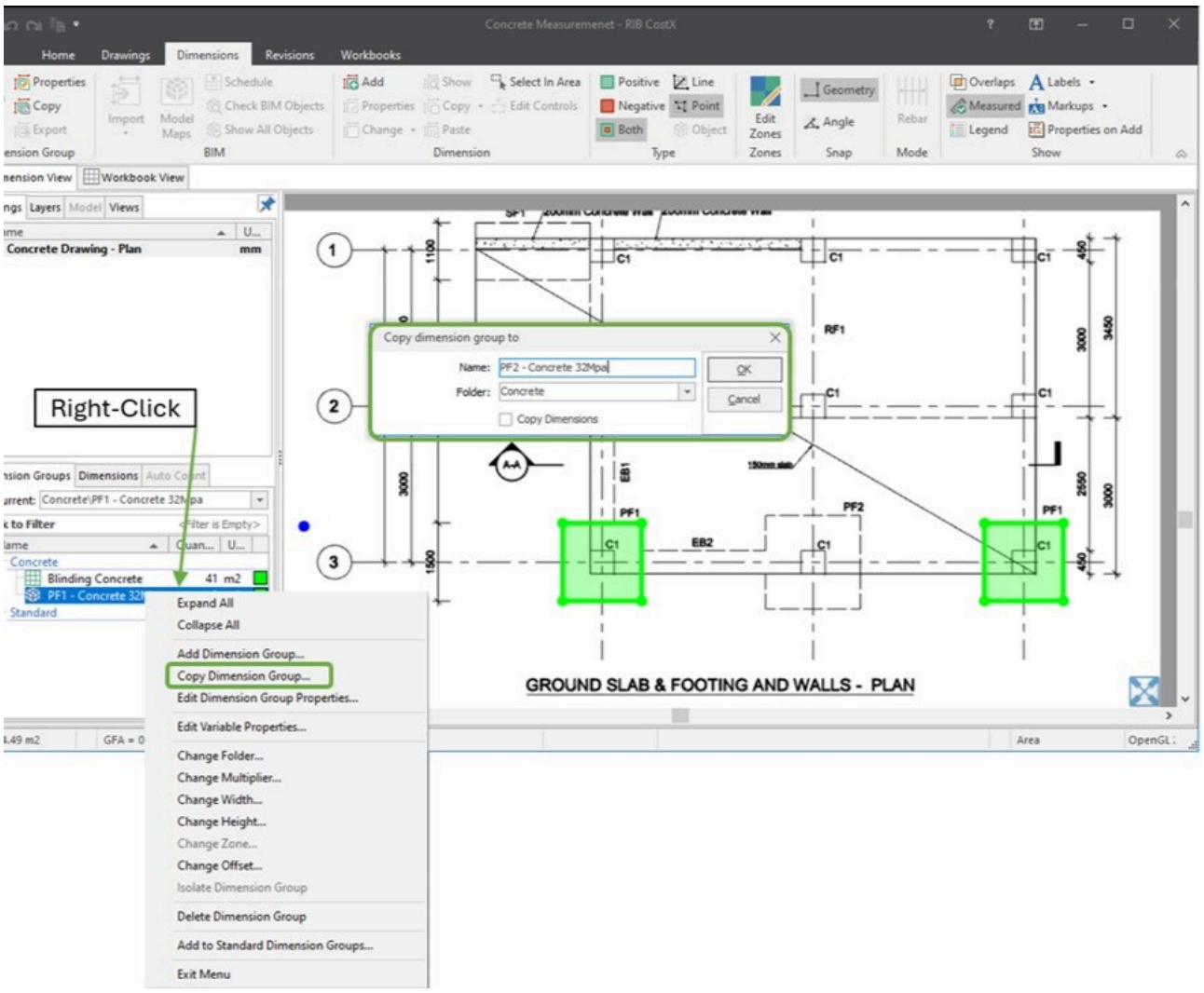


Figure 3.21: Screenshot of dimension group for pad footings using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 9: Measure the PF2 by tracing the footprint of the pad footing item, following the same steps as in Step 7. The measurement of PF2 is shown in Figure 3.22.

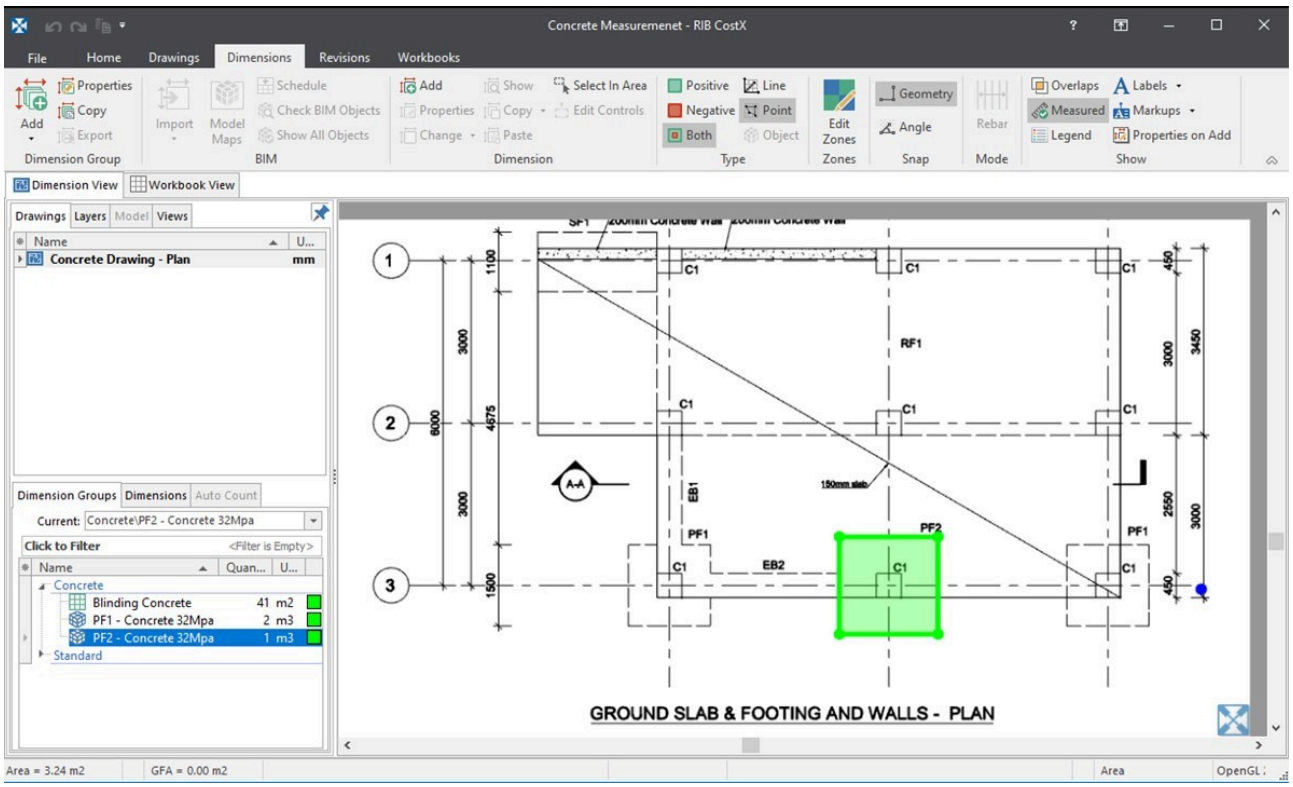


Figure 3.22: Screenshot of pad footing (PF2) measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Note: In most projects, this method allows for checking that all pad footings are accounted for by selecting all footings and reviewing the floor plan, ensuring the items are highlighted similarly to Figure 3.23.

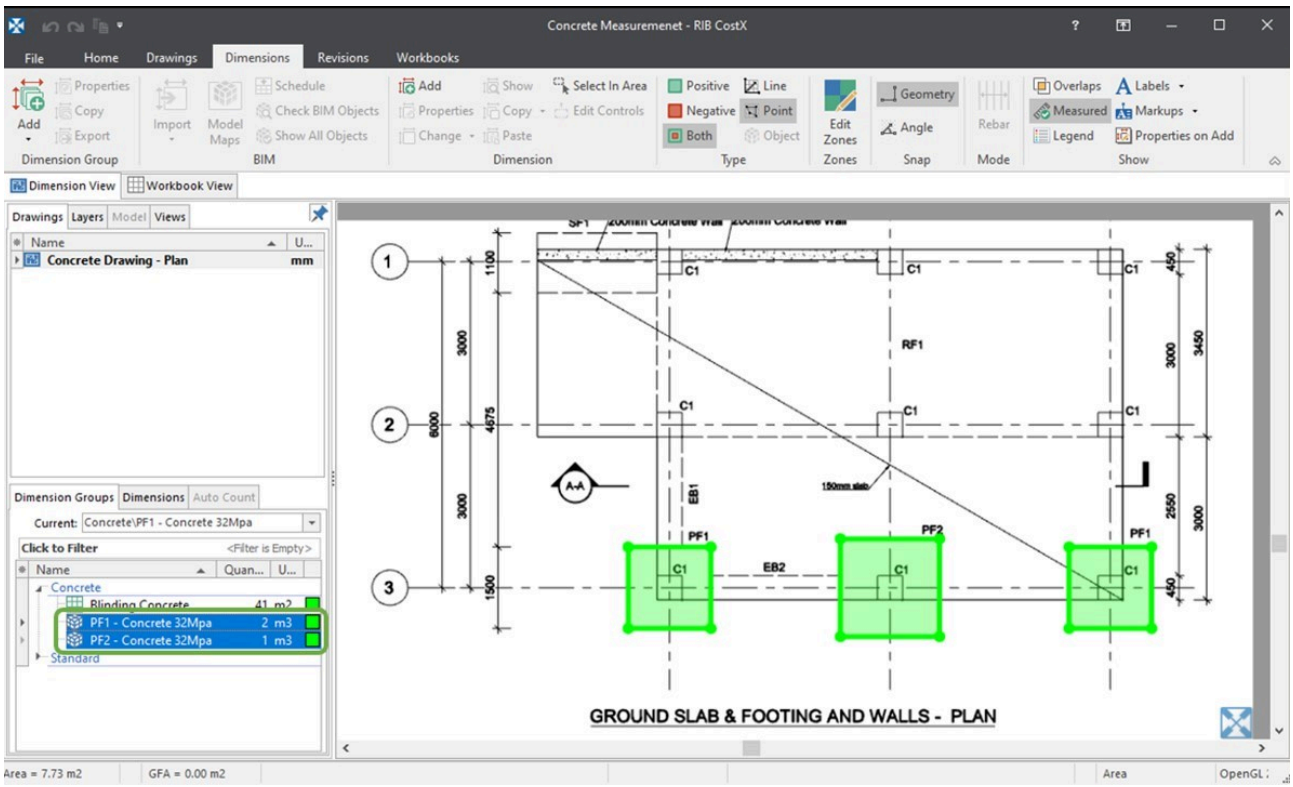


Figure 3.23: Screenshot of checking pad footings on plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.4 Computer-based measurement of concrete for strip footing

The drawing represents one type of strip footing (SF1).

Step 10: Create a dimension group for strip footing 1 (SF1 – Concrete 32 MPa) under the folder named "Concrete" to measure the concrete quantity (Figure 3.24). Concrete for strip footing is measured in m^3; therefore, set the "Measurement Type" to "Length", and the "Default Display" to "Volume". Assign the "Default Width" to "1.10" m and "Default Height" to "0.30" m obtained from the footing schedule.

Note: The use of default width and default height in the dimension group enables us to achieve volume measurement using different techniques, such as measuring a length multiplied by the default width and height or measuring area multiplied by the default height. we can measure the area from the plan and insert a default height to get the volume.

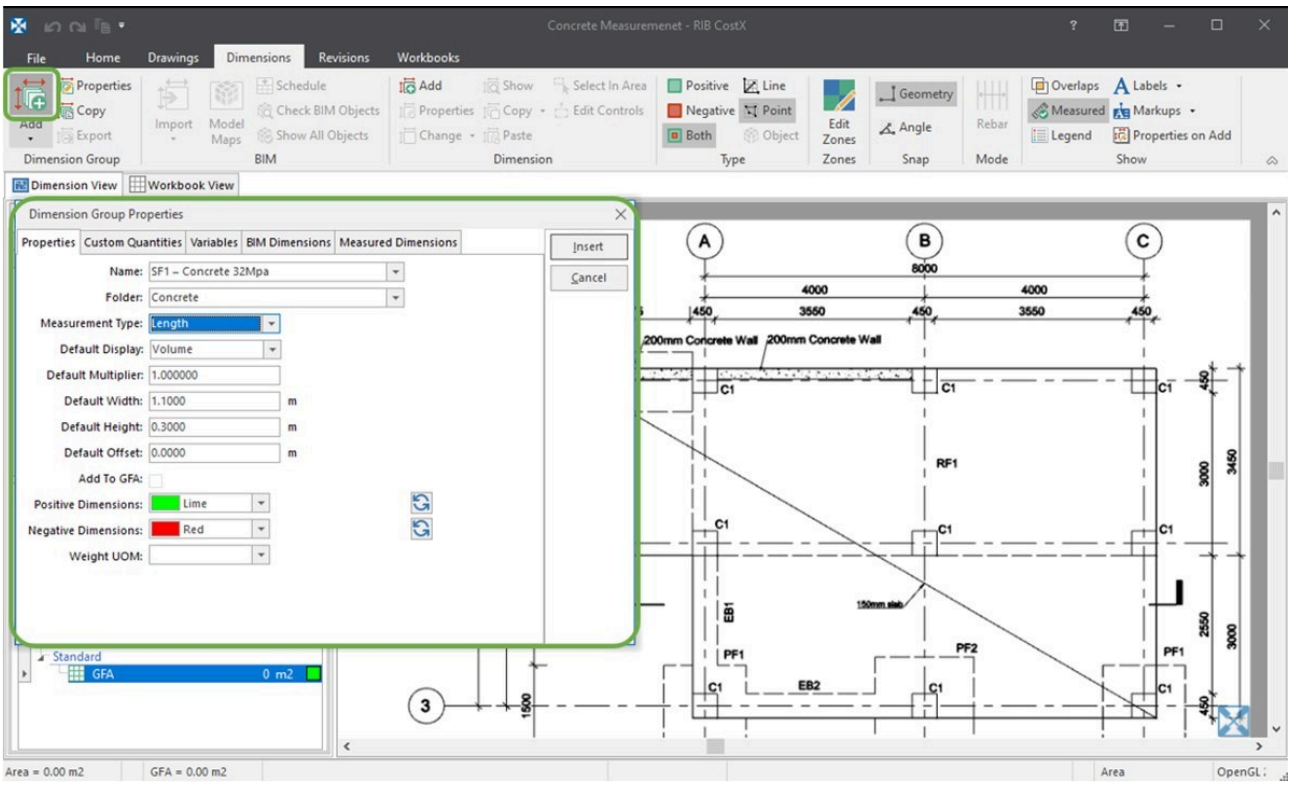


Figure 3.24: Screenshot of creating a dimension group for strip footing SF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 11: Using the Point method, capture the strip footing length. Hover the mouse over the dimension group name to view the measurement details, as illustrated in Figure 3.25.

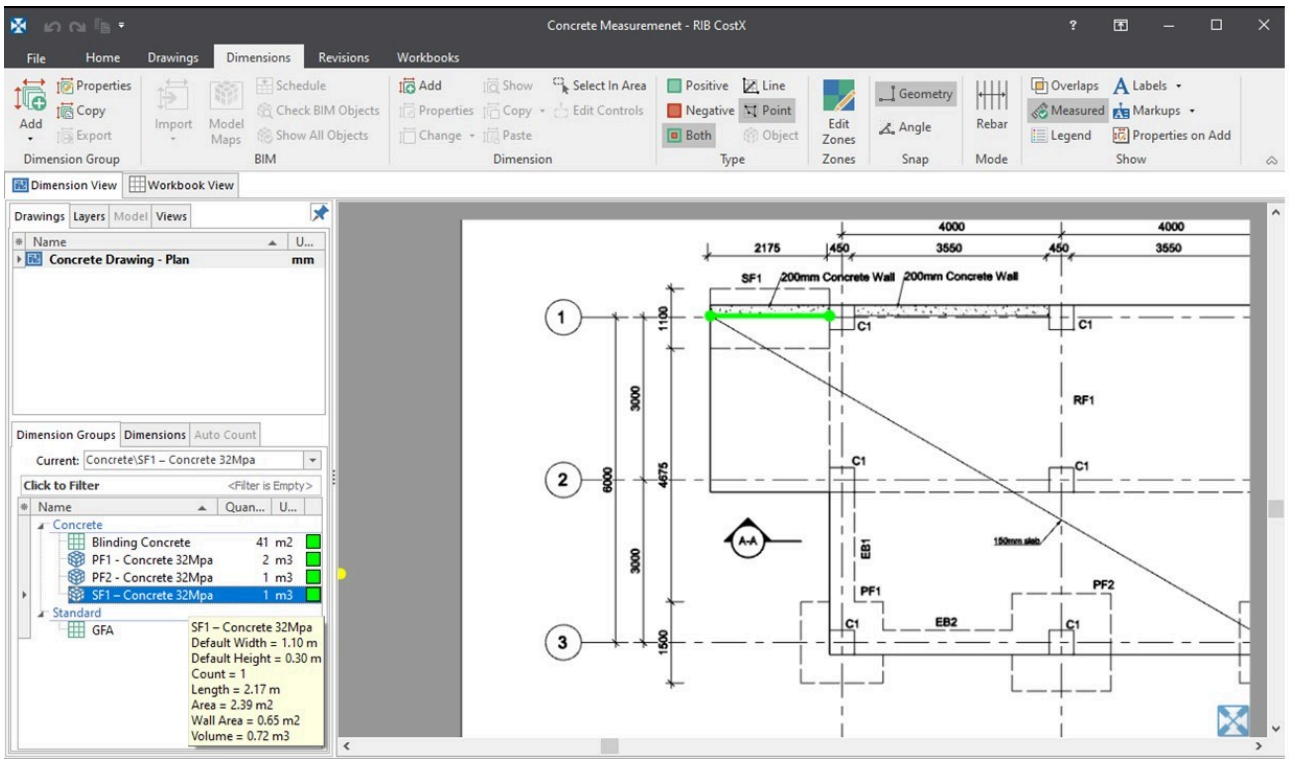


Figure 3.25: Screenshot of using the Point method for measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.5 Computer-based measurement of concrete for raft footing

The drawing shows a raft slab on the floor plan where the footing schedule indicates the 400 mm thickness and 50 MPa concrete strength.

Step 12: Create a dimension group for raft footing (RF1 – 32 Mpa Concrete) under the folder named "Concrete" to measure concrete quantity. The concrete of footings is measured in m^3; therefore, set the "Measurement Type" to "Area" and "Default Display" to "Volume". Assign the "Default Height" to "0.40" m, as shown in Figure 3.26.

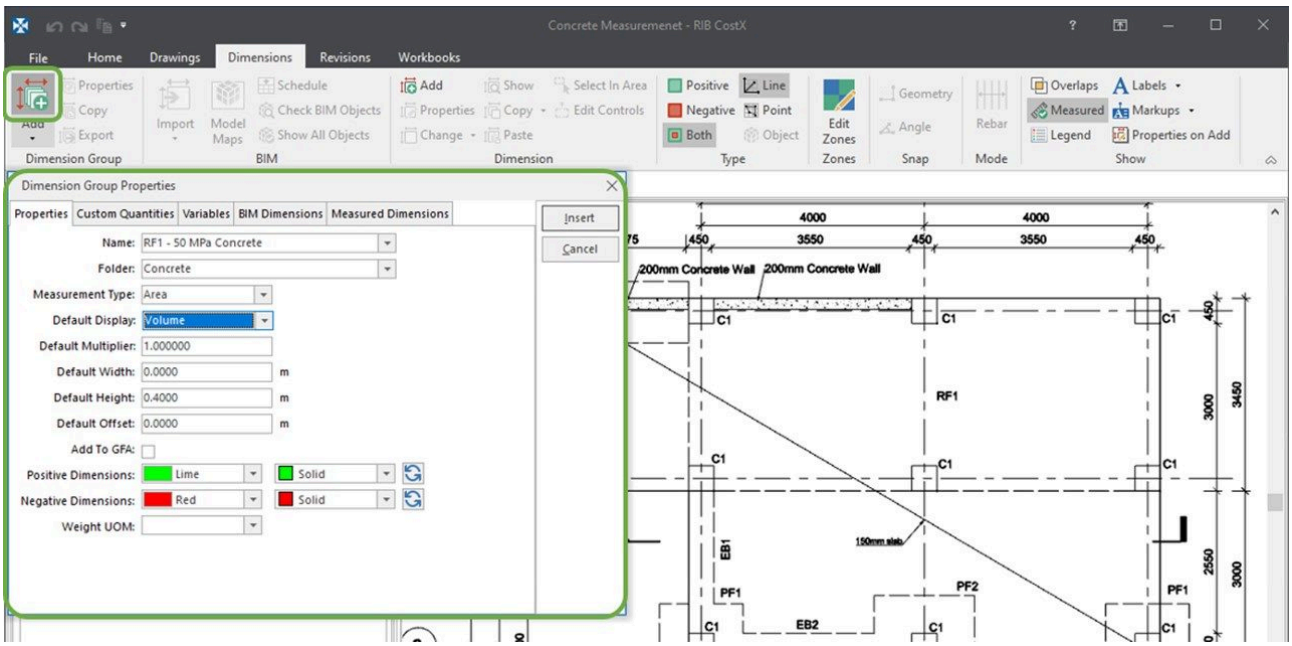


Figure 3.26: Screenshot of creating a dimension group for raft footing using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 13: Using the "Line" mode, select the perimeter of the raft footing, as illustrated in Figure 3.27. Hover the mouse over the dimension group name to view the measurement details.

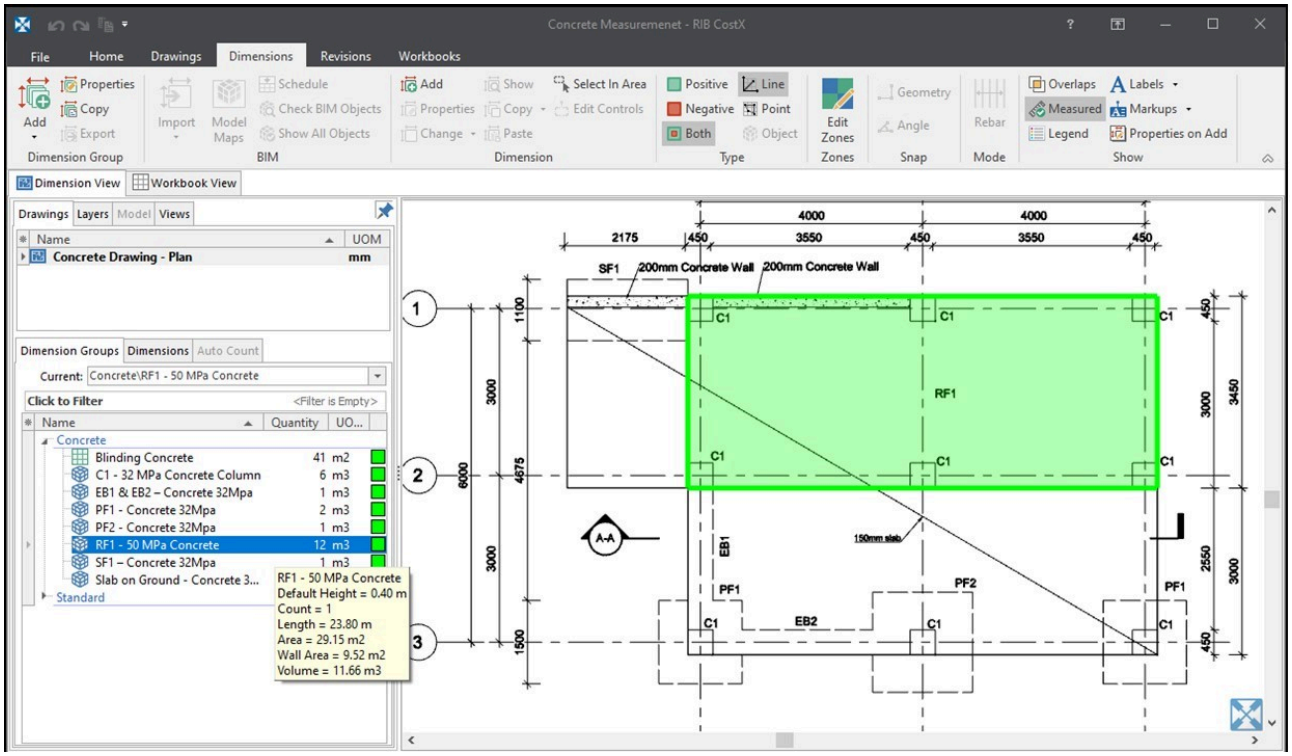


Figure 3.27: Screenshot of using the Line method for measurement of raft footing using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.6 Computer-based measurement of concrete for beam

The drawing represents two types of beams: Edge Beam 1 (EB1) and Edge Beam 2 (EB2). For the measurement of the concrete, both beam types have the same width and depth, as well as the same concrete strength grade. So, both types can be measured in a dimension group.

Step 14: Create a dimension group for Edge Beam 1 and 2 (EB1 and EB2 – Concrete 32 MPa) under the folder named "Concrete" to measure the concrete quantity. The concrete of beams is measured in m^3; therefore, set the "Measurement Type" to "Length" and "Default Display" to "Volume". Assign the "Default Width" to "0.45" m and "Default Height" to "0.40" m obtained from the footing schedule (see Figure 3.28).

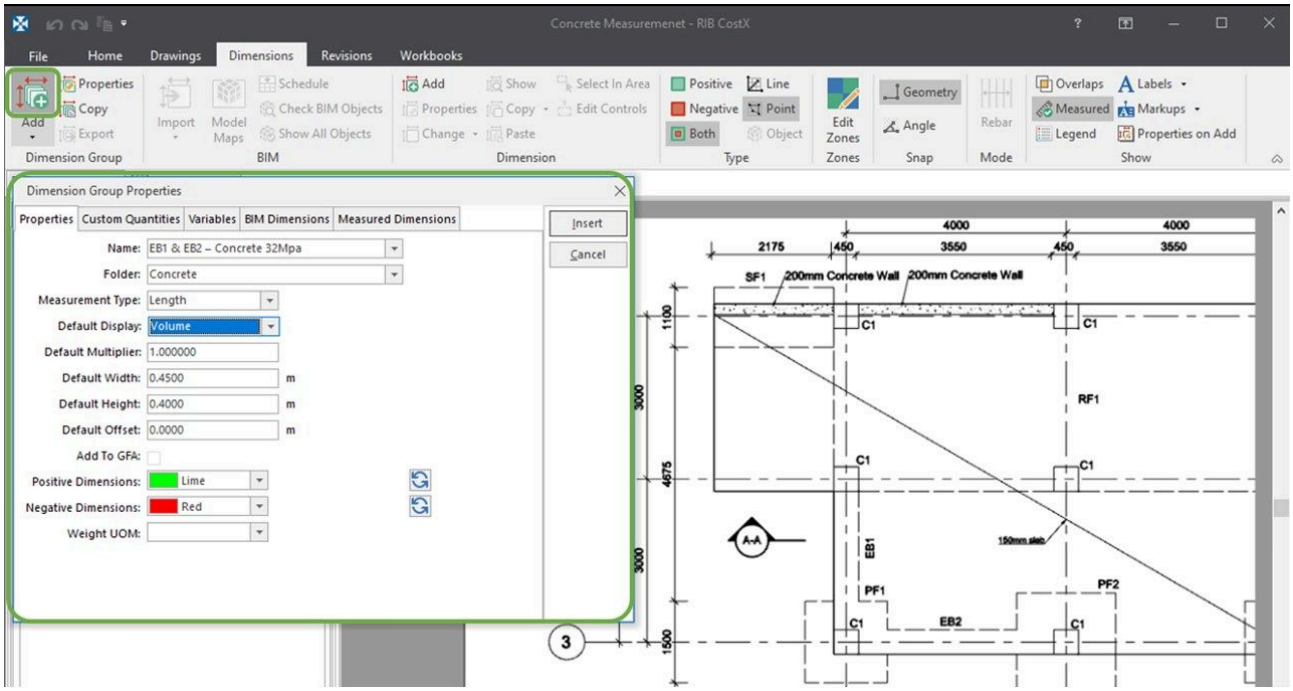


Figure 3.28: Screenshot of creating a dimension group for edge beams using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 15: Using the "Point" method, capture the strip footing length, as illustrated in Figure 3.29. Hover the mouse over the dimension group name to view the measurement details.

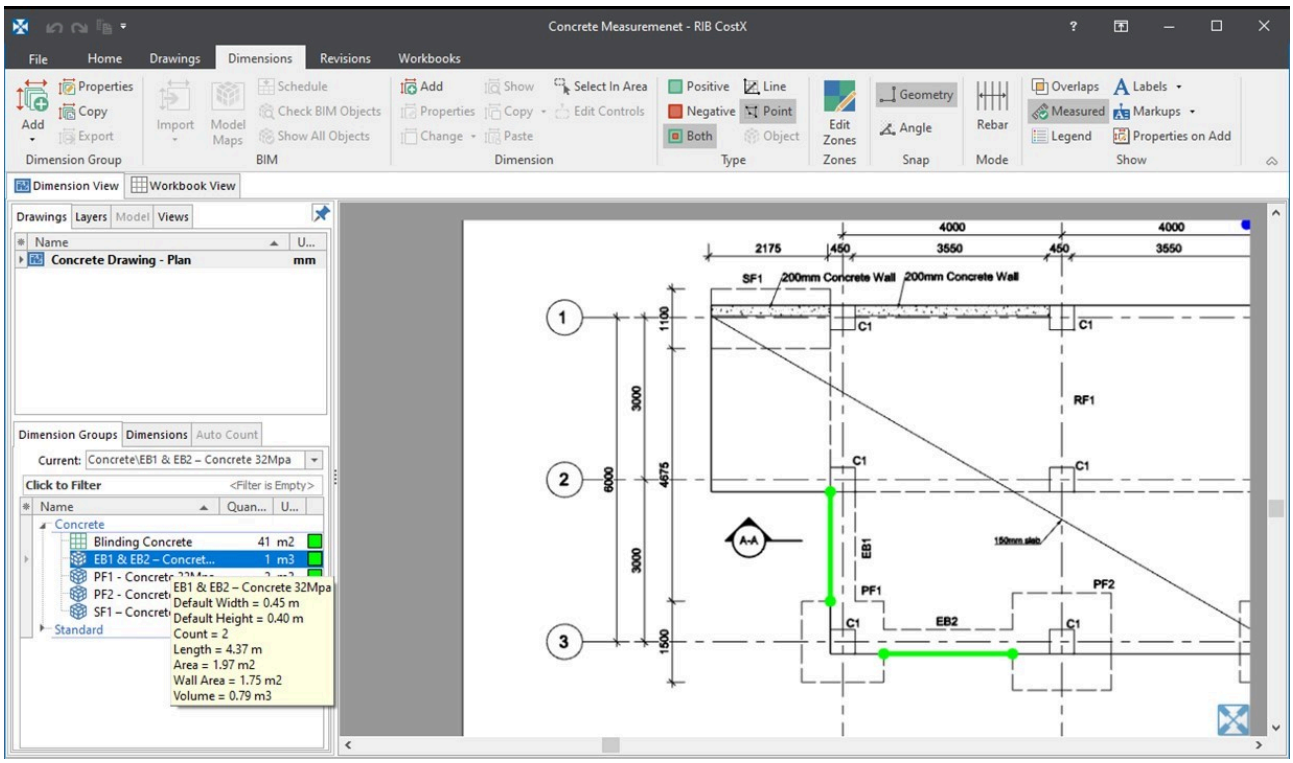


Figure 3.29: Screenshot of using Point method for measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.7 Computer-based measurement of concrete for slab (on ground)

The drawing shows a slab on the ground that covers the floor plan, indicating a 150 mm thickness of 32 MPa concrete.

Step 16: Create a dimension group for slab on ground (Slab on Ground – Concrete 32 MPa) under the folder named "Concrete" to measure concrete quantity. The concrete for slabs is measured in m^3, while its description requires stating the area; therefore, set the "Measurement Type" to "Area" and "Default Display" to "Volume". Assign the "Default Height" to "0.15" m obtained from the drawing annotation (Figure 3.30).

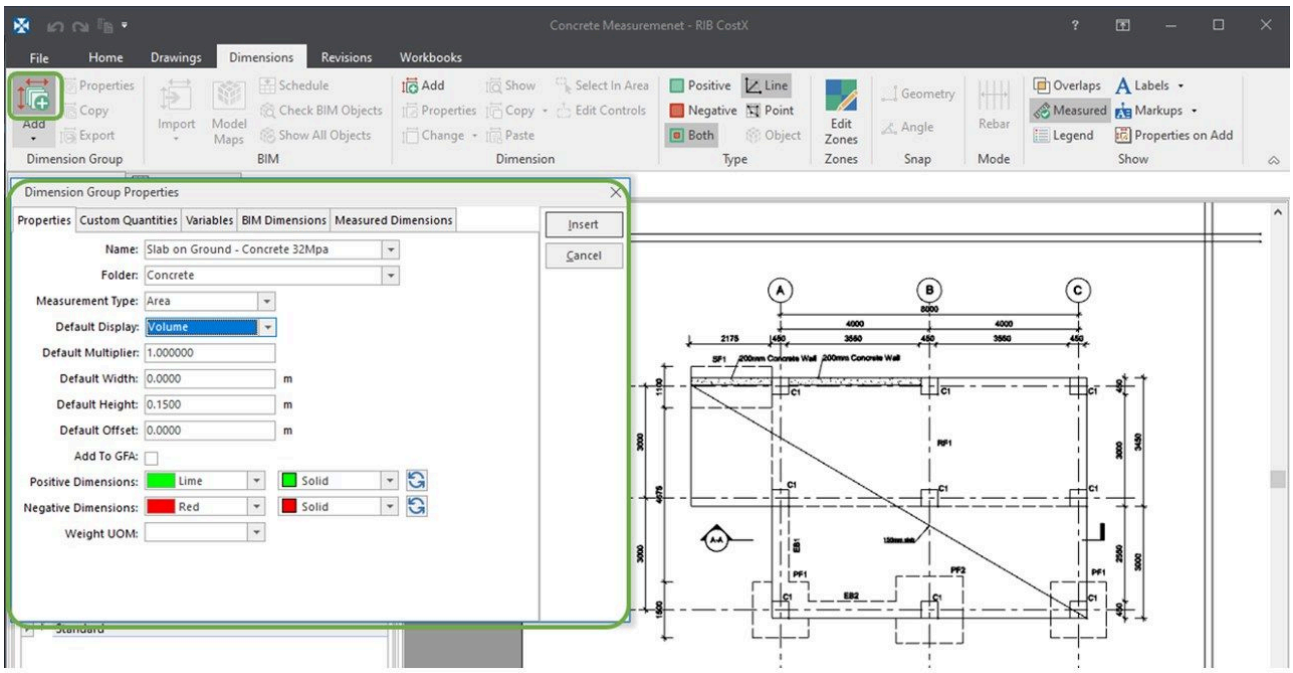


Figure 3.30: Screenshot of creating a dimension group for slab on ground using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 17: Using the "Line" method, select the perimeter of slab on ground, as illustrated in Figure 3.31. Hover the mouse over the dimension group name to view the measurement details.

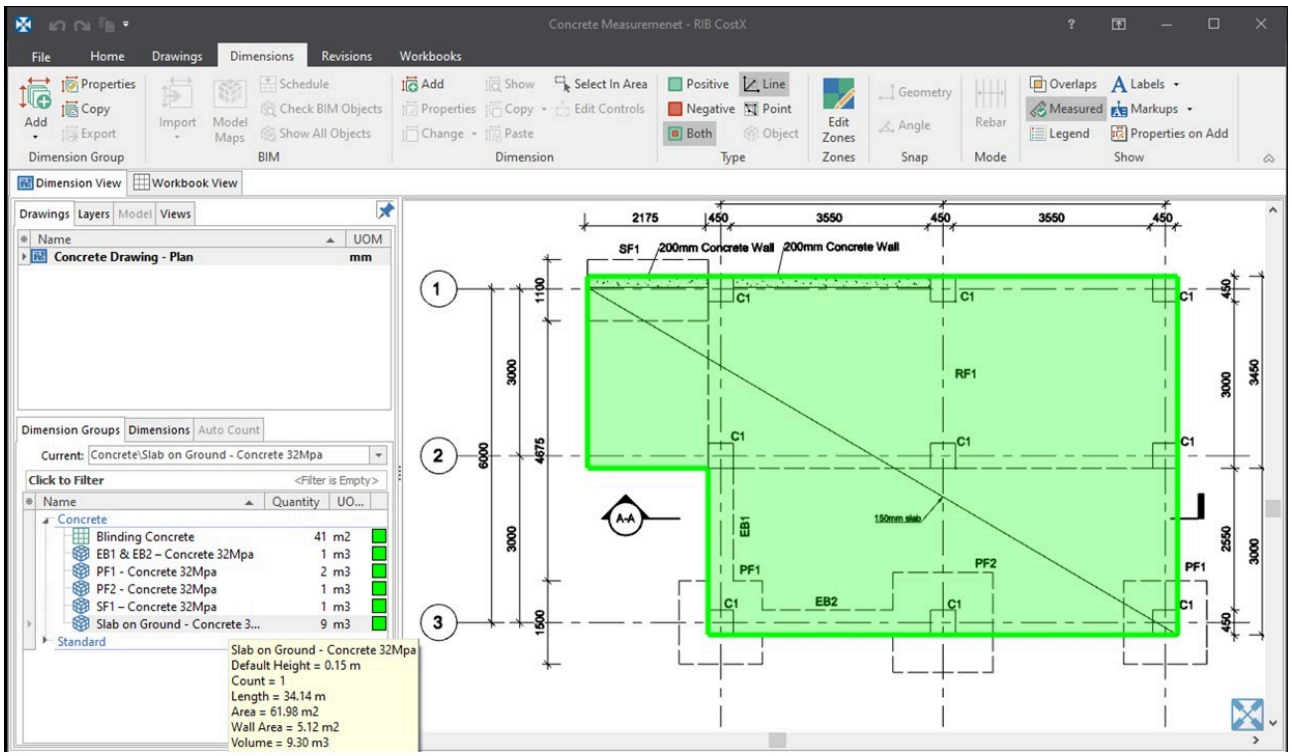


Figure 3.31: Screenshot of using Line method for measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.8 Computer-based measurement of concrete for column

The drawing shows a number of concrete columns of one type (C1) in 32 MPa concrete grade. The height of the columns for concrete measurement is 3.35 m.

Step 18: Create a dimension group for "C1 – 32 MPa Concrete Column" under the folder named "Concrete" to measure concrete quantity. The concrete of columns is measured in m^3; therefore, set the "Measurement Type" to "Area" and "Default Display" to "Volume". Assign the "Default Height" to "3.35" m (Figure 3.32).

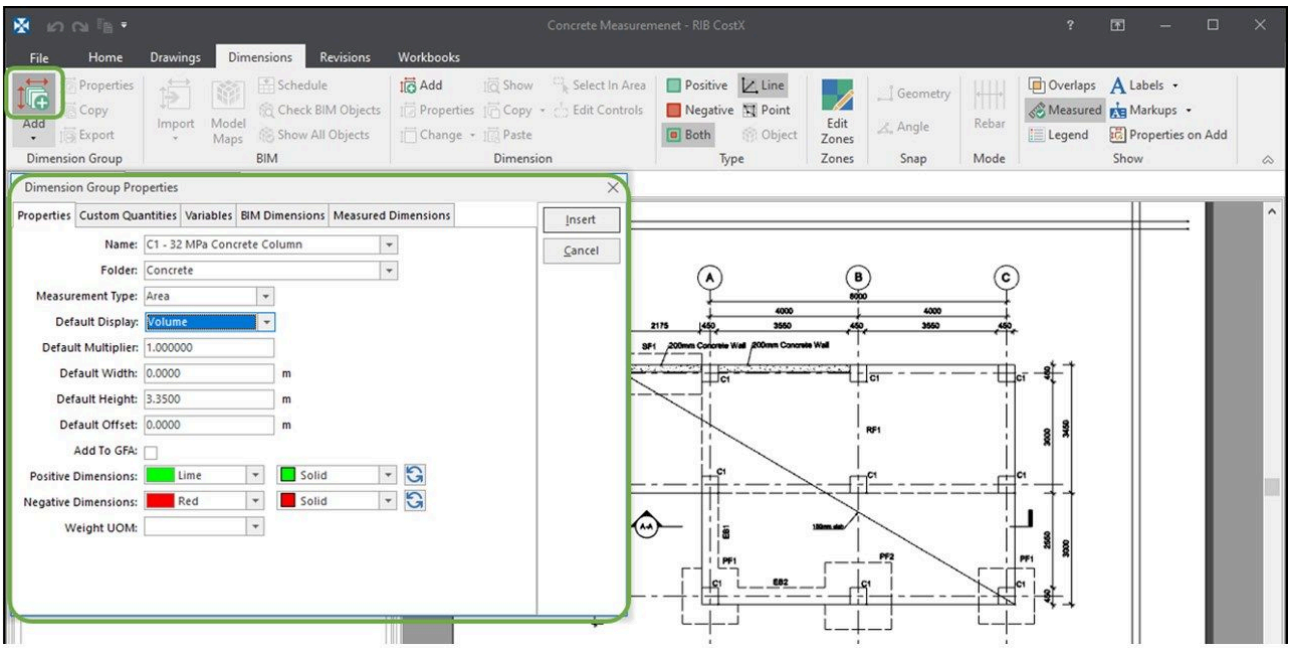


Figure 3.32: Screenshot of creating a dimension group for concrete columns using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 19: Choose the "Line" method for the measurement. Press and hold the "L" key (on the keyboard) and select the perimeter of the columns (left click the mouse to take the length). Pressing and holding the "L" key enables previewing the polylines, making the selection of columns much faster. If one of the polylines is not closed, press the "enter" key on the keyboard. The measurement is illustrated in Figure 3.33.

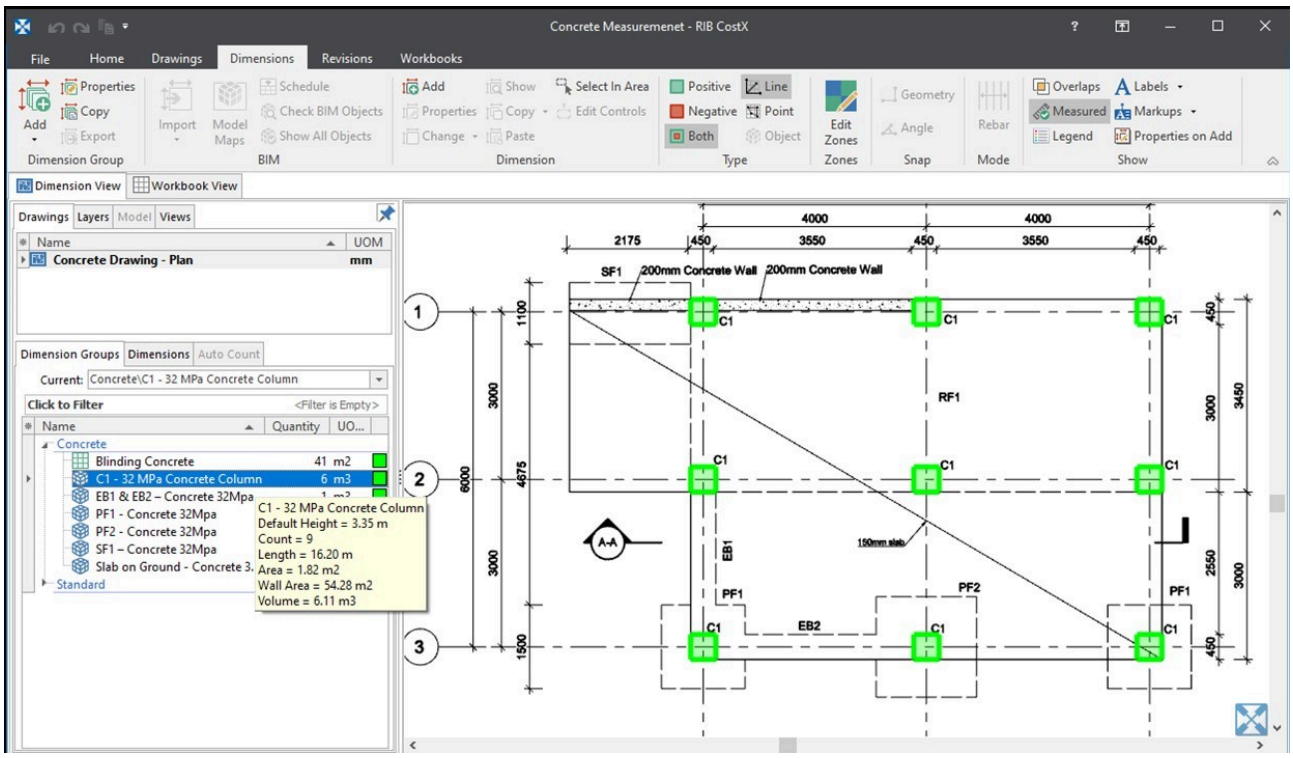


Figure 3.33: Screenshot of using Line method for measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

3.4.9 Computer-based measurement of concrete for walls

The drawing shows two concrete walls in 32 MPa concrete grade. The height of the concrete walls for concrete measurement is 2 m.

Step 20: Create a dimension group for "Wall – 32 MPa Concrete" under the folder named "Concrete" to measure the concrete quantity of the concrete wall. The concrete for walls is measured in m^3while they are categorised based on the thickness; therefore, set the "Measurement Type" to "Length" and "Default Display" to "Volume". Assign the "Default Width" to "0.2" m and "Default Height" to "2" m (Figure 3.34).

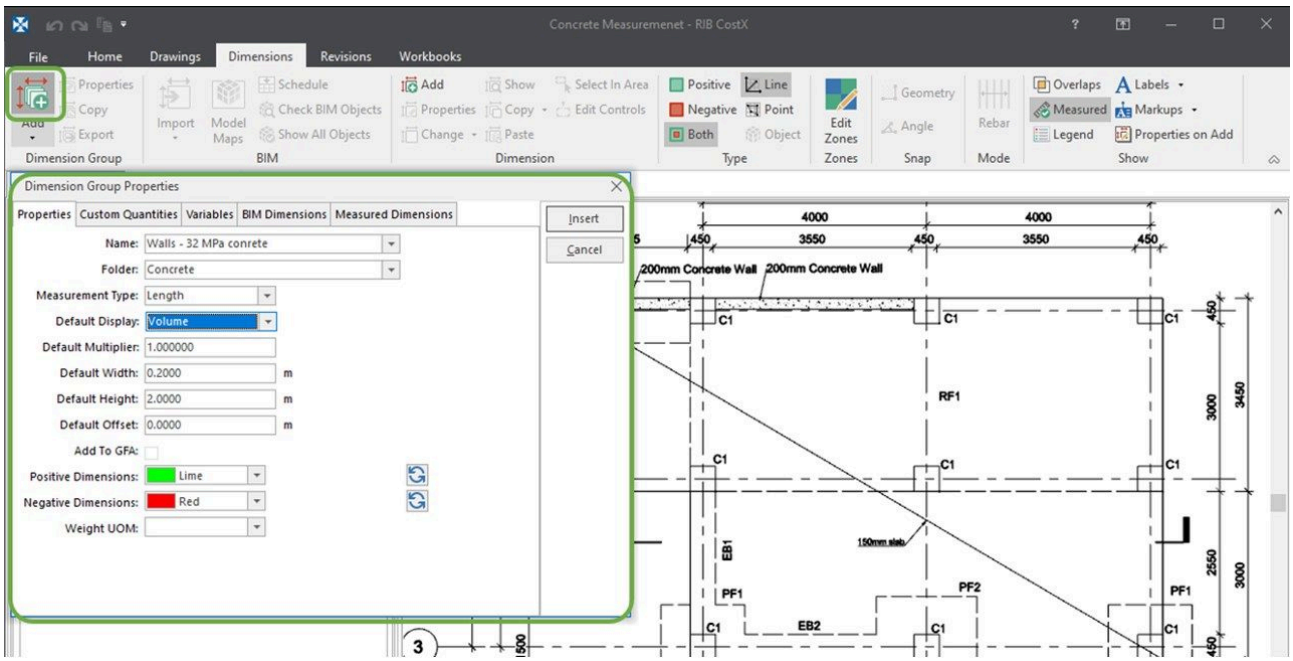


Figure 3.34: Screenshot of creating a dimension group for concrete walls using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 21: Choose the "Point" method and measure the length of the walls as illustrated in Figure 3.35. Hover the mouse over the dimension group name to view the measurement details.

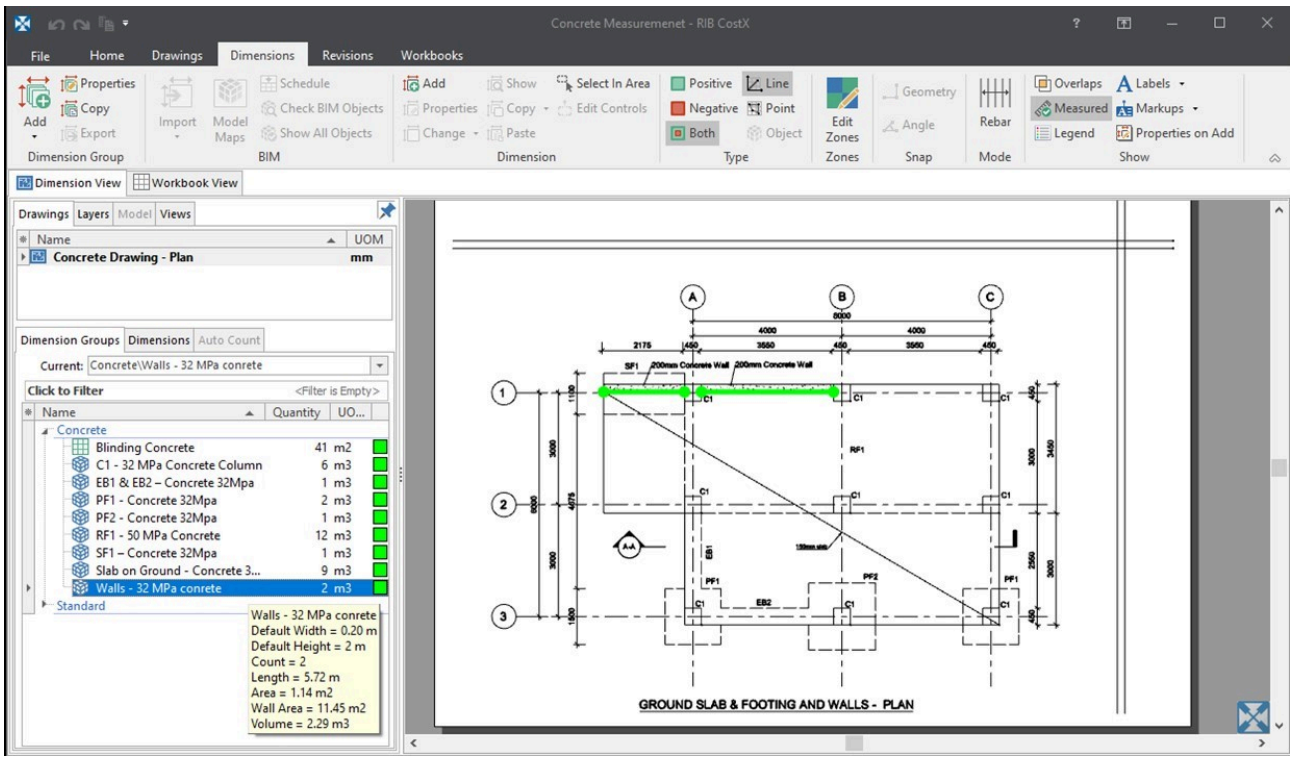


Figure 3.35: Screenshot of using the Point method for concrete wall measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Note:You may review the measurement in 3D by clicking on the “View in 3D” within the “Drawing Tools” of the “Drawing” tab. Then, select multiple dimension groups using Ctrl or Shift on the keyboard or the folder that contains the dimension groups. You can rotate the 3D view by clicking and holding it, thenmoving your mouse(Figure 3.36).

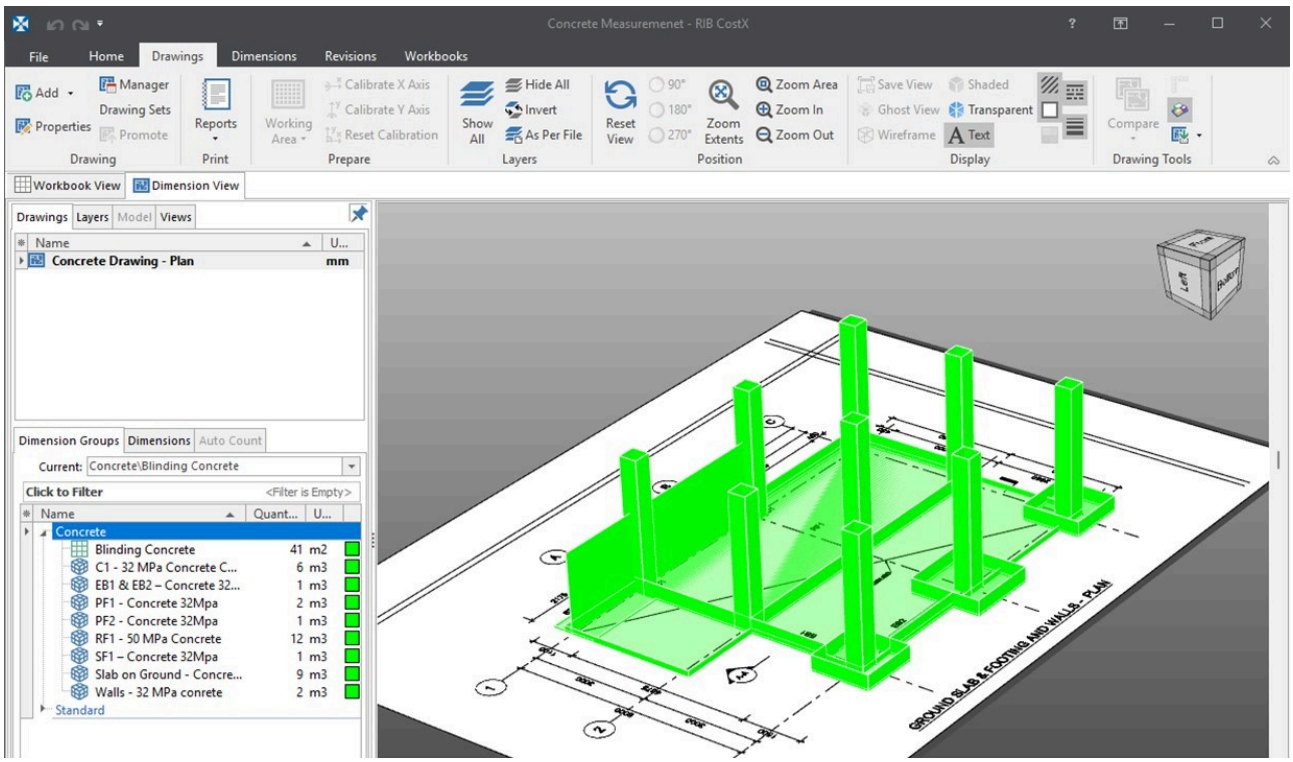


Figure 3.36: Screenshot of 3D view of concrete measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

You may change the colour of each dimension group by double-clicking on the dimension group and changing the colour for “Positive Dimensions” in the “Dimension group Properties” Window. Figure 3.37shows a sample of a view when the colour has changed.

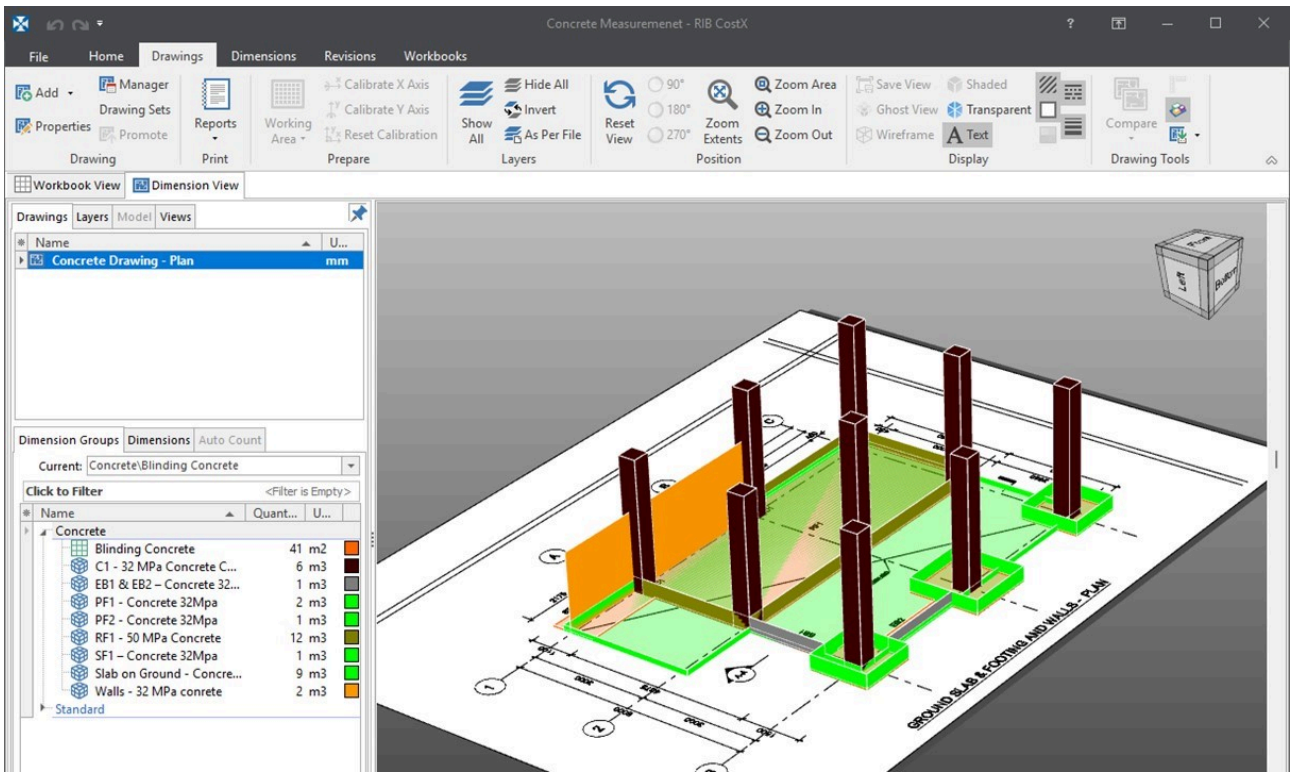


Figure 3.37: Screenshot of 3D view of concrete measurement in customised colour using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Note: Clicking on “View in 3D” toggles between 2D and 3D view.

3.4.10 Workbooks, transfer quantities, and write descriptions

Step 22: Create a workbook named “Concrete Building” (Figure 3.38).

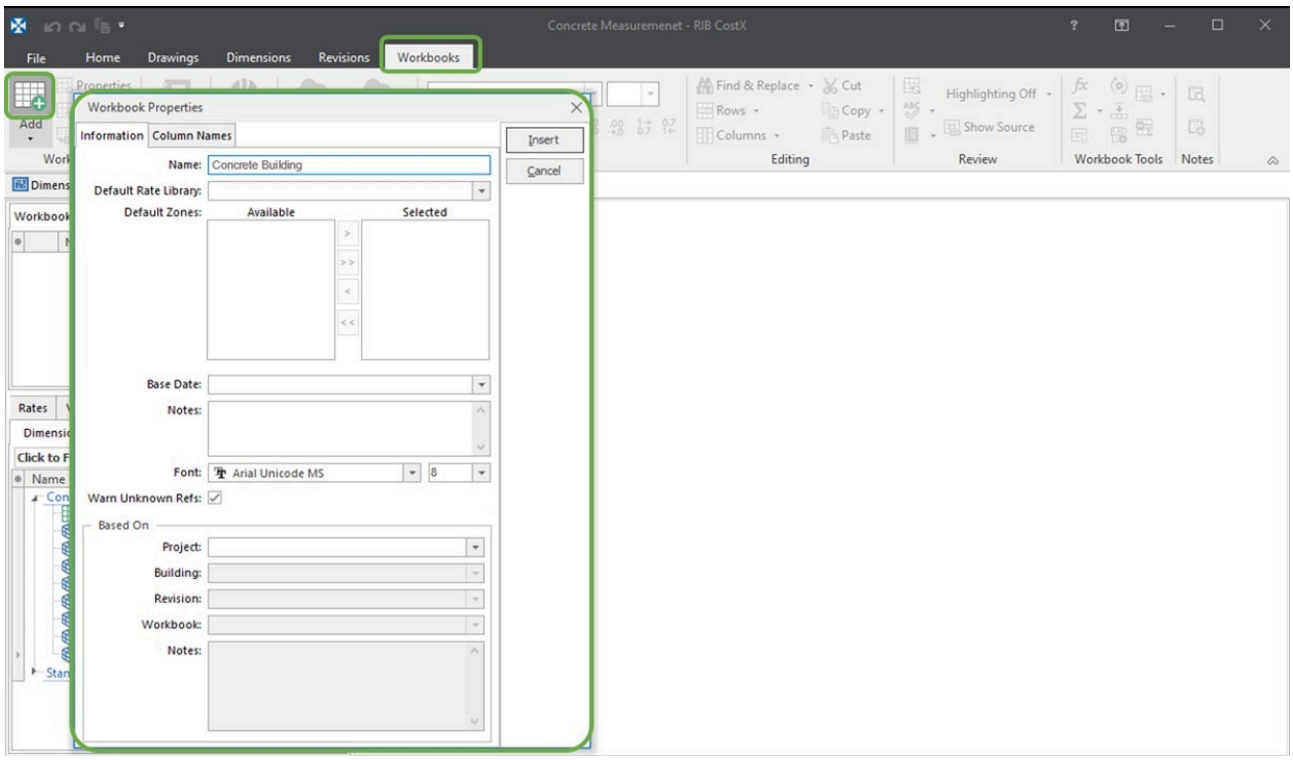


Figure 3.38: Screenshot of creating "Concrete Building" workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 23: In the first level of the new workbook, set the heading as "Concrete" on the first row and double-click on the subtotal Cell of the first row to enter the second level of the workbook under the "Concrete" heading (Figure 3.39).

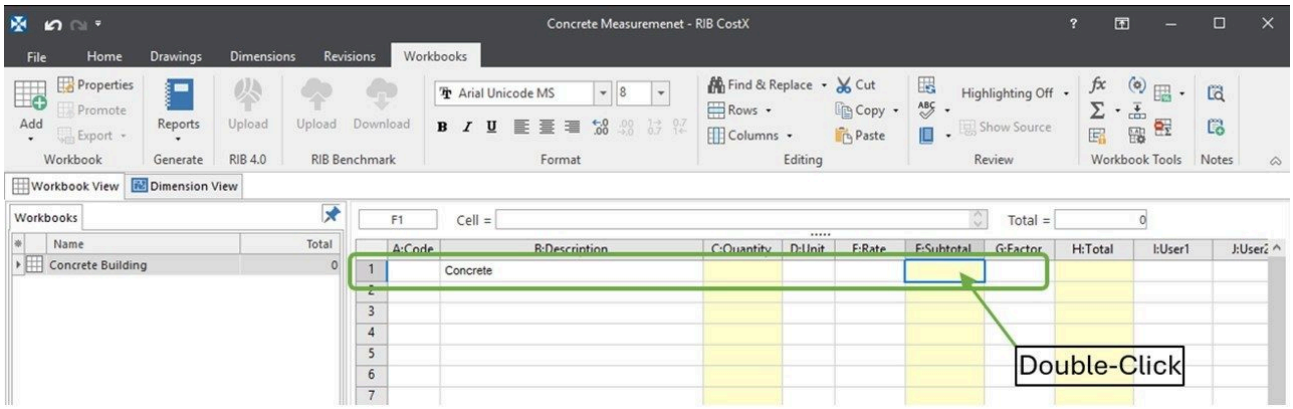


Figure 3.39: Screenshot of workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 24: On the second level of the workbook, under the concrete heading, include the sample descriptions for concrete measurement from Table 3.3, either by typing in or using the copy and paste process as shown in Figure 3.40.

Note: The area noted in the description of "slab on ground' and "concrete wall" can be obtained from the measurements within their relevant dimension group. For Example, the "area" quantity for "slab on ground" and the "wall area" quantity for "concrete wall". This information can be obtained by hovering the mouse over the dimension group. Alternatively, this information can be transferred to the row in the workbook in the User1 Cell for future reference. The transfer process is explained in Step 26.

Table 3.3: A sample of concrete descriptions

	Item	**Description**
1	Preamble note	Tenderers shall refer to the Introduction, General Rules and Recommendations section of the ANZSMM.
2	Preamble note	Tenderers shall refer to relevant specification sections containing particulars of concrete work.
3	Preamble note	Tenderers shall refer to the measurement and prices clauses of the concrete work and form work sections in ANZSMM.
4	Preamble item	Allow for samples of concrete.
5	Preamble item	Allow for carrying out testing of material and concrete specimen.
6	Preamble item	Allow for protecting and curing concrete.
7	Blinding concrete	15 MPa plain concrete in a 50 mm-thick blinding layer poured on the excavated surface and compacted.
8	Pad footing	32 MPa in-situ reinforced concrete, for pad footings >1 m^2 on plan, poured into formwork and compacted.
9	Strip footing	32 MPa in-situ reinforced concrete, for strip footings poured into formwork and compacted.
10	Raft footing	50 MPa in-situ reinforced concrete, for raft footings poured into formwork and compacted.
11	Ground beam	32 MPa in-situ reinforced concrete, for ground beams poured into formwork and compacted.
12	Slab on ground	32 MPa in-situ reinforced concrete, for 150-200 thick slab on ground poured into formwork and compacted (62 m^2).
13	Columns	32 MPa in-situ reinforced concrete to rectangular columns poured into formwork and compacted.
14	Concrete wall	32 MPa in-situ reinforced concrete, for 200-250 thick concrete wall poured into formwork and compacted (12 m^2).

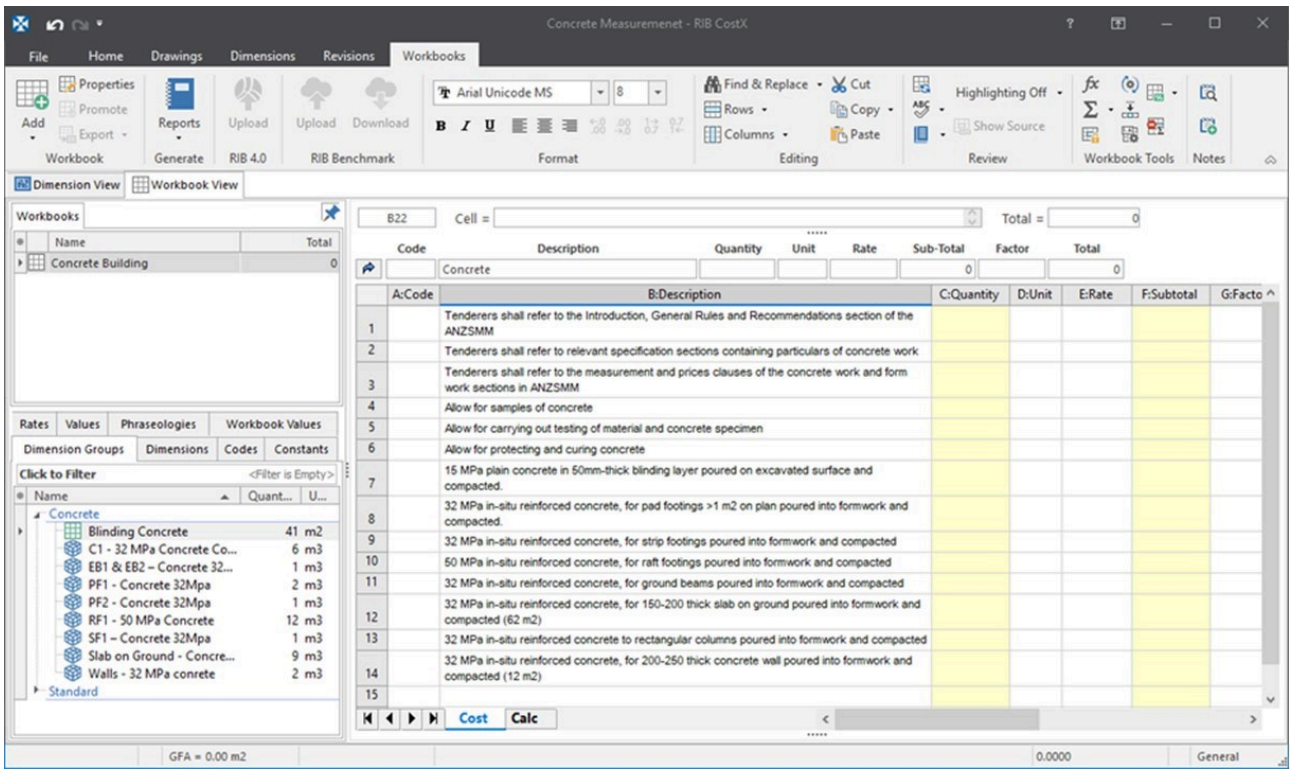


Figure 3.40: Screenshot of inserting descriptions into the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 25: Include the units of measurement as illustrated in Figure 3.41.

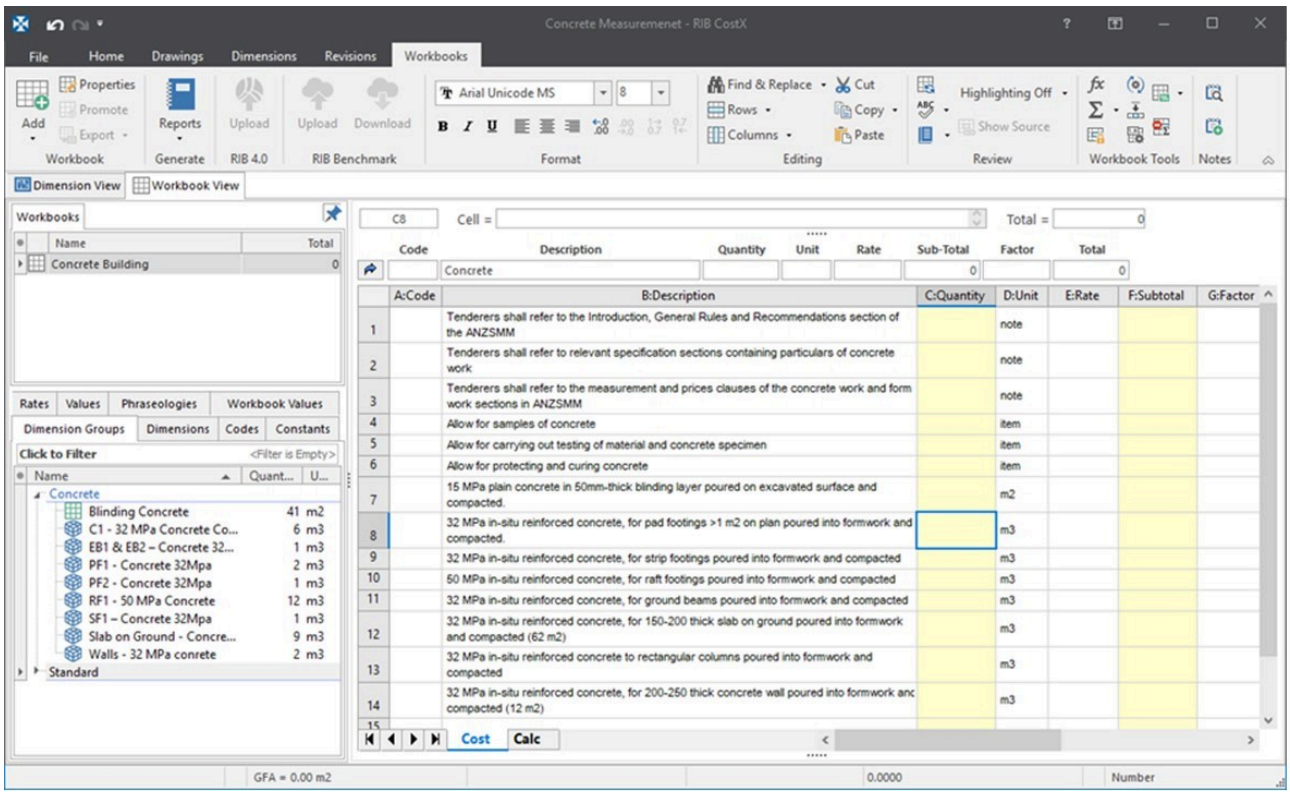


Figure 3.41: Screenshot of entering the units of measurement into the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 26: Double-click on the quantity cell of the measured items to enter the "Qty" sheetof the item. Then, transfer the quantities by dragging the Dimension groups and dropping them into the most relevant cell of the first row in the "Qty" sheet. In the "Add Quantity" window, check and choose the appropriate "Quantity Type" as shown in Figures 3.42 and 3.43.

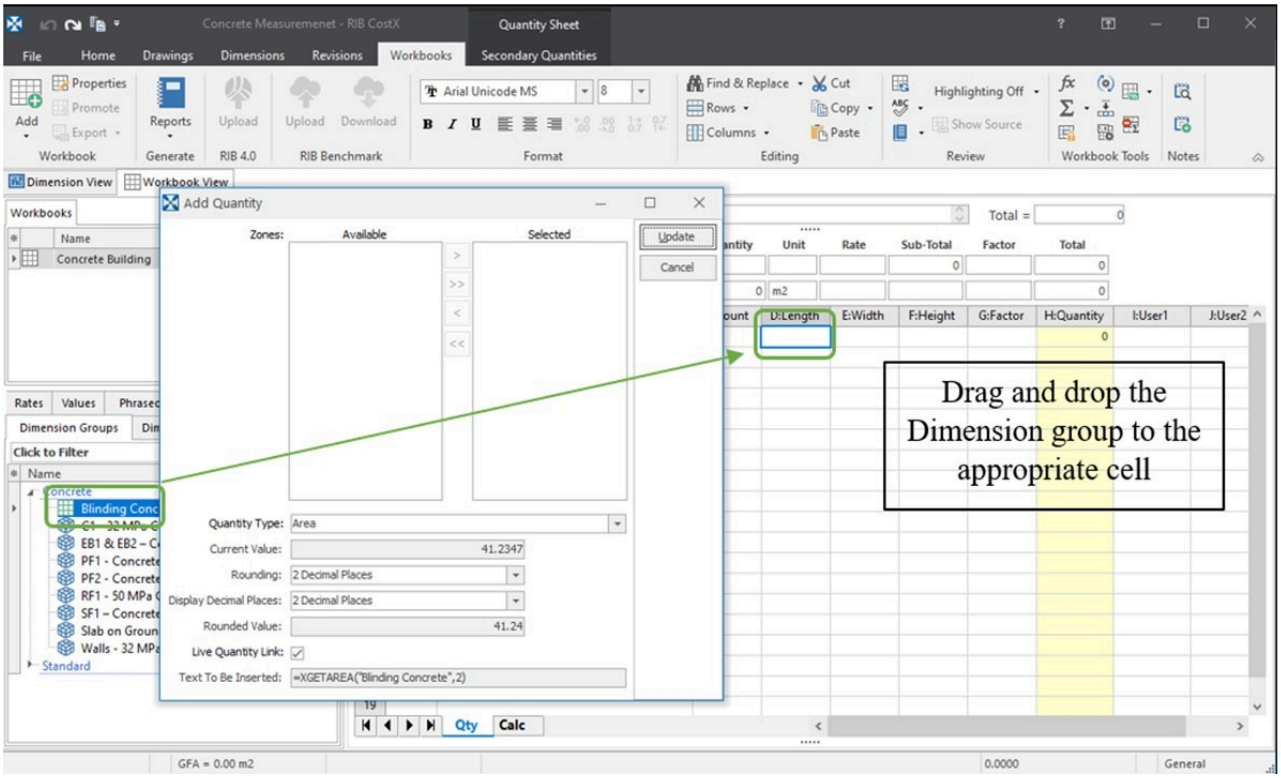


Figure 3.42: Screenshot of transferring quantities into workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

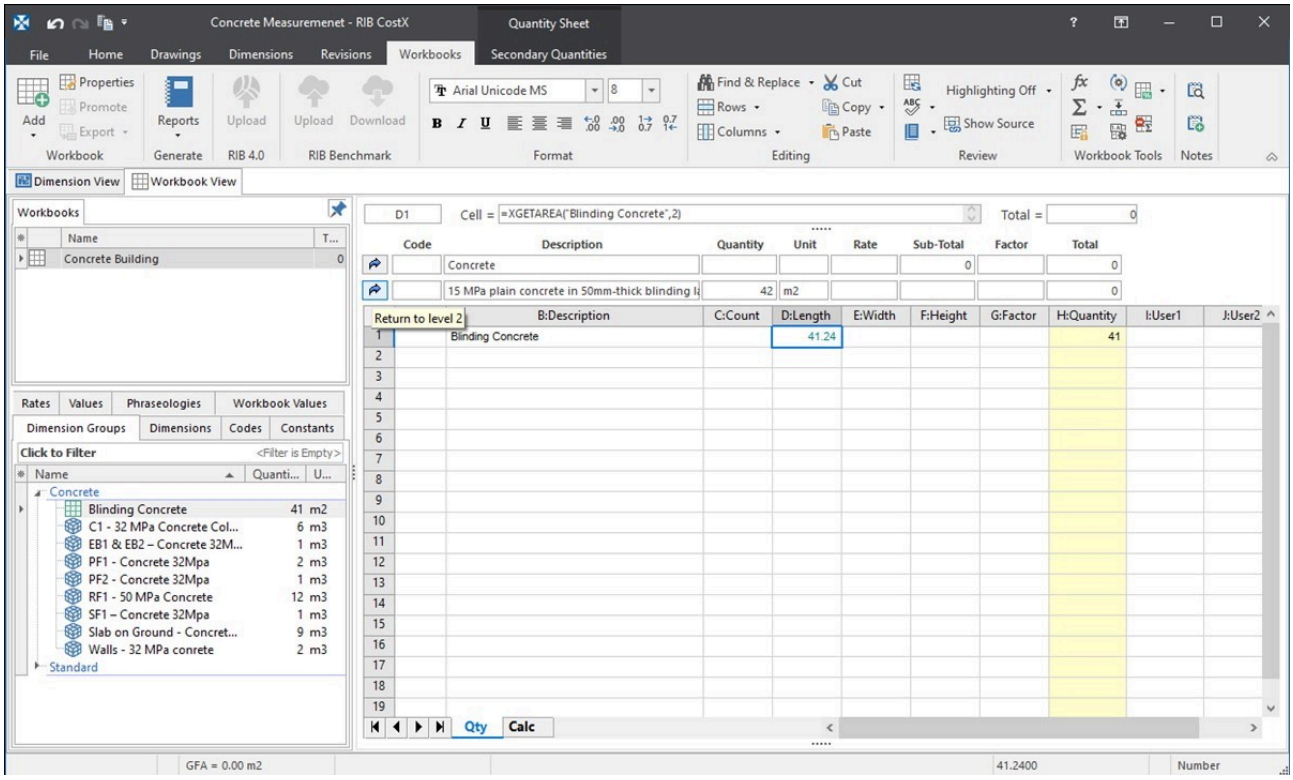


Figure 3.43: Screenshot of adding quantities into workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Note: The standard requires that the subcategory for pad footing is the size on plan, whether less than or more than 1 m^2. Refer to the footing schedule; both pad footing types are larger than 1 m^2on plan. Additionally, the concrete grade for both pad footings is the same, so they will be presented in a single category. To add multiple dimension groups into the "Qty" sheet in one process requires multiple selections of dimension groups, which can be achieved by selecting them using Ctrl or Shift keyboard and clicking on the Dimension groups. Then, drag and drop the dimension groups into the corresponding cell (Figures 3.44 and 3.45).

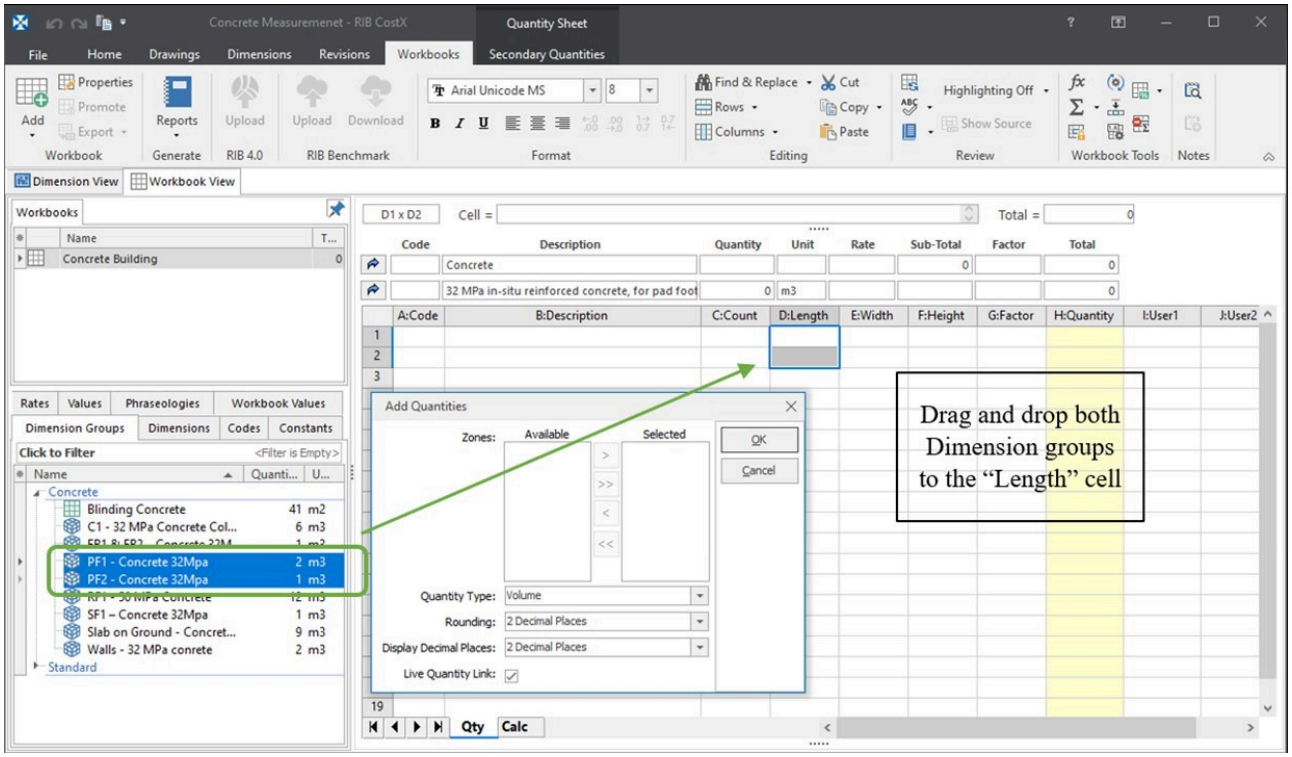


Figure 3.44: Screenshot of transferring pad footing quantities into workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

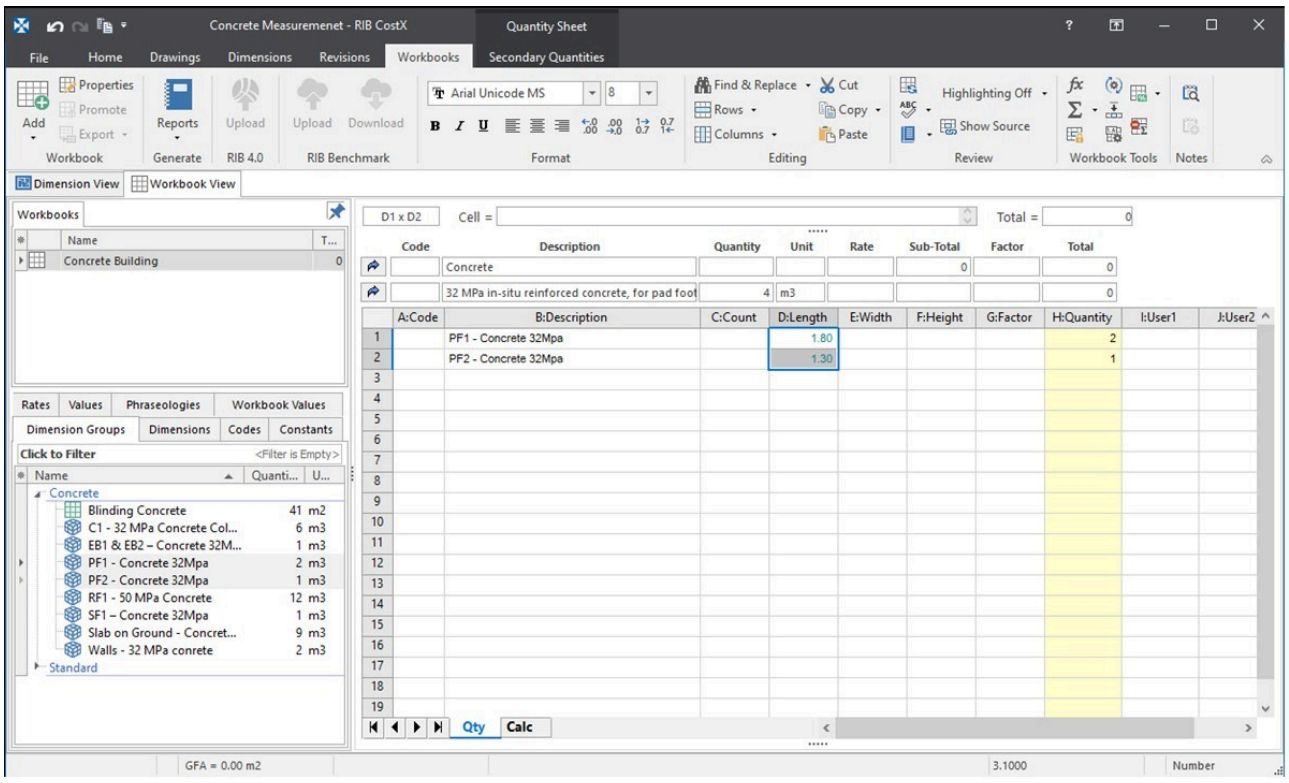


Figure 3.45: Screenshot of adding pad footing quantities into workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Transfer all quantities to the related descriptions to complete the workbook, as shown in Figure 3.46.

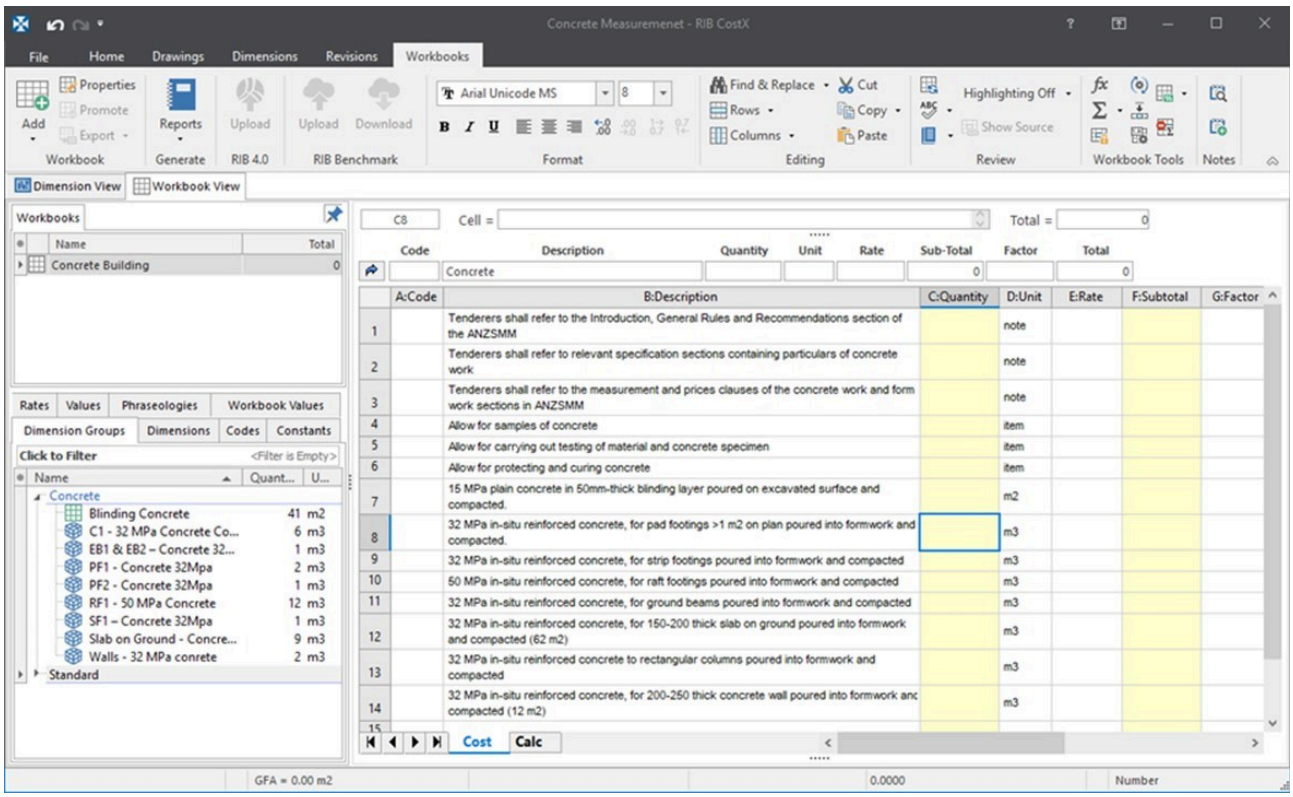


Figure 3.46: Screenshot of transferring the measured quantities to the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 27: On the workbook tab heading, generate BQ by clicking on the "Report"icon on the ribbon workbook. Then, on the "Reports" window dialogue box, choose the "Bills of Quantities" report and then click on "Generate" and then "Preview" to preview the report. Then, click on Ok (Figure 3.47).

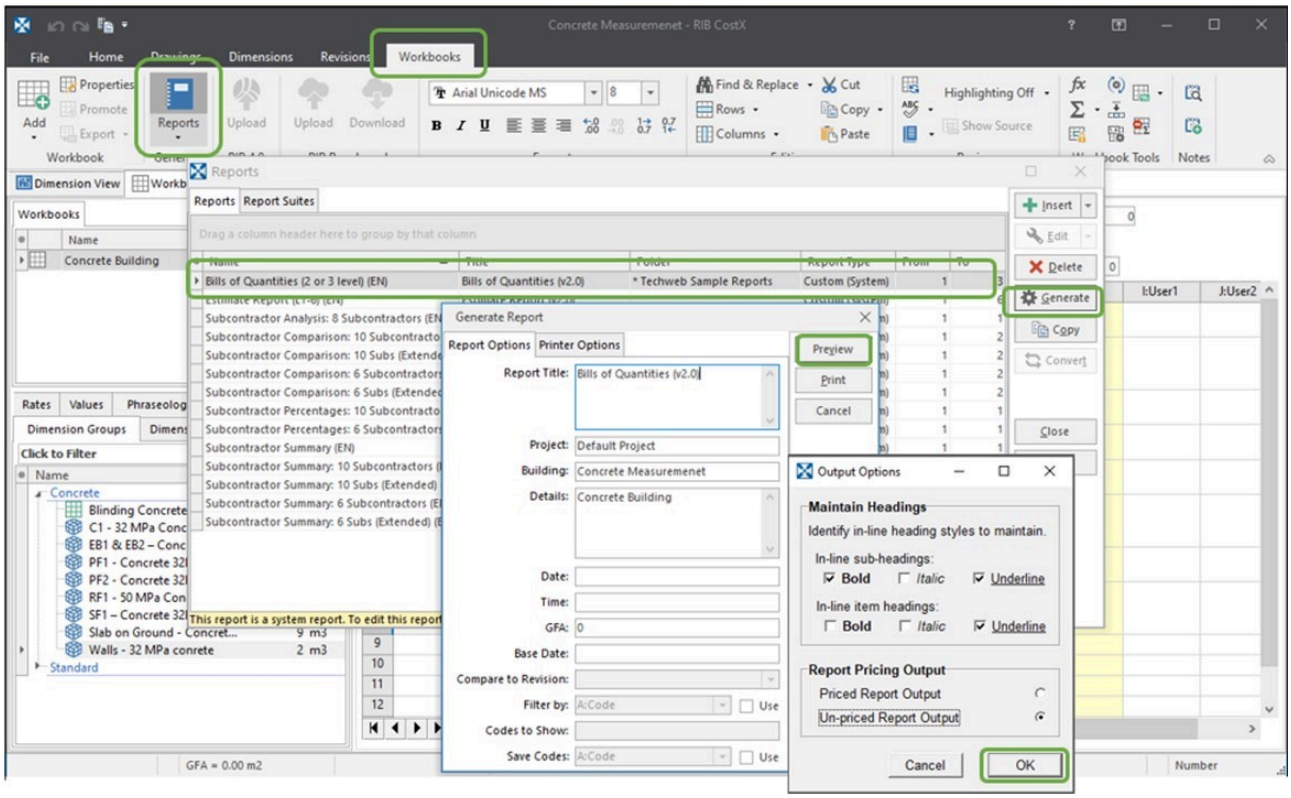
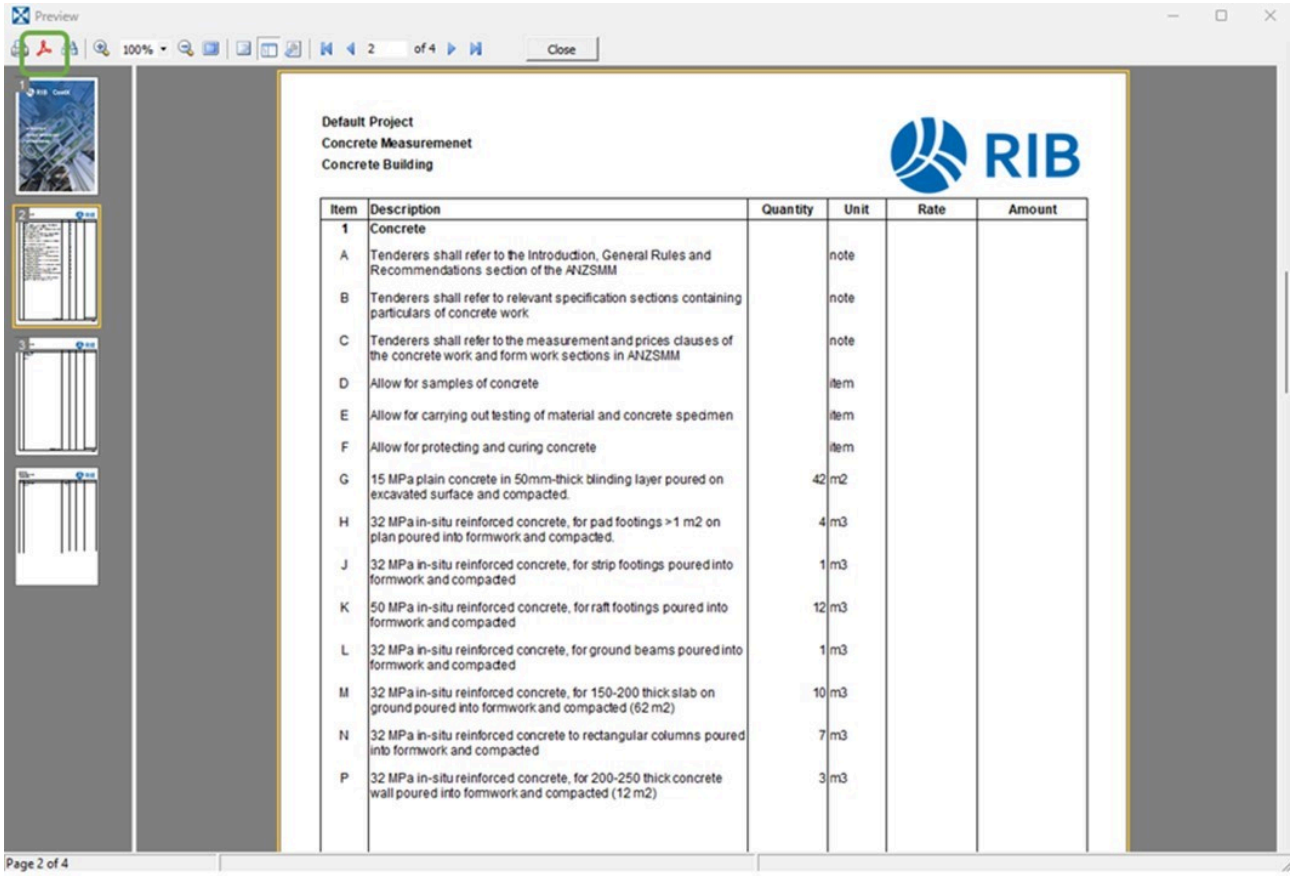


Figure 3.47: Screenshot of generating BQ using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 28: As shown in Figure 3.48, the report is now visible and can be converted to PDF by clicking the Adobe icon and saving it as a PDF.



Item	Description	Quantity	Unit	Rate	Amount
1	Concrete				
A	Tenderers shall refer to the Introduction, General Rules and Recommendations section of the ANZSMM		note		
B	Tenderers shall refer to relevant specification sections containing particulars of concrete work		note		
C	Tenderers shall refer to the measurement and prices clauses of the concrete work and form work sections in ANZSMM		note		
D	Allow for samples of concrete		item		
E	Allow for carrying out testing of material and concrete specimen		item		
F	Allow for protecting and curing concrete		item		
G	15 MPa plain concrete in 50mm-thick blinding layer poured on excavated surface and compacted.	42	m2		
H	32 MPa in-situ reinforced concrete, for pad footings >1 m2 on plan poured into formwork and compacted.	4	m3		
J	32 MPa in-situ reinforced concrete, for strip footings poured into formwork and compacted	1	m3		
K	50 MPa in-situ reinforced concrete, for raft footings poured into formwork and compacted	12	m3		
L	32 MPa in-situ reinforced concrete, for ground beams poured into formwork and compacted	1	m3		
M	32 MPa in-situ reinforced concrete, for 150-200 thick slab on ground poured into formwork and compacted (62 m2)	10	m3		
N	32 MPa in-situ reinforced concrete to rectangular columns poured into formwork and compacted	7	m3		
P	32 MPa in-situ reinforced concrete, for 200-250 thick concrete wall poured into formwork and compacted (12 m2)	3	m3		

Figure 3.48: Screenshot of saving BQ as PDF using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

CHAPTER 4: MEASUREMENT OF FORMWORKS

4.1 OVERVIEW

This chapter focuses on the measurement of formwork for pad footings, columns, beams, and slabs, detailing their technical specifications, the relevant measurement rules, and the measurement process using CostX software.

4.2 TYPES OF FORMWORKS

According to the Australian standard method of measurement, formwork refers to all temporary structures required to support and contain concrete, and it includes centring, shuttering, moulds, and all the necessary shores, struts and supports. Formwork can be made from a variety of materials, including timber, steel, aluminium, plastic, and engineered wood products. The choice of material depends on factors such as the type of concrete structure, required surface finish, budget, and whether the formwork will be reused multiple times.

In building construction, formwork plays a vital role in shaping and supporting concrete elements until they achieve sufficient strength. For instance, formwork is required for raft footing systems to define the shape of the foundation and support the wet concrete during placement and curing (refer to Figure 4.1 for an example of formwork used in a raft footing system).

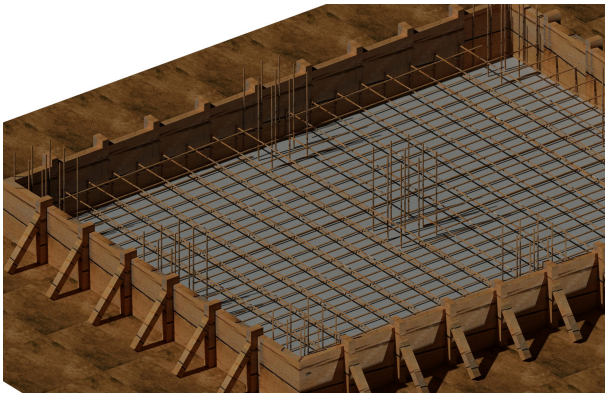


Figure 4.1: Formwork for the raft foundation system
(Source: Created by Amirreza Aminalavije)

Formwork is also used when preparing for the casting of concrete in strip footing systems to provide a stable mould that ensures the correct dimensions and alignment of the footing (refer to Figure 4.2 for an example of strip footing formwork).

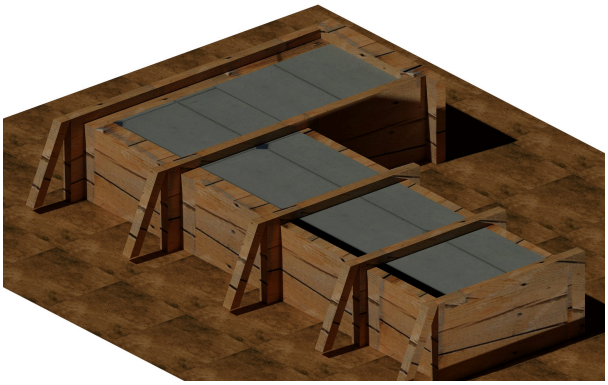


Figure 4.2: Formwork for the strip footing (Source: Created by Amirreza Aminalavije)

Similarly, pad footings, which are commonly used to support isolated columns, require well-constructed formwork to maintain the intended size and geometry during concrete placement (see Figure 4.3).



Figure 4.3: Formwork for the pad footing (Source: Created by Amirreza Aminalavije)

In addition to footings, formwork is also required for horizontal elements such as slabs. Soffit formwork for slabs is typically made of steel, timber, or similar materials. These systems are supported by props and bracings to ensure structural stability and proper levelling (see Figure 4.4 for a typical soffit formwork setup).

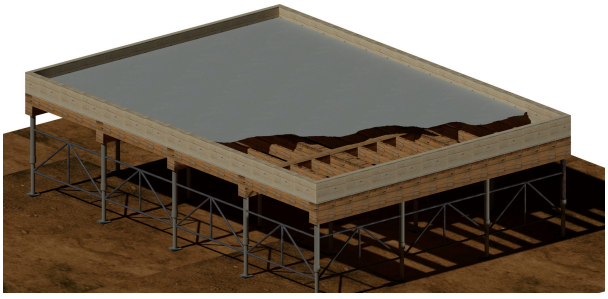


Figure 4.4 Formwork for the soffit of the slab (Source: Created by Amirreza Aminalavije)

Moreover, beams require formwork for both sides and the soffit (underside) to maintain shape and alignment. Beam formwork must be well-supported to withstand the pressure exerted by wet concrete (refer to Figure 4.5).

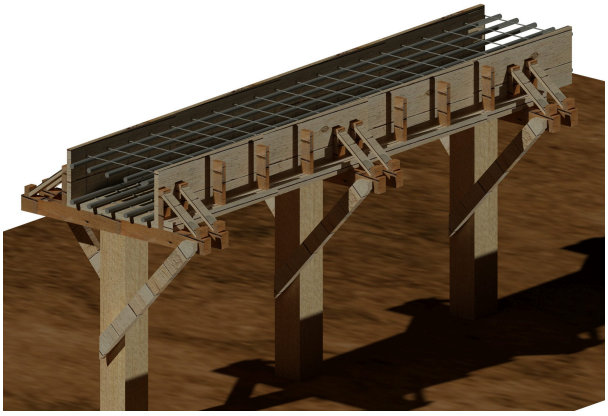


Figure 4.5: Beam formwork (Source: Created by Amirreza Aminalavije)

Vertical structural elements, such as columns and walls, also rely on formwork. These forms are typically made of steel, plywood, or engineered timber and must be tightly secured to prevent deformation and leakage during concrete placement. Figure 4.6 illustrates an example of column formwork.



Figure 4.6: Column formwork (Source: Created by Amirreza Aminalavije)

4.3 FORMWORK MEASUREMENT RULES

The measurement rules for formwork are detailed in Section 7 of the ANZSMM, which provides standardised guidelines for the quantification and pricing of formwork in construction projects. Both preamble notes and preamble items are provided in the BQs to serve as essential references for tenderers and quantity surveyors. The preamble notes direct users to relevant specification sections that outline the technical requirements for formwork construction. In addition, preamble items are included for engineer certification of formal design and for the preparation of shop drawings. This provision allows an appropriate allowance to be made for the design and documentation of the formwork system where these are not supplied free of charge.

Generally, formwork is measured by area and expressed in m^2. The standard classifies formwork for the faces of footings as either partially above ground or wholly below ground, depending on their exposure. Soffits of slabs are categorised based on their slope, with classifications for horizontal, slope not exceeding 15 degrees, slope exceeding 15 degrees, and permanently cambered forms. Similarly, formwork for the sides of columns, beams and piers is classified as either isolated or attached, and the sectional shape of the columns or piers must be clearly stated in the description. Where columns or piers are circular in cross-section, the formwork must be measured in linear metres (m) rather than m^2, and their diameter must also be included in the description.

Additional measurement rules are provided in the classification table. For example, Measurement Rule 6 (M6) requires that each class of formwork be measured separately to ensure accurate itemisation for pricing purposes. For a more comprehensive understanding of the measurement procedures, pricing, and definitions, the authors encourage readers to refer Section 7 of the ANZSMM.

Item descriptions must also comply with the conventions set out in the standards. For instance, when describing formwork for the soffit of slabs, the strutting height must be stated. These descriptions should also align with the technical specifications relevant to the project. An example of an appropriate description for slab formwork can be:

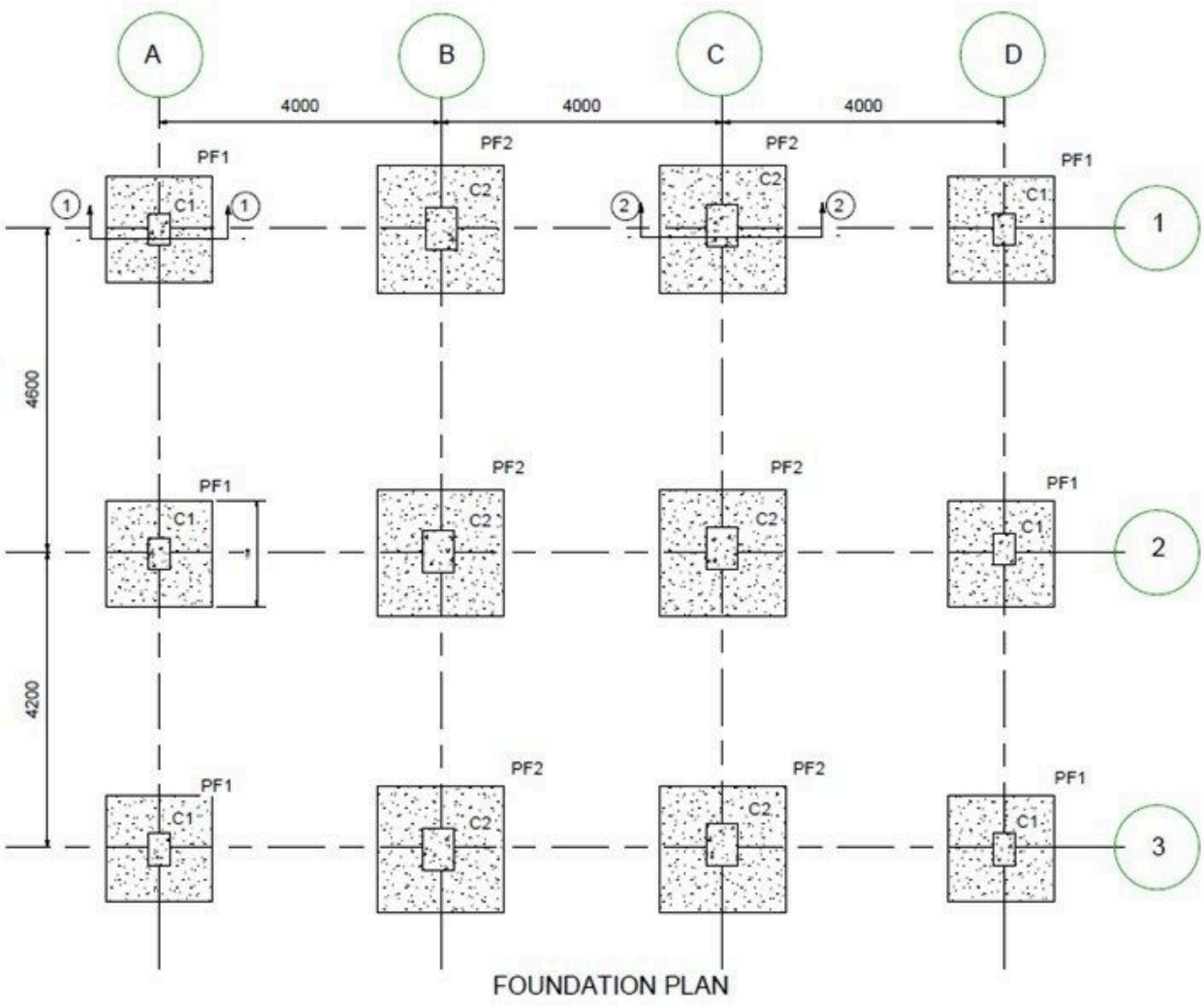
"Provide Class 3 timber formwork for horizontal soffits of the slab, including strutting 3 m – 4 m high."

4.4 MEASUREMENT PROCESS FOR FORMWORK USING COSTX SOFTWARE

This section presents a step-by-step guide for measuring formwork using CostX software. It explains the complete workflow, including creating dimension groups, applying measurement rules, and generating detailed reports. By following these instructions, readers will gain practical experience with CostX and learn how to accurately calculate formwork quantities for footings, slabs, beams, and columns.

4.4.1 Computer-based measurement of pad footing formwork

Based on the drawing provided below (Figure 4.7), carry out a digital quantity take-off for the formwork required for pad footings. Using the measured quantities, prepare a detailed BQ utilising CostX software.



PAD FOOTING SCHEDULE

	DIMENSIONS			REINFORCEMENT	
MARK	LENGTH	WIDTH	DEPTH	X-BARS	Y-BARS
PF1	1500	1500	450	N16-200 Bottom	N16-200 Bottom
PF2	1800	1800	450	N20-200 Top & Bottom	N20-200 Top & Bottom

Figure 4.7: Foundation plan (Source: Created by Authors)

Step 1: Add the drawing and calibrate the X and Y axes (Figures 4.8 and 4.9).

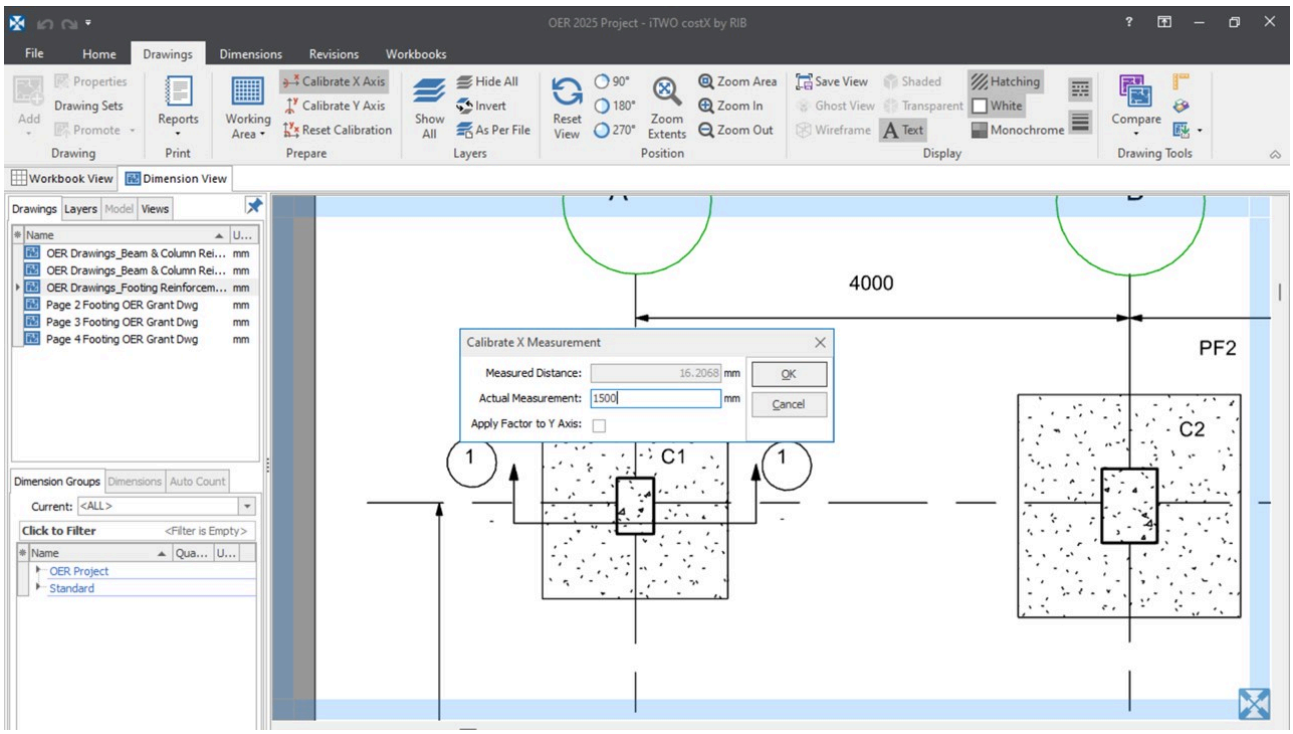


Figure 4.8: Screenshot of calibrating X axis for pad footing formwork measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

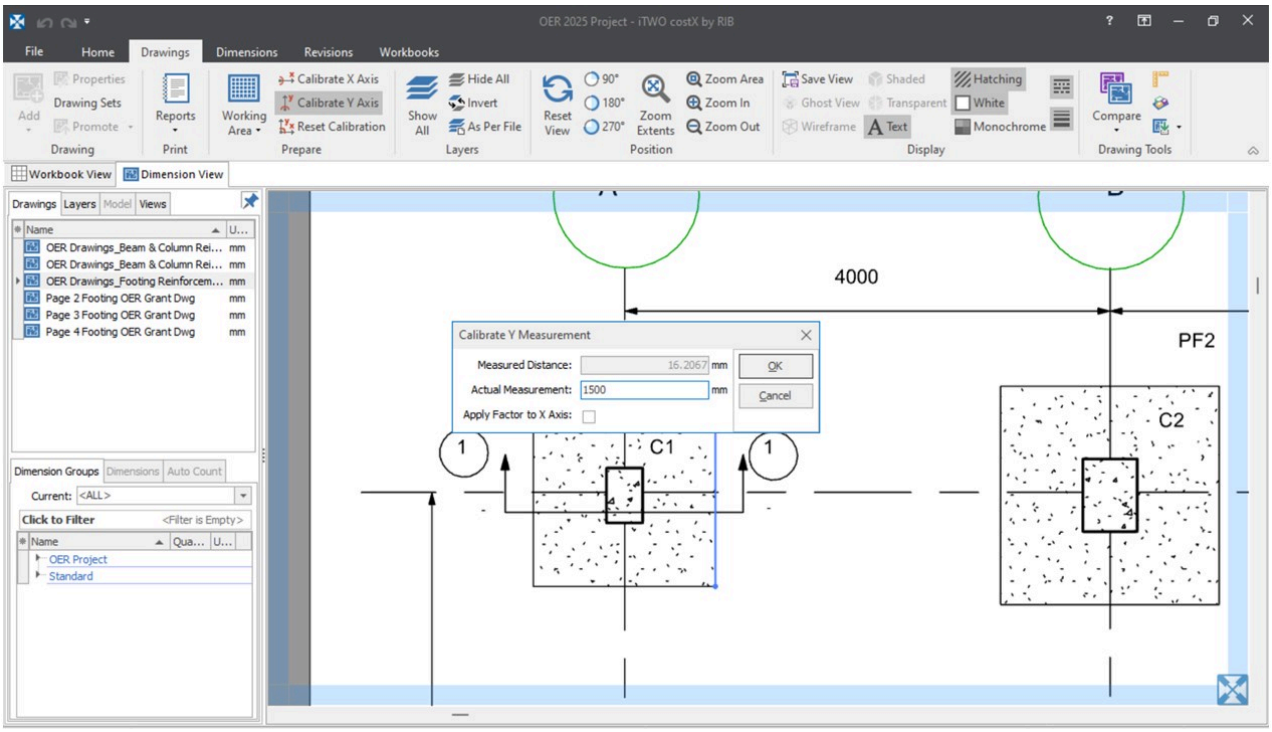


Figure 4.9: Screenshot of calibrating Y axis for pad footing formwork measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 2: Add dimension groups (Figure 4.10 and Figure 4.11)

- Measure the length from the plan and display the quantity as wall area or vertical area (m^2).
- Default multiplier: 6 (representing the number of PF1 footings with identical dimensions).
- Default height: 0.45 m (as noted in the drawing).

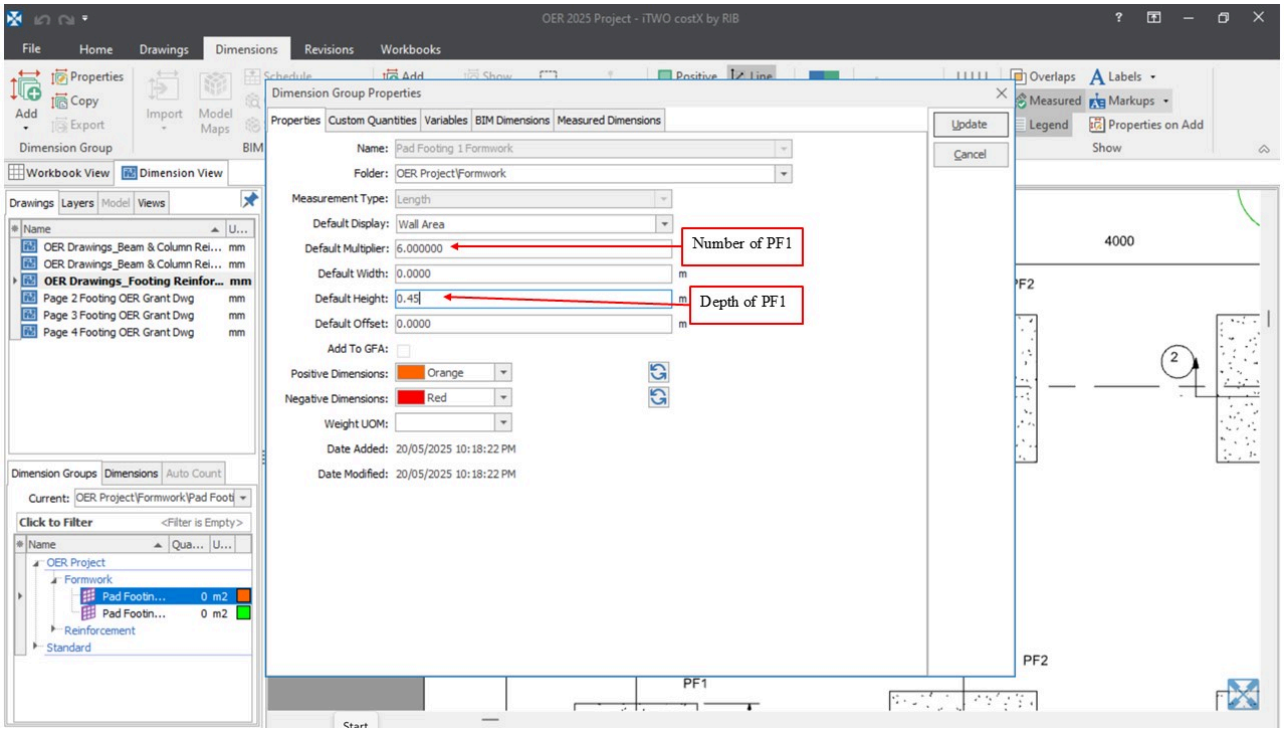


Figure 4.10: Screenshot of creating a dimension group for PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

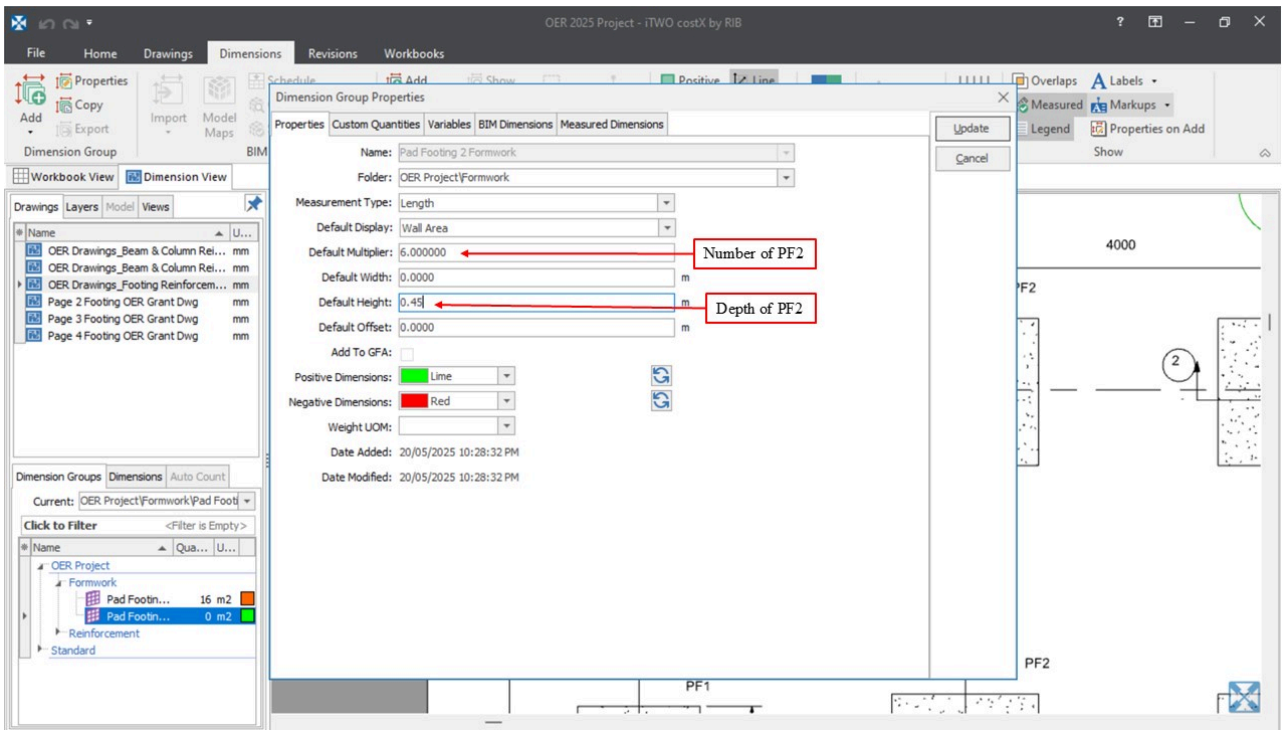


Figure 4.11: Screenshot of creating a dimension group for PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Measure PF1 and PF2 (Figures 4.12 to 4.14).

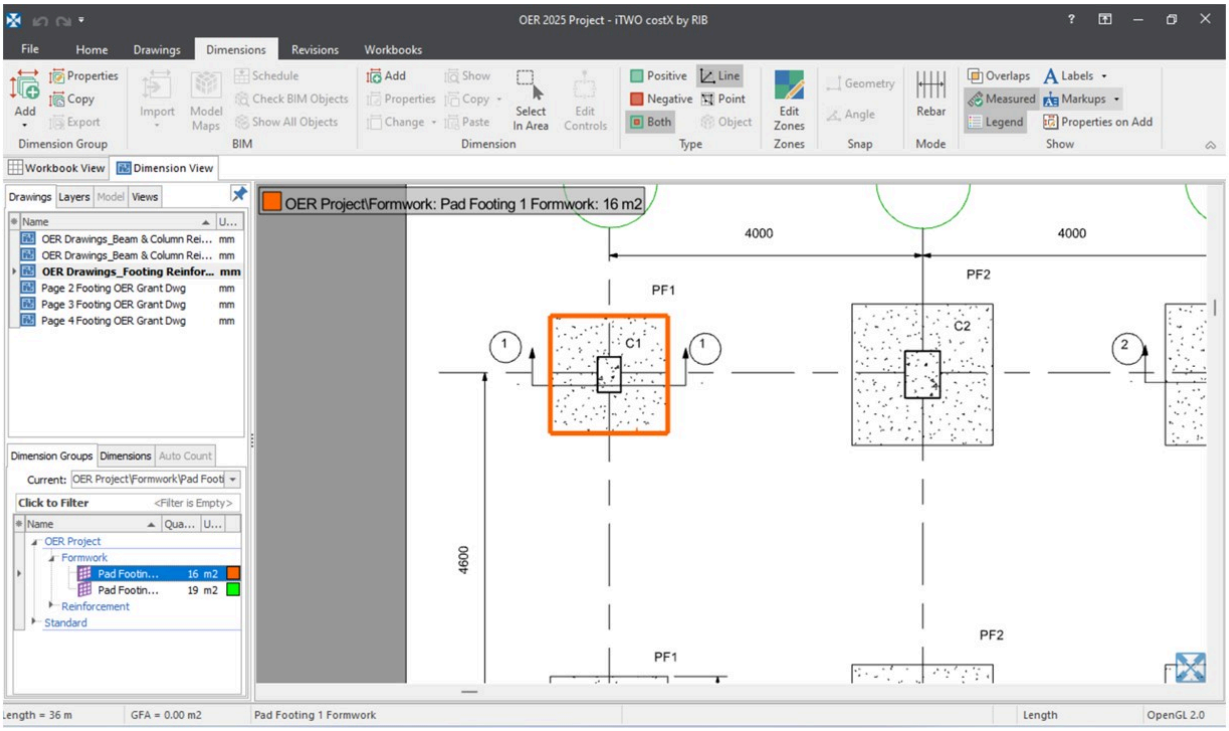


Figure 4.12: Screenshot of measuring PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

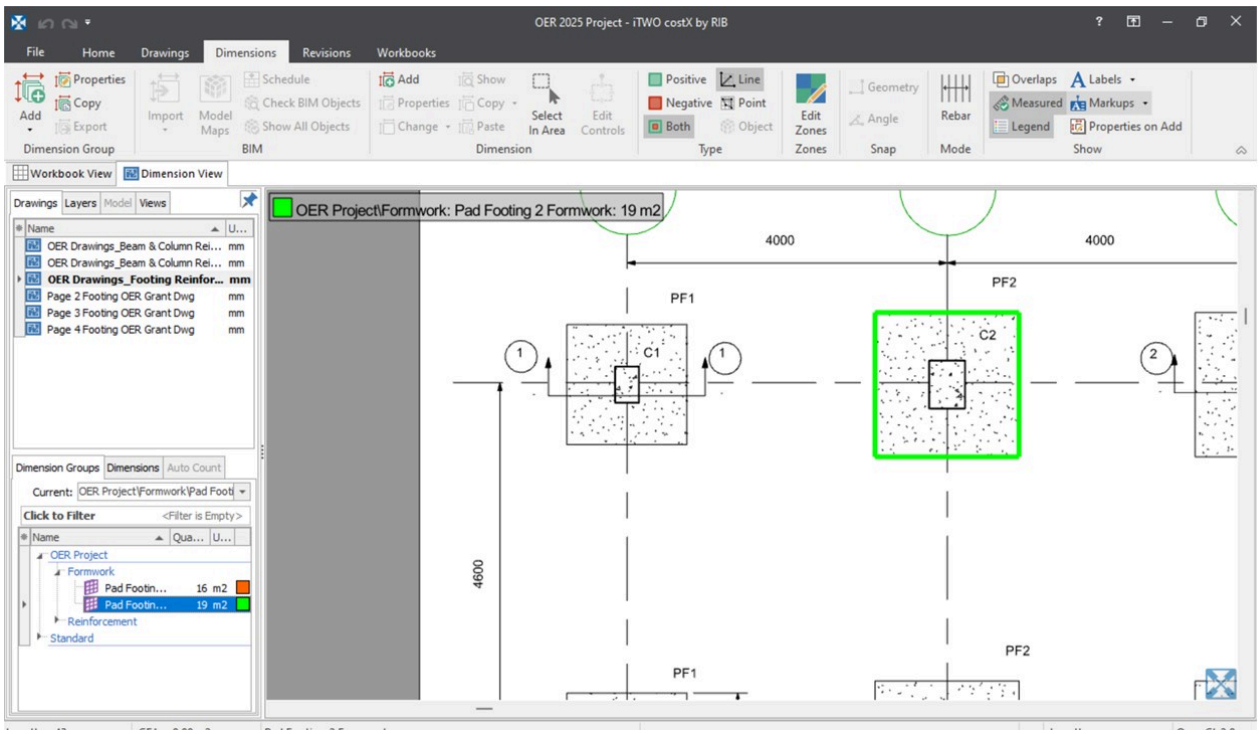


Figure 4.13: Screenshot of measuring PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

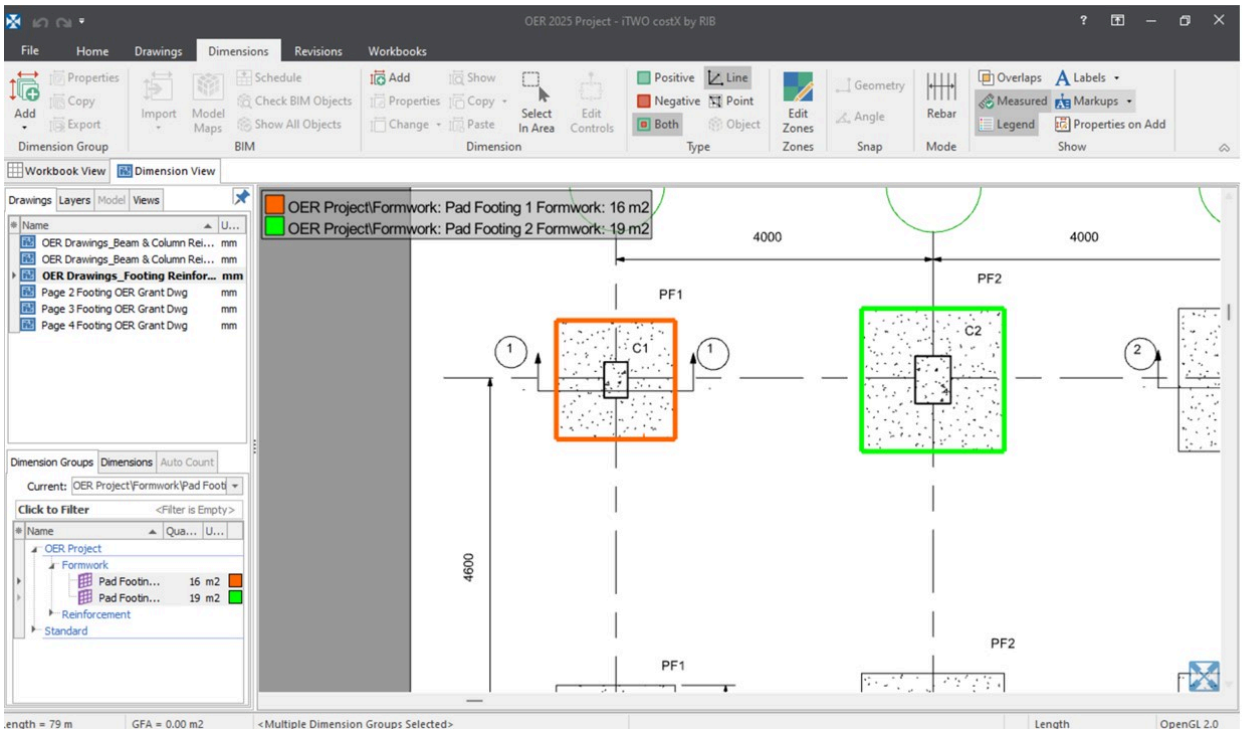


Figure 4.14: Screenshot of PF1 and PF2 quantities using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 4: Add workbooks, transfer quantities and write descriptions (Figures 4.15 to 4.18).

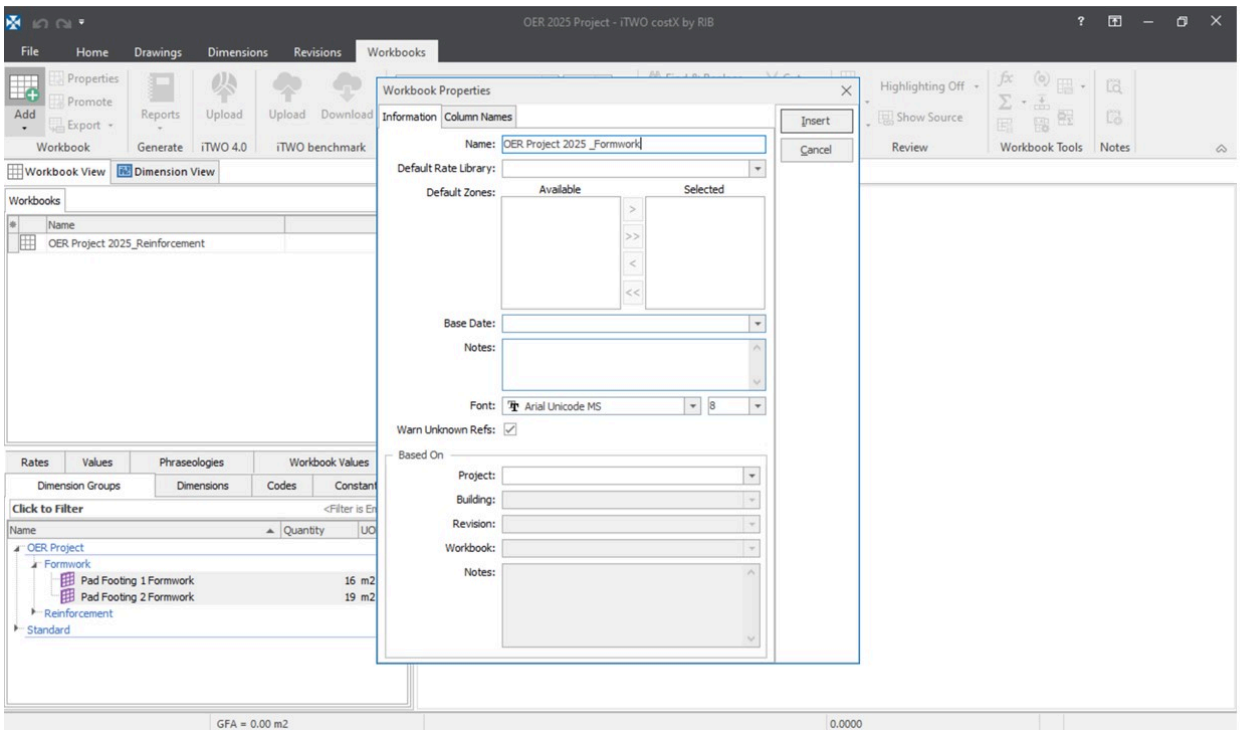


Figure 4.15: Screenshot of workbook properties and name selection using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

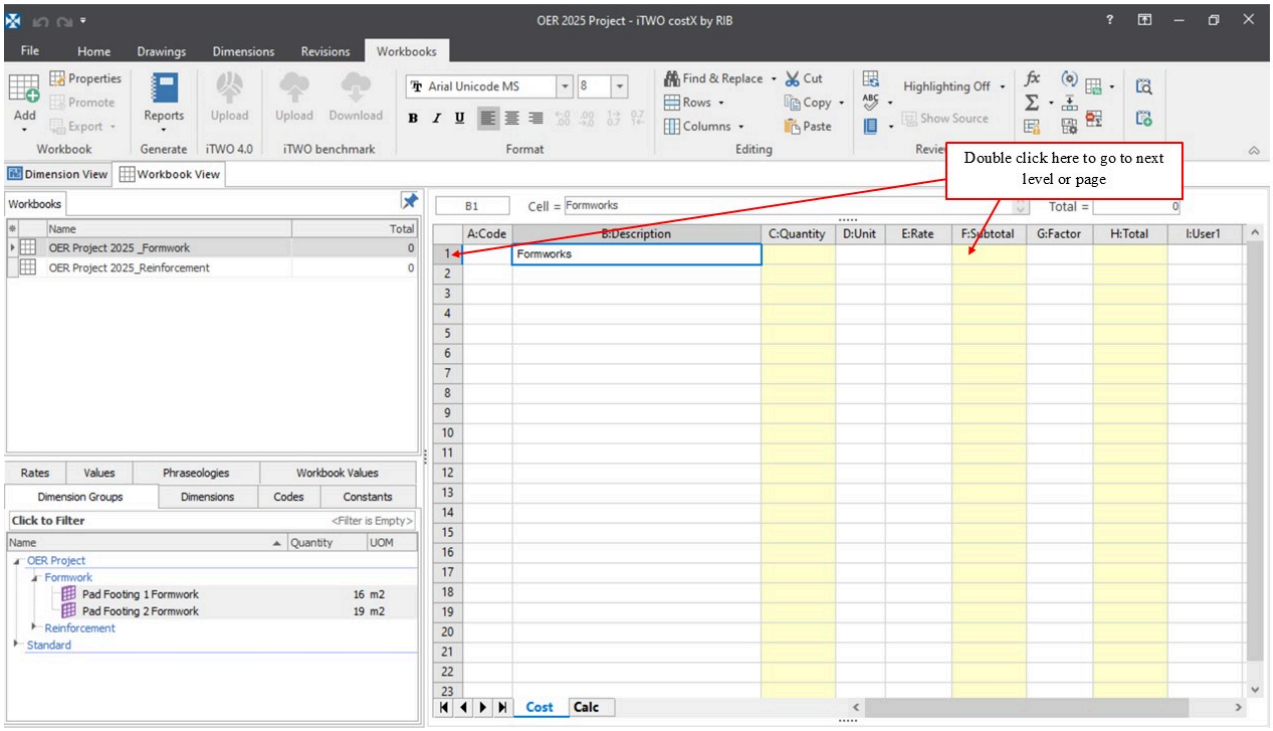


Figure 4.16: Screenshot of first level of the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Next, you can do the following activities on the workbook:

- Insert preamble notes and items, and description of the formworks to pad footings.

- Insert units of measurement.

- Transfer quantities from the dimension group to the workbook.

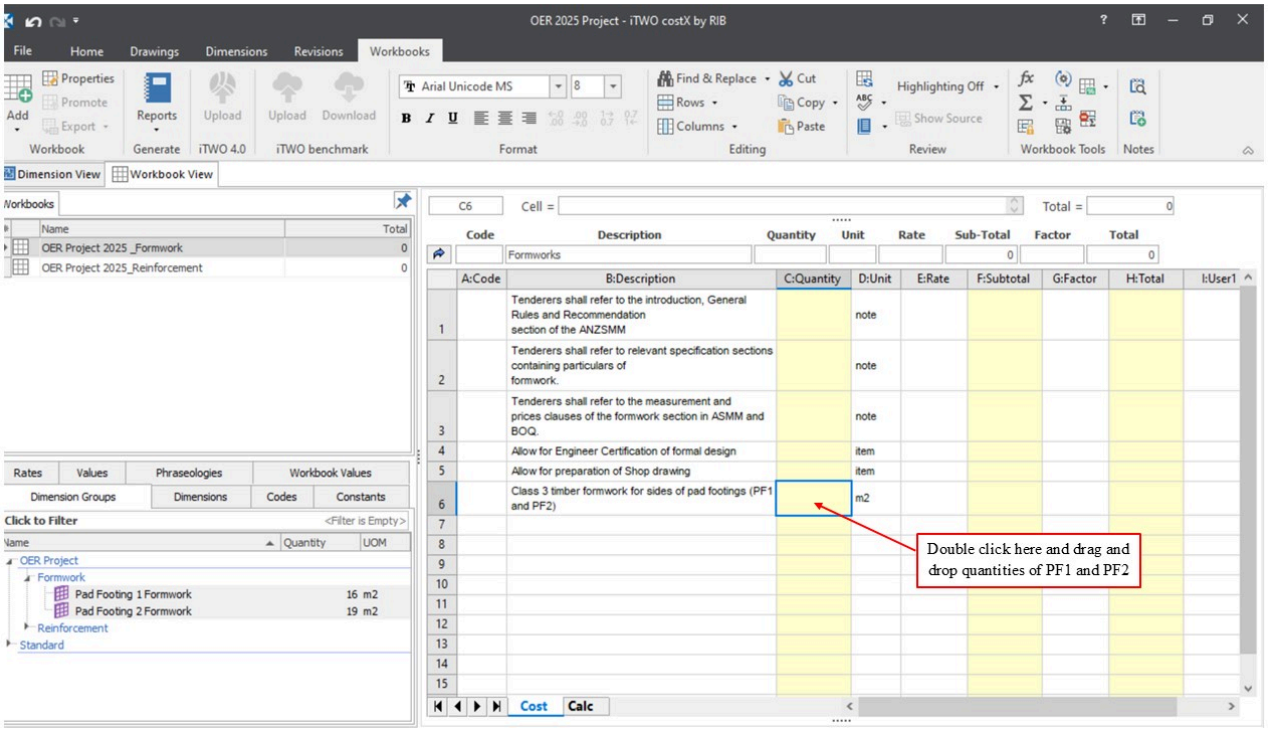


Figure 4.17: Screenshot of second level of the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

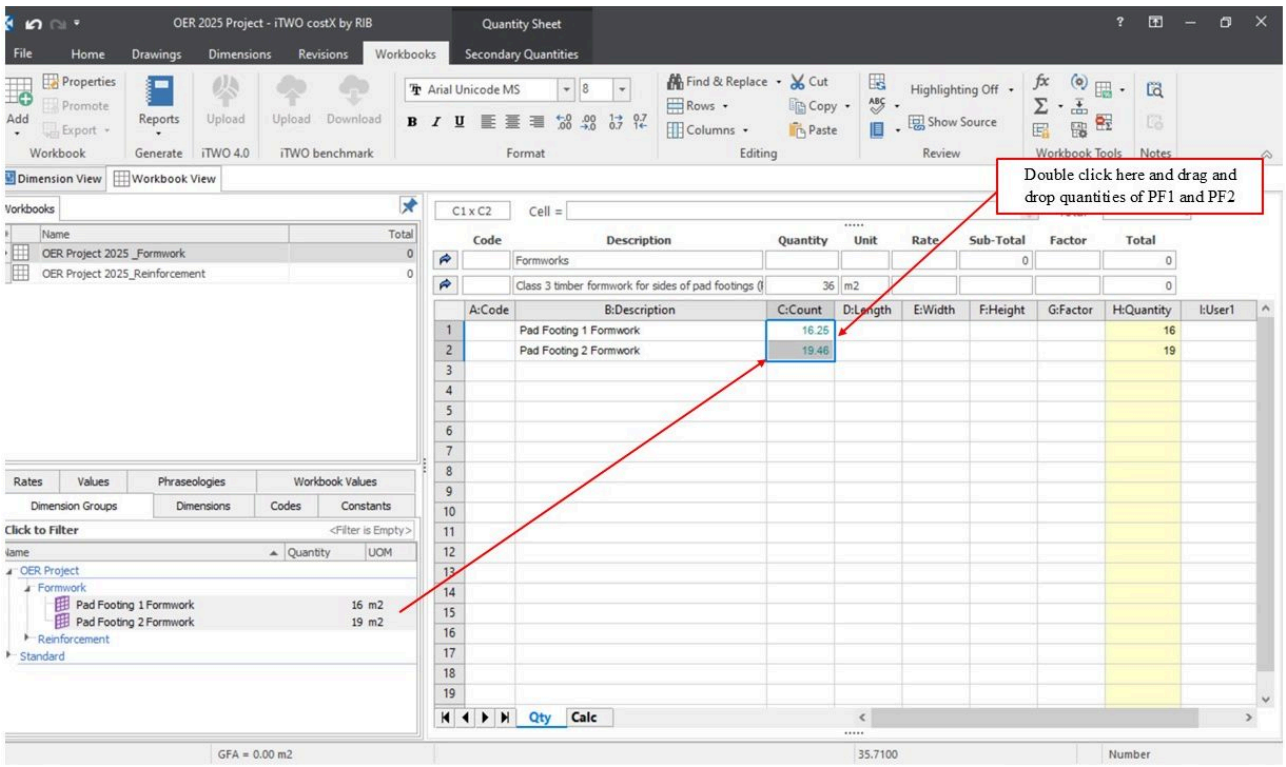


Figure 4.18: Screenshot of adding quantities to workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Generate reports (Figures 4.19 and 4.20).

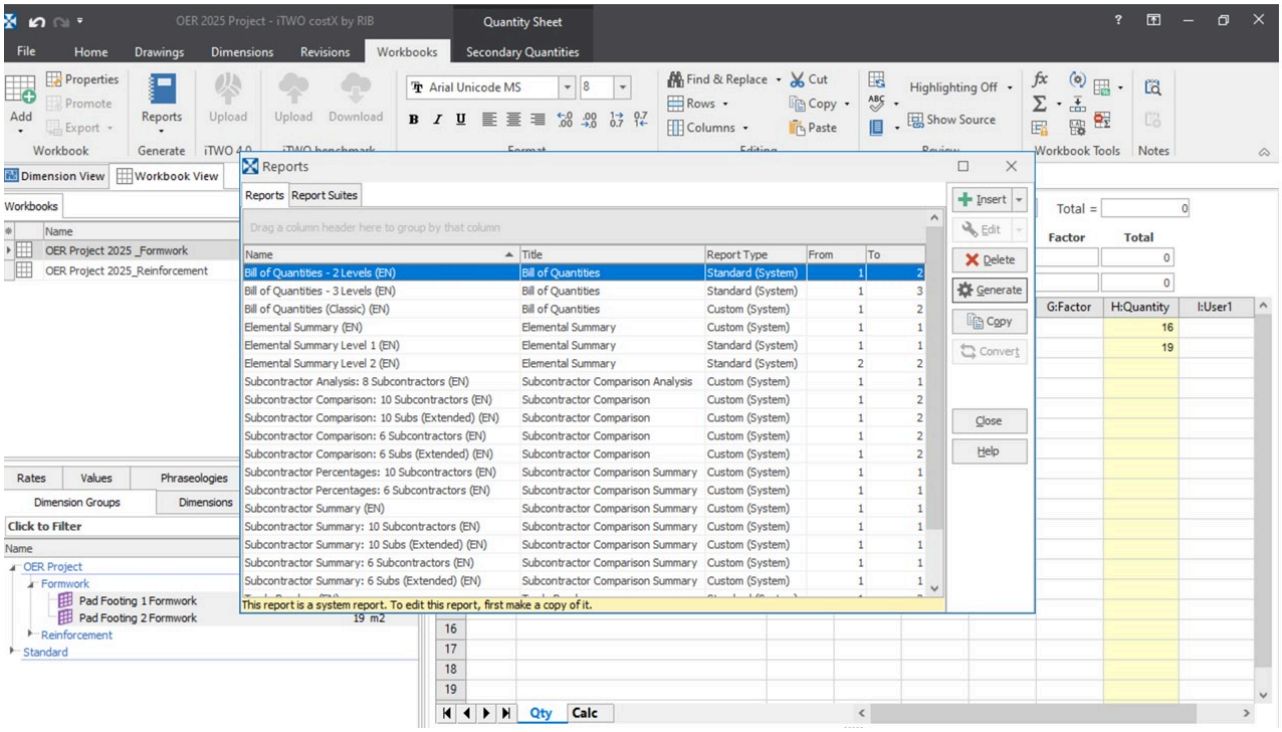


Figure 4.19: Screenshot of selecting report type using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

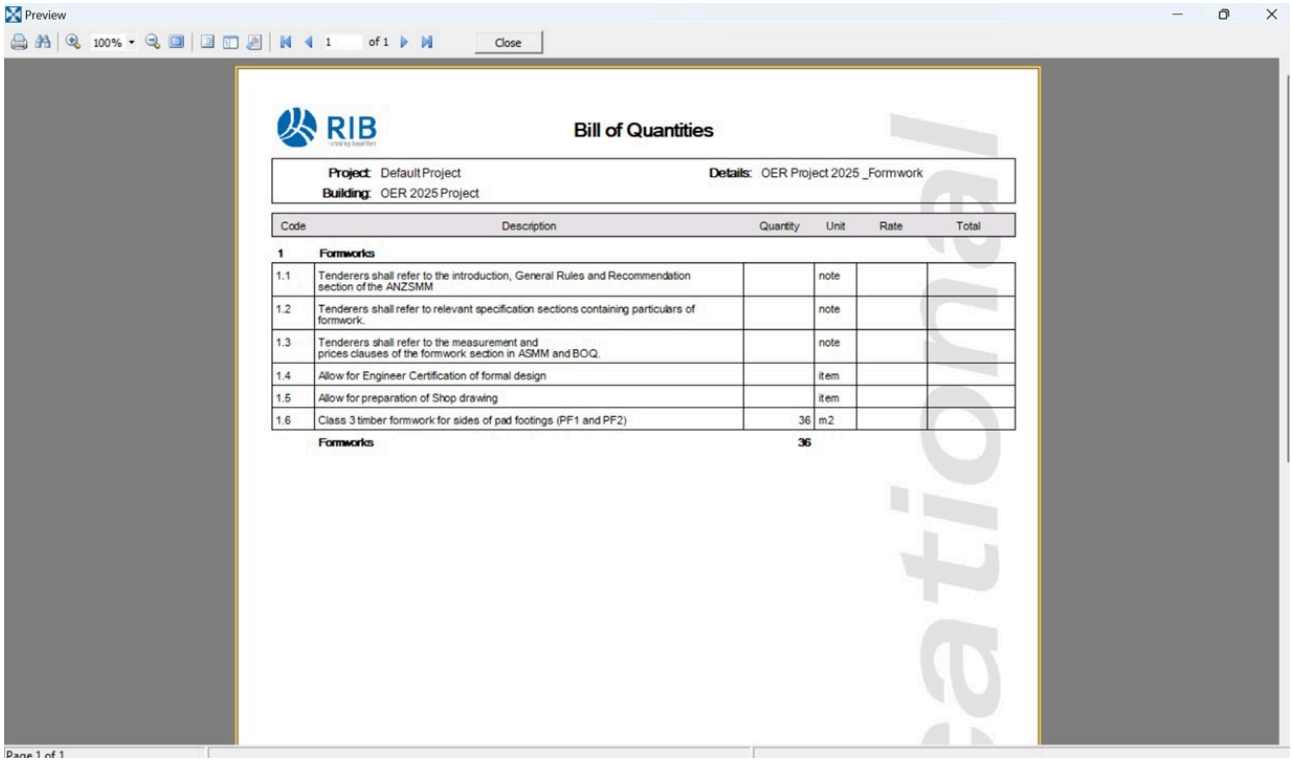


Figure 4.20: Screenshot of generated report using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

4.4.2 Computer-based measurement of column, beam and slab formworks

Based on the drawings provided below (Figures 4.21 to 4.23), carry out a digital quantity take-off for the formwork required for the following structural elements: sides of columns, sides and soffits of beams, and the soffit of the roof slab. Using the measured quantities, prepare a detailed BQ in CostX software.

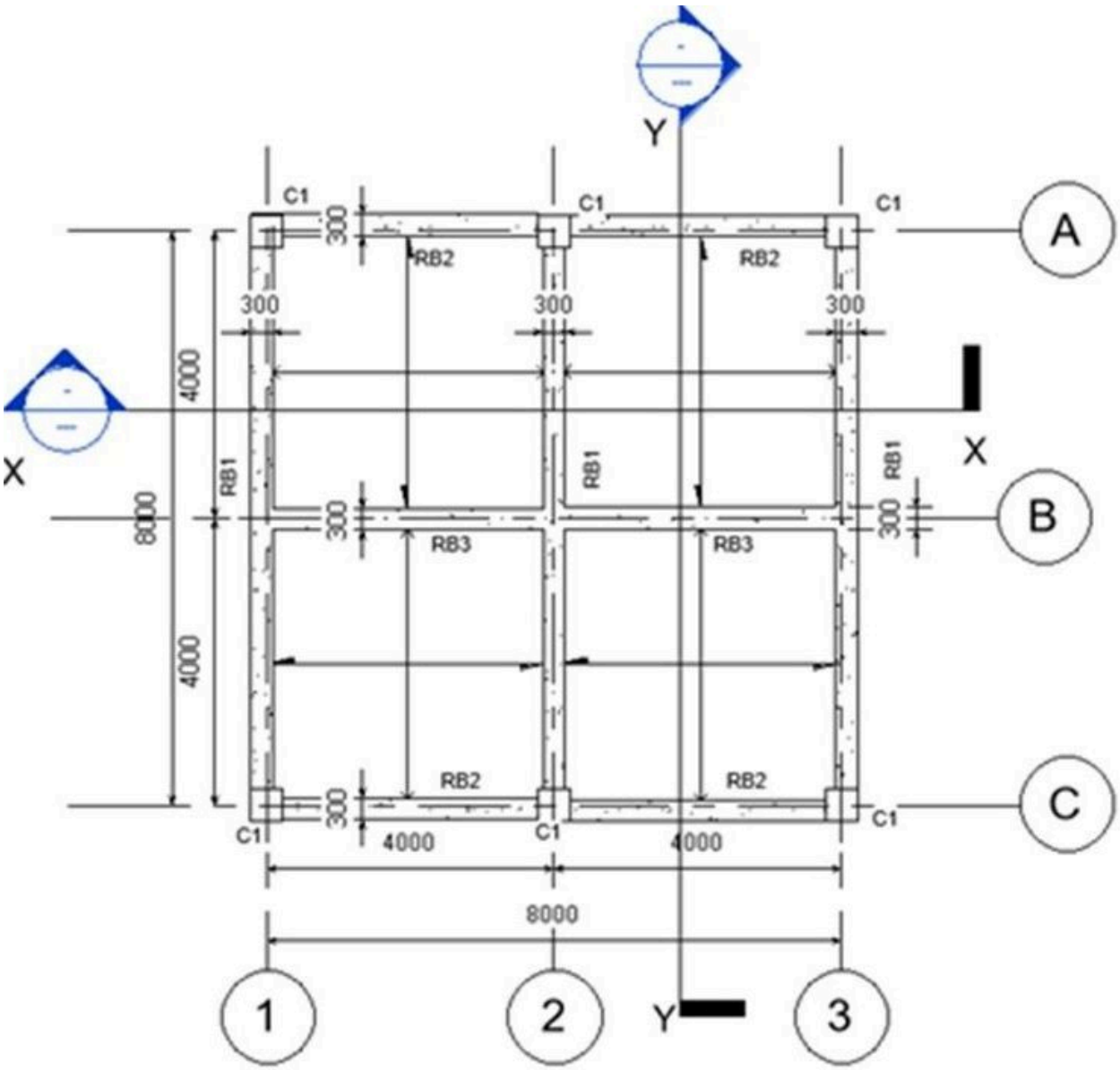
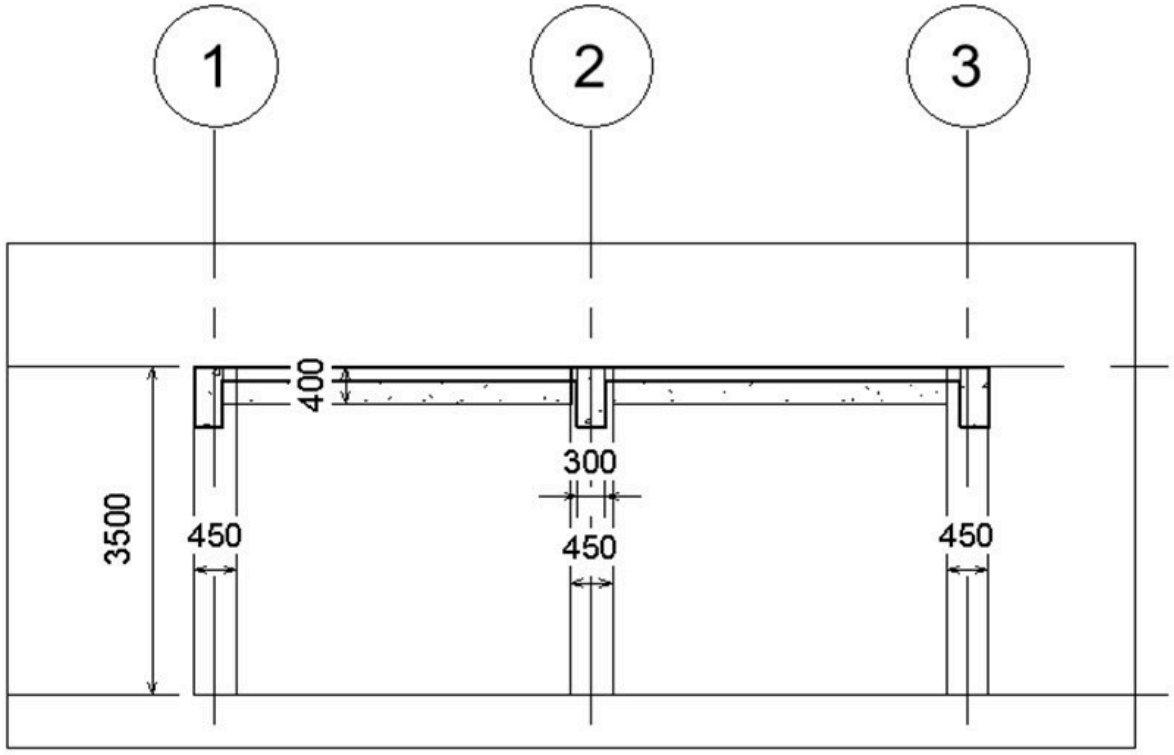


Figure 4.21: Beam, column and suspended slab plan (Source: Created by Authors)



Section X-X

Notes:

1. Columns: 450 X 450
2. Beams: RB1= 300 wide, top of roof slab to underside of beam = 650
3. Beams: RB2 and RB3 = 300 wide, top of roof slab to underside of beam = 400

Figure 4.22: Section X-X (Source: Created by Authors)

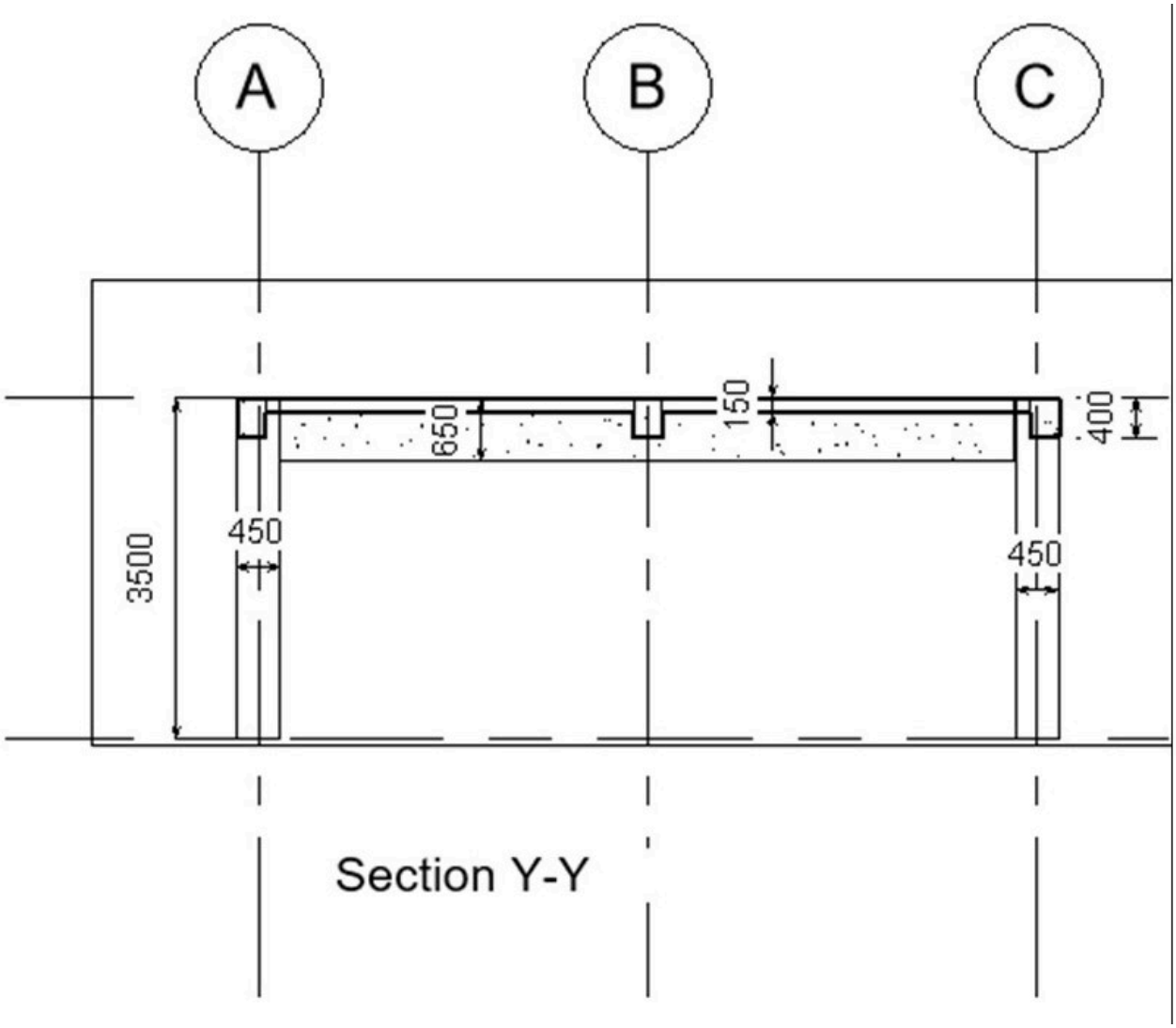


Figure 4.23: Section Y-Y (Source: Created by Authors)

Step 1: Add the drawings and calibrate the X and Y axes (Figures 4.24 and 4.25).

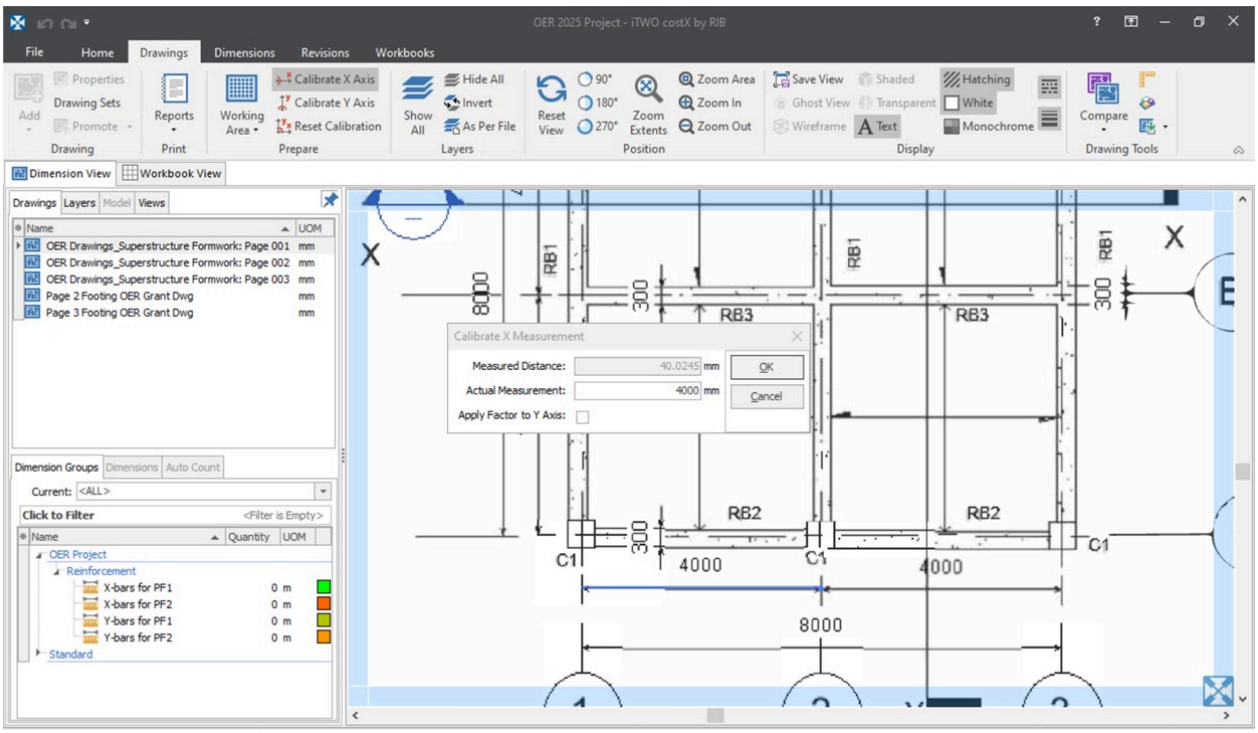


Figure 4.24: Screenshot of calibrating X axis for column, beam and slab formwork measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

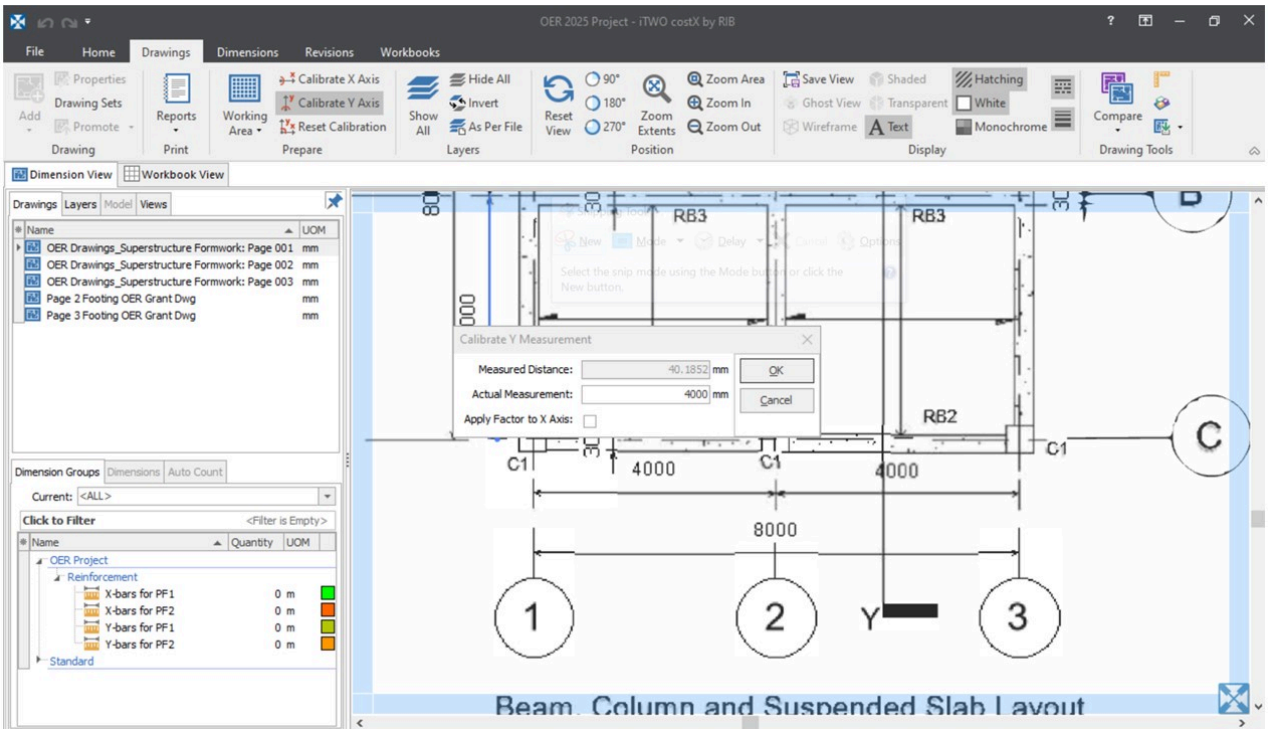


Figure 4.25: Screenshot of calibrating Y axis for column, beam and slab formwork measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 2: Add dimension groups (Figures 4.26 to 4.28).

The following dimension group is set up to calculate the required formwork area for vertical structural elements, columns. The setup considers project-specific parameters:

- Column Height Calculation: The clear height of each column is calculated by subtracting the slab thickness from the floor-to-floor height:
    - Floor-to-floor height = 3,500 mm
    - Slab thickness = 150 mm
    - Therefore, effective column height = 3,500 mm – 150 mm = 3,350 mm (or 3.35 m).
- Measurement Type: The selected measurement type is length, as the system uses the linear height of columns to help determine the total surface area of formwork required.
- Default Display Setting: The wall area setting is used as the default display. This means that the calculated output will represent the surface area of formwork needed for the sides of the columns (i.e. height × perimeter).
- Default Multiplier: A default multiplier of 6 is applied to account for the number of identical columns in this group. This automates the calculation of total formwork area across all six columns.

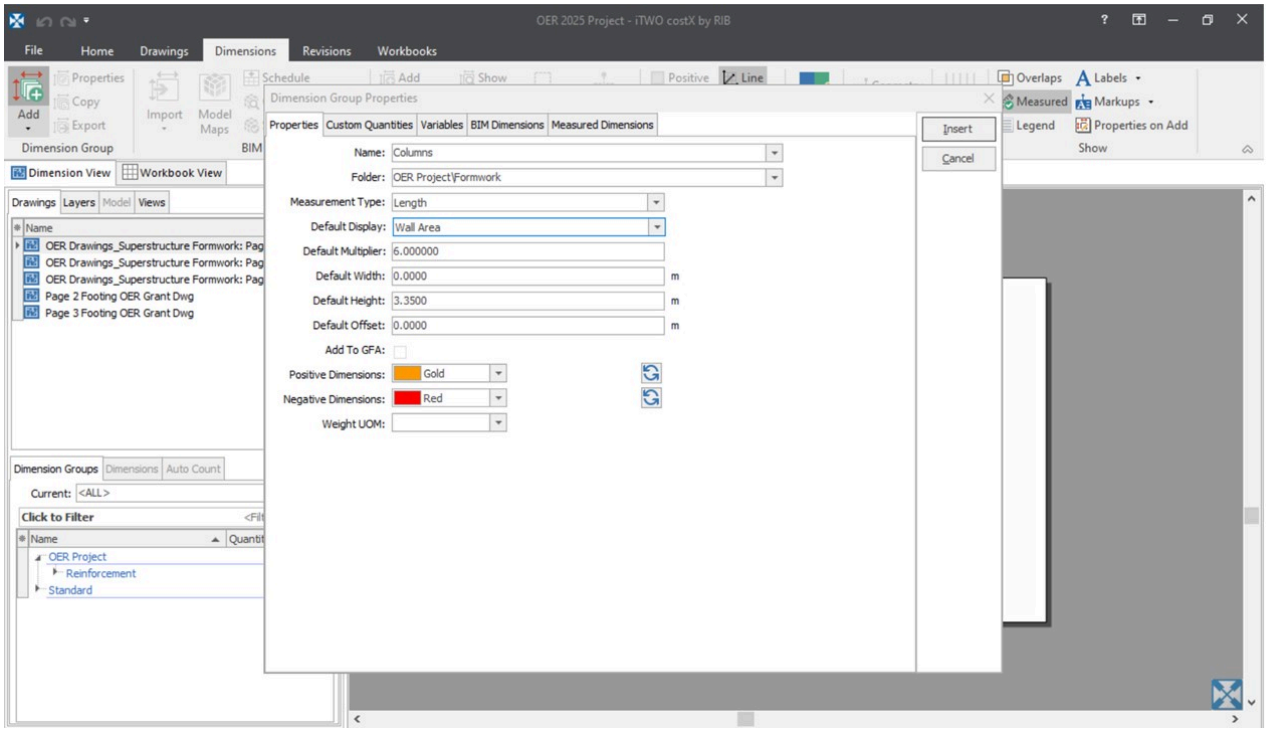


Figure 4.26: Screenshot of creating a dimension group for columns formwork using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The following dimension group is configured to calculate the required formwork area for edge roof beams identified as RB1. The setup is based on the dimensions and positioning of the beam within the structural layout.

- Girth Calculation for Beam Formwork 1 (RB1-Edge): The girth refers to the total perimeter of the beam surfaces that require formwork, including the two vertical sides and the soffit (underside) of the beam. For RB1, the girth is calculated as follows:
    - External vertical face = 650 mm
    - Soffit (underside of beam) = 300 mm
    - Internal vertical face = 500 mm (derived as 650 mm – 150 mm slab thickness)
    - Total girth = 650 + 300 + 500 = 1,450 mm (or 1.45 m).
- Measurement Type: The measurement type is set to length, as the linear extent of the beam is used to calculate the total formwork area (girth × length of beam).
- Default Multiplier: A default multiplier of 2 is applied, representing two identical RB1 beams in this group. This ensures that the total formwork quantity is calculated for both beams simultaneously.

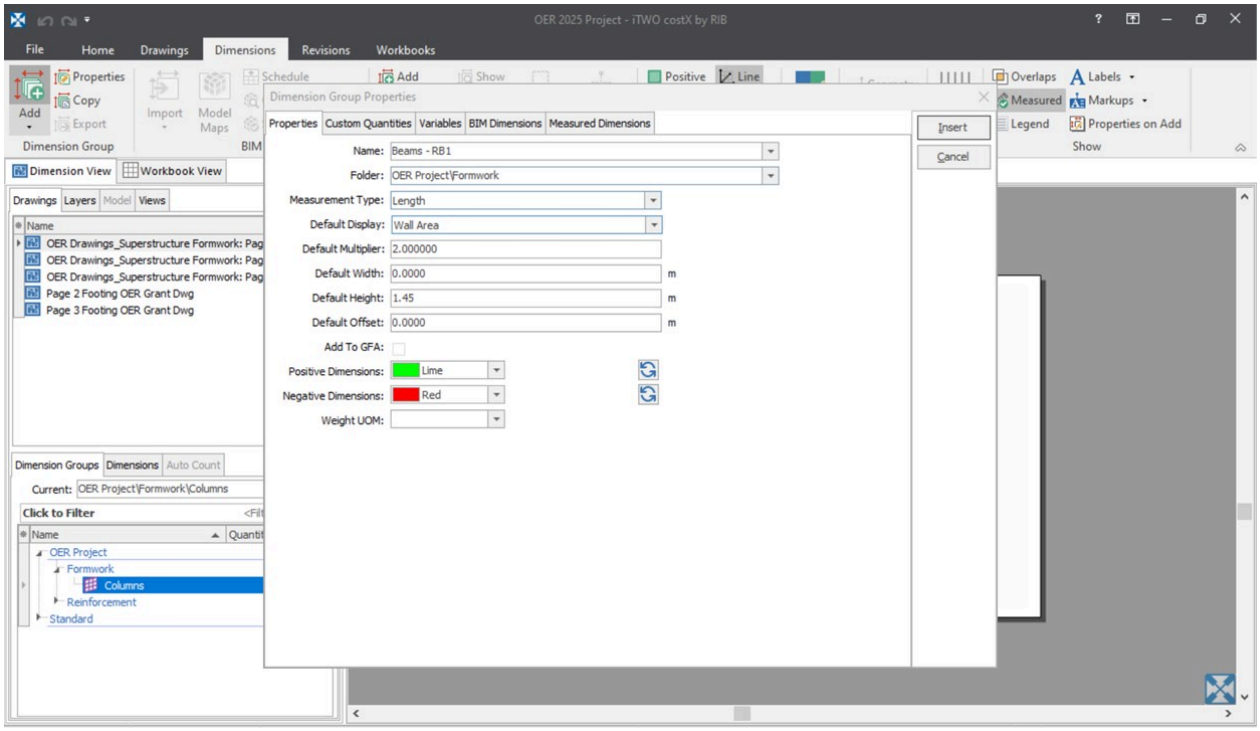


Figure 4.27: Screenshot of creating a dimension group for edge beams formwork (RB1-Edge) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The following dimension group is set up to calculate the required formwork area for centrally located beams identified as RB1 (centre). These beams are positioned between slabs and require formwork on both vertical faces and the soffit.

- Girth Calculation for Beam Formwork (RB1 – Centre): The girth represents the total perimeter of the surfaces requiring formwork. Since the beam is centrally located and flanked by slabs on both sides, the formwork is applied to:
    - Left vertical face = 500 mm
    - Soffit (underside of the beam) = 300 mm
    - Right vertical face = 500 mm
    - Total girth = 500 + 300 + 500 = 1,300 mm (or 1.30 m).
- Measurement Type: The measurement type is set to length, allowing the system to multiply the girth by the beam's linear span to calculate the total area of formwork required.

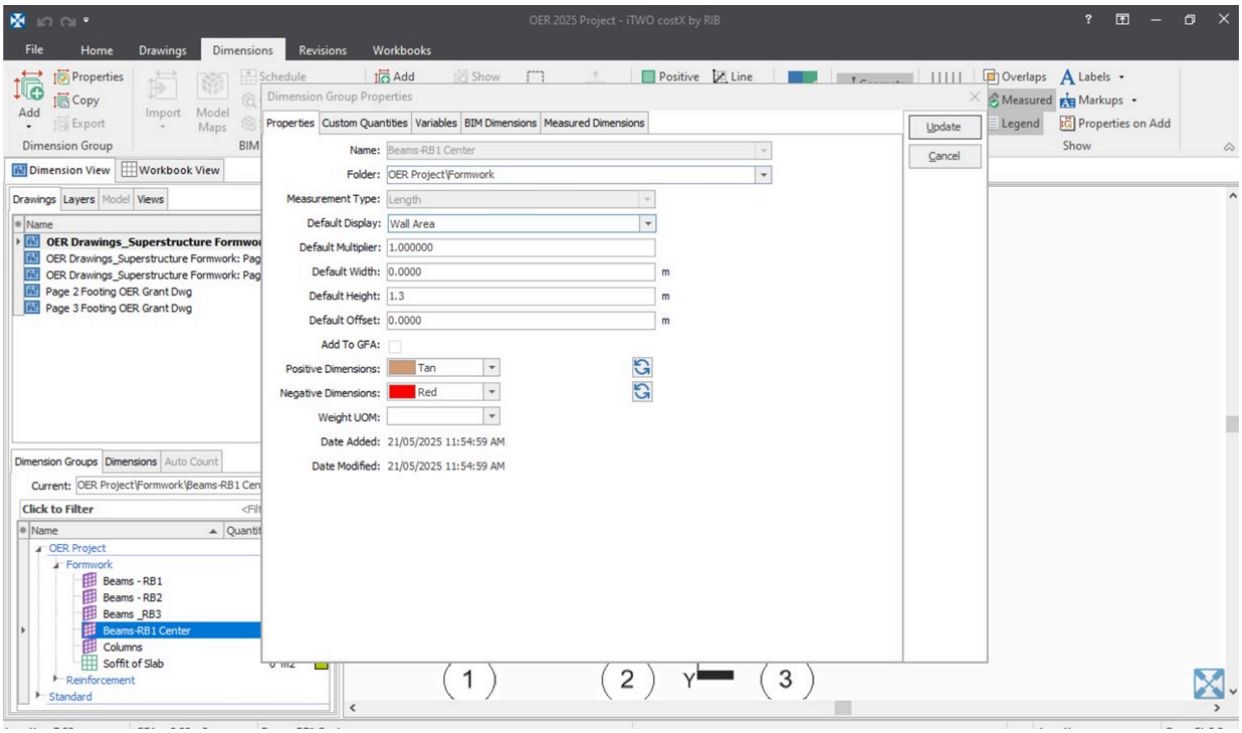


Figure 4.28: Screenshot of creating a dimension group for central beams formwork (RB1-Centre) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The following dimension group is configured to calculate the formwork requirements for secondary edge

beams identified as RB2 (Figure 4.29). These beams are located along slab edges, requiring formwork on the external face, soffit, and a partially enclosed internal face.

- Girth Calculation for Beam Formwork (RB2): The girth represents the sum of the vertical and horizontal surfaces requiring formwork. For RB2, the formwork is applied to:
    - External vertical face = 400 mm
    - Soffit (underside of beam) = 300 mm
    - Internal vertical face = 250 mm (derived as 400 mm – 150 mm slab thickness)
    - Total girth = 400 + 300 + 250 = 950 mm (or 0.95 m).
- Measurement Type: Measurement is based on length, which allows the girth to be multiplied by the beam length for area calculation.
- Default Multiplier: A default multiplier of 4 is applied, accounting for four identical RB2 beams in this group. This ensures automatic calculation of the total formwork area required for all instances.

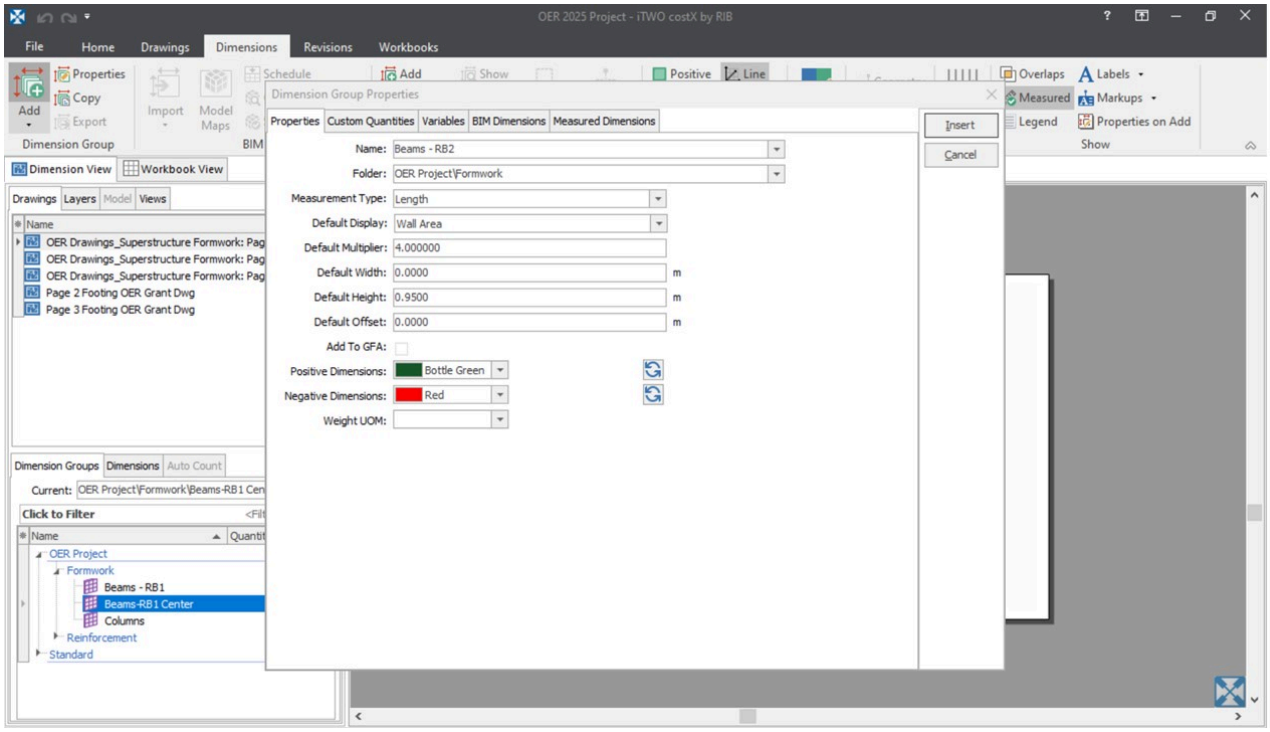


Figure 4.29: Screenshot of creating a dimension group for beams formwork (RB2) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The following dimension group is designed to estimate the formwork requirements for internal beams

identified as RB3 (Figure 4.30). These beams are fully enclosed between slabs, requiring formwork only on the two vertical sides and the soffit.

- Girth Calculation for Beam Formwork (RB3): The girth is the combined height of the surfaces requiring formwork. Since RB3 is an internal beam, the formwork is needed on:
    - Left vertical face = 250 mm
    - Soffit (underside of beam) = 300 mm
    - Right vertical face = 250 mm
    - Total girth = 250 + 300 + 250 = 800 mm (or 0.80 m).
- Measurement Type: The measurement type is set to length, allowing the calculated girth to be multiplied by the beam span to determine the total area of formwork required.
- Default Multiplier: A default multiplier of 2 is used, reflecting that there are two identical RB3 beams in this dimension group. This ensures the total formwork area is calculated for both beams collectively.

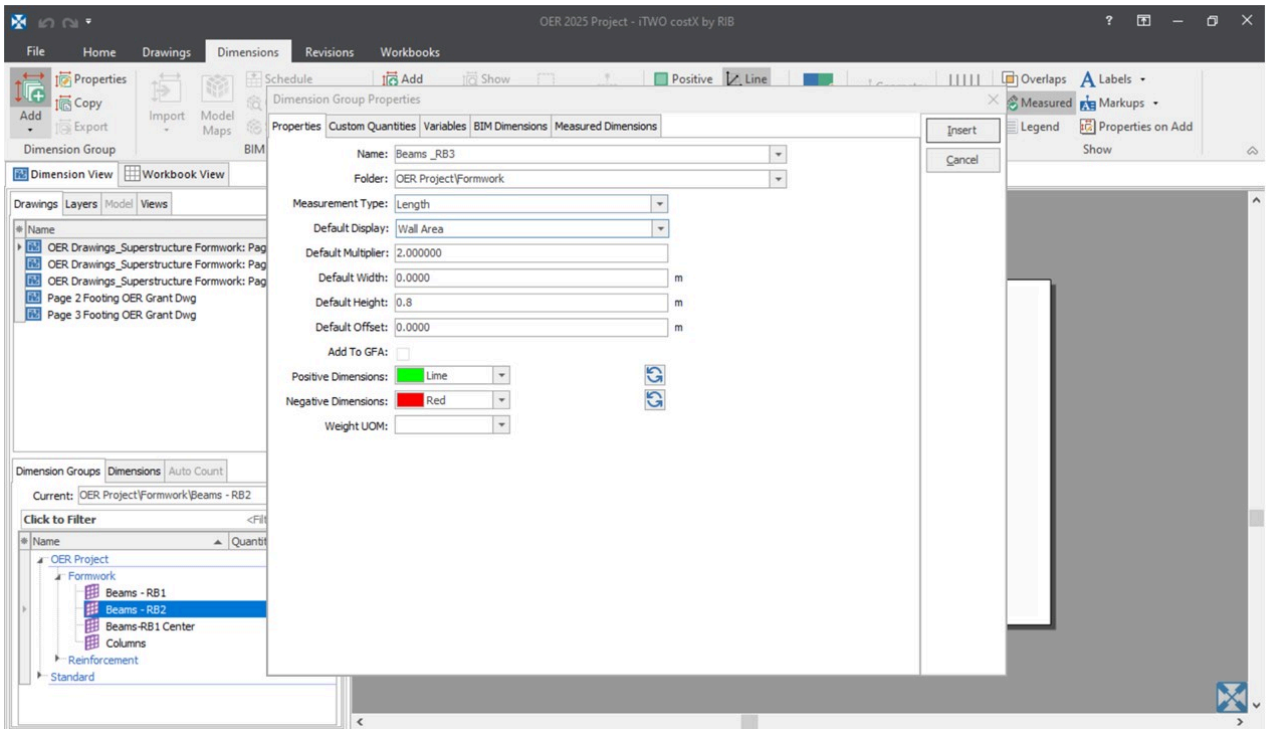


Figure 4.30: Screenshot of creating a dimension group for beams formwork (RB3) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The following dimension group is configured to calculate the formwork required for the underside (soffit) of the slab (Figure 4.31), including considerations for temporary support height.

- Measurement Type: The measurement is based on area, as formwork to the soffit of the slab is applied horizontally across the slab surface.

- Default Display: The default display is set to area, enabling the quantity take-off to show the total square meters of formwork required.

- Height of Strutting (Shoring Height): Temporary supports (shores or props) are required to hold the soffit formwork at the correct elevation. This height will be mentioned in the description for slab formwork following the ANZSMM requirement.

    - Floor-to-floor height = 3,500 mm

    - Slab thickness = 150 mm

    - Effective height of strutting = 3,500 mm – 150 mm = 3,350 mm (or 3.35 m).

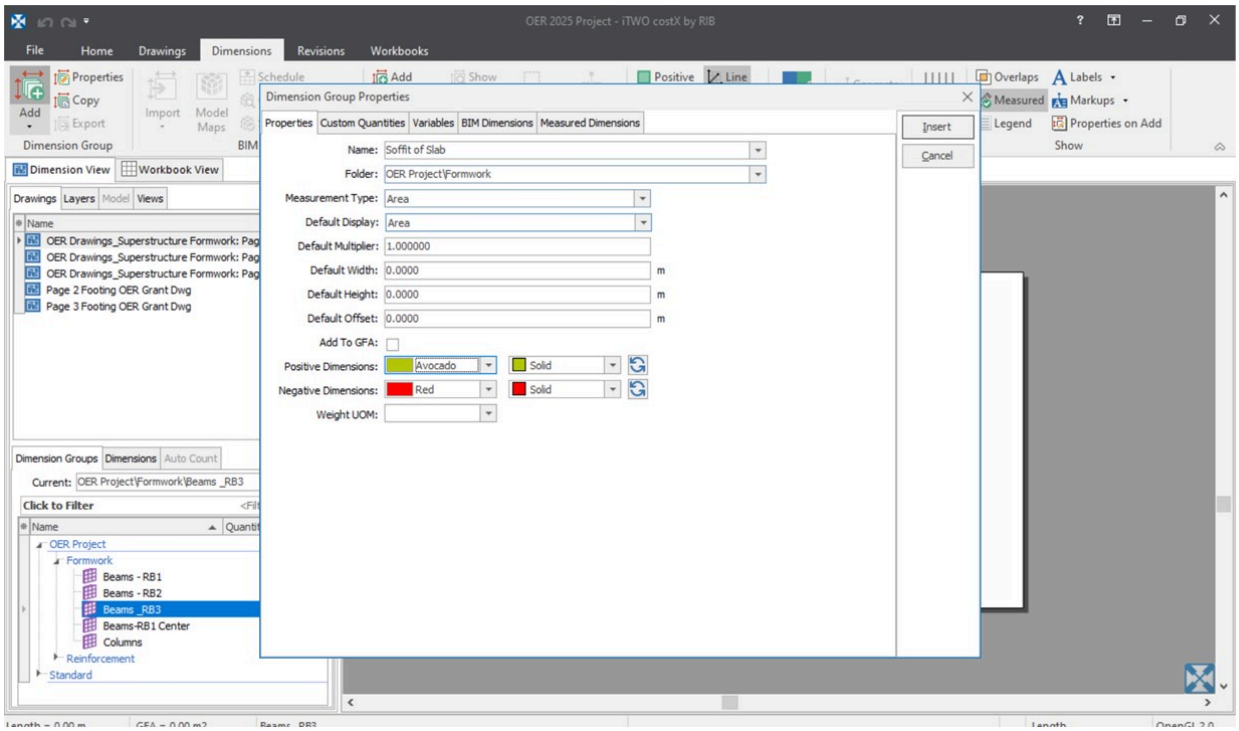


Figure 4.31: Screenshot of creating a dimension group for soffit of slab formwork using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Measure formworks (Figures 4.32 to 4.37).

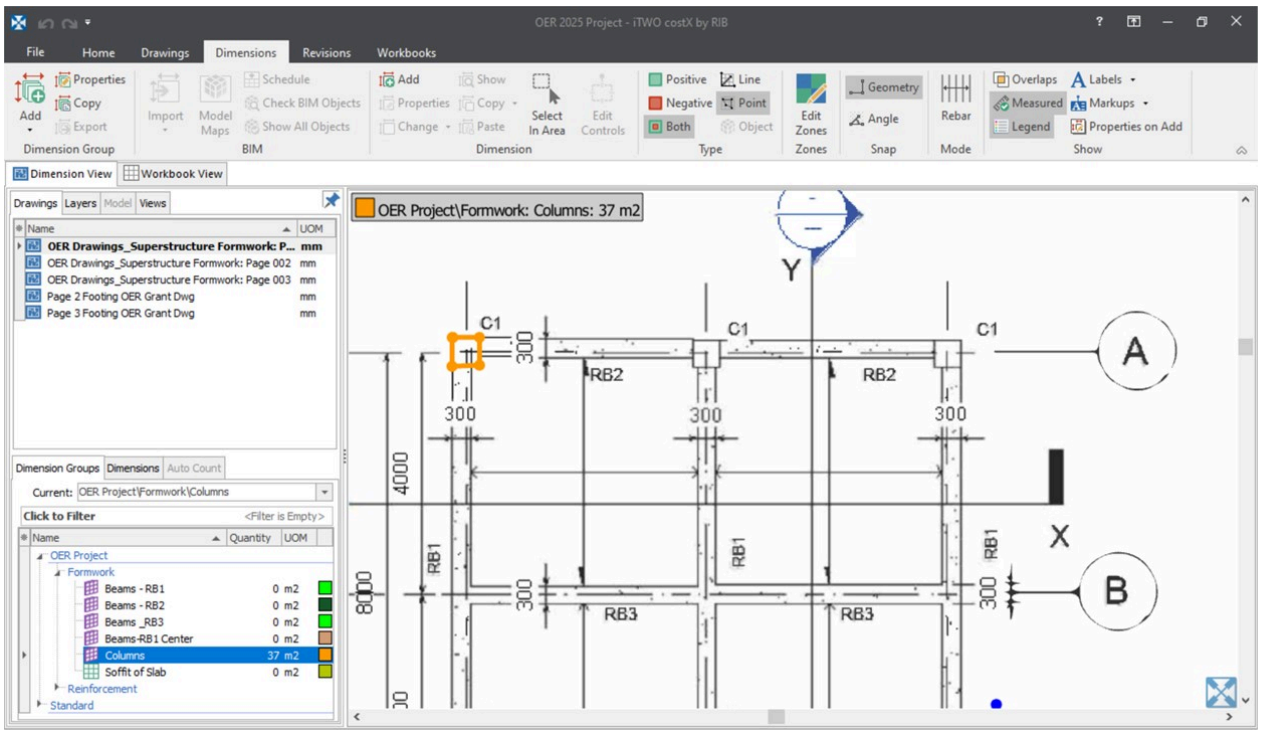


Figure 4.32: Screenshot of measuring columns formwork using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Note: As perthe standard, formwork at the intersection of primary and secondary beams shallnot be deducted from the primary beam's formwork quantity. This means the full surface area of the RB1 beams including intersecting zones with secondary beams must be included in the total formwork measurement for RB1.

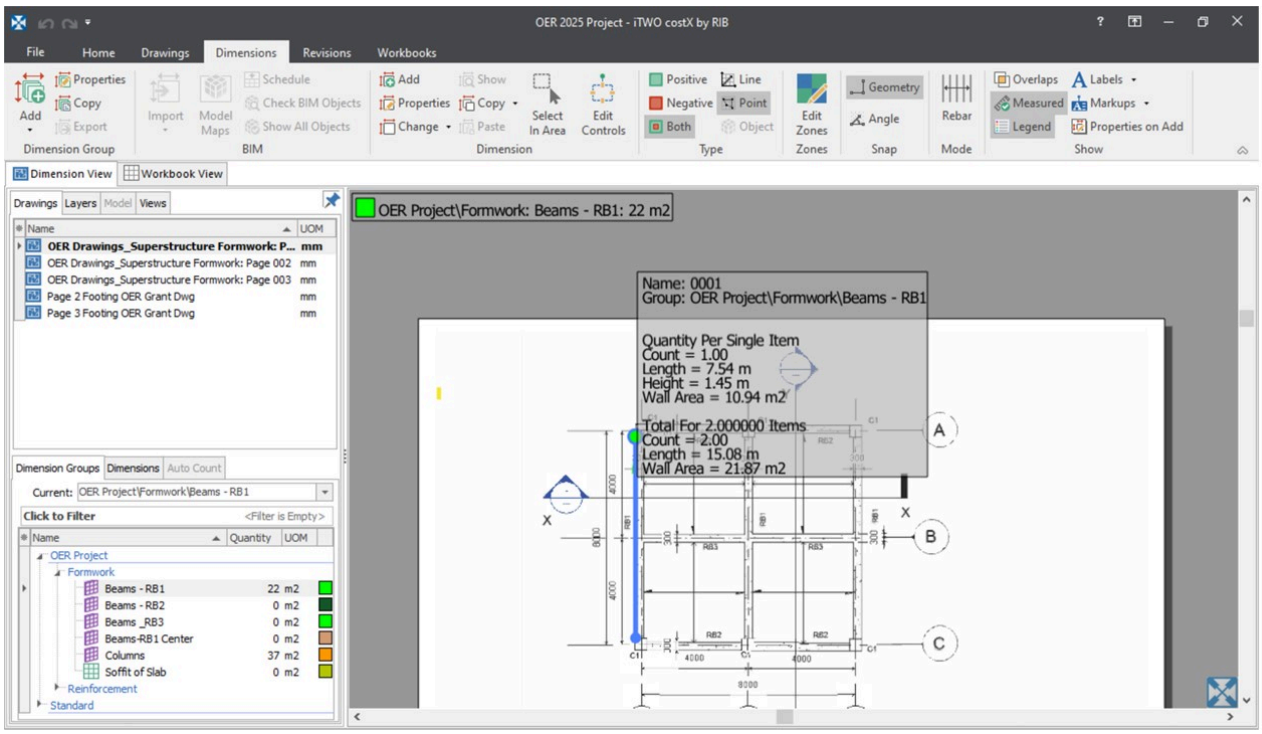


Figure 4.33: Screenshot of measuring dimensions of edge beams formwork (RB1-Edge) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

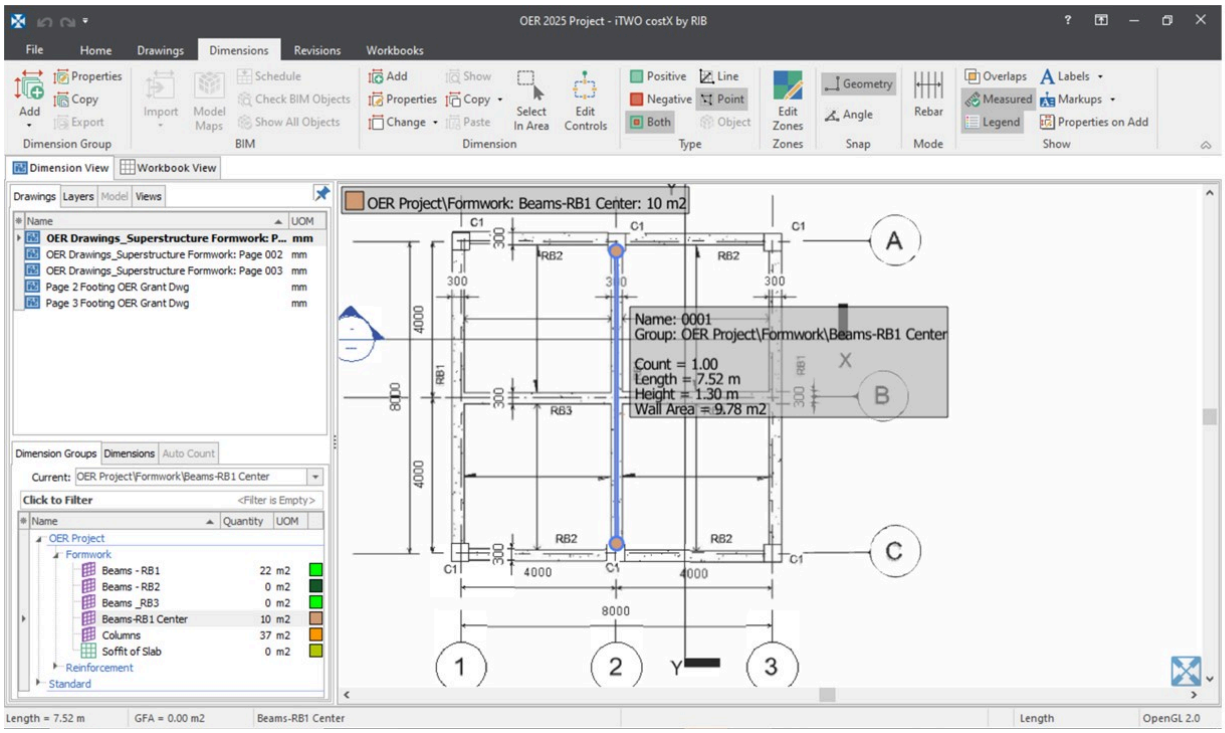


Figure 4.34: Screenshot of measuring dimensions of central beams formwork (RB1-Centre) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

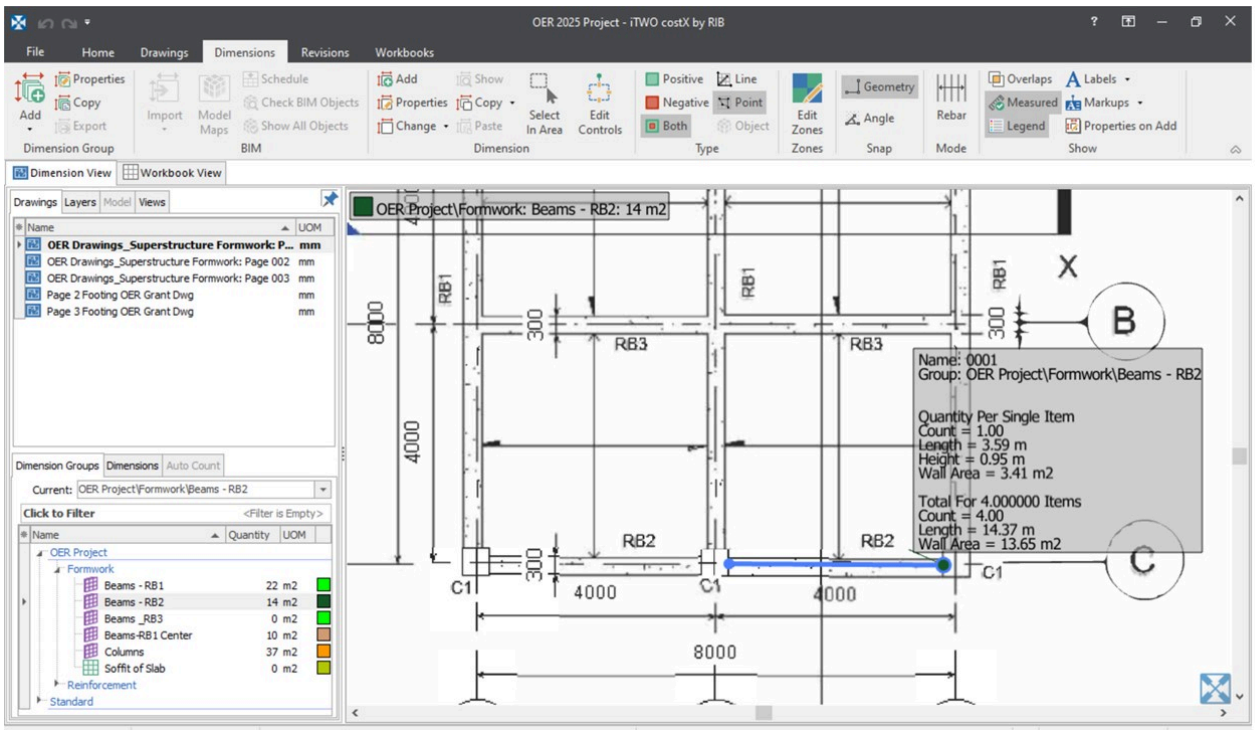


Figure 4.35: Screenshot of measuring dimensions of beams formwork (RB2) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

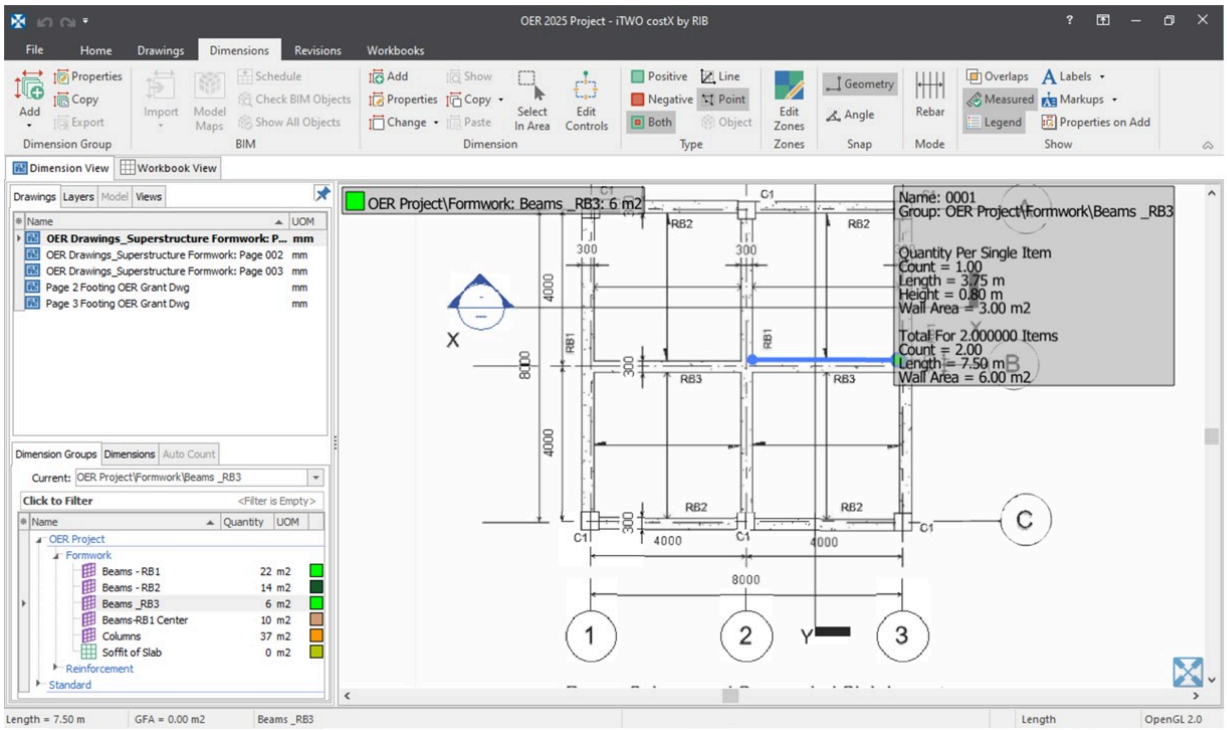


Figure 4.36: Screenshot of measuring dimensions of beams formwork (RB3) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

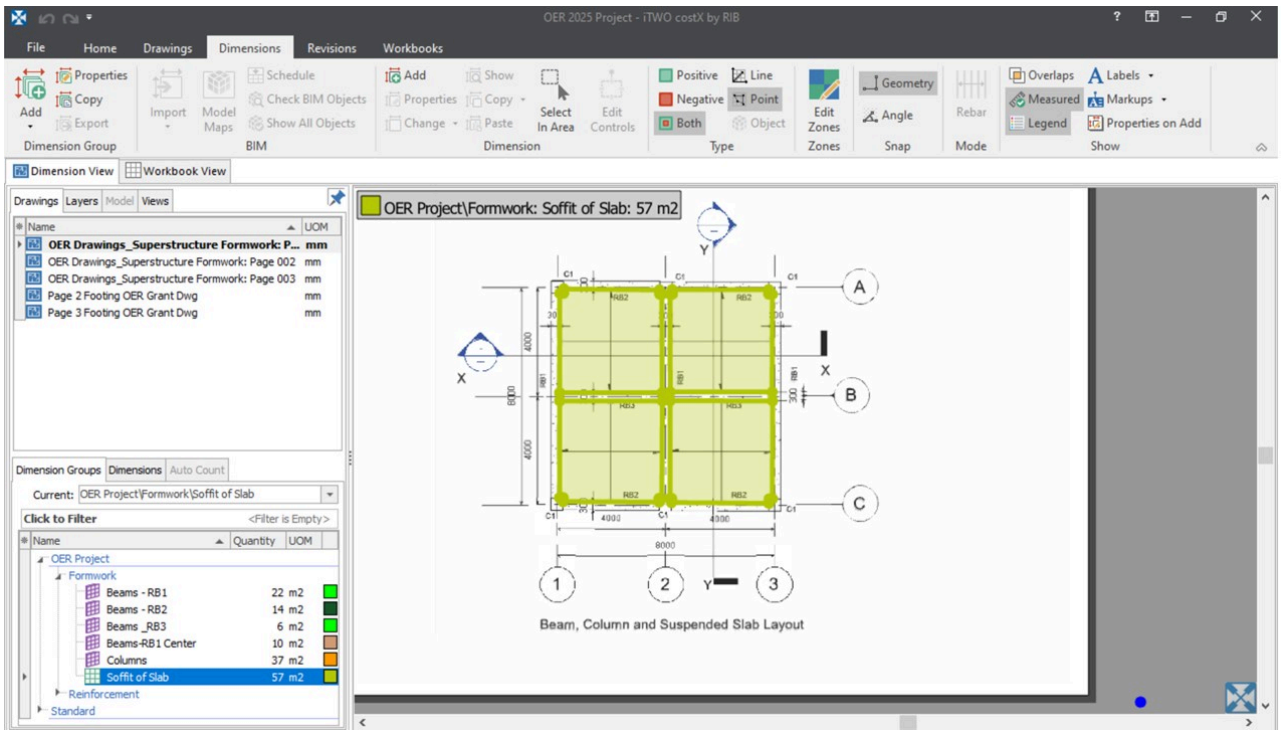


Figure 4.37: Screenshot of measuring dimensions of soffit of slab formwork using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 4: Add workbooks, transfer quantities and write descriptions (Figures 4.38 to 4.41).

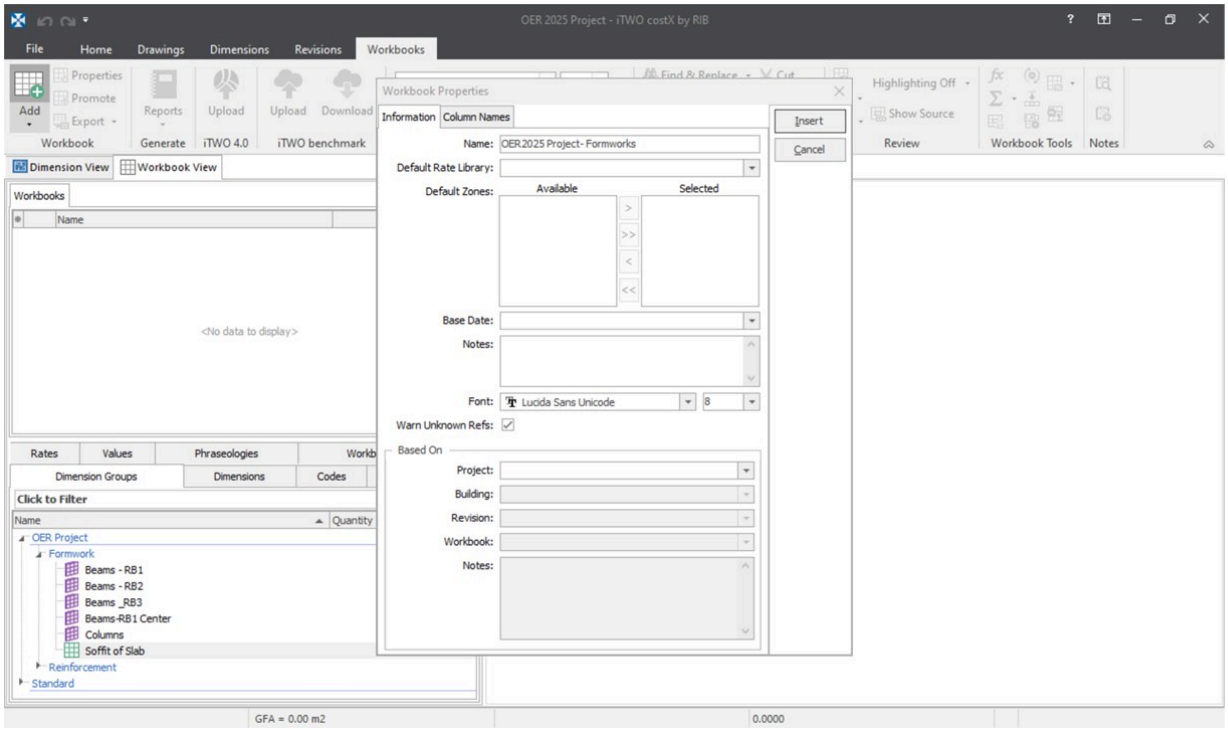


Figure 4.38: Screenshot of workbook properties and selecting a name for formworks using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

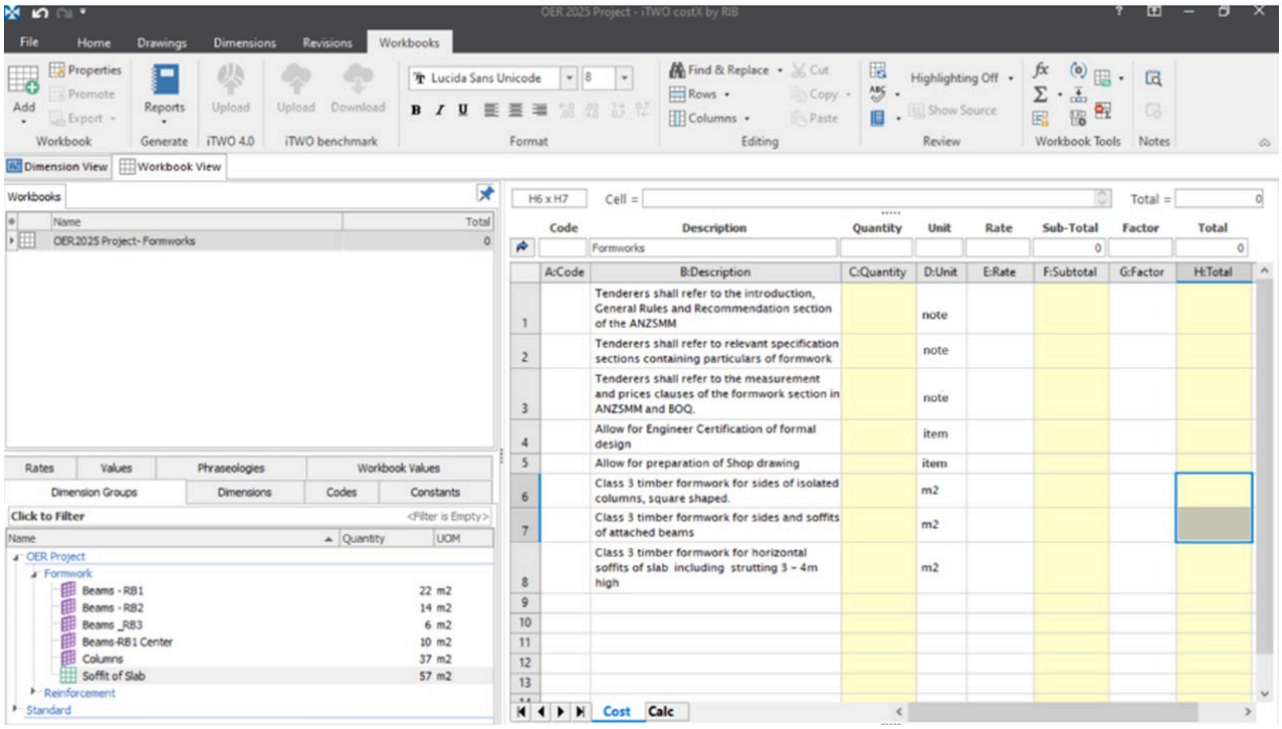


Figure 4.39: Screenshot of adding descriptions and units for formworks using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

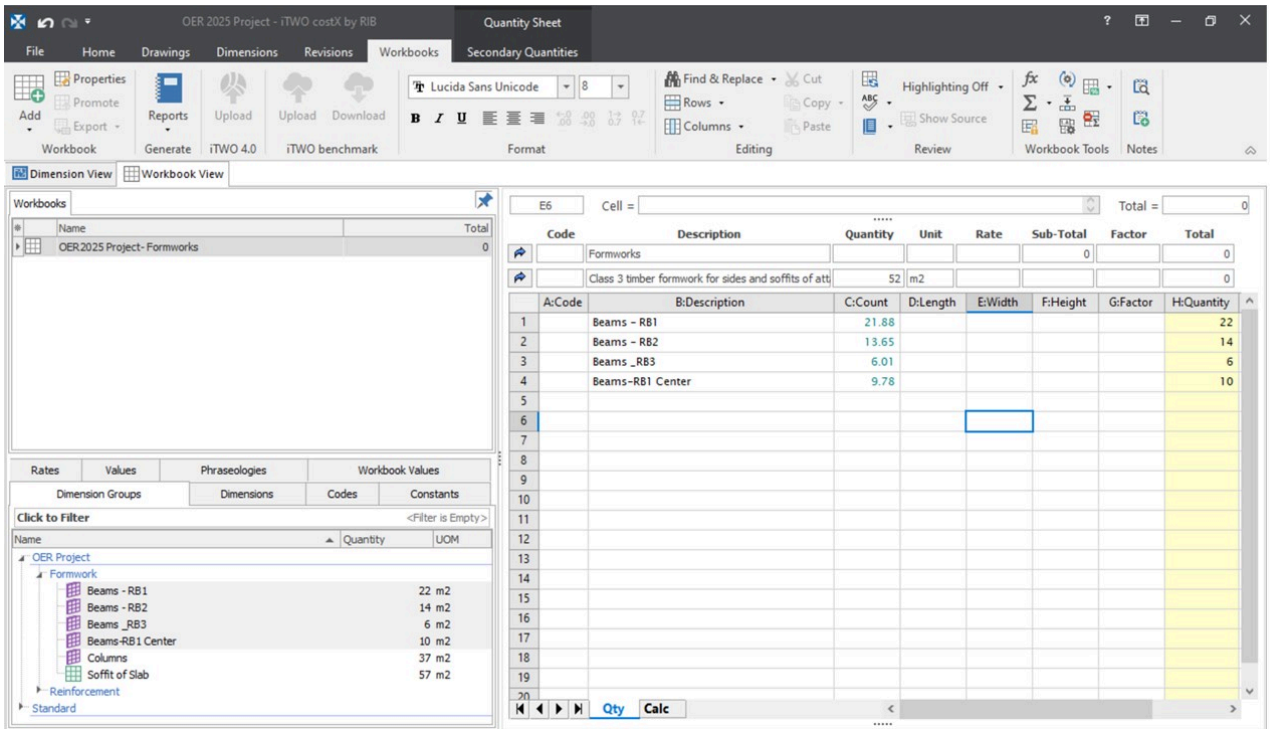


Figure 4.40: Screenshot of adding beam dimensions to second level of the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

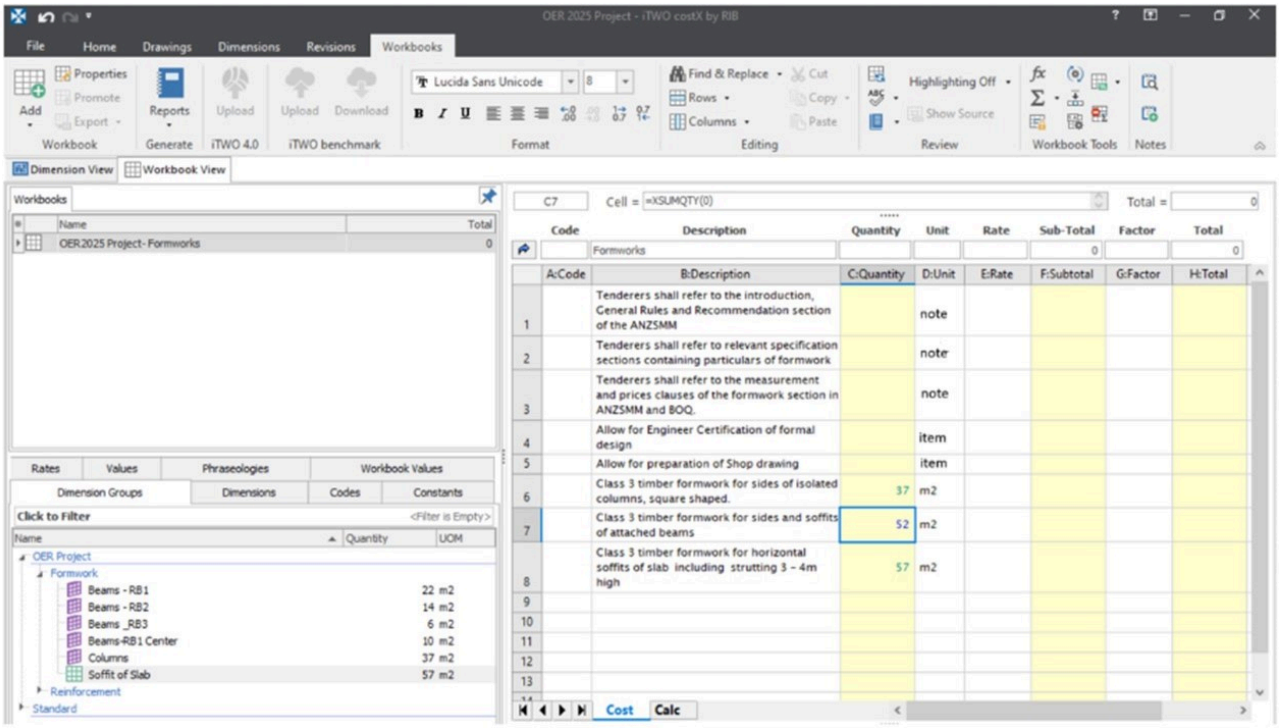


Figure 4.41: Screenshot of adding measurements to workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Generate reports (Figure 4.42 and Figure 4.43).

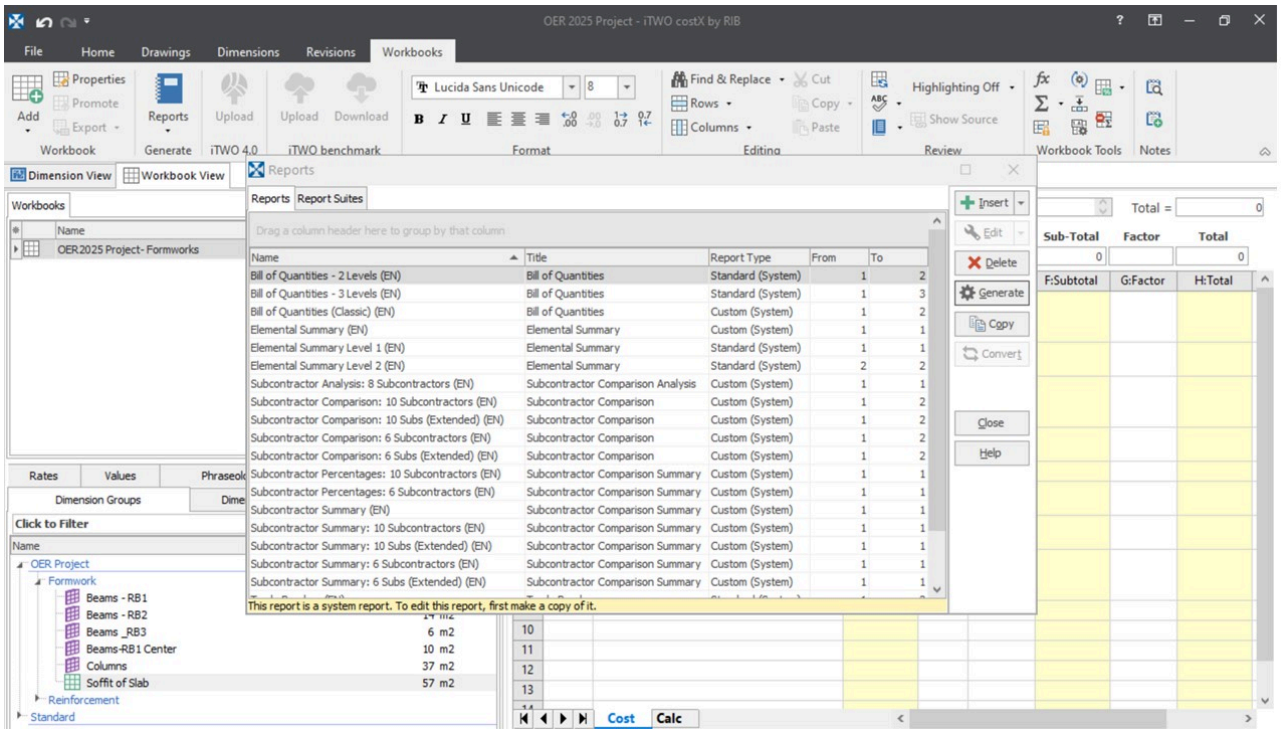
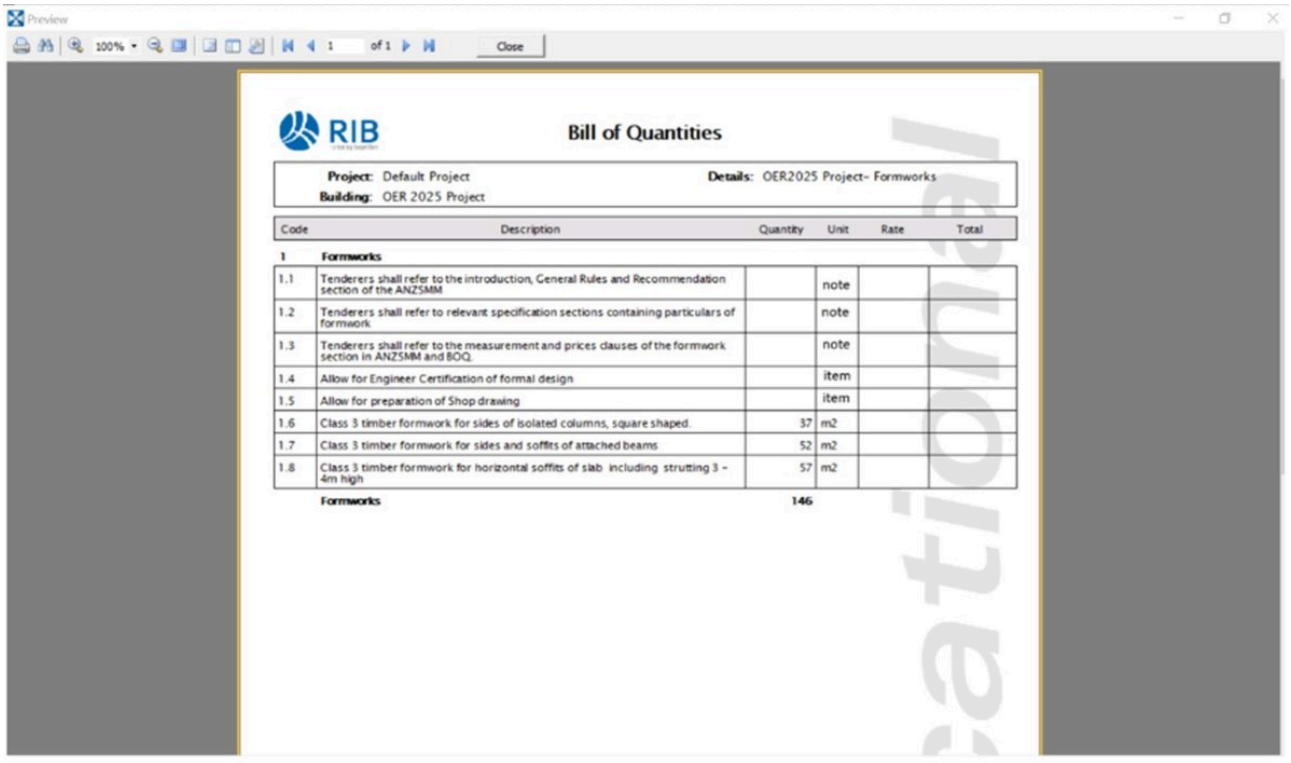


Figure 4.42: Screenshot of selecting report type using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.



RIB

Bill of Quantities

Project: Default Project
Building: OER 2025 Project
Details: OER2025 Project- Formworks

Code	Description	Quantity	Unit	Rate	Total
1	**Formworks**				
1.1	Tenderers shall refer to the introduction, General Rules and Recommendation section of the ANZSMM		note		
1.2	Tenderers shall refer to relevant specification sections containing particulars of formwork		note		
1.3	Tenderers shall refer to the measurement and prices clauses of the formwork section in ANZSMM and BOQ.		note		
1.4	Allow for Engineer Certification of formal design		item		
1.5	Allow for preparation of Shop drawing		item		
1.6	Class 3 timber formwork for sides of isolated columns, square shaped.	37	m2		
1.7	Class 3 timber formwork for sides and soffits of attached beams	52	m2		
1.8	Class 3 timber formwork for horizontal soffits of slab including strutting 3 - 4m high	57	m2		
	Formworks	**146**			

Figure 4.43: Screenshot of generated workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

CHAPTER 5: MEASUREMENT OF REINFORCEMENT

5.1 OVERVIEW

This chapter focuses on the measurement of reinforcement for pad footings, columns, and beams, detailing their technical specifications, the relevant measurement rules, and the measurement process using CostX software.

5.2 TYPES OF REINFORCEMENTS

Reinforcement is a term used in the construction industry to refer to materials, mainly steel, that are embedded in concrete to improve its tensile strength. This includes deformed and plain steel bars (without surface deformations), welded wire mesh, and other steel products. Since concrete is strong in compression but weak in tension, reinforcement is essential to prevent cracking and structural failure, ensuring concrete structures' durability and load-bearing capacity. Figure 5.1 below illustrates the stress distribution across a beam's cross-section under bending. The upper portion of the beam is subjected to compressive stresses, while the lower portion experiences tensile stresses. Therefore, steel reinforcement should be placed in the tension zone to enhance the beam's strength and prevent failure.

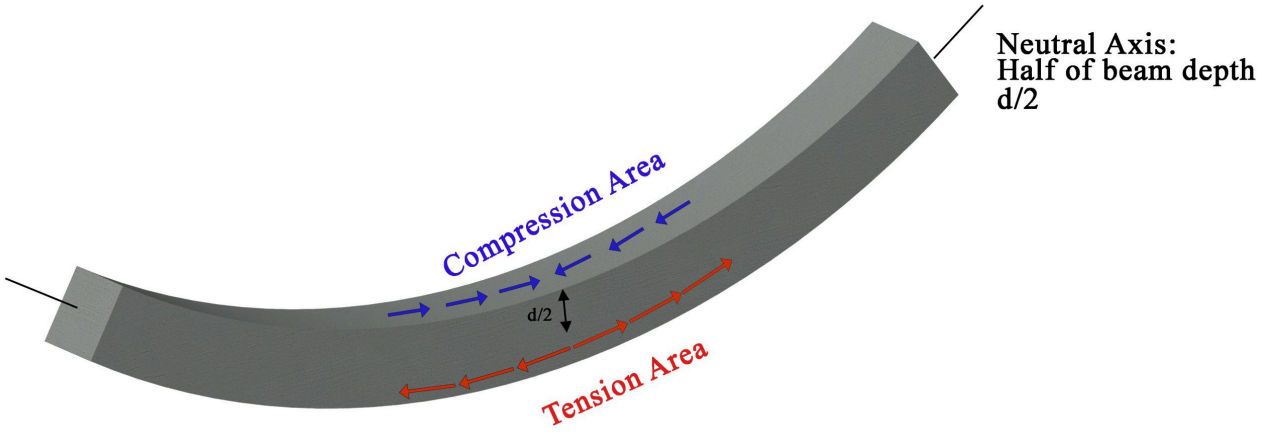


Figure 5.1: Stress distribution in a beam under bending (Source: Created by Amirreza Aminalavije)

A reinforcement bar is a steel product manufactured with dimensional tolerances to ensure consistency in construction applications. While it is typically supplied in straight lengths, it is also available in coiled form for specific uses (Figure 5.2).



Figure 5.2: Coiled reinforcement bars (Source: Created by Amirreza Aminalavije)

Reinforcing bars are identified based on both the quantity and diameter of the bars. The designation follows a standardized format, where the first number represents the total number of bars, and the subsequent number indicates the diameter of each bar in millimetres. For instance, a specification such as 6N12 denotes a set of six reinforcing bars, each with a 12 mm diameter. This notation helps in accurately specifying reinforcement requirements for structural design and construction.

Reinforcing mesh is a prefabricated steel reinforcement product used in concrete construction to enhance tensile strength. It is available in two primary forms: flat sheets and rolls. Flat sheets are manufactured with reinforcing bars up to 12 mm in diameter, while rolls are typically made with bars up to 5 mm in diameter. The typical standard sheet size for reinforcing mesh is 6 metres in length by 2.4 metres in width. The mesh is composed of reinforcing steel bars welded together in either a square or rectangular grid pattern. Depending on the structural requirements, reinforcing mesh can be supplied in two main types (Figure 5.3): square mesh and rectangular mesh. Square mesh is designated using “SL” notation, such as SL72, SL82, SL92, and SL102, while rectangular mesh is identified with “RL” notation, such as RL1218, RL1018, and RL918. The designation of these meshes is based on two factors namely (i) the diameter of each reinforcing bar and (ii) the spacing between consecutive bars. For example, SL62 is a square mesh consisting of 6 mm diameter bars arranged at 200 mm intervals in both directions, and RL1218 is a rectangular mesh consisting of 12 mm diameter bars spaced at 100 mm intervals in one direction and 8 mm diameter bars spaced at 200 mm intervals in the perpendicular direction.

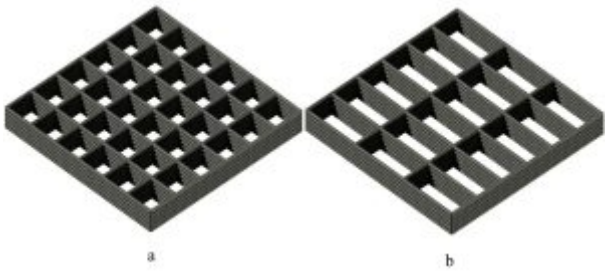


Figure 5.3: Square (a) and rectangular (b) meshes
(Source: Created by Amirreza Aminalavije)

Trench mesh (Figure 5.4 a) is a type of reinforcing mesh specifically designed for concrete footings and beams, typically manufactured in long, narrow strips to suit these applications. It is commonly used in strip footings, edge beams, and other structural elements requiring continuous reinforcement. The designation of trench mesh is based on the number of longitudinal bars and their diameter. For example, 3-L11TM consists of three longitudinal bars, each with a diameter of 11 mm, while 4-L12TM consists of four longitudinal bars, each with a diameter of 12 mm.

In addition to the longitudinal bars, ligatures (fitments) are often incorporated to separate the top and bottom layers of trench mesh in residential slabs or to assist in the fabrication of beam and column cages. These ligatures (Figure 5.4 b) help maintain the correct positioning of reinforcement within the concrete, ensuring structural integrity and compliance with engineering specifications.

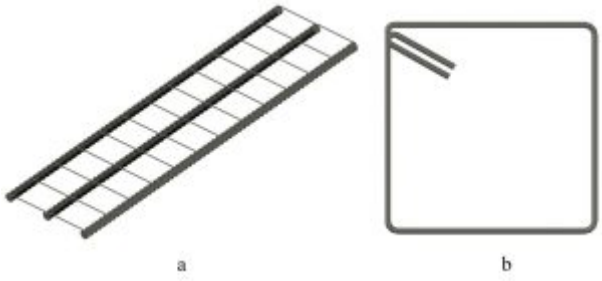


Figure 5.4: Ligature (Source: Created by Amirreza Aminalavije)

5.3 REINFORCEMENT MEASUREMENT RULES

The measurement rules for reinforcement are outlined in Section 8 of the ANZSMM, which provides standardized guidelines for quantifying reinforcement works in construction projects. The preamble notes and preamble items for reinforcement serve as key references for tenderers and quantity surveyors. The preamble notes direct tenderers to relevant specification sections containing reinforcement details such as material properties, fabrication, and installation requirements. The preamble item is typically given for bending schedules where not supplied free to the builder, and these schedules must state quantities of all reinforcement. This preamble item allows for an allowance (cost) to be made for the preparation of bending schedules, ensuring accurate documentation of reinforcement quantities, particularly when they are not provided to the builder at no additional cost.

Reinforcement bars are typically measured by weight and expressed in tonnes (t). Fabric reinforcement is measured by area and expressed in square metres (m^2). Trench mesh, on the other hand, is measured by length and expressed in linear metres (m). For a comprehensive understanding of the detailed measurement rules, pricing methods, and definitions, readers are encouraged to refer directly to Section 8 of the ANZSMM.

When writing descriptions for reinforcement bars, for instance, the type and size of the bars must be clearly specified. In addition to the guidance provided in the ANZSMM, descriptions should reference the specification notes issued by the structural engineer. For example, a typical description for reinforcement in pad footings might read:

"Provide 20 mm diameter deformed mild steel reinforcement bars to AS 1302 in pad footings."

For a more comprehensive understanding of the measurement procedures, pricing, and definitions, the authors encourage readers to refer Section 8 of the ANZSMM.

5.4 MEASUREMENT PROCESS FOR REINFORCEMENT USING COSTX SOFTWARE

When calculating the total length of reinforcement bars, it is important to account for the concrete cover (cc) as shown in Figure 5.5. In addition, you must allow for the inclusion of hooks or cogs (refer to Figure 5.6) where applicable. If the details of hooks or cogs are not clearly specified on the structural drawings or in the project specifications, then the minimum requirements set out in relevant Australian Standards, such as AS3600 (Concrete Structures), should be used during the measurement process.

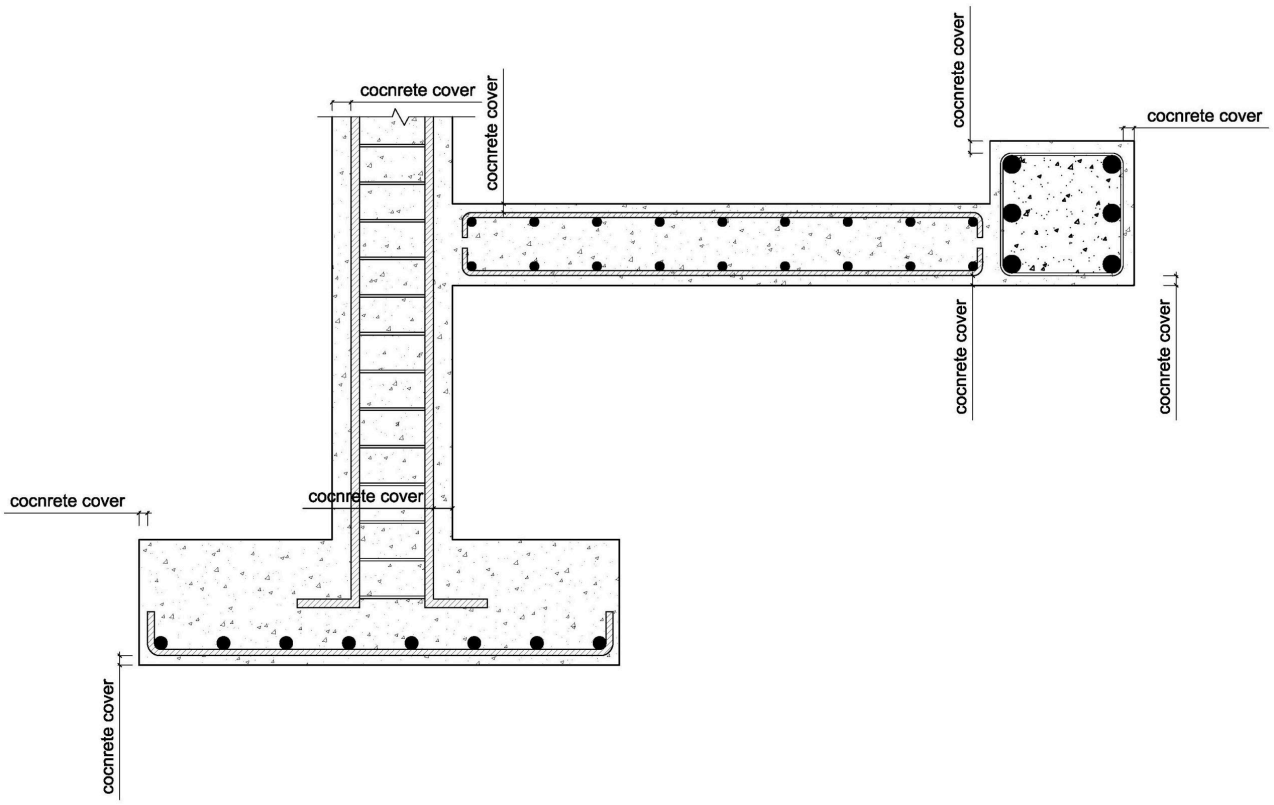


Figure 5.5: Concrete cover (Source: Created by Amirreza Aminalavije)

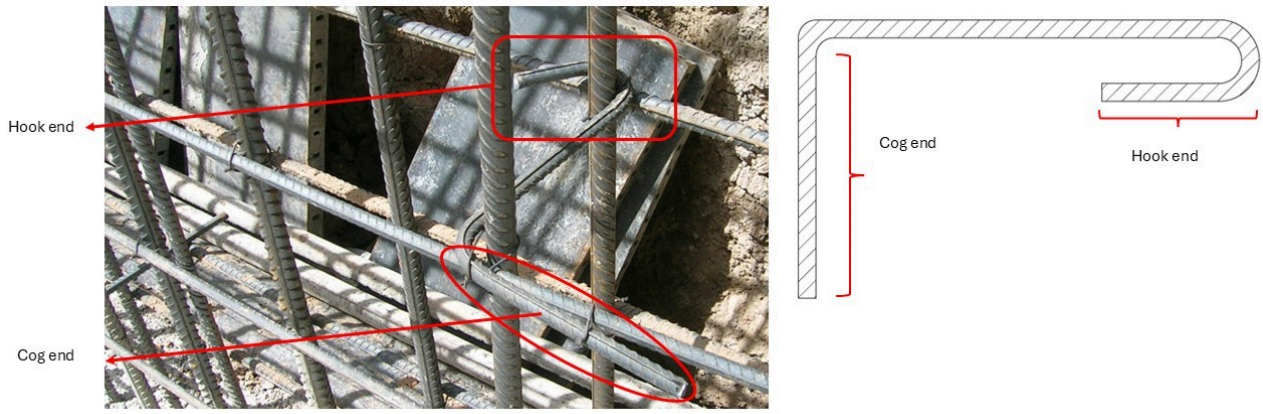


Figure 5.6: Hook and cog ends (Source: Created by Amirreza Aminalavije)

The following steps are typically followed to determine the quantity of reinforcement bars required for a construction project:

Step 1: Calculate the total length of reinforcement bars

- Determine the total length by multiplying the number of bars by the length of each bar.
- Total length of bars (m) = Number of bars × Length of each bar

Step 2: Obtain the unit weight of the bar

- Refer to Table 5.1 below to find the mass per unit length (in kg/m) for the specific diameter of the reinforcement bar being used. These values are based on standard steel bar sizes. Alternatively, you can calculate the weight per meter using the formula:
- Unit weight (kg/m) = (Diameter in mm) ^{2} ÷ 162

Step 3: Calculate the total weight in kilograms

- Multiply the total length of the bars (from Step 1) by the unit weight (from Step 2).
- Weight (kg) = Total length of bars (m) × Unit weight (kg/m)

Step 4: Convert the weight from kilograms to tonnes

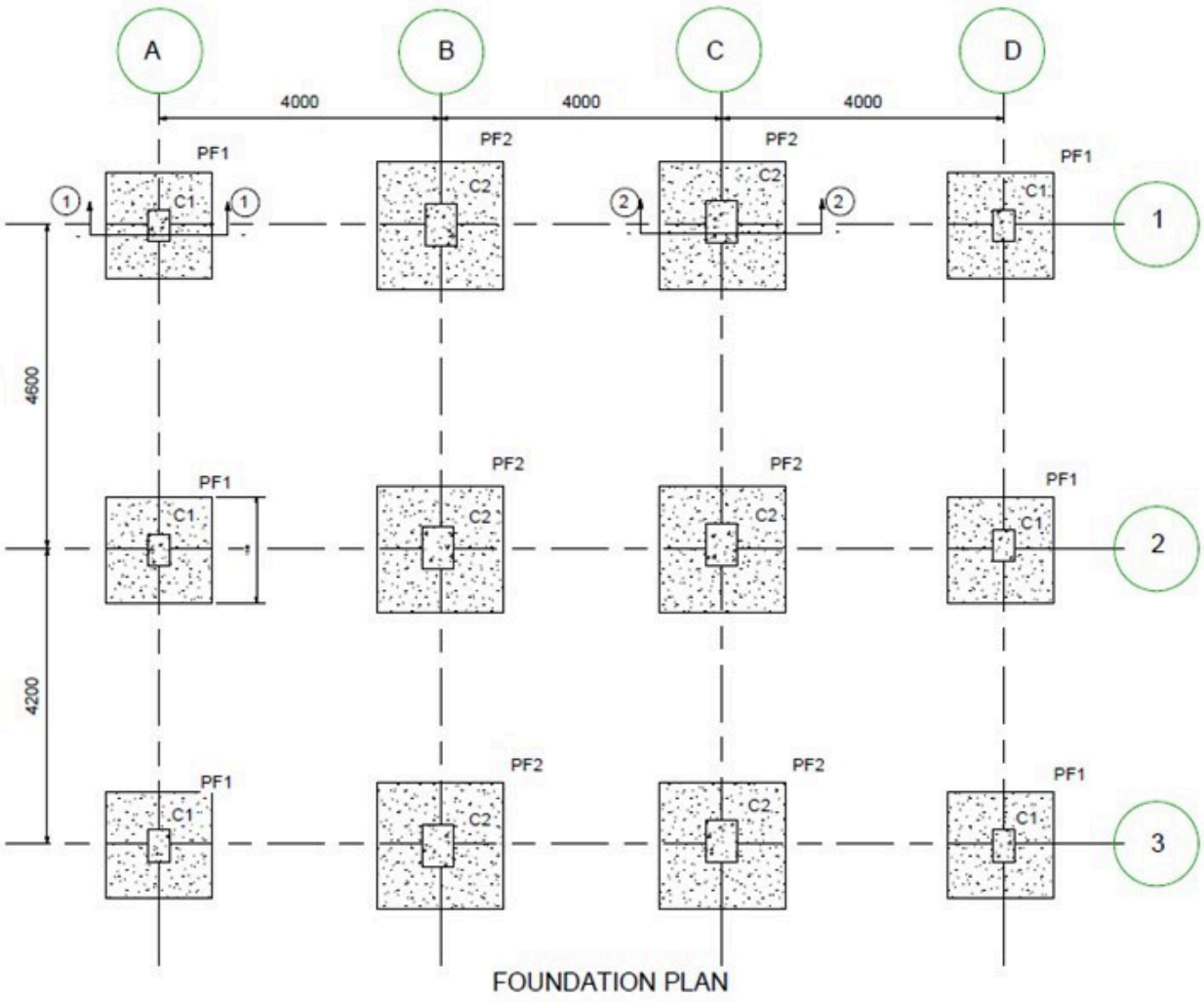
- Finally, convert the total weight from kilograms to tonnes by dividing the weight in kg (Step 3) by 1,000.
- Weight (tonnes) = Weight (kg) ÷ 1,000

Table 5.1: Mass per meter length of reinforcing steel (Source: Created by Authors)

Nominal Diameter (mm)	Mass per meter linear (kg/m)	Nominal Diameter (mm)	Mass per meter linear (kg/m)
6	0.222	20	2.469
8	0.395	24	3.556
10	0.617	28	4.840
12	0.889	32	6.321
14	1.210	36	8.000
16	1.580	40	9.887

5.4.1 Computer-based measurement of reinforcement for pad footings

Based on the drawings provided below (Figures 5.7 to 5.9), perform a digital quantity take-off for the reinforcement bars in the pad footings. Using the measured quantities, prepare a detailed BQ using iTWO CostX software.



PAD FOOTING SCHEDULE

MARK	DIMENSIONS LENGTH	WIDTH	DEPTH	REINFORCEMENT X-BARS	Y-BARS
PF1	1500	1500	450	N16-200 Bottom	N16-200 Bottom
PF2	1800	1800	450	N20-200 Top & Bottom	N20-200 Top & Bottom

Figure 5.7: Foundation plan (Source: Created by Authors)

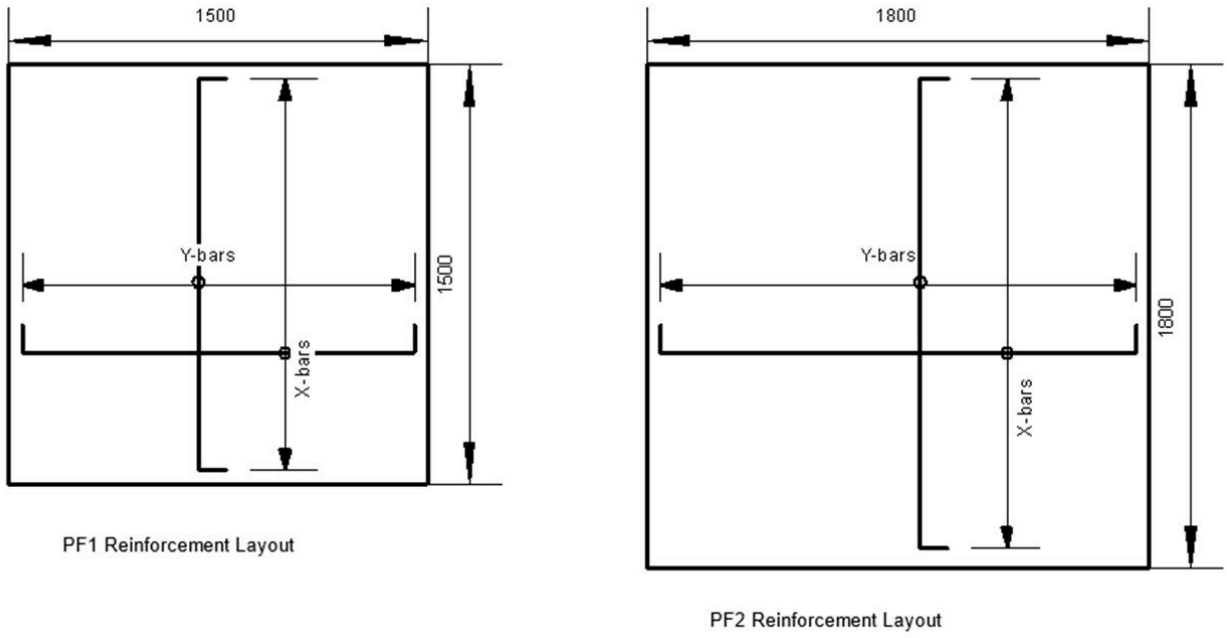


Figure 5.8: Reinforcement layouts (Source: Created by Authors)



Figure 5.9: Sections (Source: Created by Authors)

The following steps show how to measure pad footing reinforcement bars:

Step 1: Add the drawings and calibrate X and Y axis (Figures 5.10 and 5.11).

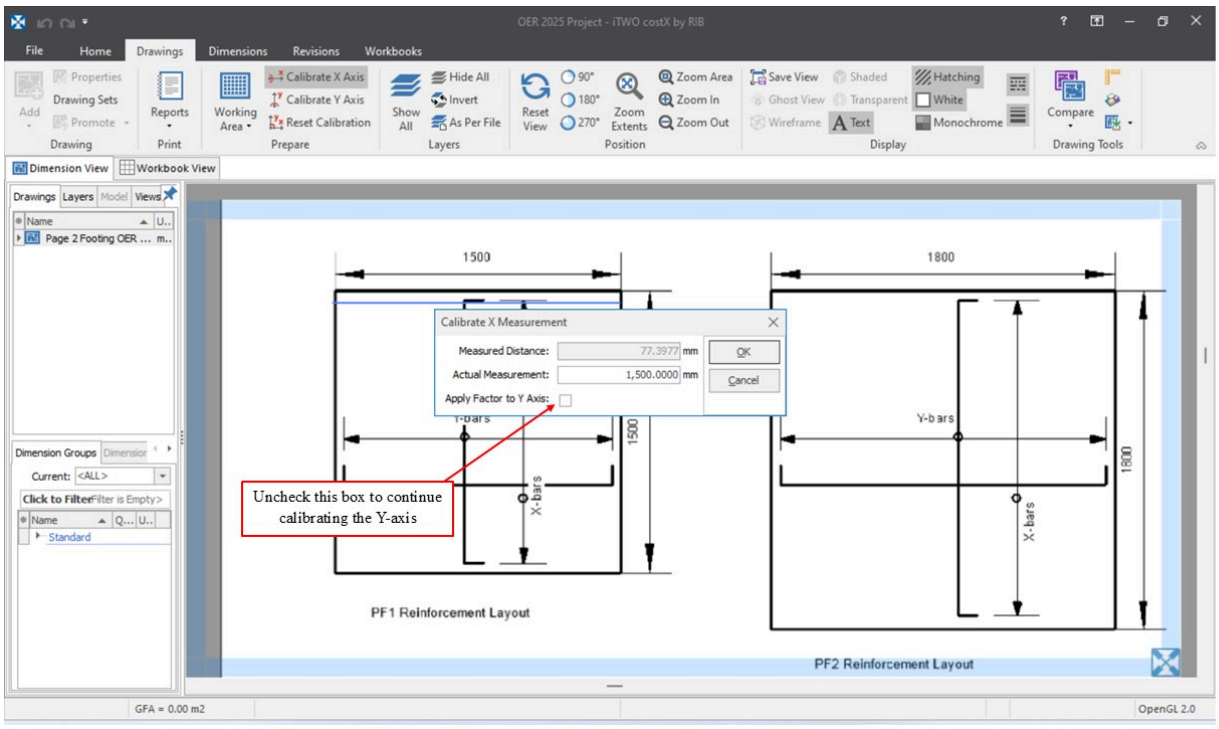


Figure 5.10: Screenshot of calibrating X axis for reinforcement measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

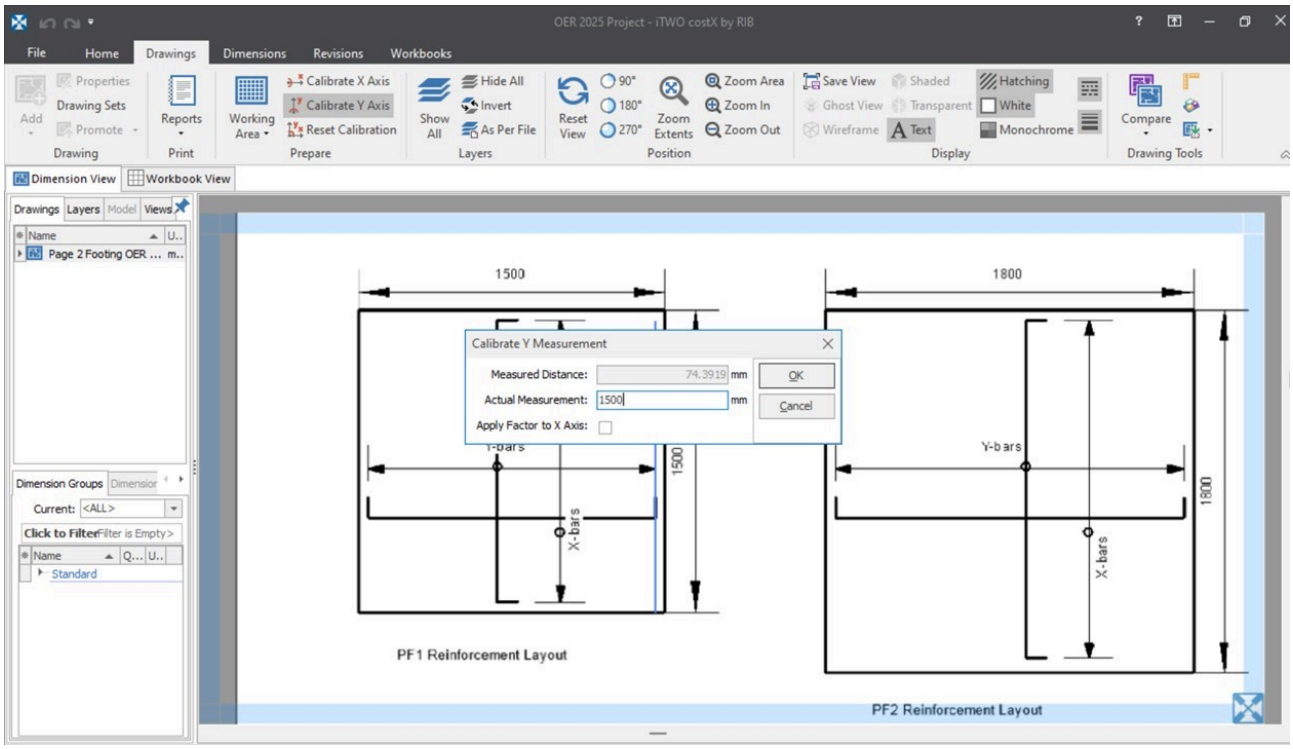


Figure 5.11: Screenshot of calibrating Y axis for reinforcement measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The calibration can be checked by remeasuring the distance between two known points on the calibrated drawing as follows (Figure 5.12).

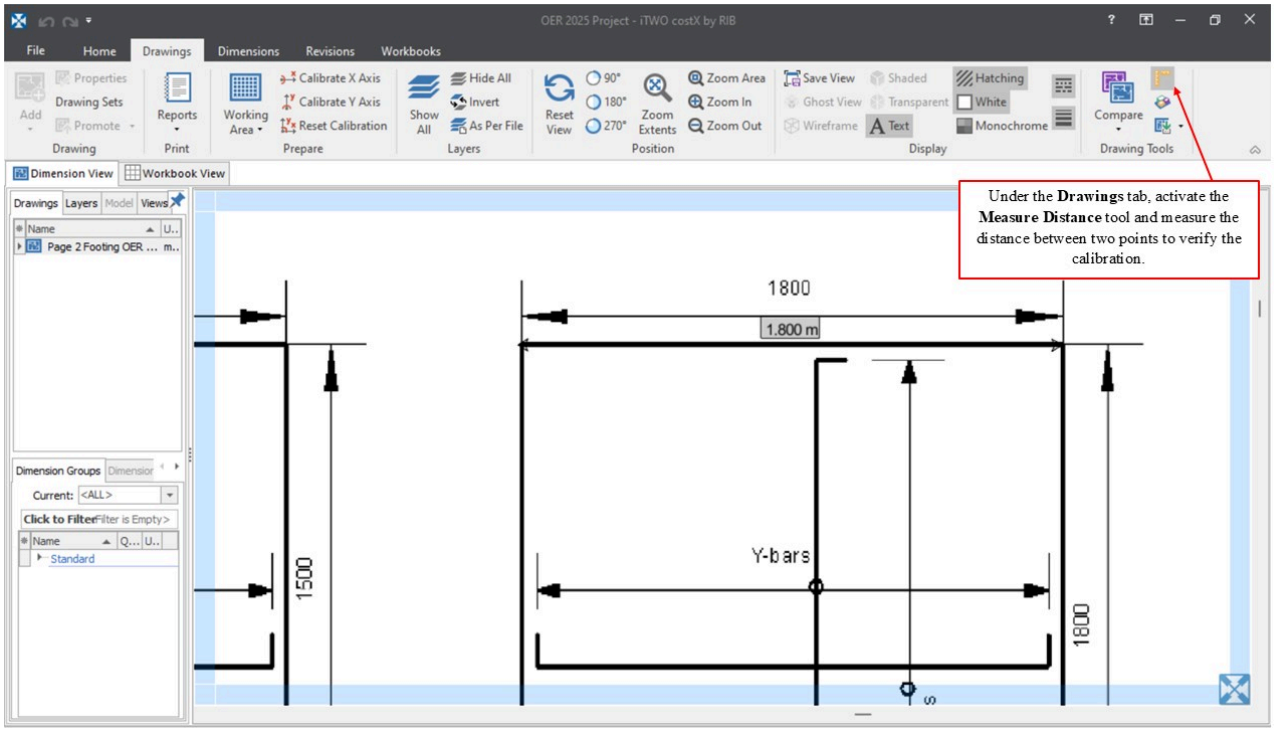


Figure 5.12: Screenshot of verifying calibration using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 2: Add dimension groups (Figures 5.13 to 5.16).

- *Dimension group for X-bars for PF1*

"Default Multiplier" = 6 pad footings (PF1) × 1 layer of reinforcement (bottom layers of reinforcement for each footing) = 6

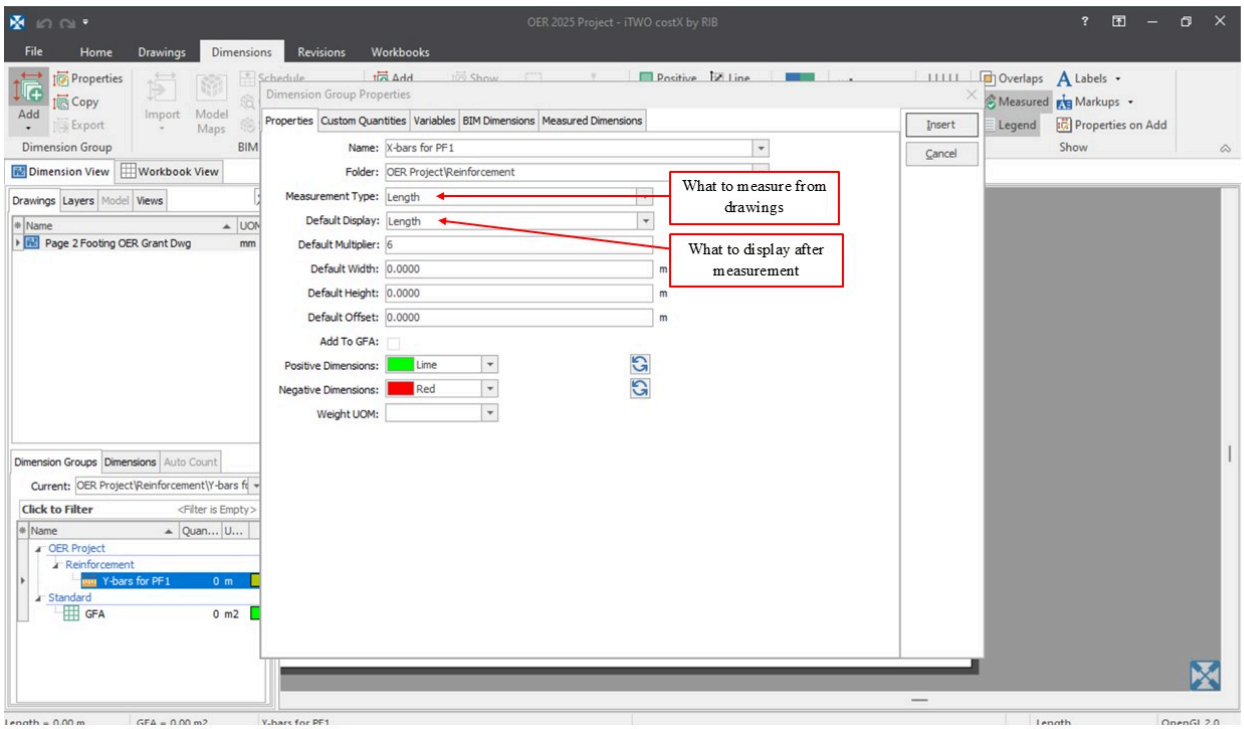


Figure 5.13: Screenshot of creating a dimension group for X bars of PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- *Dimension group for Y-bars for PF1*

"Default Multiplier" = 6 pad footings (PF1) × 1 layer of reinforcement (bottom layers of reinforcement for each footing) = 6

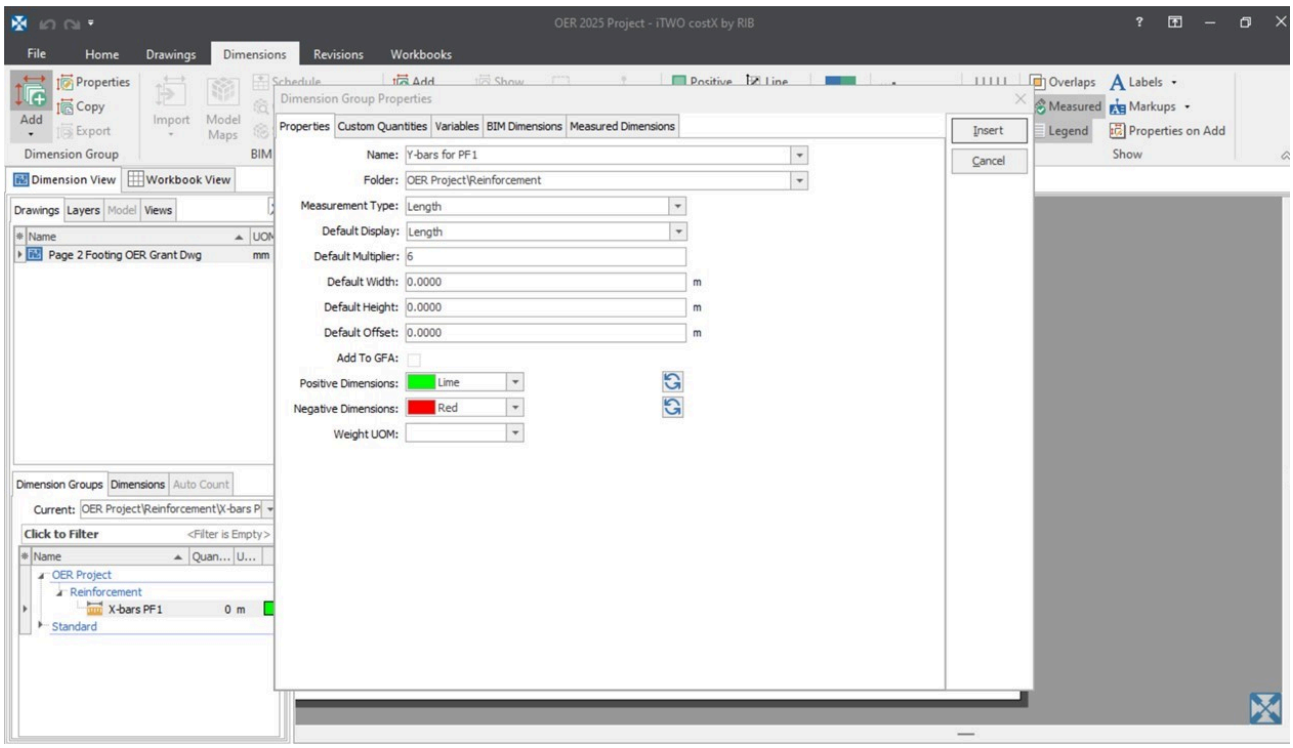


Figure 5.14: Screenshot of creating a dimension group for Y bars of PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- *Dimension group for X-bars for PF2*

"Default Multiplier" = 6 pad footings (PF2) × 2 layer of reinforcement (top and bottom layers of reinforcement for each footing) = 12

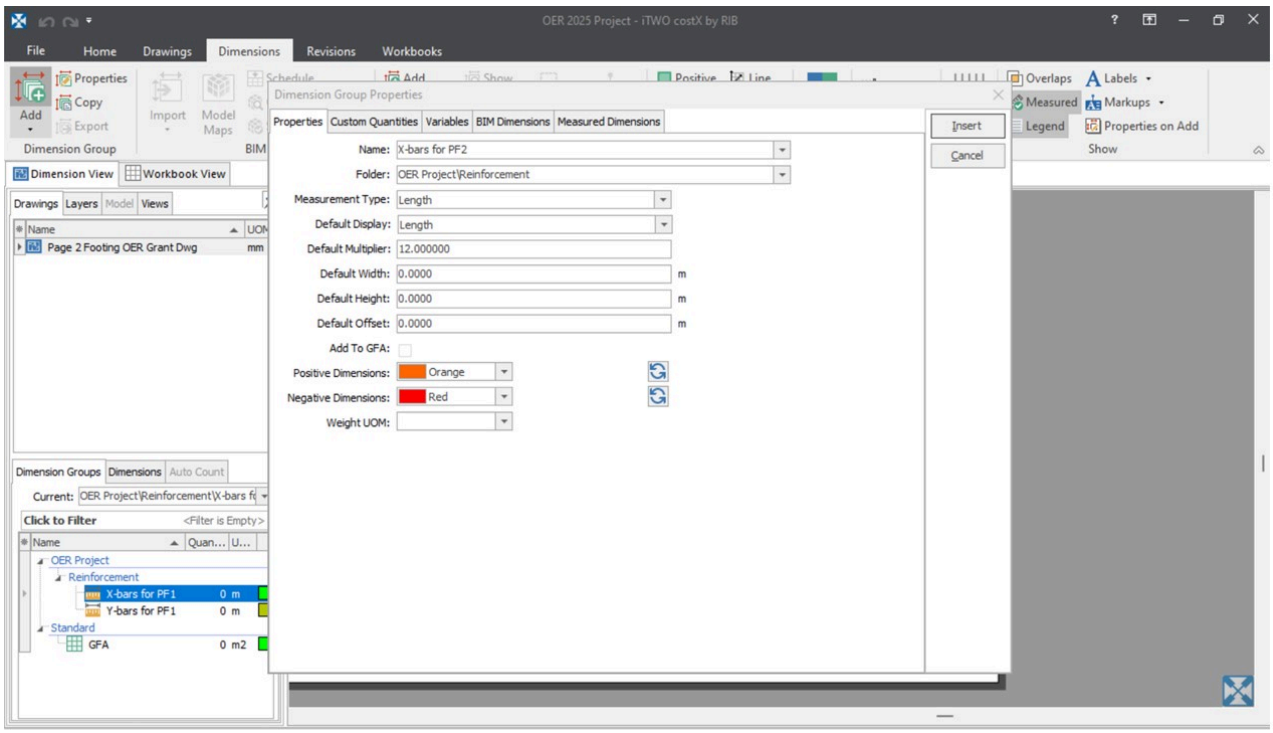


Figure 5.15: Screenshot of creating a dimension group for X bars of PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- *Dimension group for Y-bars for PF2*

"Default Multiplier" = 6 pad footings (PF2) × 2 layer of reinforcement (top and bottom layers of reinforcement for each footing) = 12

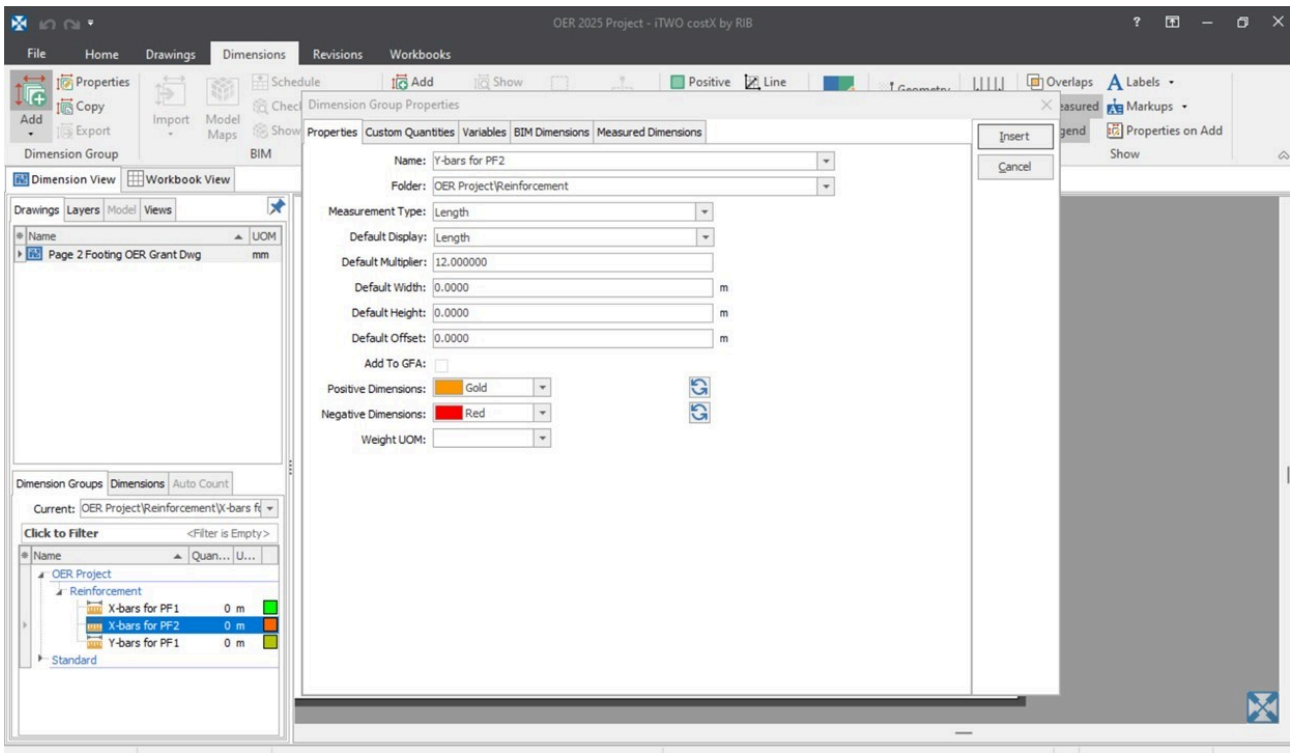


Figure 5.16: Screenshot of creating a dimension group for Y bars of PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Measure bars (Figures 5.17 to 5.20).

- *Measure X-bars for PF1 (Figures 5.17 and 5.18)*

To measure reinforcement bars, first activate the "Rebar" tool. Set the bar spacing to 200 mm (0.2 m), as specified in the Pad Footing Schedule on the drawing. For example, 'PF1 N16-200 Bottom' indicates that 16 mm diameter bars are placed at 200 mm centres at the bottom of the pad footing. Next, account for the additional bar length required for cogs (bends) at each end. Each bar includes two 350 mm bends, totalling 700 mm (0.7 m). This extra length can be measured from Section 1-1 of the drawing (Figure 5.17) and should be checked against the minimum requirements in the Australian Standard (AS3600).

Alternatively, the cog length can be calculated by deducting the concrete cover from the overall depth of the footing. In this case, the depth of the pad footing is 450 mm, and the concrete cover is 50 mm at both the top and bottom. Subtracting these values gives a cog length of 350 mm (i.e. 450 mm – 50 mm – 50 mm). According to AS3600-2009, the minimum required cog length for a 16 mm diameter bar is 220 mm, so the calculated 350 mm length meets the standard.

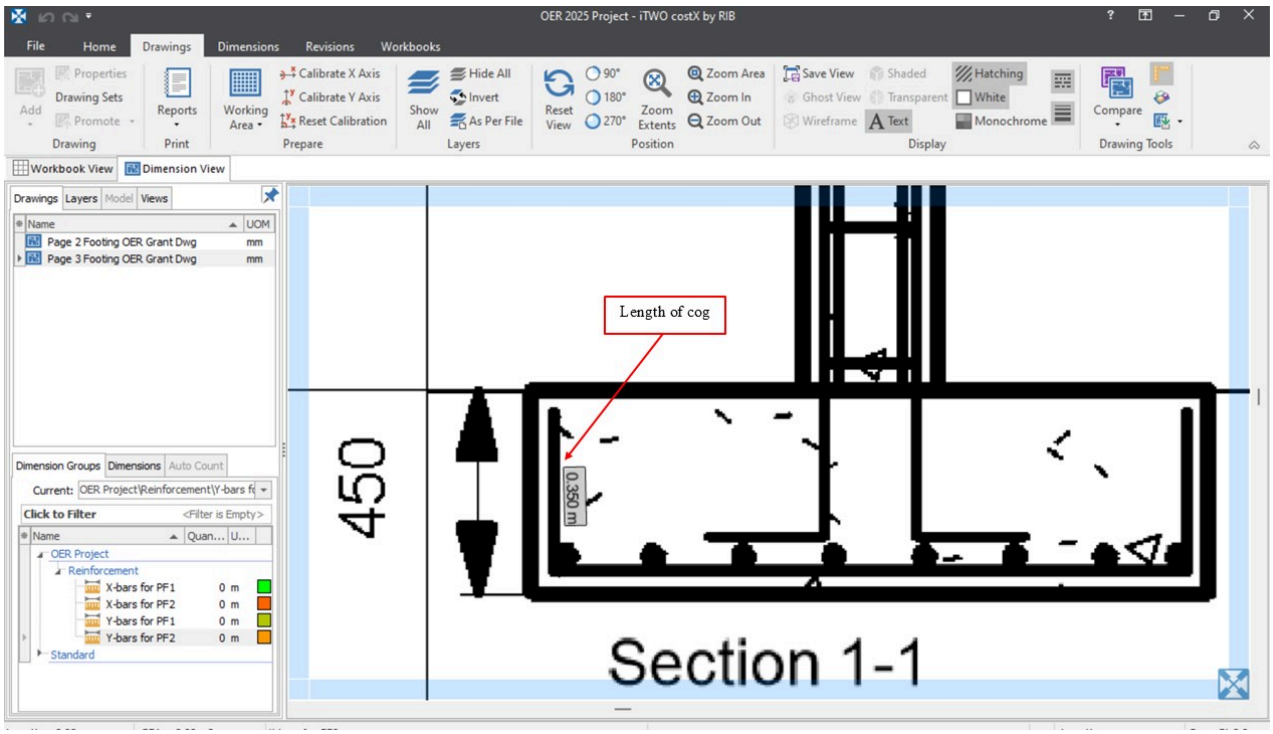


Figure 5.17: Screenshot of calculating length of the cog for PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

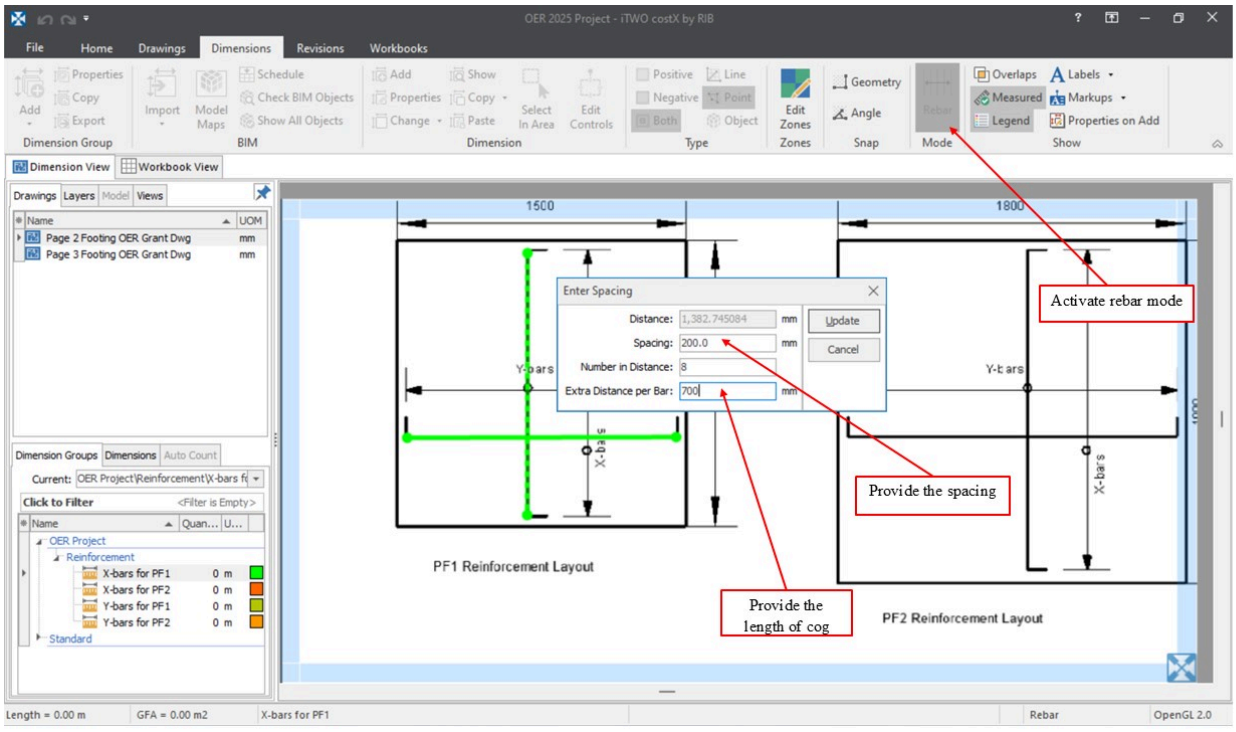


Figure 5.18: Screenshot of measuring length of X bars of PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- *Measure Y-bars for PF1 (Figure 5.19)*

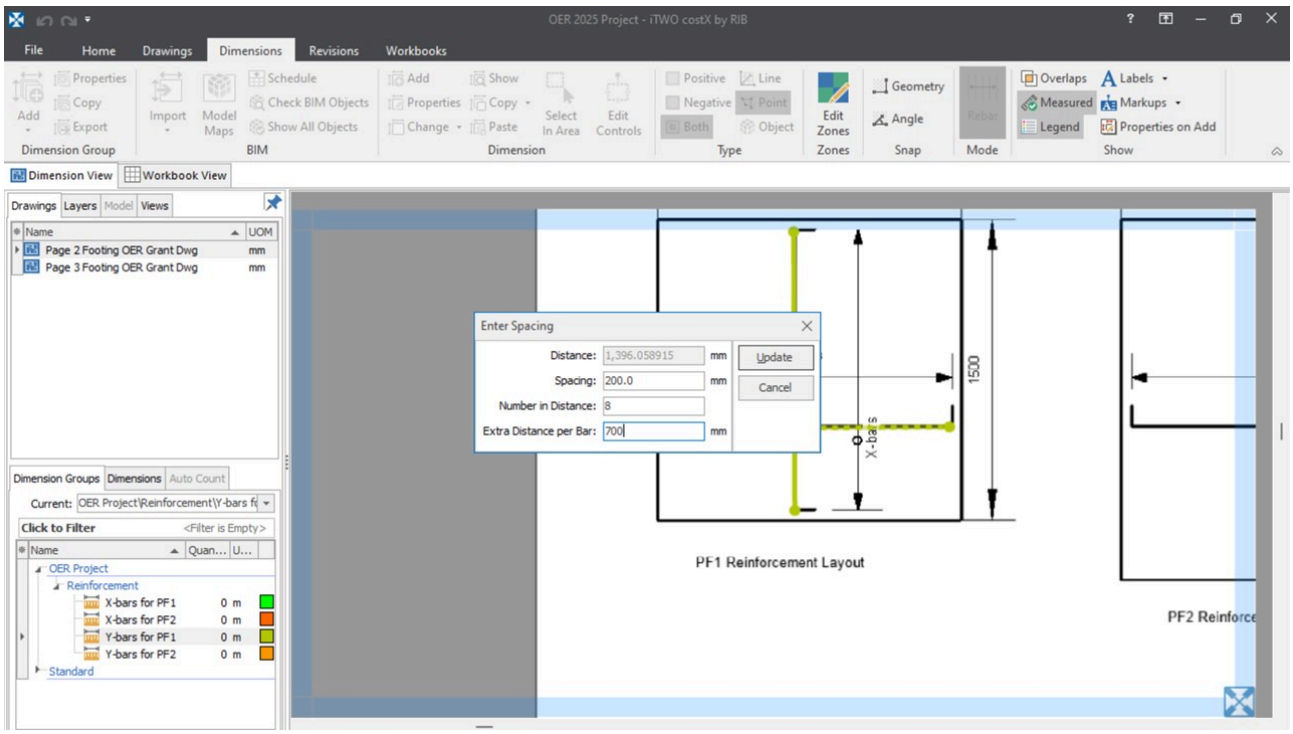


Figure 5.19: Screenshot of measuring length of Y bars of PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

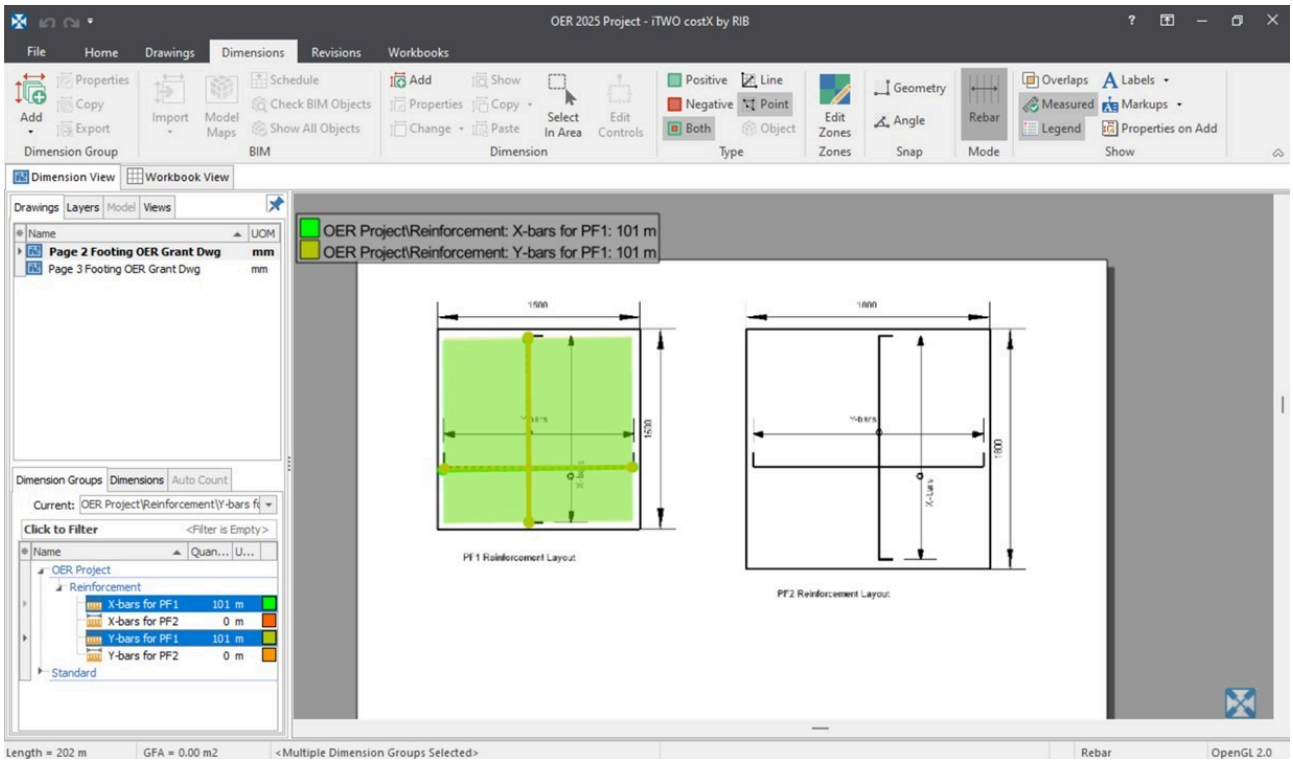


Figure 5.20: Screenshot of markups for X and Y bars of PF1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- *Measure X-bars for PF2 (Figures 5.21 and 5.22)*

The additional bar length required for cogs (bends) at each end includes two 350 mm bends, totalling 700 mm (0.7 m). This extra length can be measured from Section 2-2 of the drawing and should be checked against the minimum requirements in the Australian Standard (AS3600).

Alternatively, the cog length can be calculated by deducting the concrete cover from the overall depth of the footing. In this case, the depth of the pad footing is 450 mm, and the concrete cover is 50 mm at both the top and bottom. Subtracting these values gives a cog length of 350 mm (i.e. 450 mm – 50 mm – 50 mm). According to AS3600-2009, the minimum required cog length for a 20 mm diameter bar is 260 mm, so the calculated 350 mm length meets the standard.

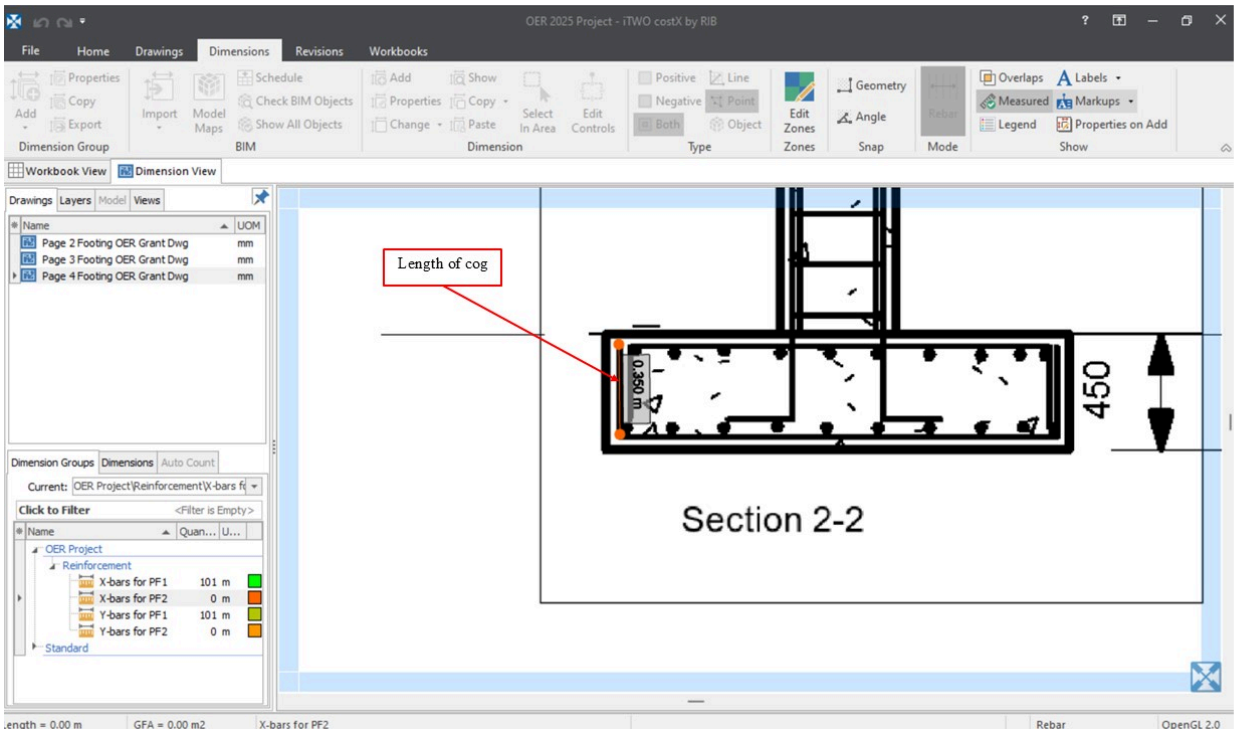


Figure 5.21: Screenshot of calculating length of the cog for PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

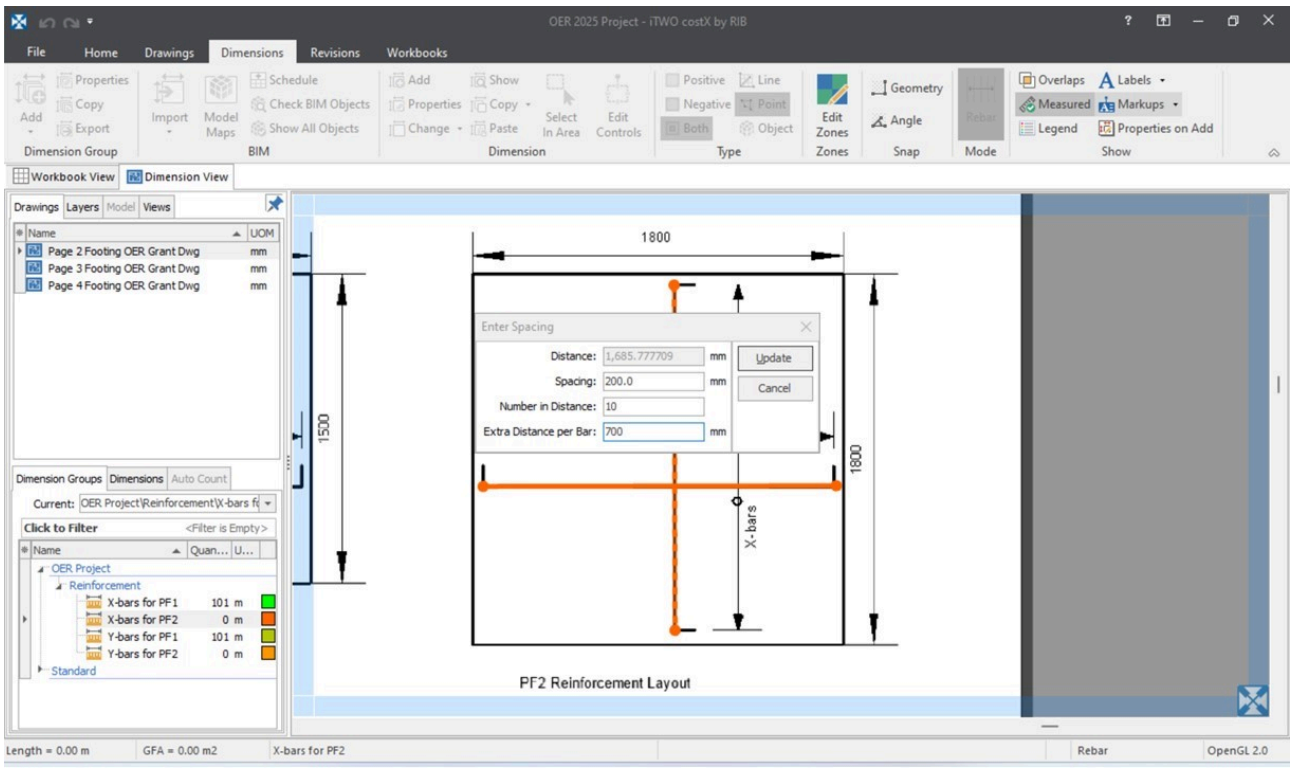


Figure 5.22: Screenshot of measuring length of X bars of PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- *Measure Y-bars for PF2 (Figure 5.23 and 5.24)*

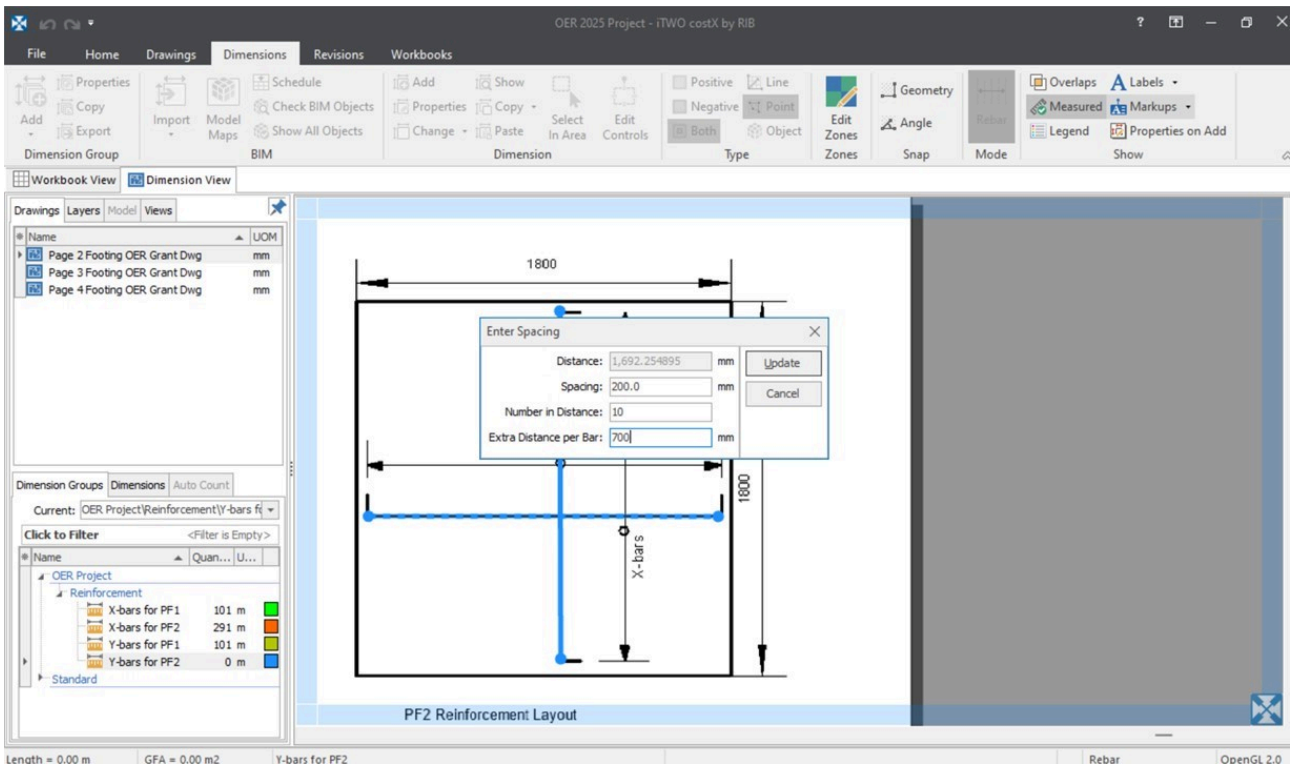


Figure 5.23: Screenshot of measuring length of Y bars of PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

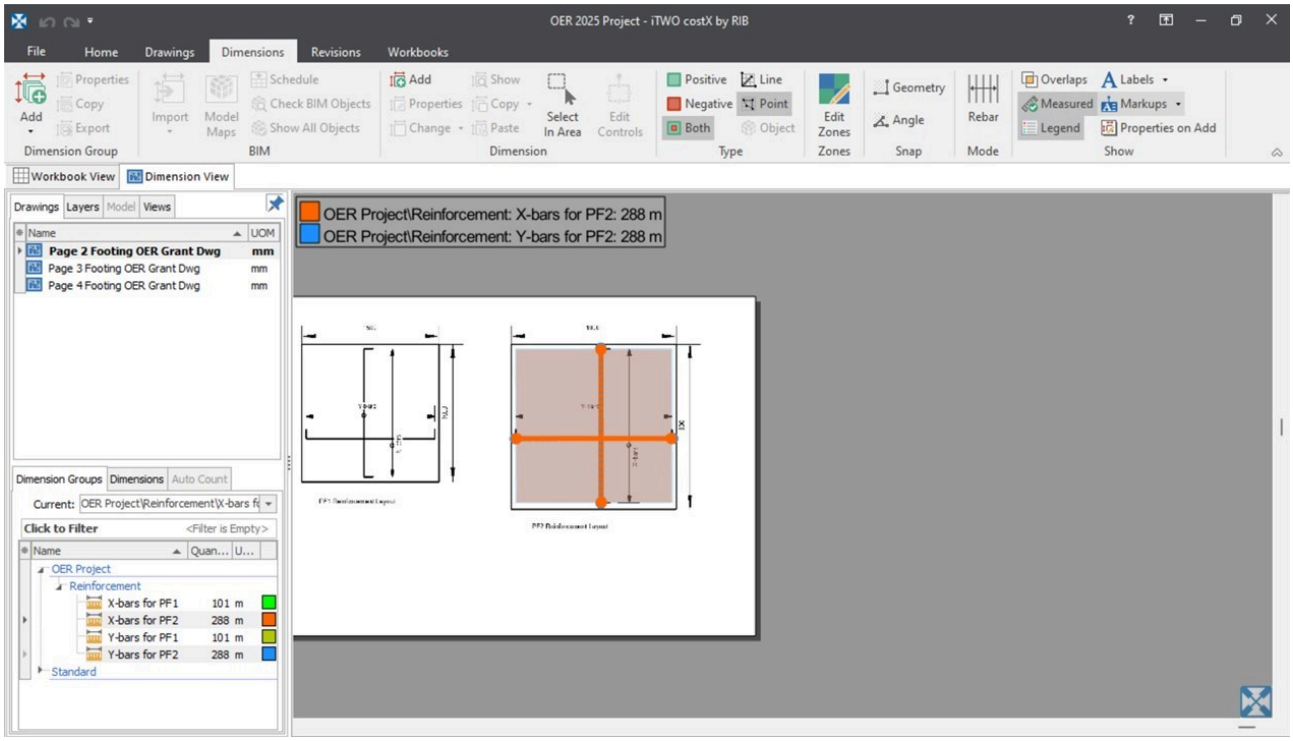


Figure 5.24: Screenshot of markups for X and Y bars of PF2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 4: Add workbooks, transfer quantities and write descriptions (Figures 5.25 to 5.28).

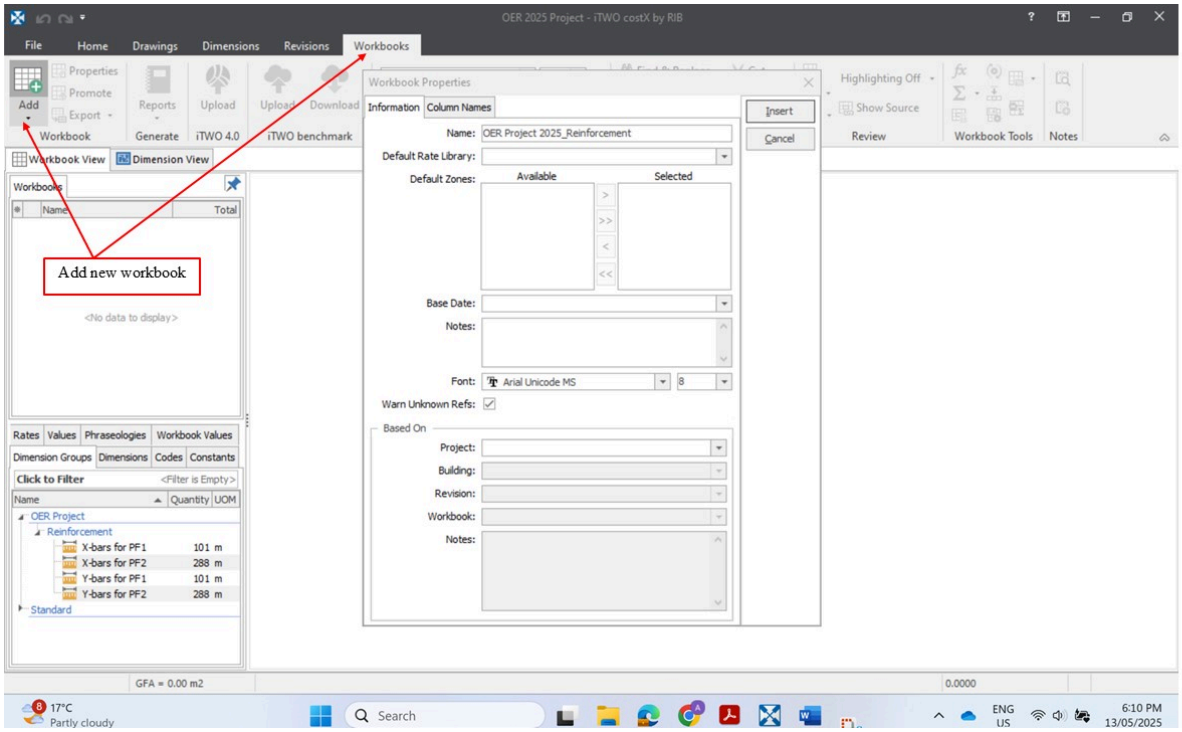


Figure 5.25: Screenshot of workbook properties and selecting a name for pad footing reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

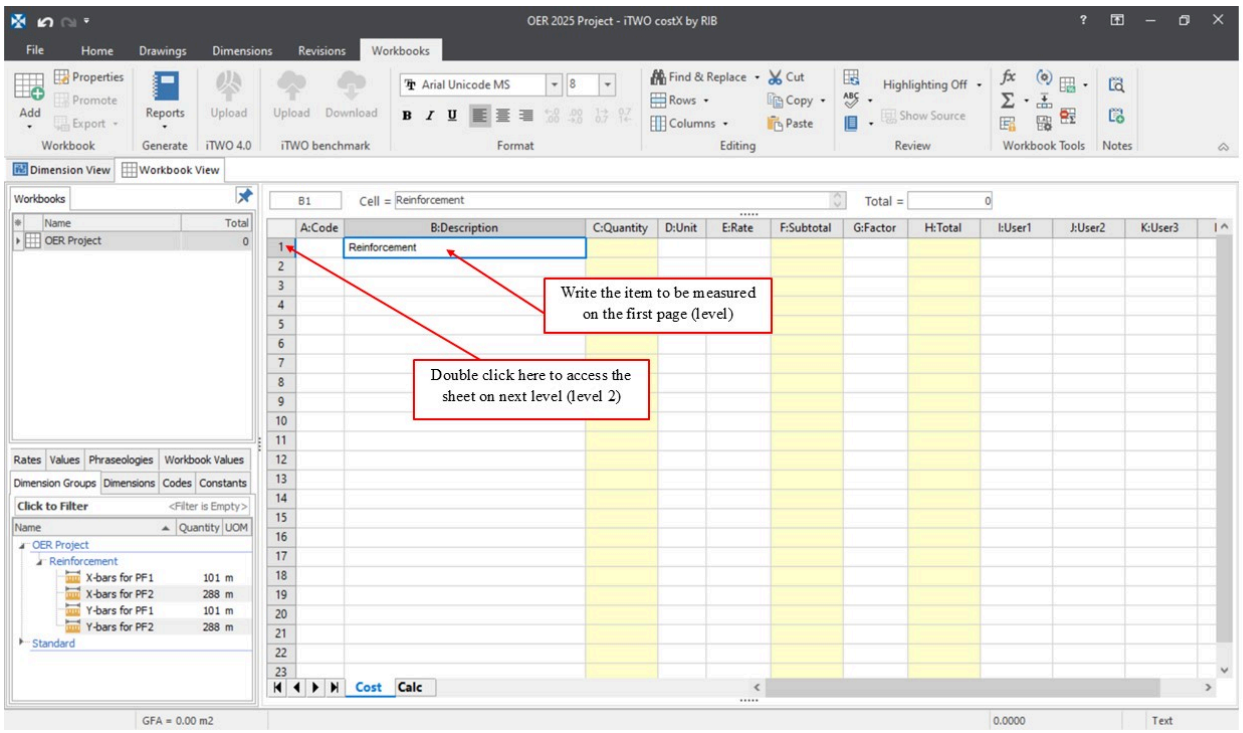


Figure 5.26: Screenshot of First level of the workbook for pad footing reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Write preamble notes and items, as well as the description of reinforcement on the second level.

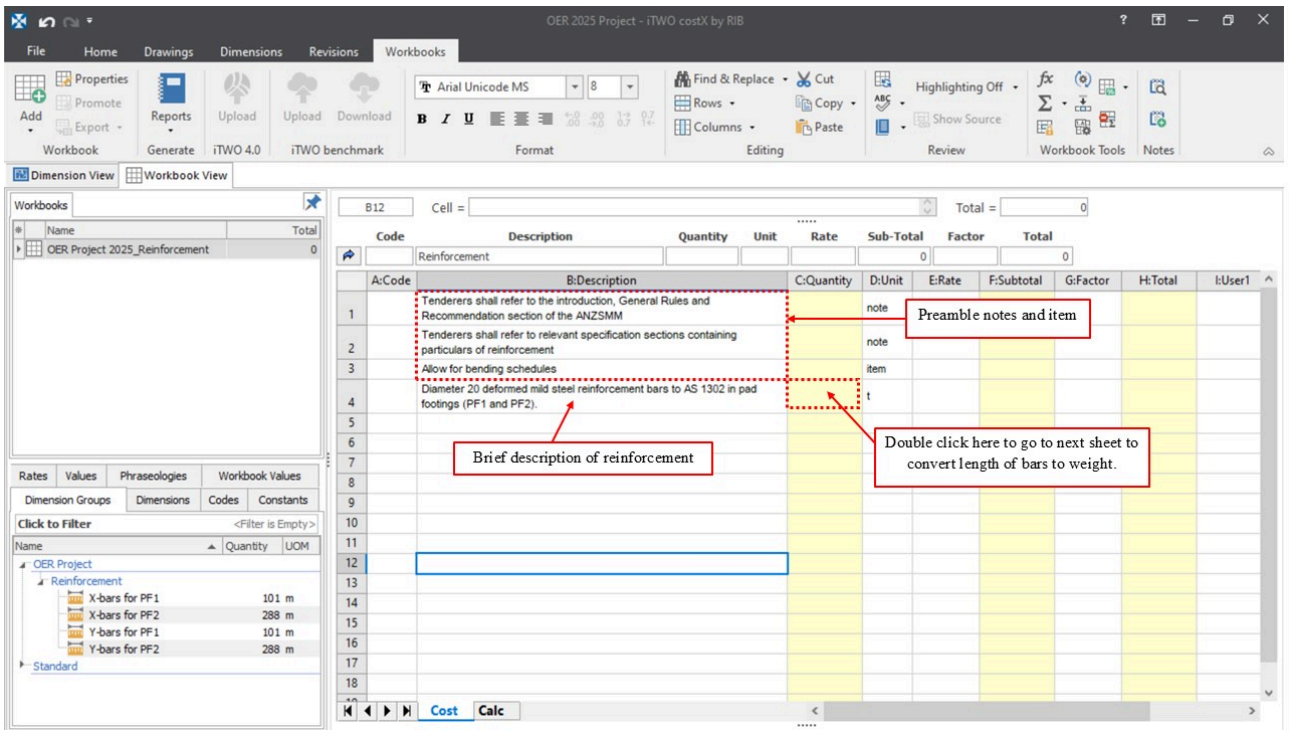


Figure 5.27: Screenshot of second level of the workbook for pad footing reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- The weight per metre of a 20 mm reinforcement bar is 2.469 kg/m, and for a 16 mm bar, it is 1.58 kg/m (refer to Table 5.1).
- Convert the weight to tonnes using the conversion factor: 1 tonne = 1,000 kg.

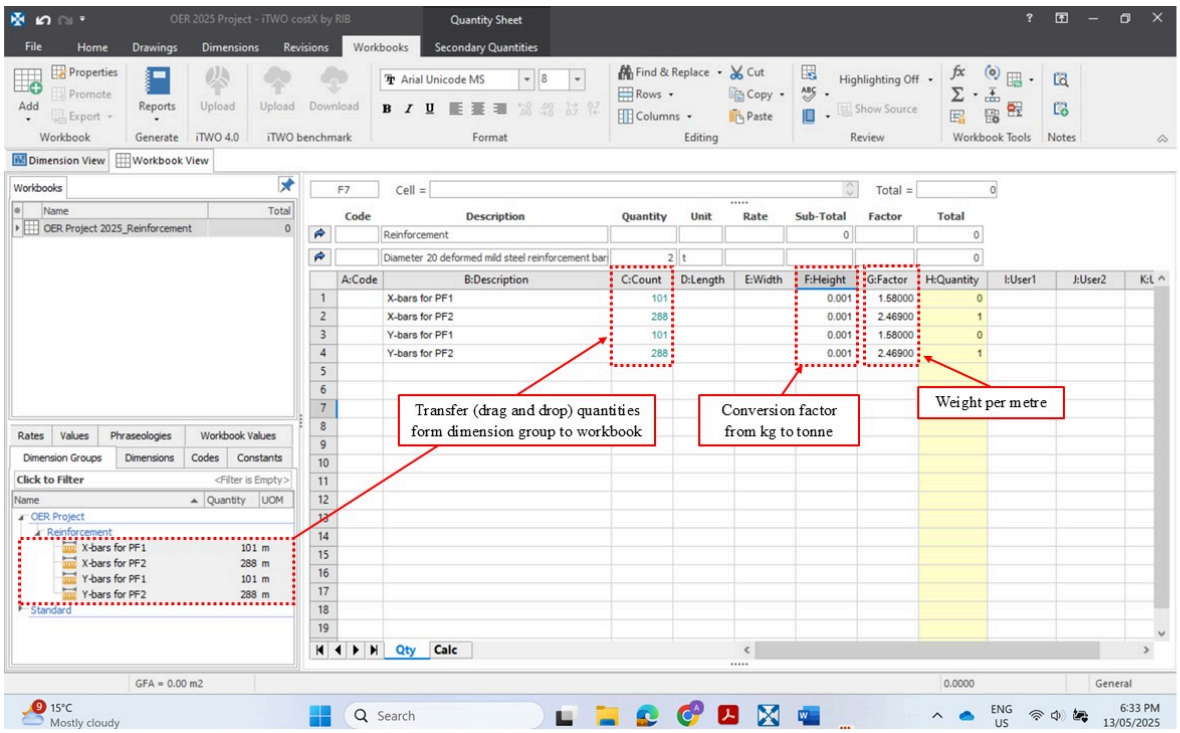


Figure 5.28: Screenshot of adding quantities of pad footing reinforcement to workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Generate reports (Figures 5.29 to 5.31)

- Choose the report format (e.g. “Bill of Quantities – 2 Levels”) and generate the report.

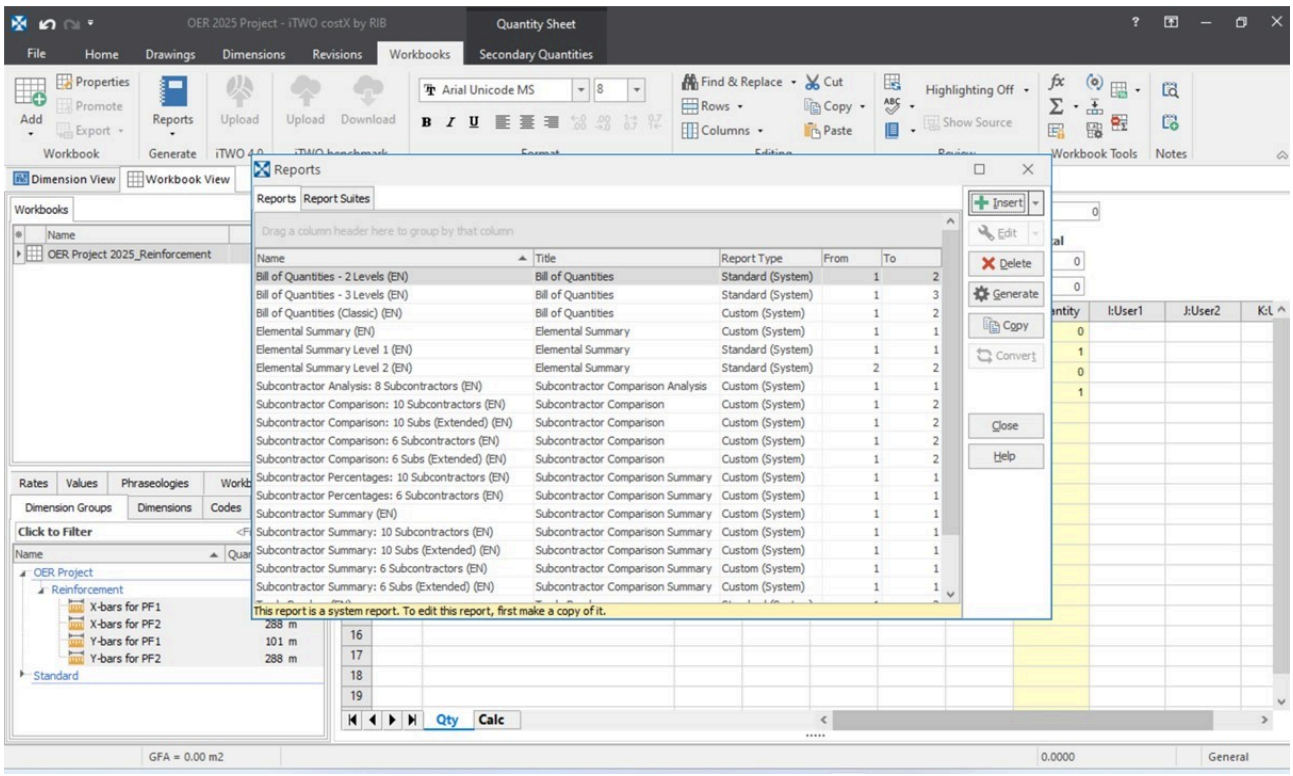


Figure 5.29: Screenshot of selecting report type for pad footing reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- Edit report details such as report title and create preview.

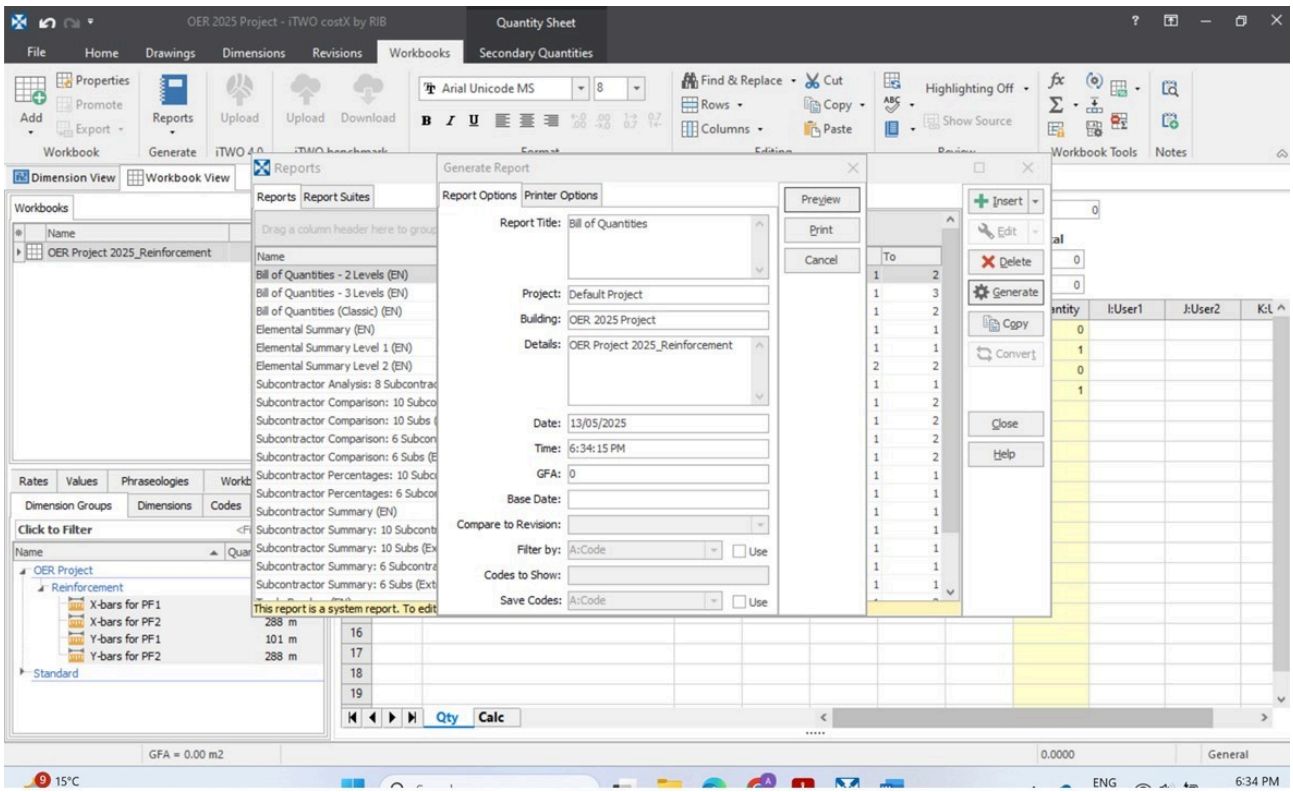


Figure 5.30: Screenshot of workbook properties ad selecting a name for pad footing reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

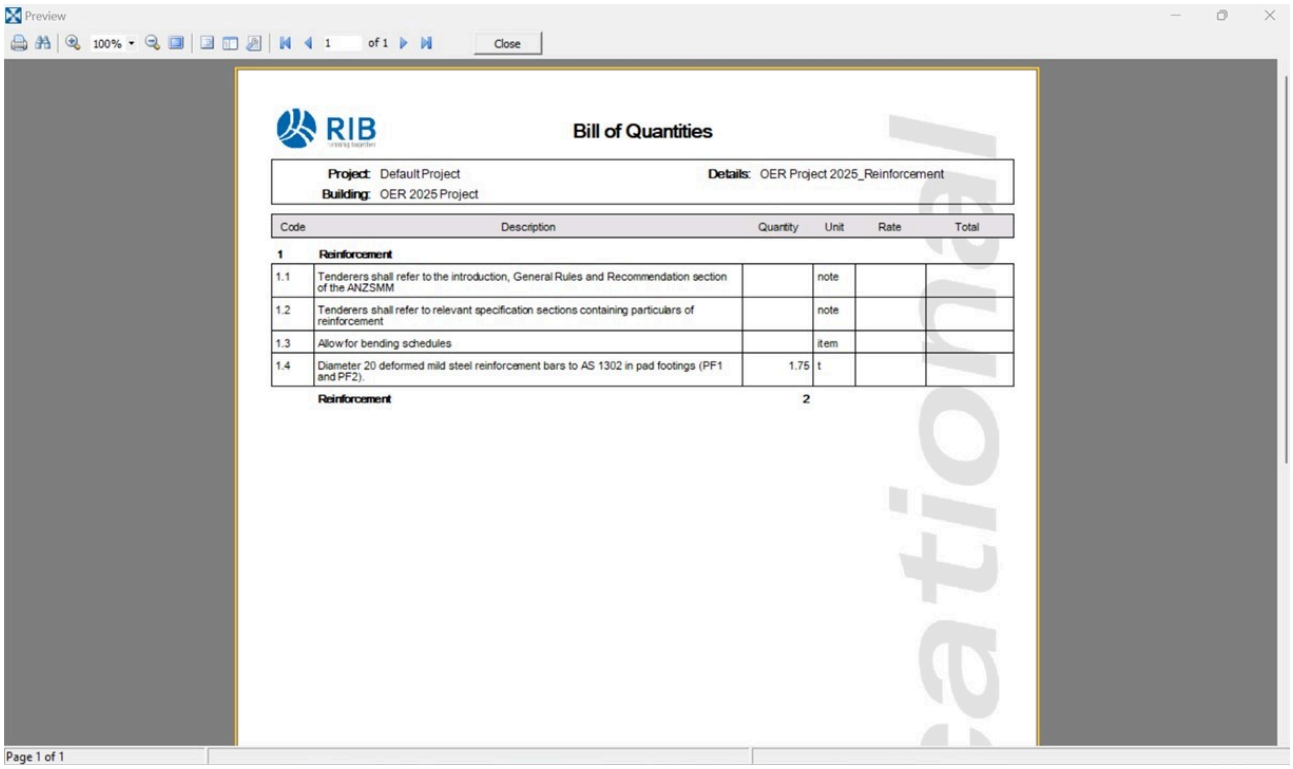


Figure 5.31: Screenshot of generated report for pad footing reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

5.4.2 Computer-based measurement of reinforcement for beam

Based on the drawings provided below (Figures 5.32 and 5.33)–, perform a digital quantity take-off for the reinforcement in beams on axis 1. Using the measured quantities, prepare a detailed BQ using iTWO CostX software.

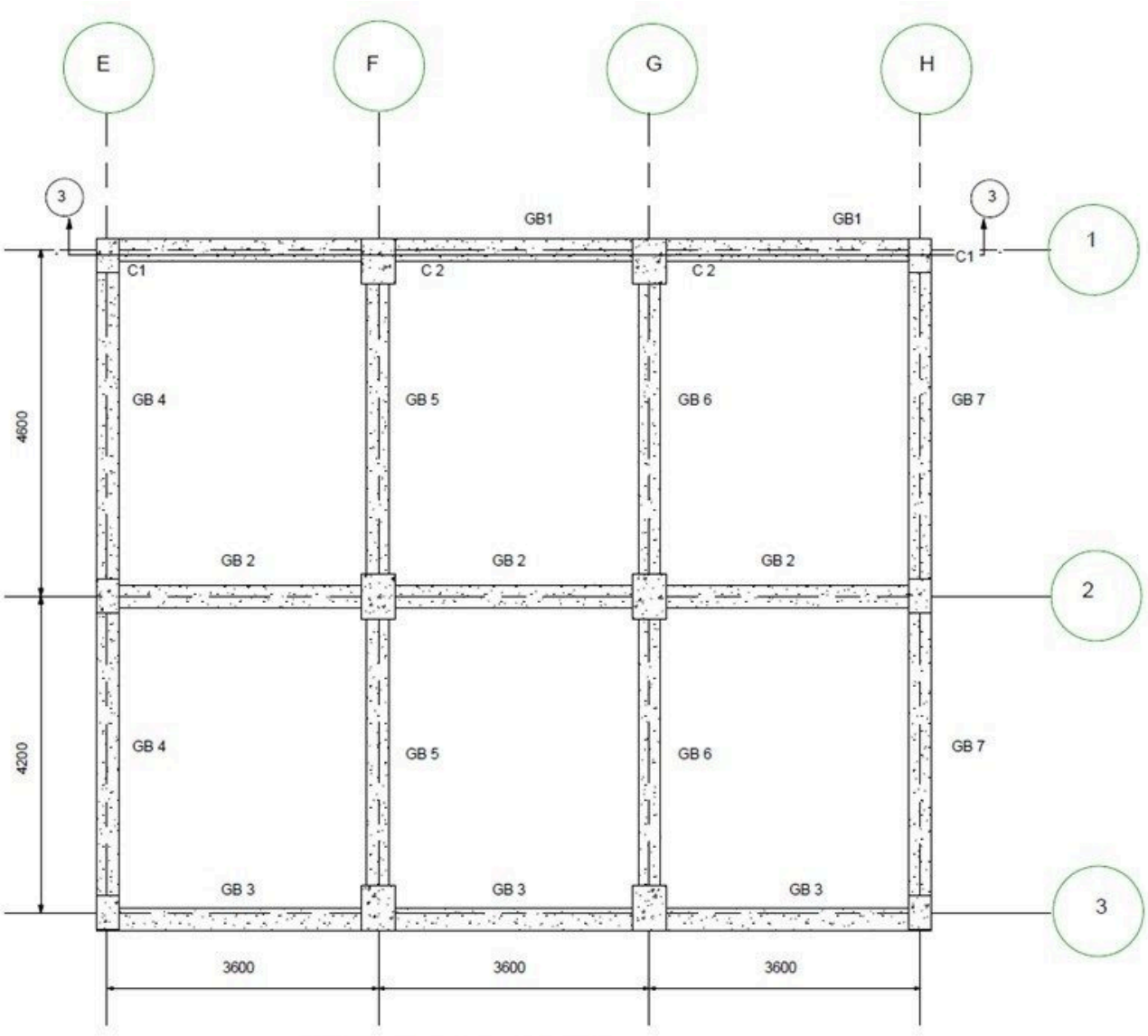


Figure 5.32: Beam and column plan (Source: Created by Authors)

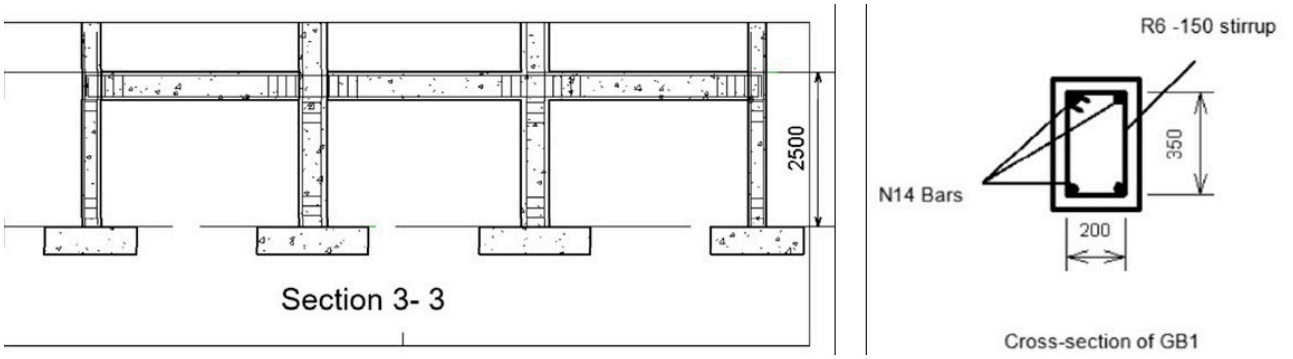


Figure 5.33: Section and detail (Source: Created by Authors)

The following steps show how to measure beam reinforcement:

Step 1: Upload the drawings and calibrate them (Figures 5.34 to 5.35).

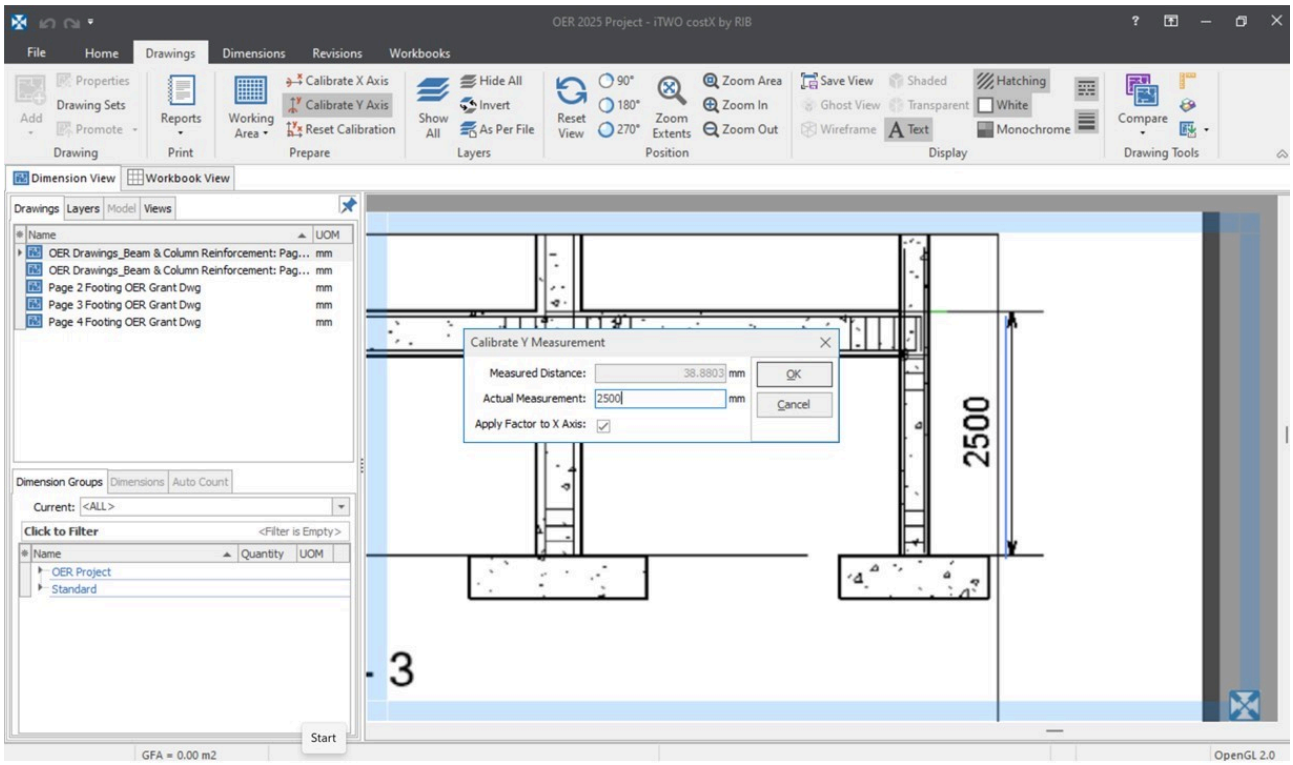


Figure 5.34: Screenshot of calibrating page 1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

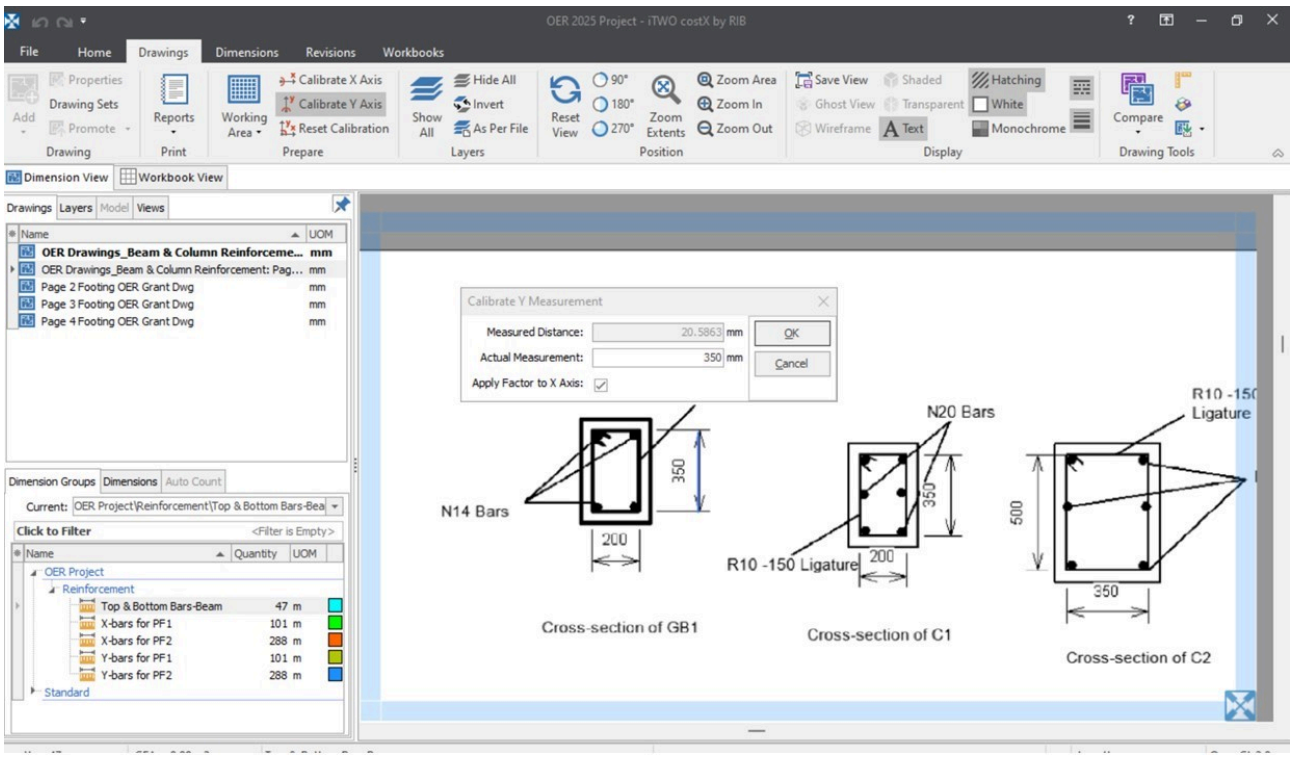


Figure 5.35: Screenshot of calibrating page 2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 2: Create dimension groups (Figure 5.36 to 5.38).

- *Dimension group for top and bottom bars*

The "Default Multiplier" is set to 4 because the reinforcement configuration includes two identical top bars and two identical bottom bars, resulting in a total of four identical bars being accounted for in the calculation.

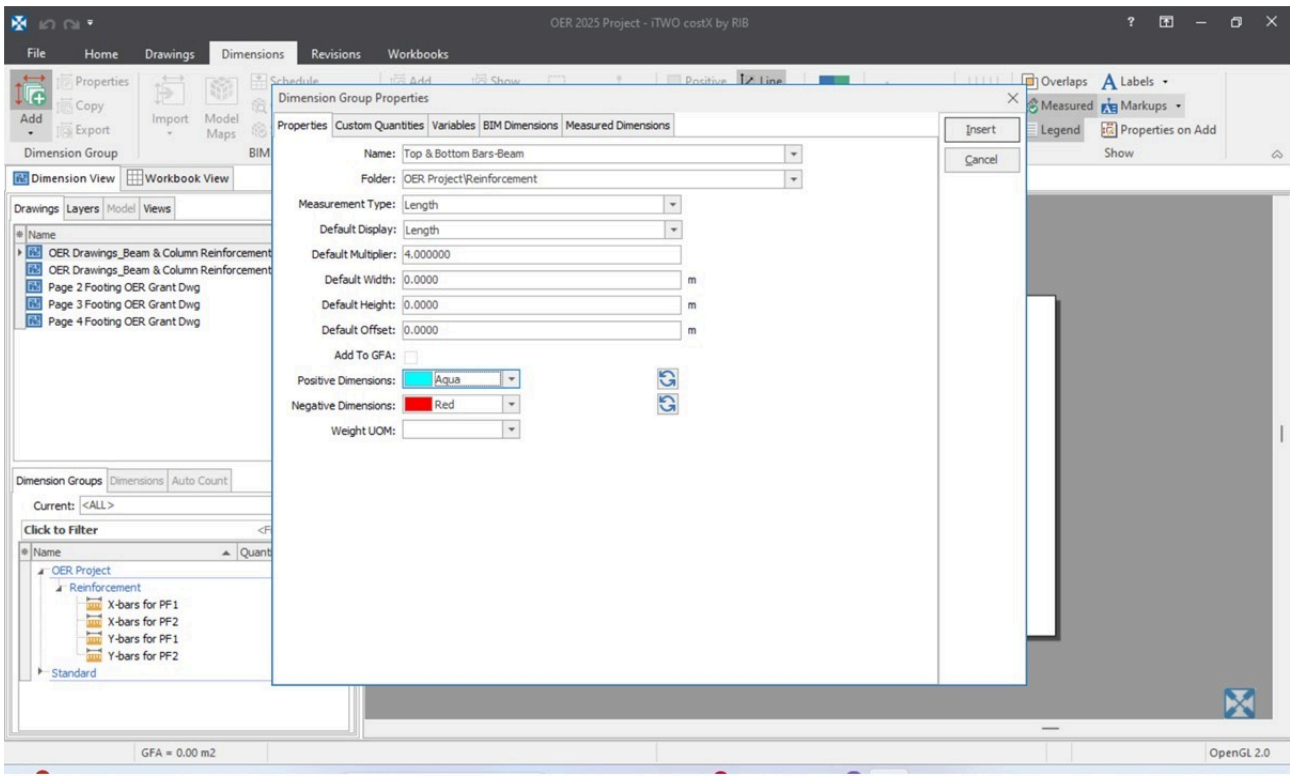


Figure 5.36: Screenshot of creating a dimension group for top and bottom bars using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- Create a dimension group for beam stirrups to measure one vertical side of the stirrup.

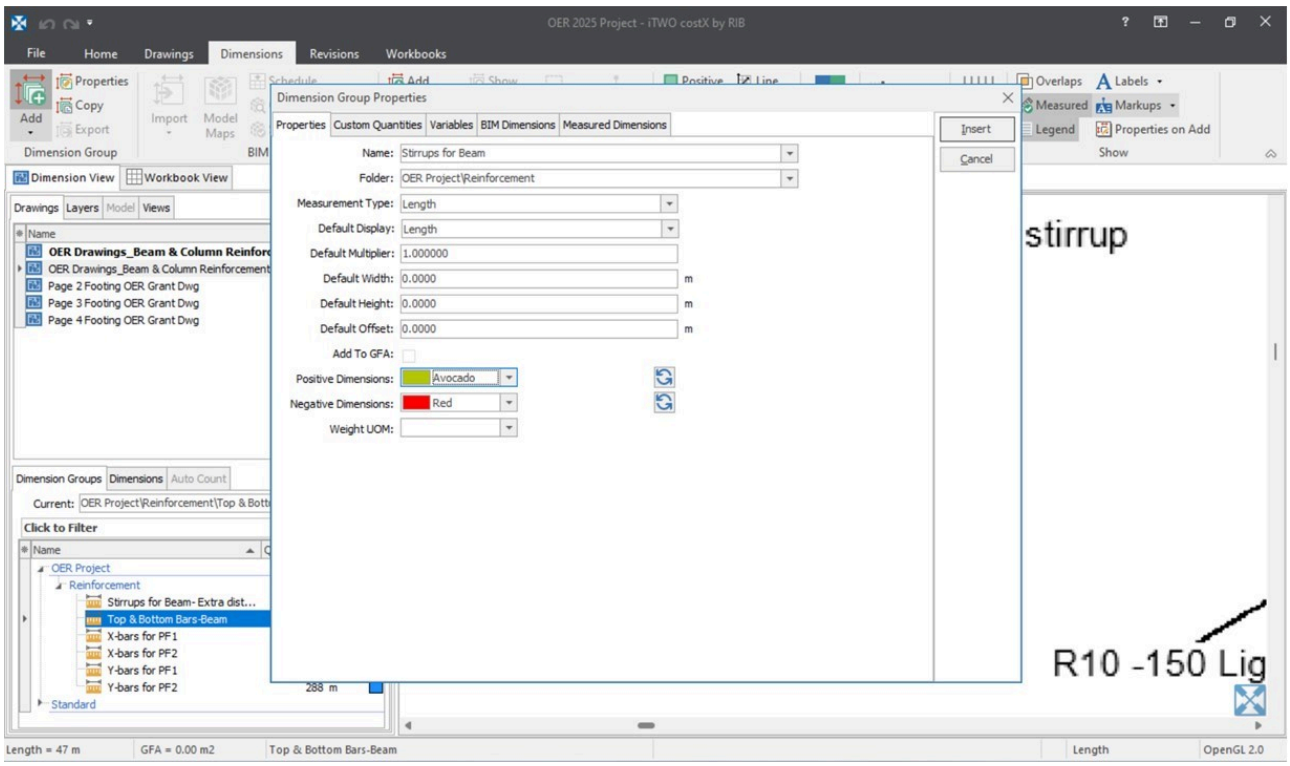


Figure 5.37: Screenshot of creating a dimension group for beam stirrups using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- Create a dimensiongroup for beam stirrups to measure the top, bottom and vertical sides of the stirrup (extra distance).

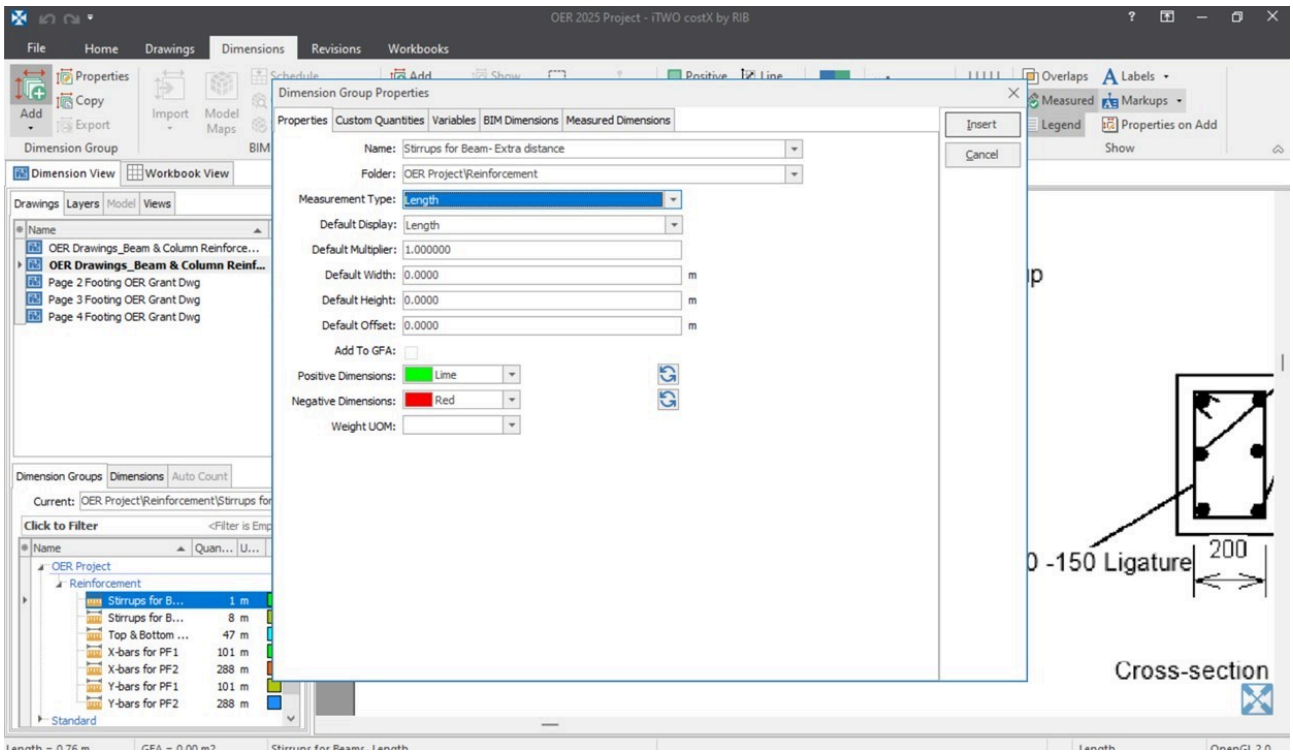


Figure 5.38: Screenshot of creating a dimension group for beam stirrups-extra distance using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Measure and show markups (Figures 5.39 to 5.42).

- Measure the top and bottom bars of the beam.

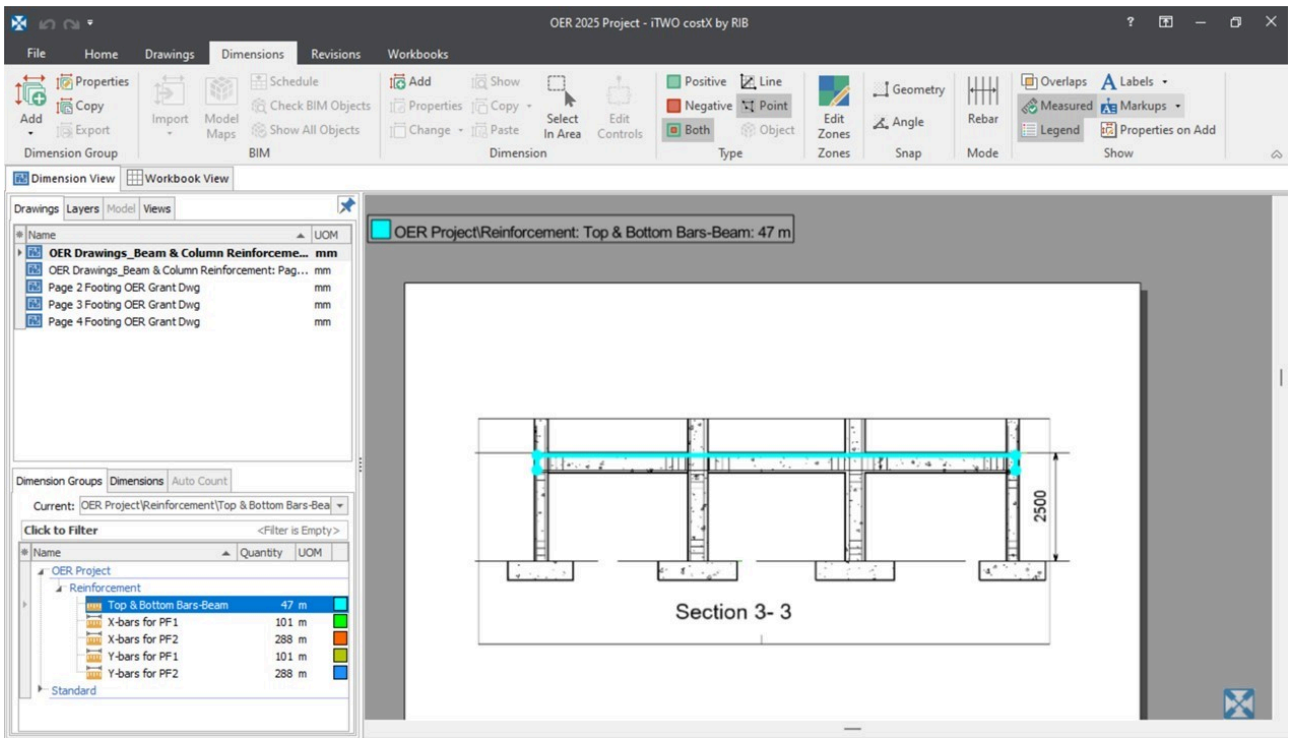


Figure 5.39: Screenshot of measuring top and bottom reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- Measure stirrups for beam (extra distance part).

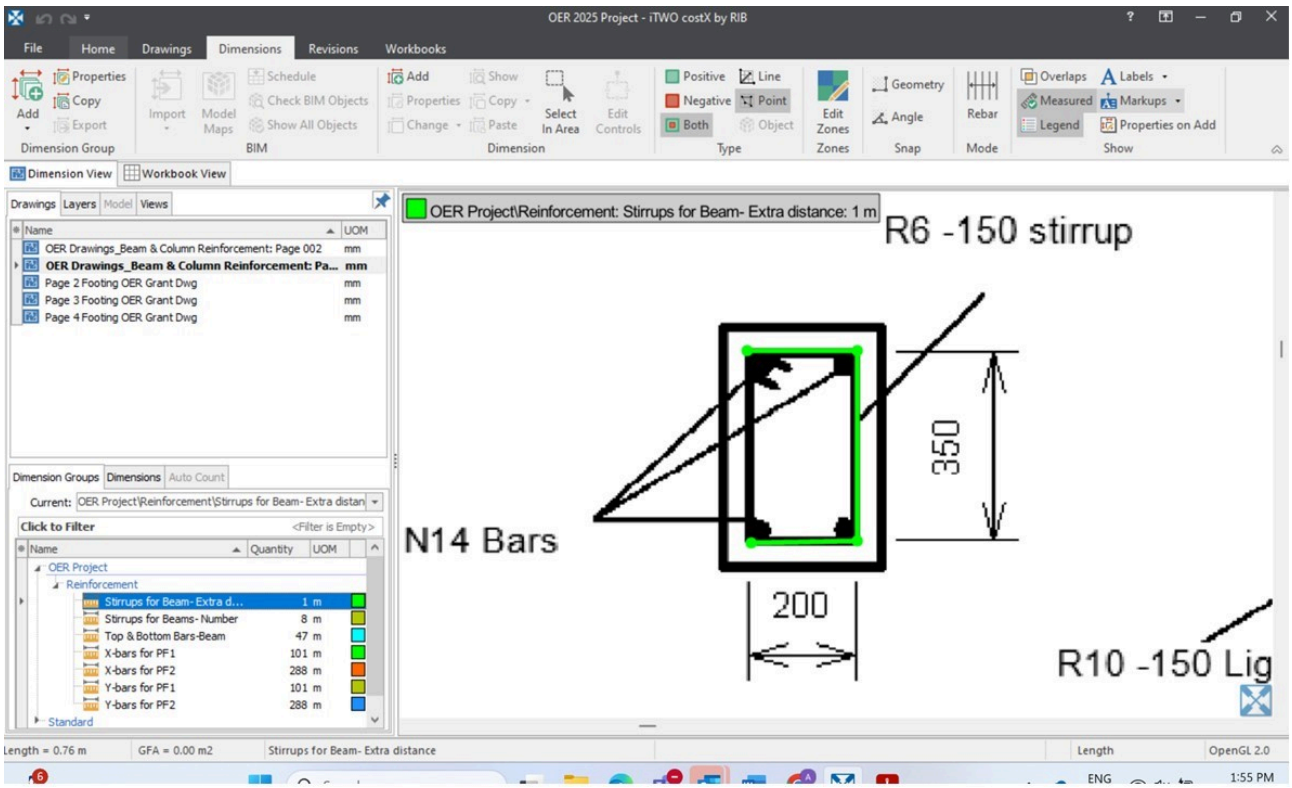


Figure 5.40: Screenshot of measuring beam stirrups-extra distance using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Note: The total extra bar length is calculated as follows:

- Measured extra distance in CostX = 0.76 m
- Hook length (from standard- AS3600) for 6 mm diameter bar = 150 mm (or 0.15 m) per hook
- Total extra distance = 0.76 m + 2 × 0.15 m = 1.06 m (or 1,060 mm).

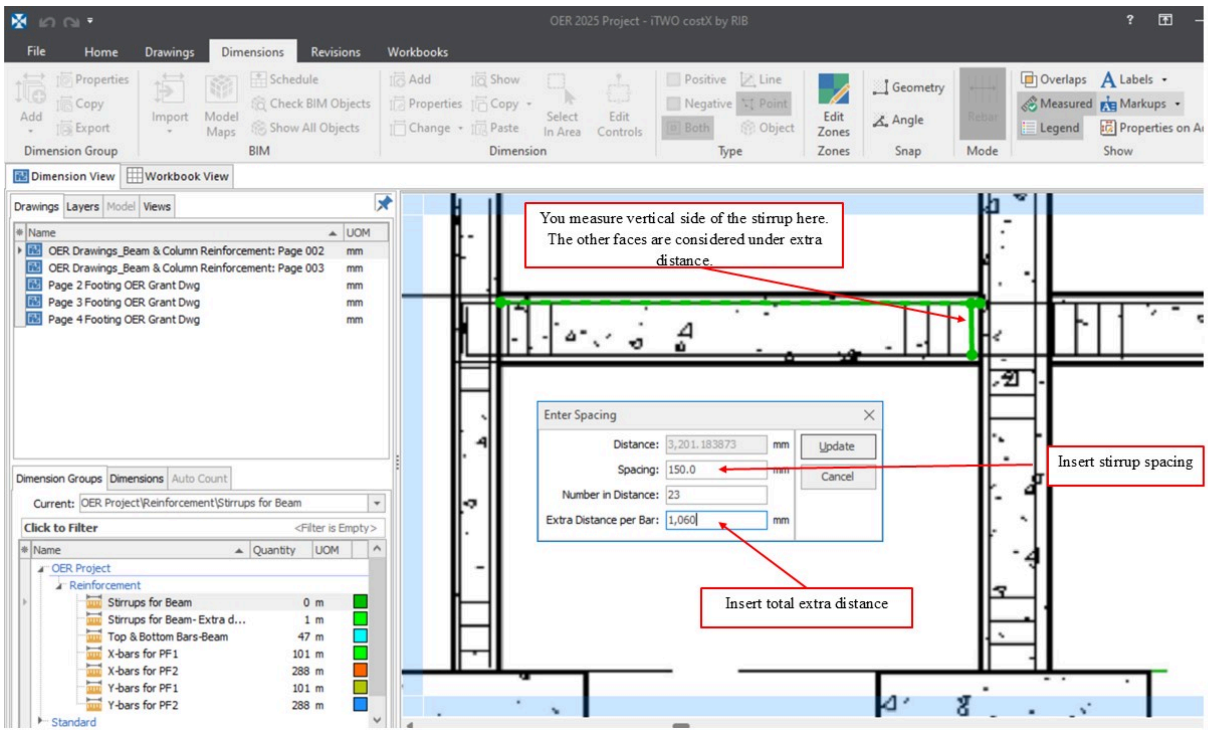


Figure 5.41: Screenshot of measuring beam stirrups using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- Markup for the entire beam on axis 1.

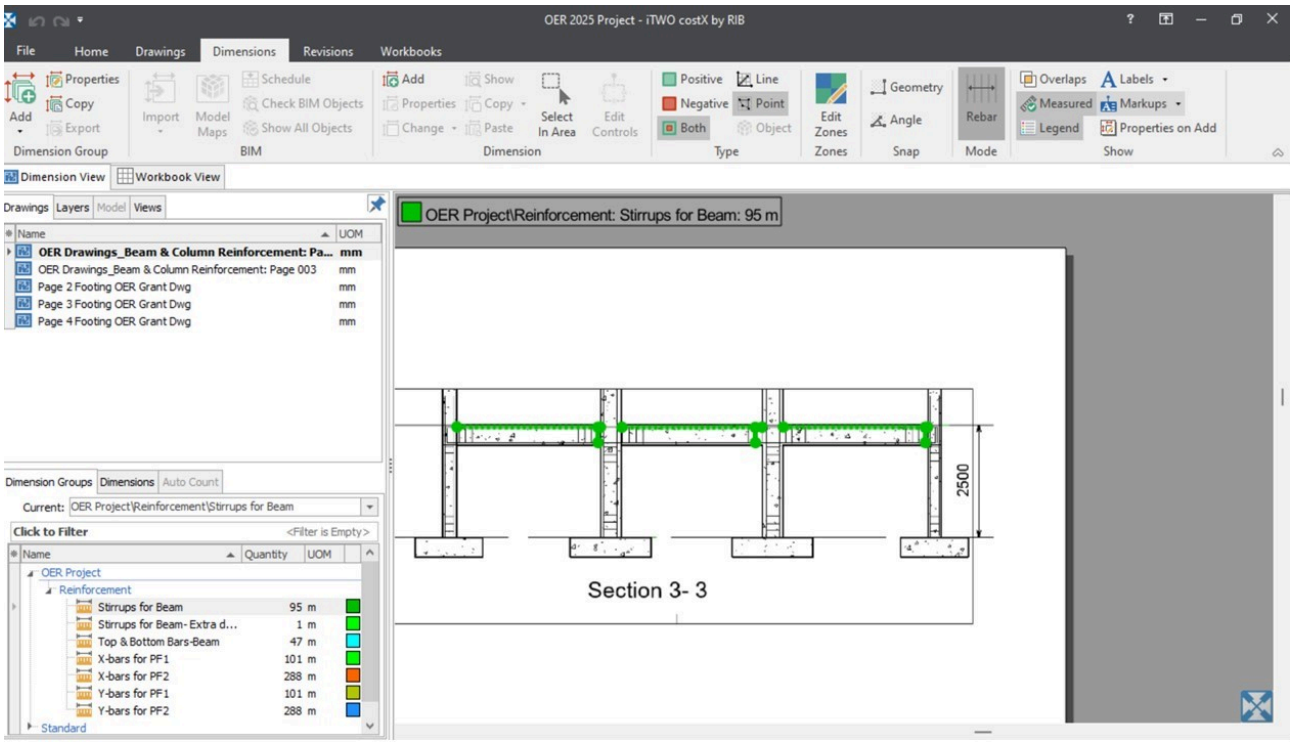


Figure 5.42: Screenshot of measured beam reinforcement markup using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 4: Create workbooks and transfer quantities (Figures 5.43 to 5.45).

- Transfer quantities for the beam main bars.

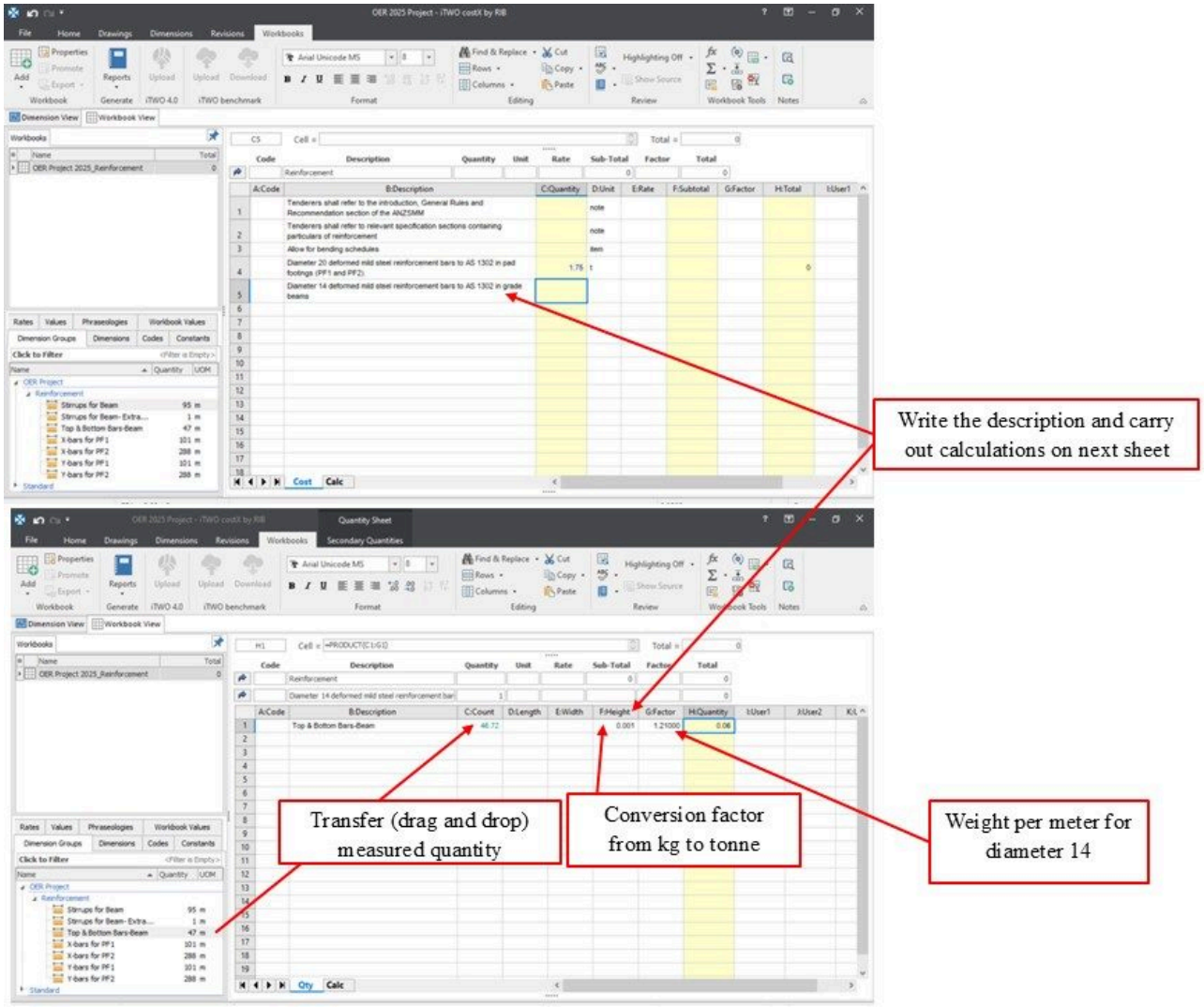


Figure 5.43: Screenshot of adding quantities of beam reinforcement to workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- Transfer quantities for the beam stirrups.

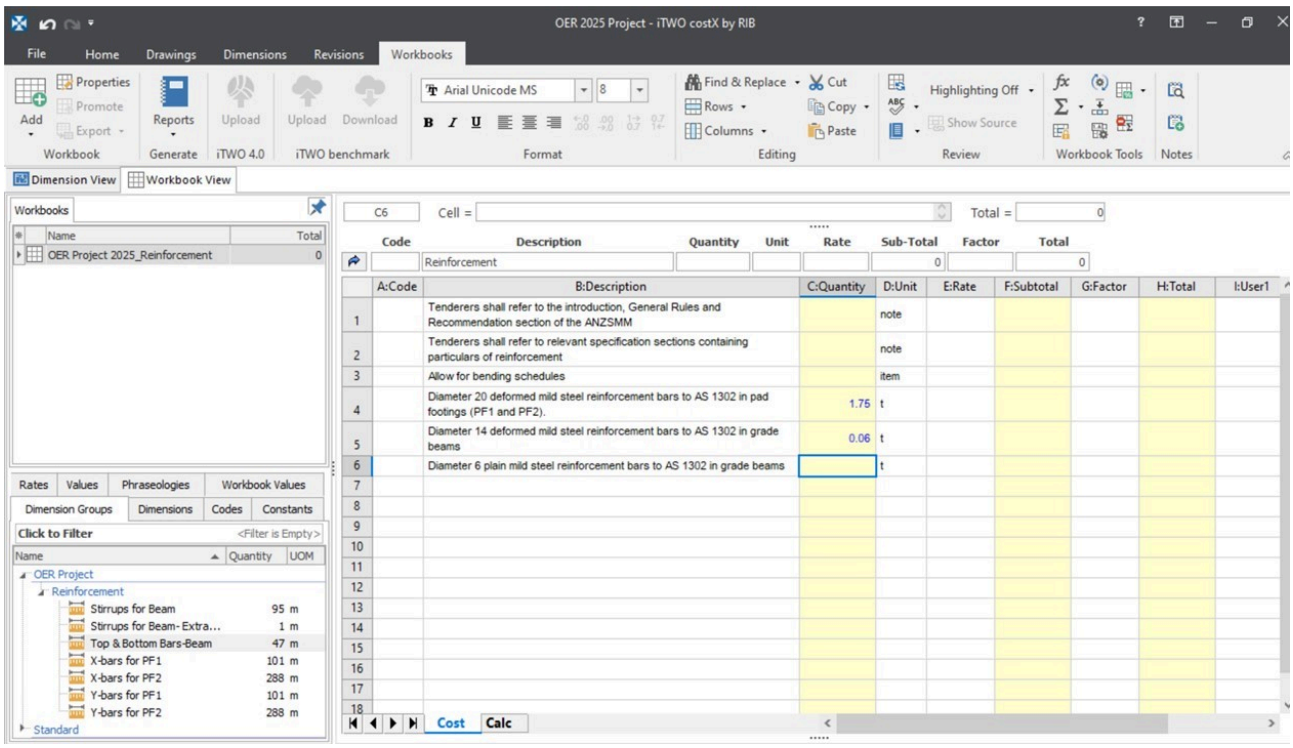


Figure 5.44: Screenshot of adding quantities beam stirrups to workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

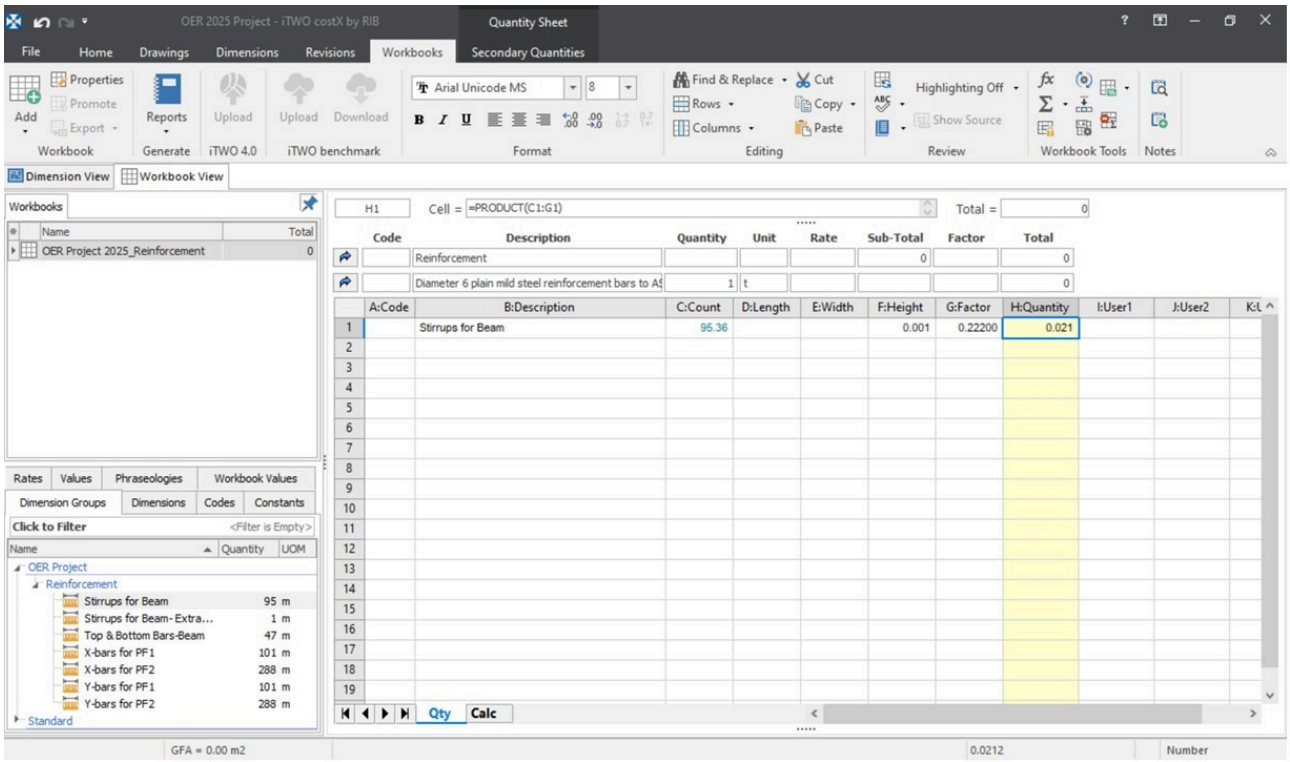


Figure 5.45: Screenshot of total beam stirrup quantity using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Generate reports (Figure 5.46).

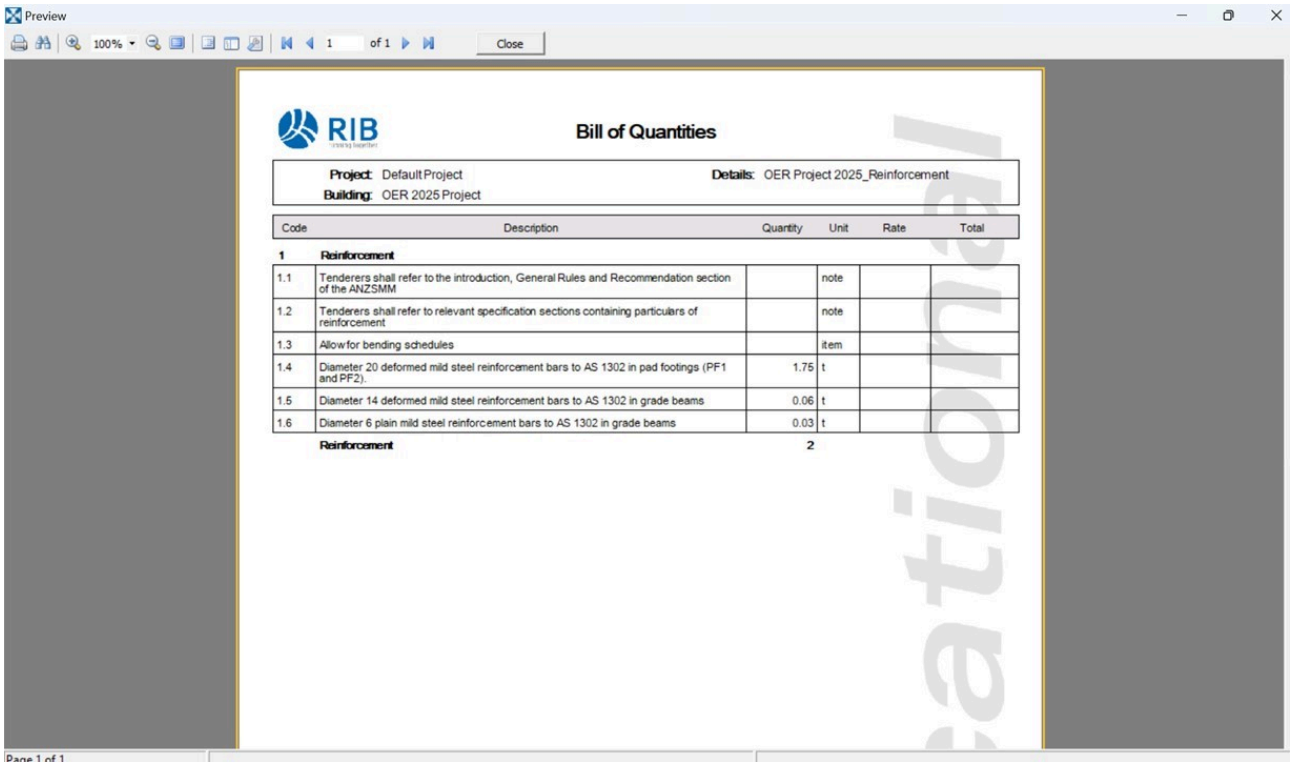


Figure 5.46: Screenshot of generated report for reinforcement of pad footings and beams using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

5.4.3 Computer-based measurement of reinforcement for column

Based on the drawings provided below (Figure 5.47 to 5.49), perform a digital quantity take-off for the reinforcement in columns (C1 and C2) on axis 1. Using the measured quantities, prepare a detailed BQ using iTWO CostX software.

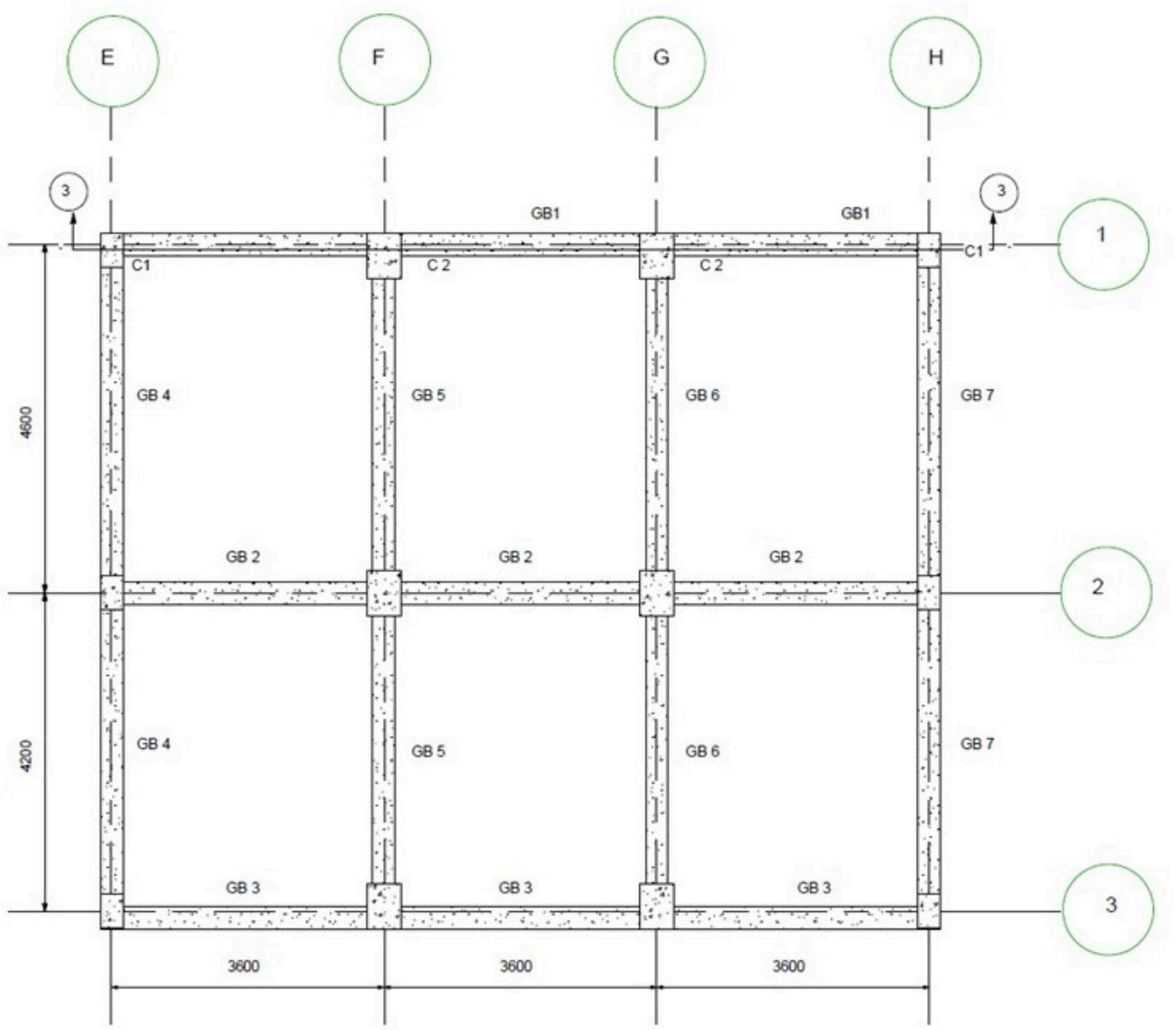


Figure 5.47: Beam and column layout plan (Source: Created by Authors)

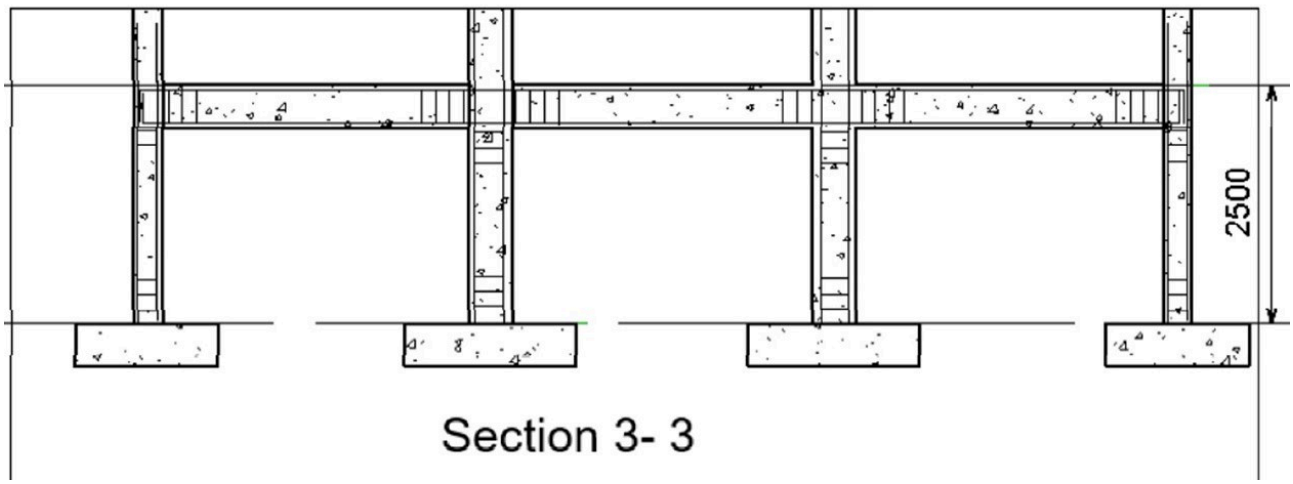


Figure 5.48: Section 3-3 (Source: Created by Authors)

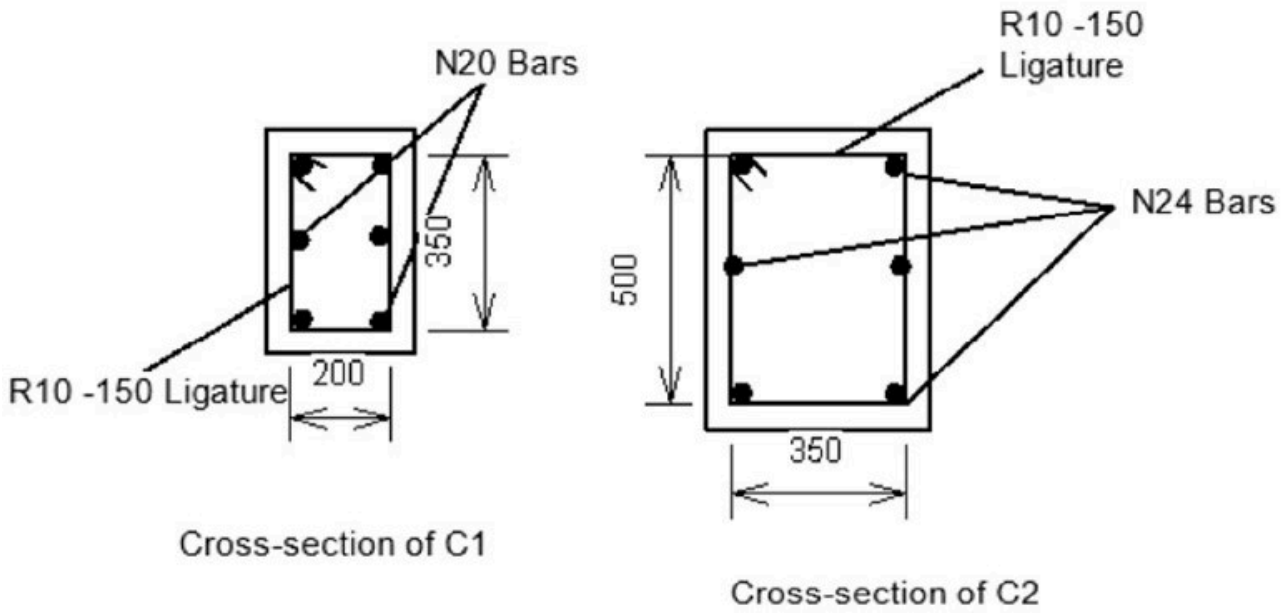


Figure 5.49: Column detail (Source: Created by Authors)

The following steps show how to measure column reinforcement:

Step 1: Upload the drawings and calibrate them (Figure 5.50).

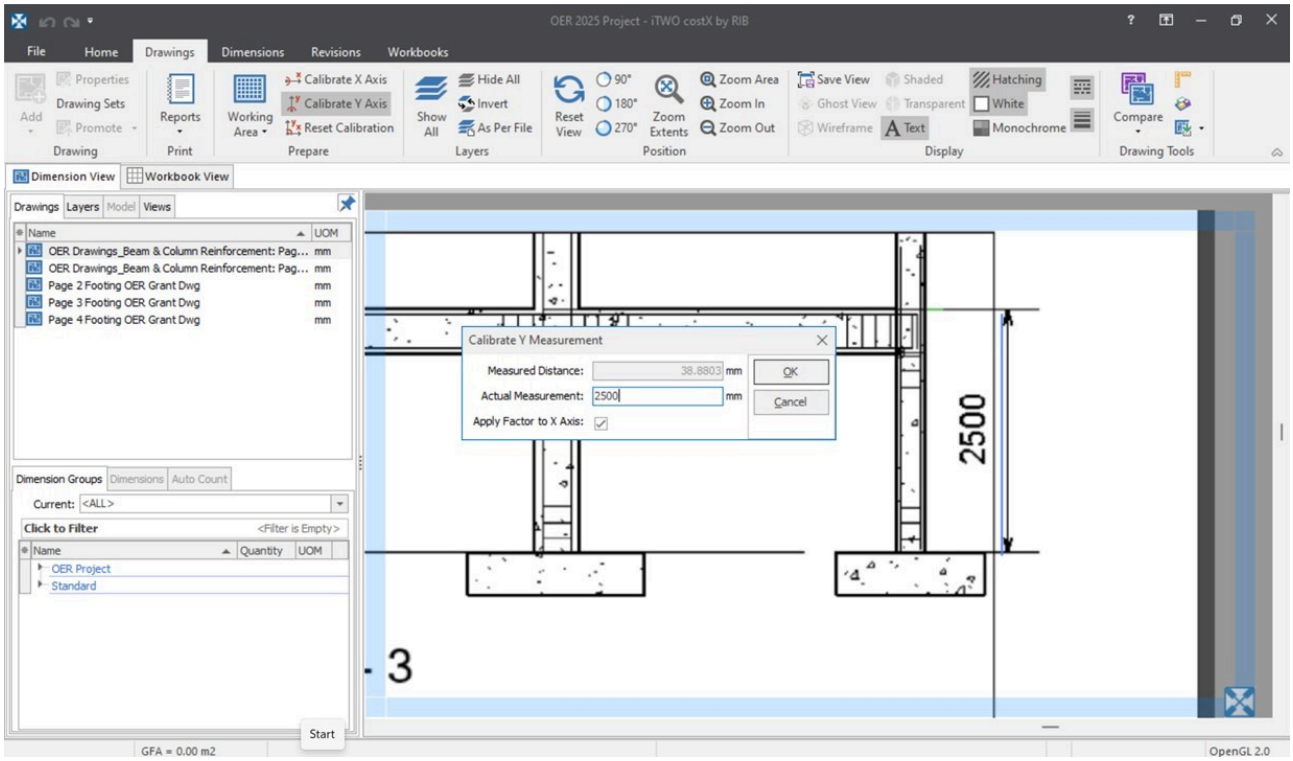


Figure 5.50: Screenshot of calibrating X and Y axes for column reinforcement measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 2: Create dimension groups (Figures 5.51 and 5.52).

- *Dimension group for main bars – C1*

The "Default Multiplier" is set to 12 because the reinforcement configuration consists of six identical vertical bars in each of the two C1 columns, resulting in a total of twelve identical bars considered in the calculation.

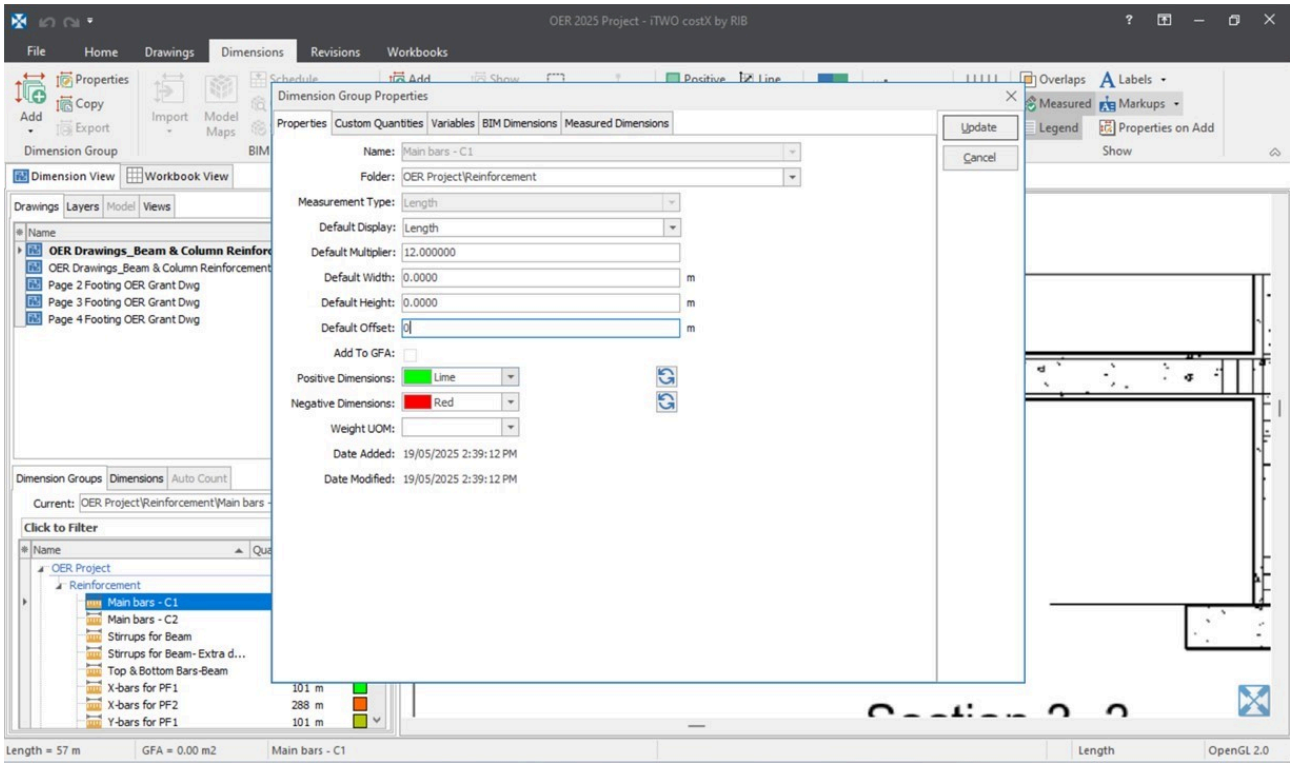


Figure 5.51: Screenshot of creating a dimension group for main bars of C1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

- *Dimension group for main bars – C2*

The "Default Multiplier" is set to 12 because the reinforcement configuration consists of six identical vertical bars in each of the two C2 columns, resulting in a total of twelve identical bars considered in the calculation.

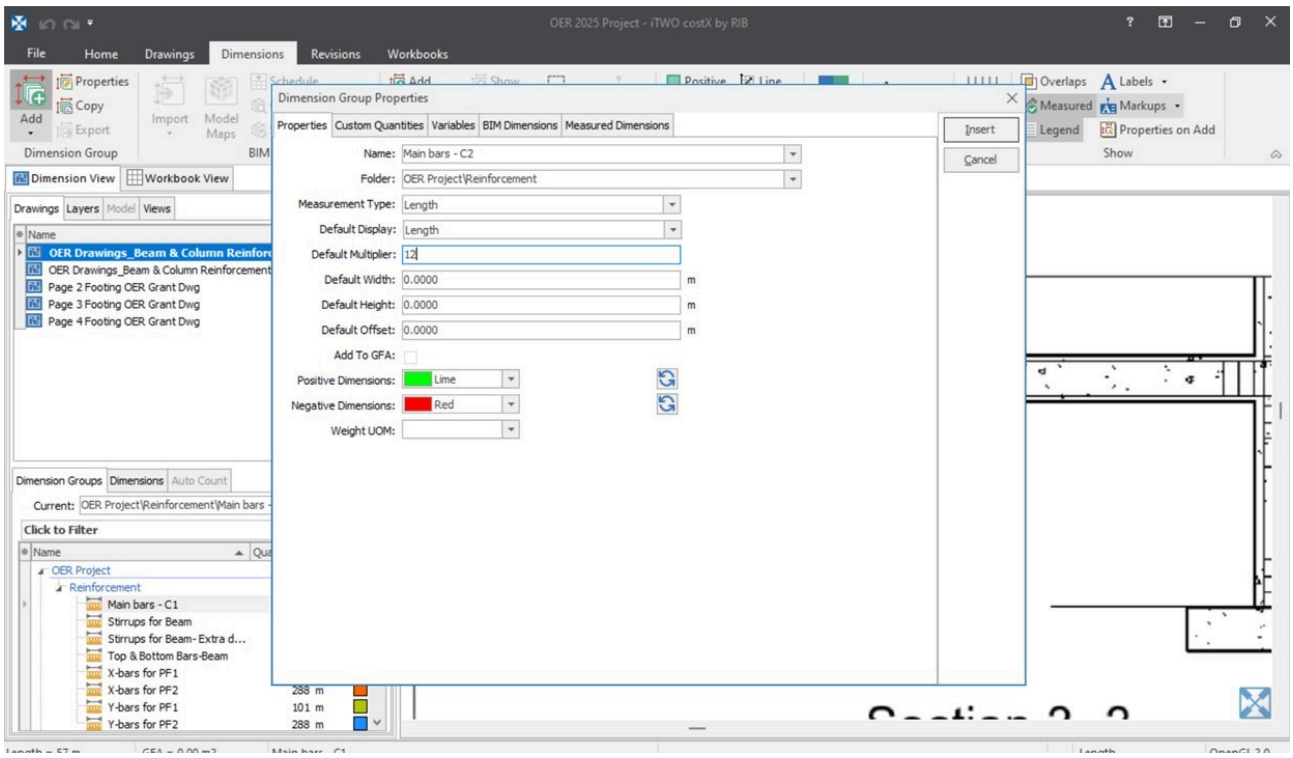


Figure 5.52: Screenshot of creating a dimension group for main bars of C2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Measure and show markups (Figure 5.53 to 5.63).

Measure the main reinforcement bars for Column C1 (Figures 5.53 to 5.58).

Note: Starter bars are to be measured separately and are not included in this quantity.

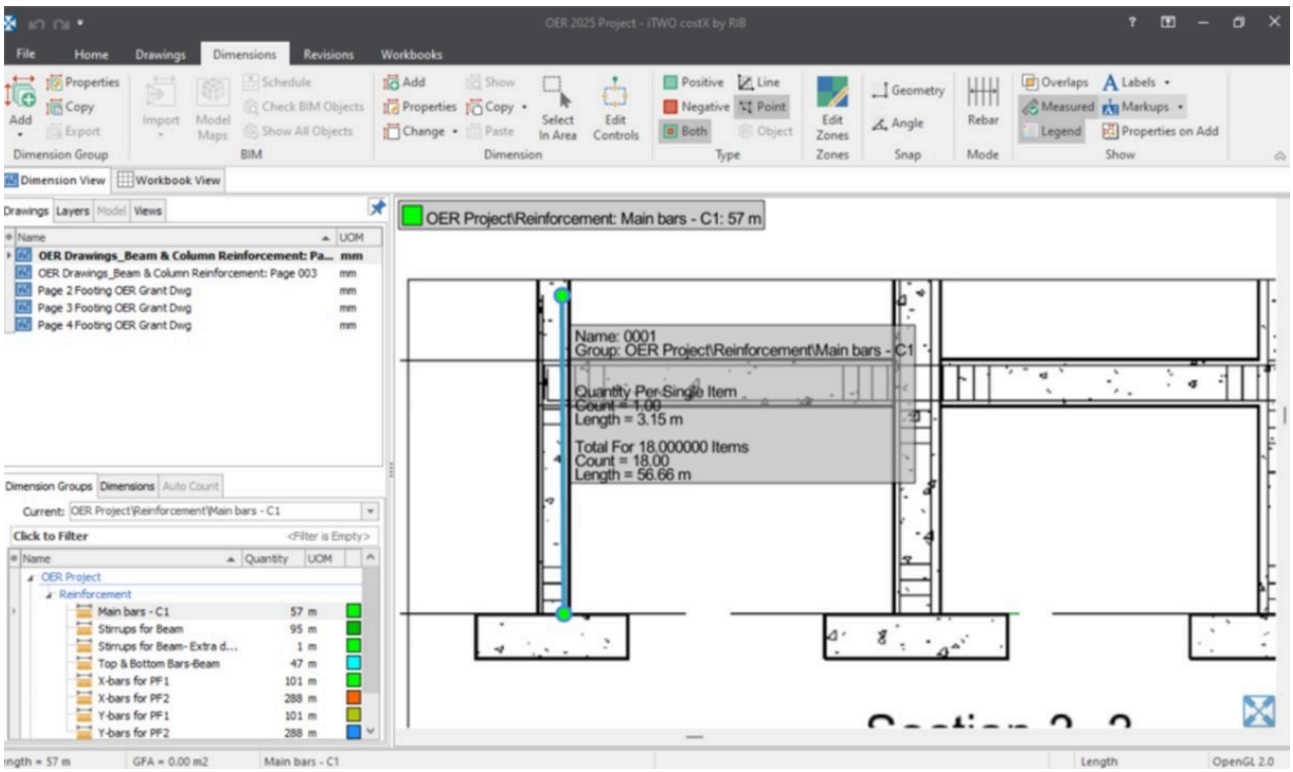


Figure 5.53: Screenshot of measuring main bars of C1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Measure ligatures for C1 (extra distance).

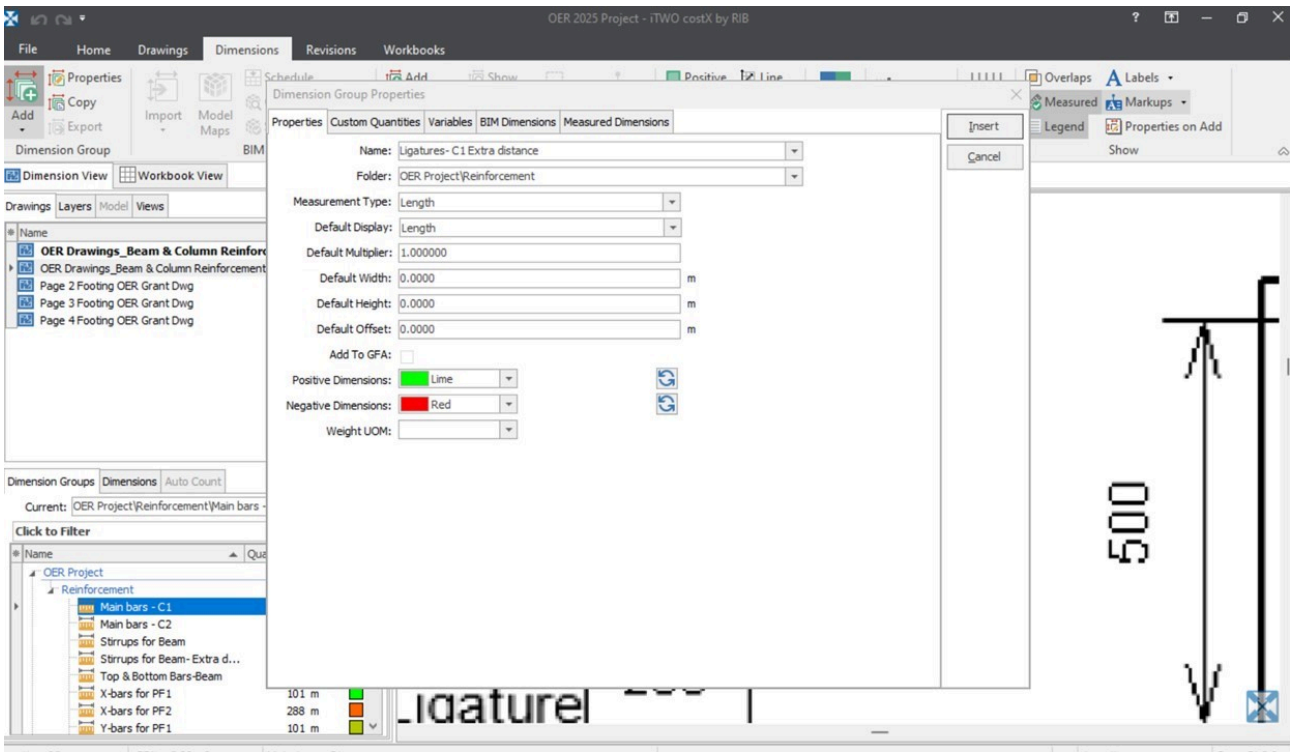


Figure 5.54: Screenshot of creating a dimension group for ligatures of C1 (extra distance) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

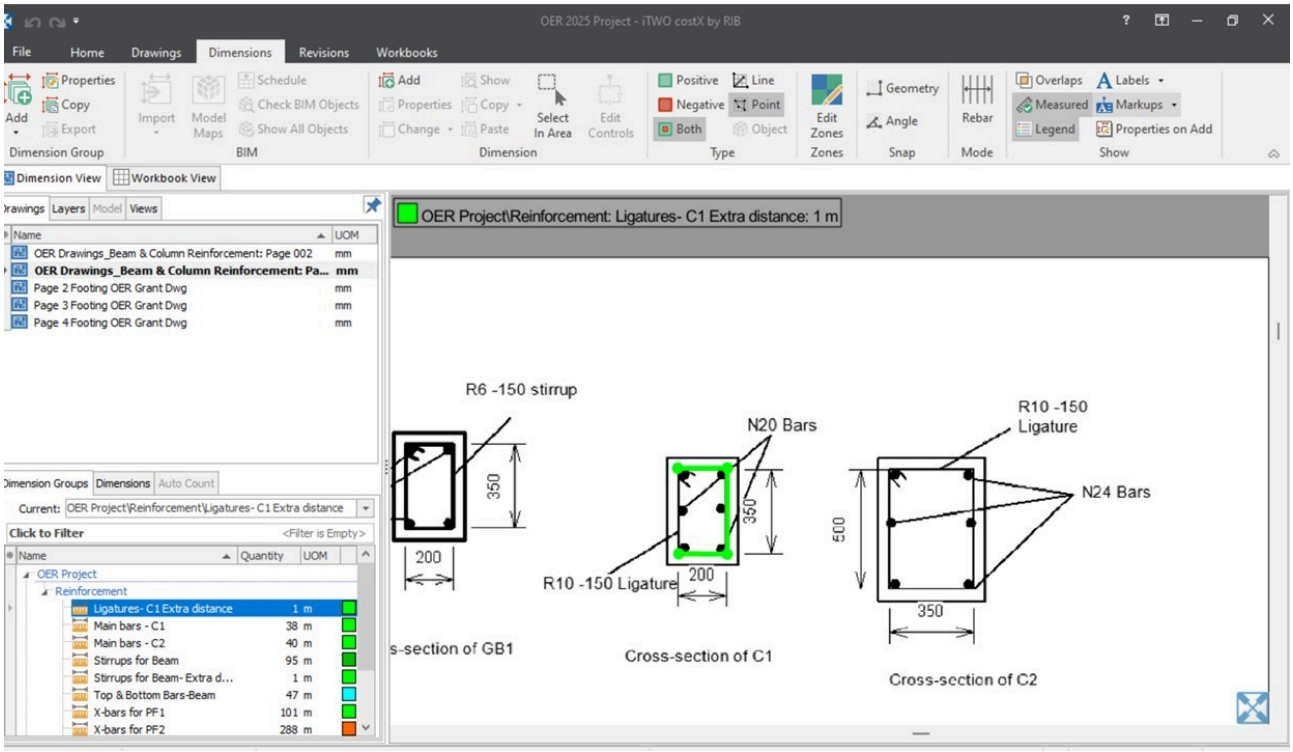


Figure 5.55: Screenshot of ligature of C1 measurement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The total extra bar length is calculated as follows:

- Measured extra distance in CostX = 0.77 m
- Hook length (from standard) for 10 mm diameter bar = 180 mm (or 0.18 m) per hook
- Total extra distance = 0.77 m + 2 × 0.18 m = 1.13 m (or 1,130 mm).

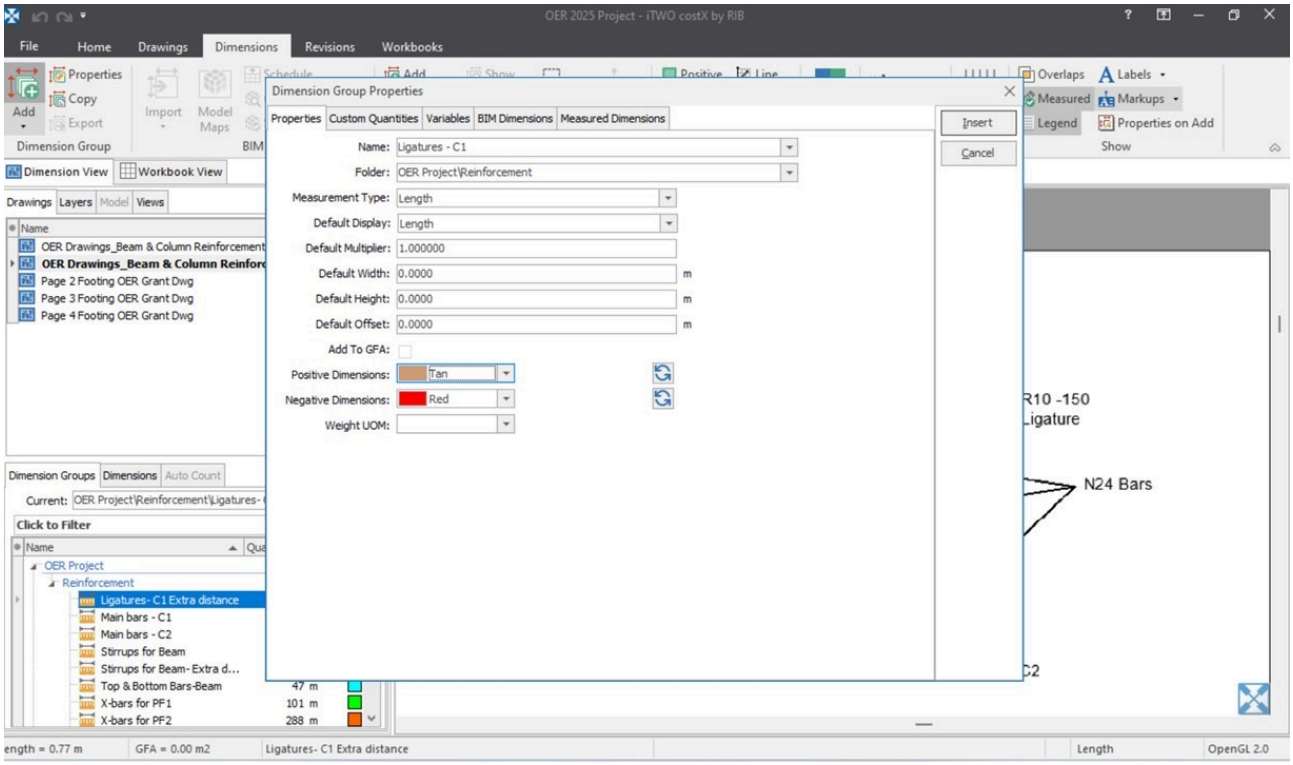


Figure 5.56: Screenshot of creating a dimension group for ligatures of C1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

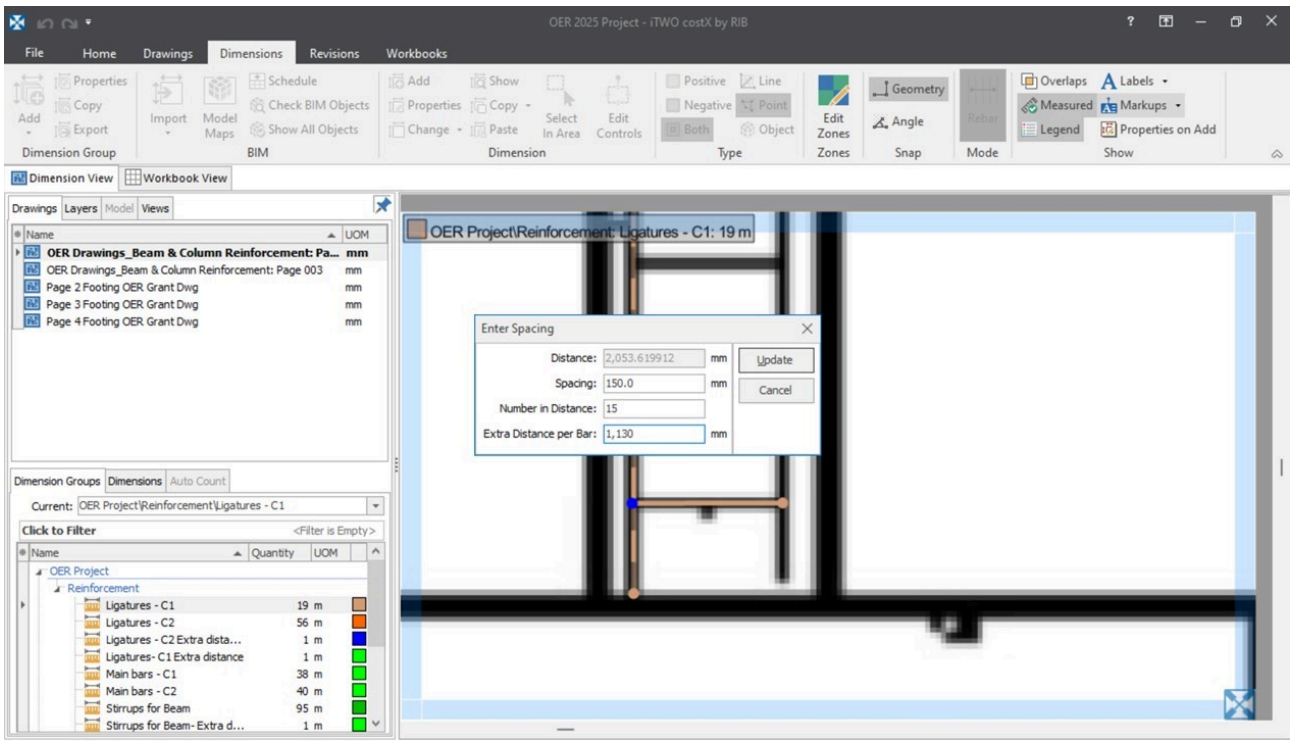


Figure 5.57: Screenshot of adding spacing for ligatures of C1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

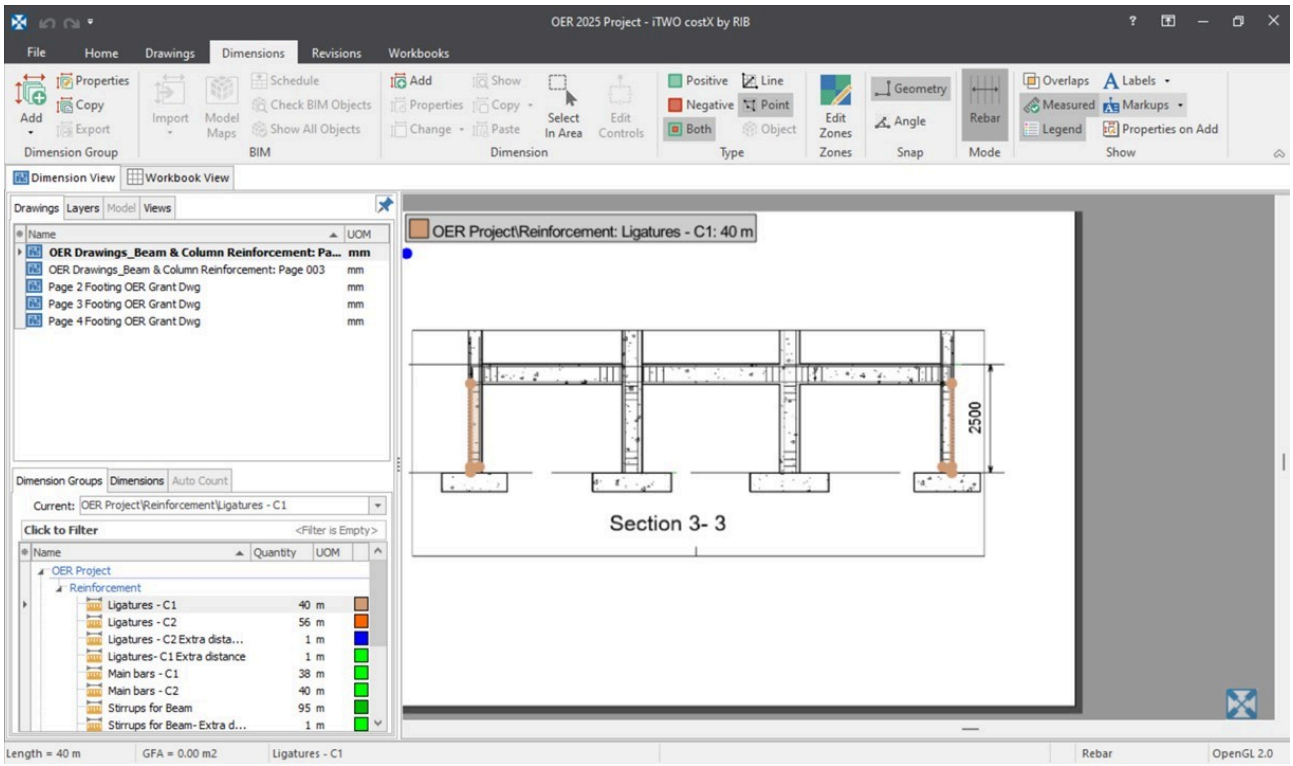


Figure 5.58: Screenshot of measuring ligatures of C1 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Measure the main bars for C2 (Figures 5.59 to 5.63).

Note: Starter bars are to be measured separately and are not included in this quantity.

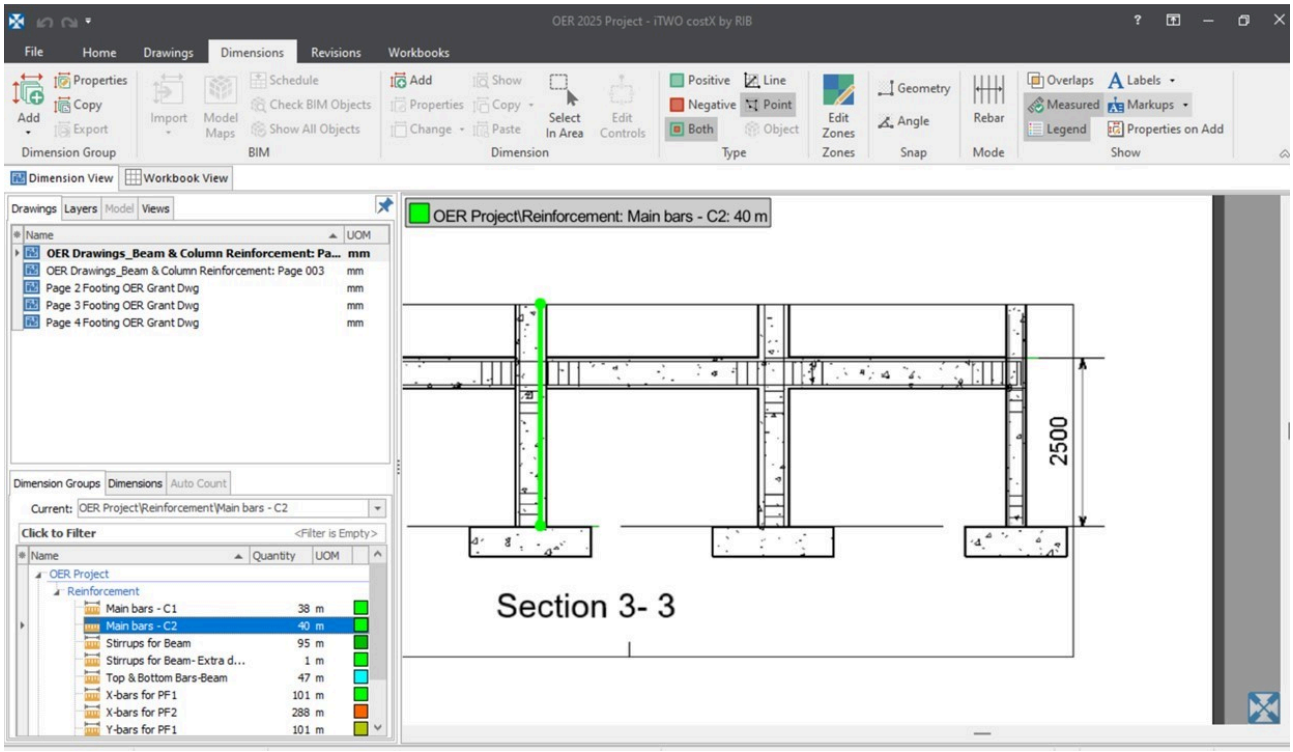


Figure 5.59: Screenshot of measuring main bars of C2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Measure ligatures for C2 (extra distance).

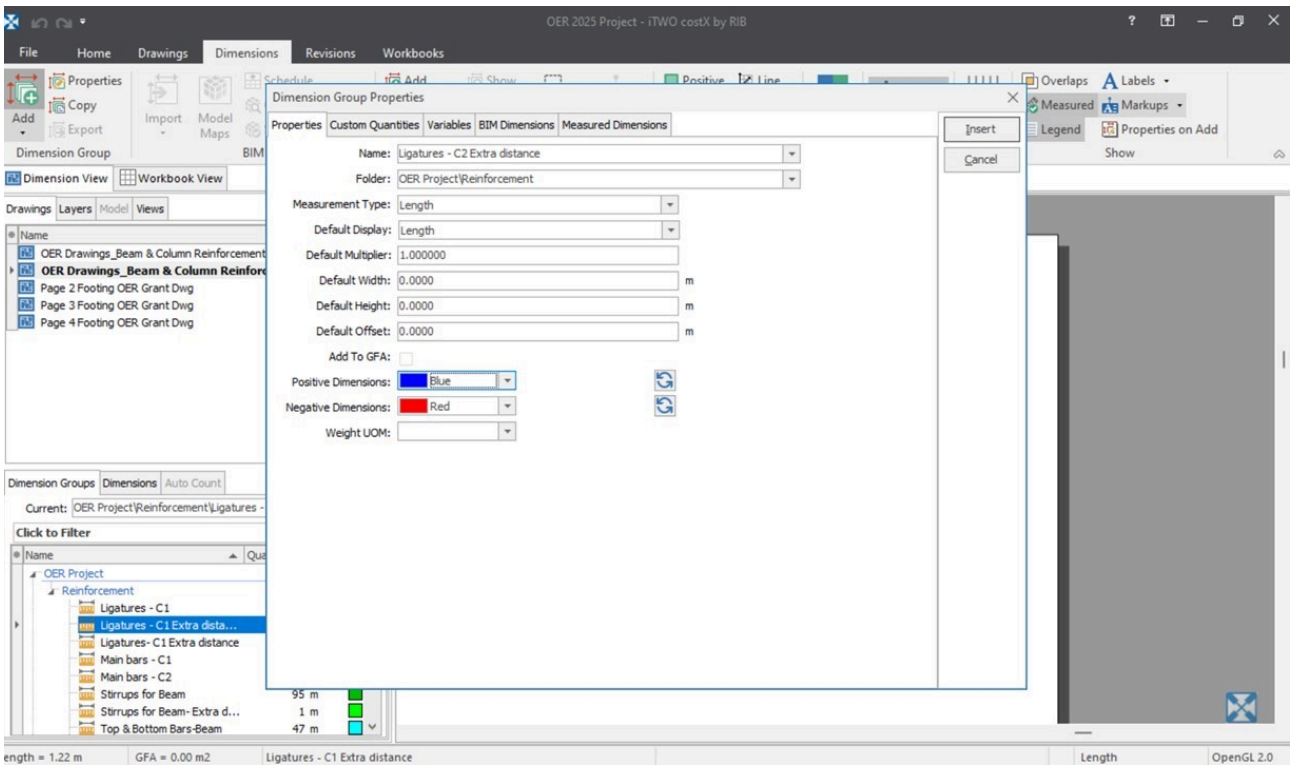


Figure 5.60: Screenshot of creating a dimension group for ligatures of C2 (extra distance) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

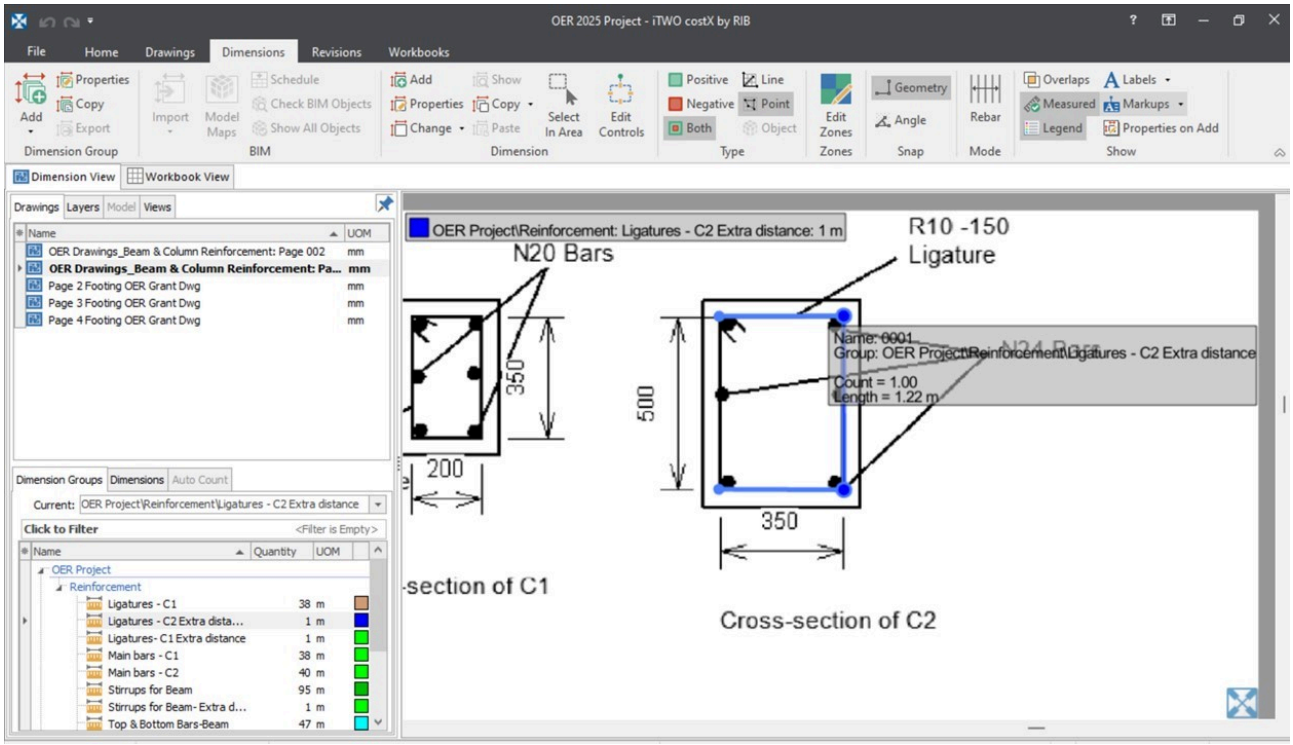


Figure 5.61: Screenshot of measuring ligatures of C2 (extra distance) using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The total extra bar length is calculated as follows:

- Measured extra distance in CostX = 1.22 m
- Hook length (from standard) for 10 mm diameter bar = 180 mm (or 0.18 m) per hook
- Total extra distance = 1.22m + 2 × 0.18 m = 1.58 m (or 1,580 mm)

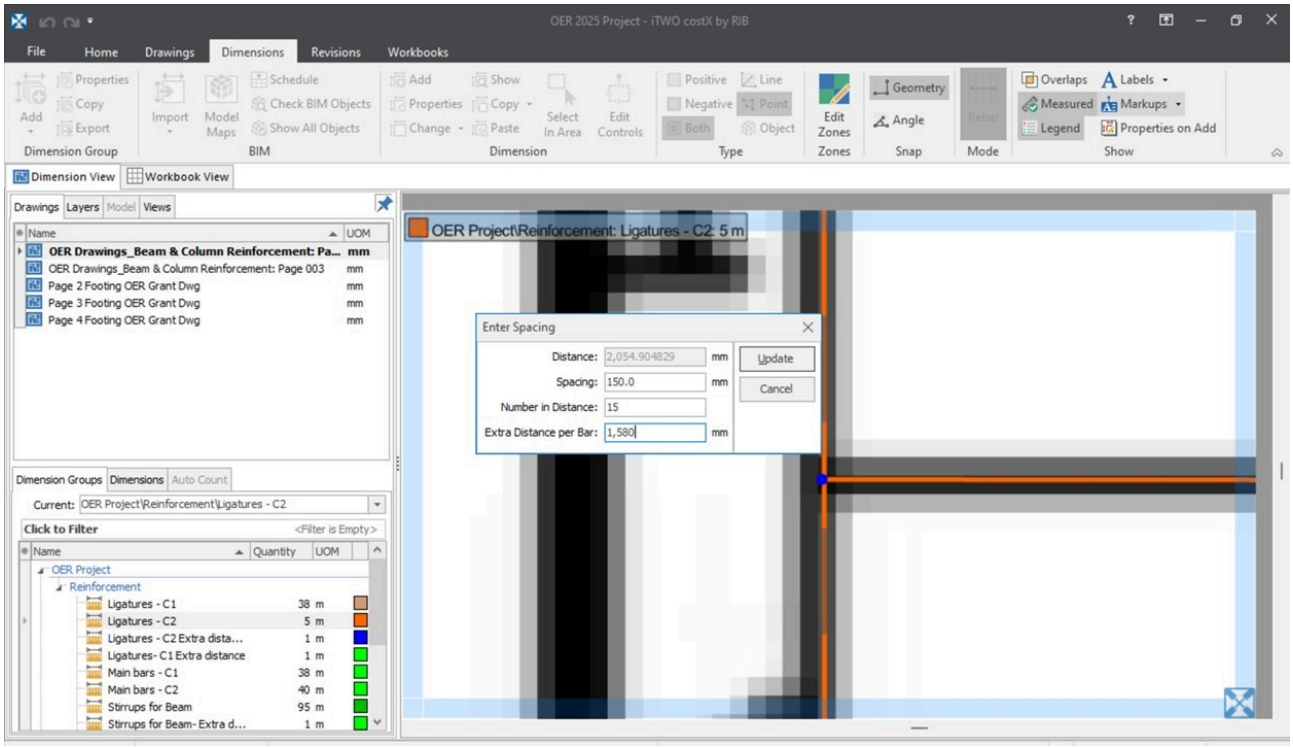


Figure 5.62: Screenshot of adding spacing for ligatures of C2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

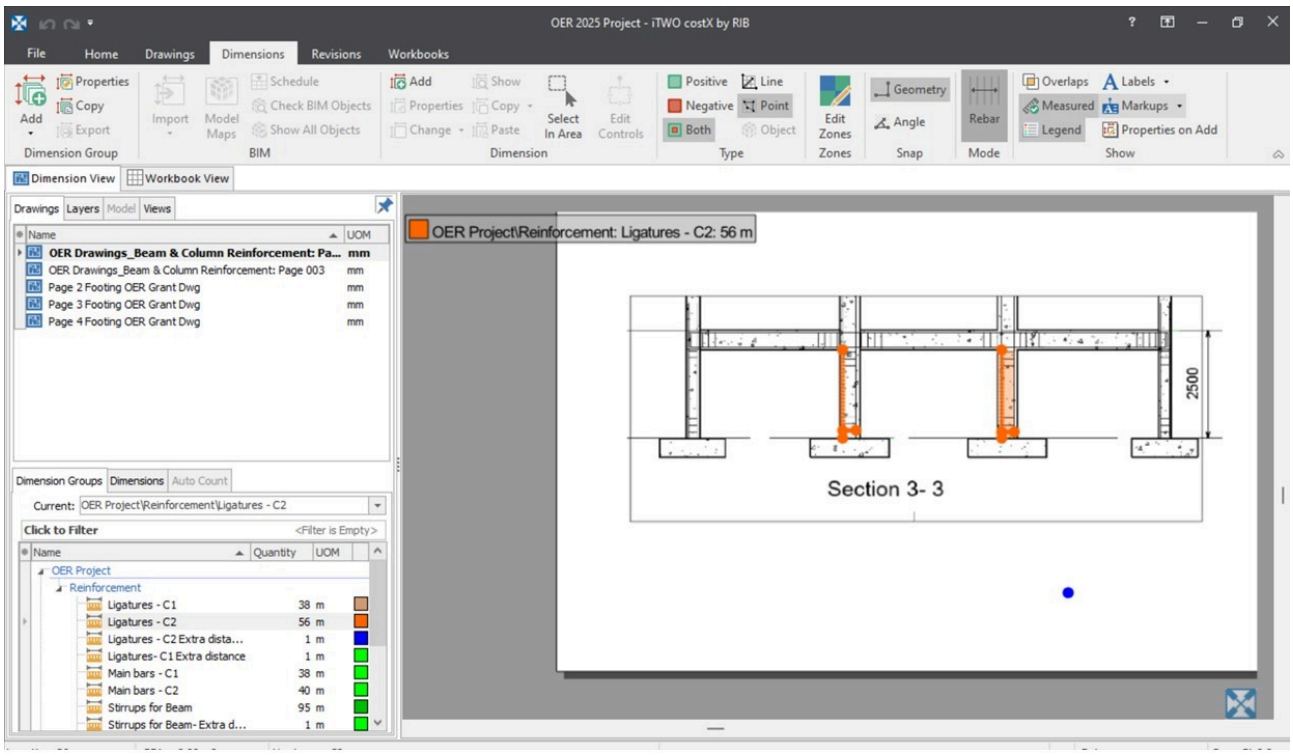


Figure 5.63: Screenshot of measuring ligatures of C2 using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 4: Create workbooks and transfer quantities (Figures 5.64 to 5.71).

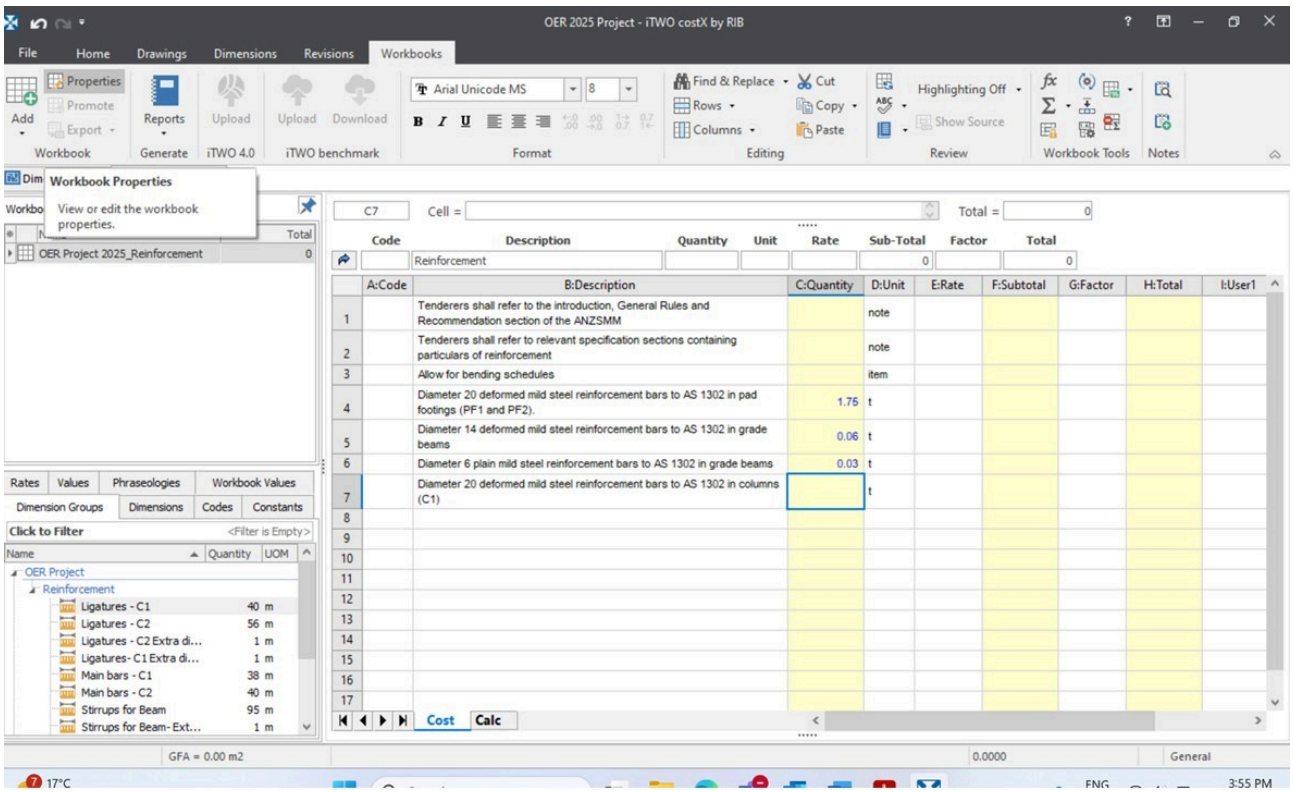


Figure 5.64: Screenshot of selecting C1 quantity cell to add quantities in the second level using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

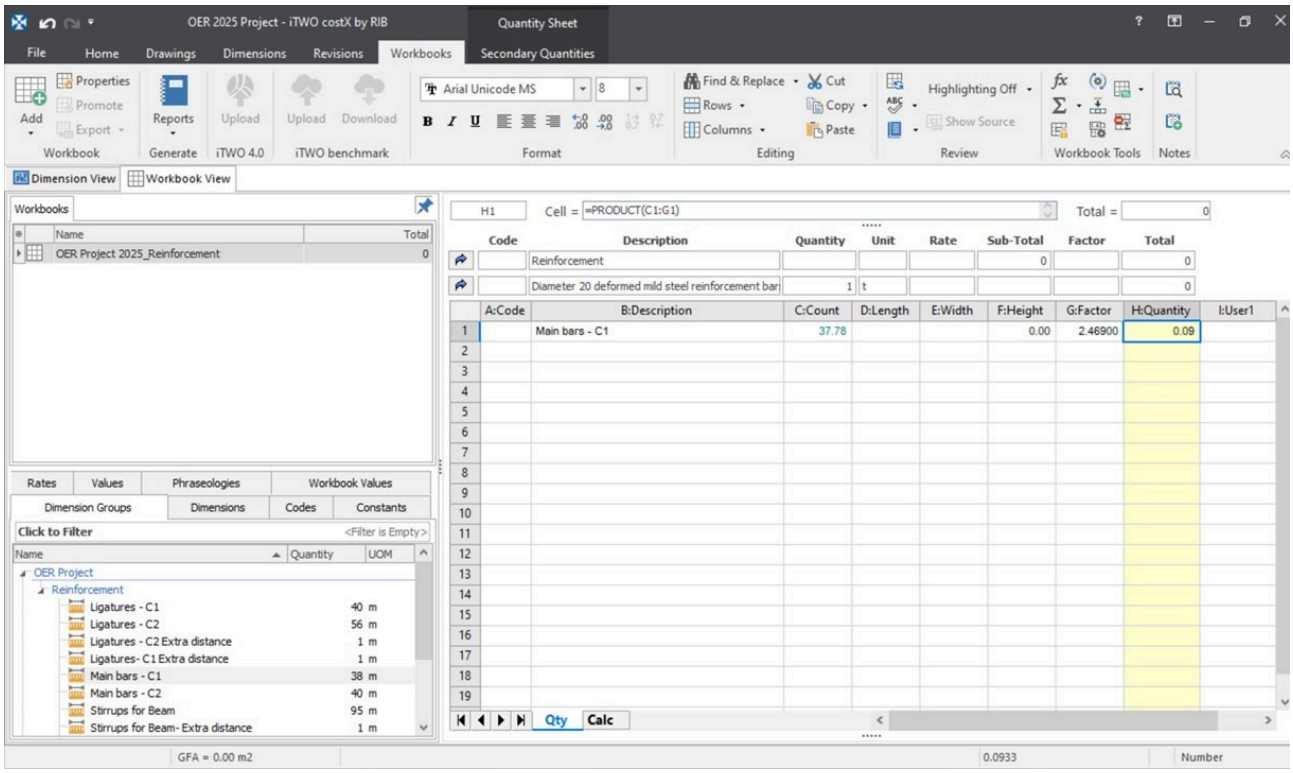


Figure 5.65: Screenshot of adding quantities of main bars of C1 to the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

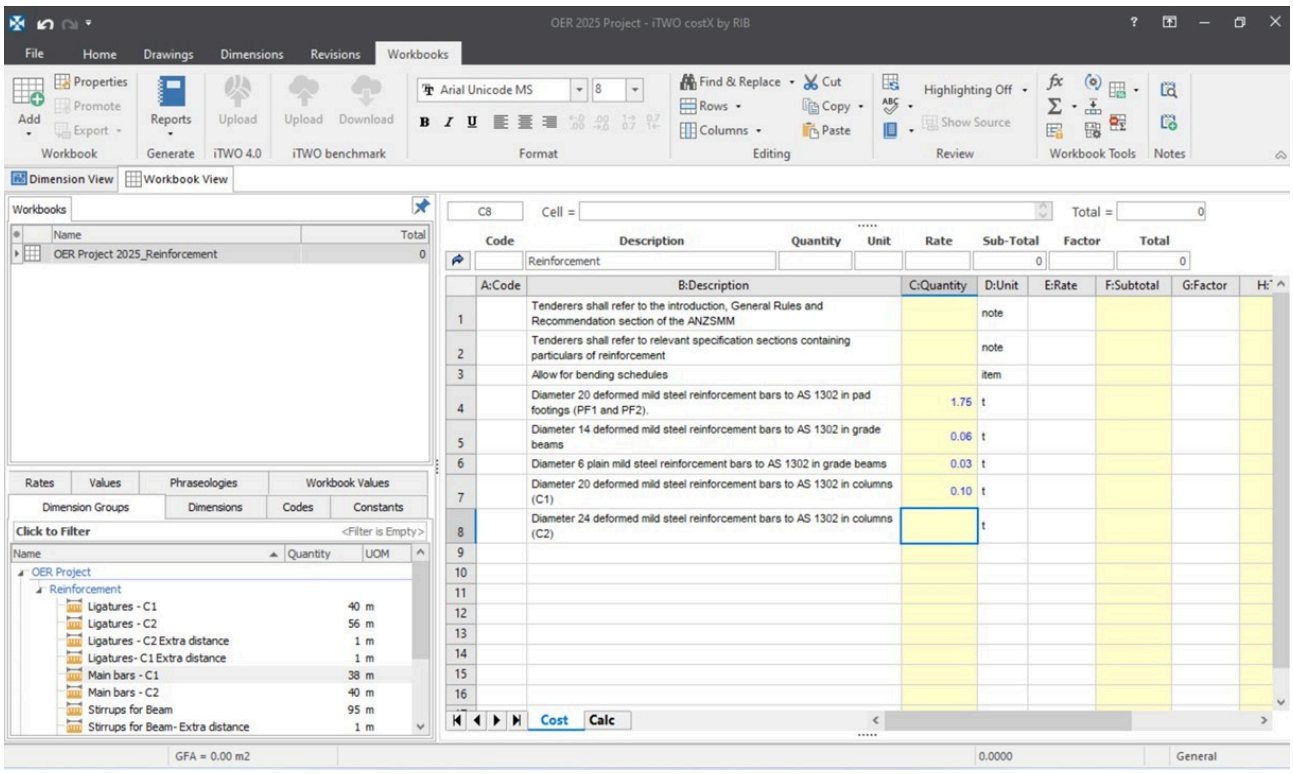


Figure 5.66: Screenshot of selecting C2 description to add quantities in the second level using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

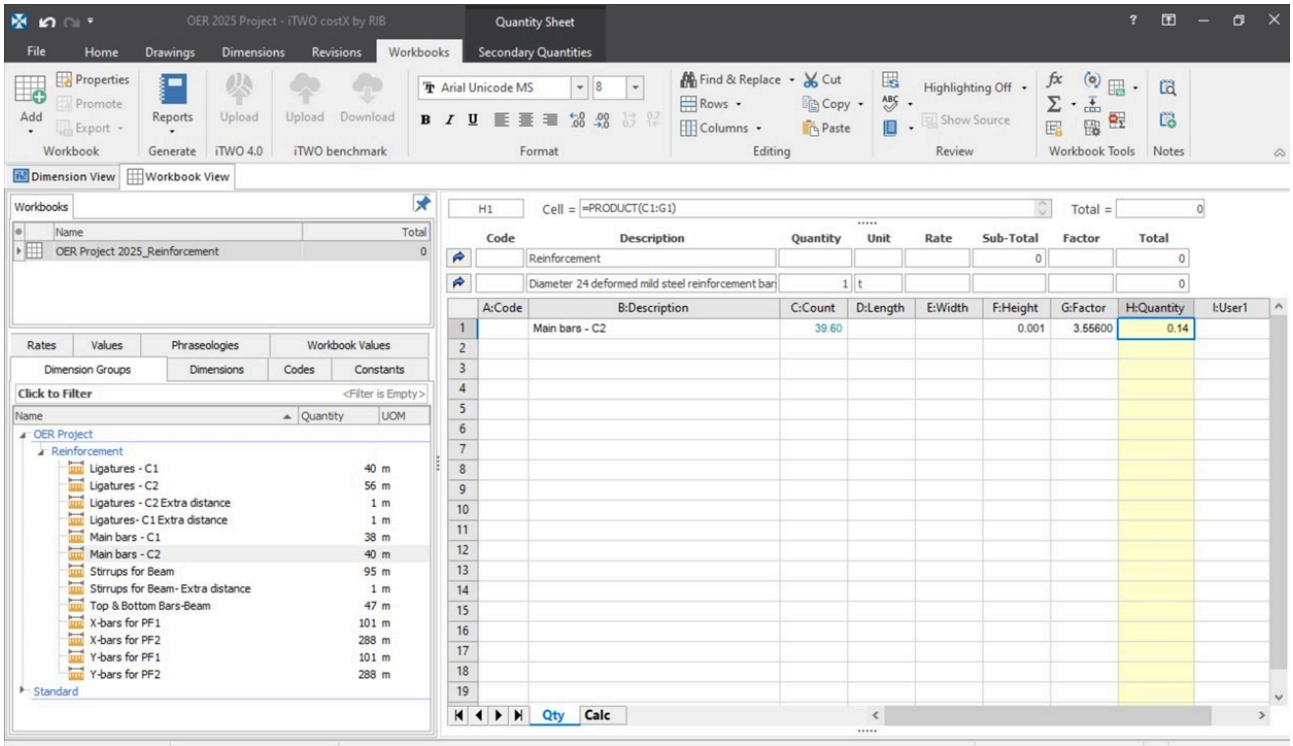


Figure 5.67: Screenshot of adding quantities of main bars of C2 to the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

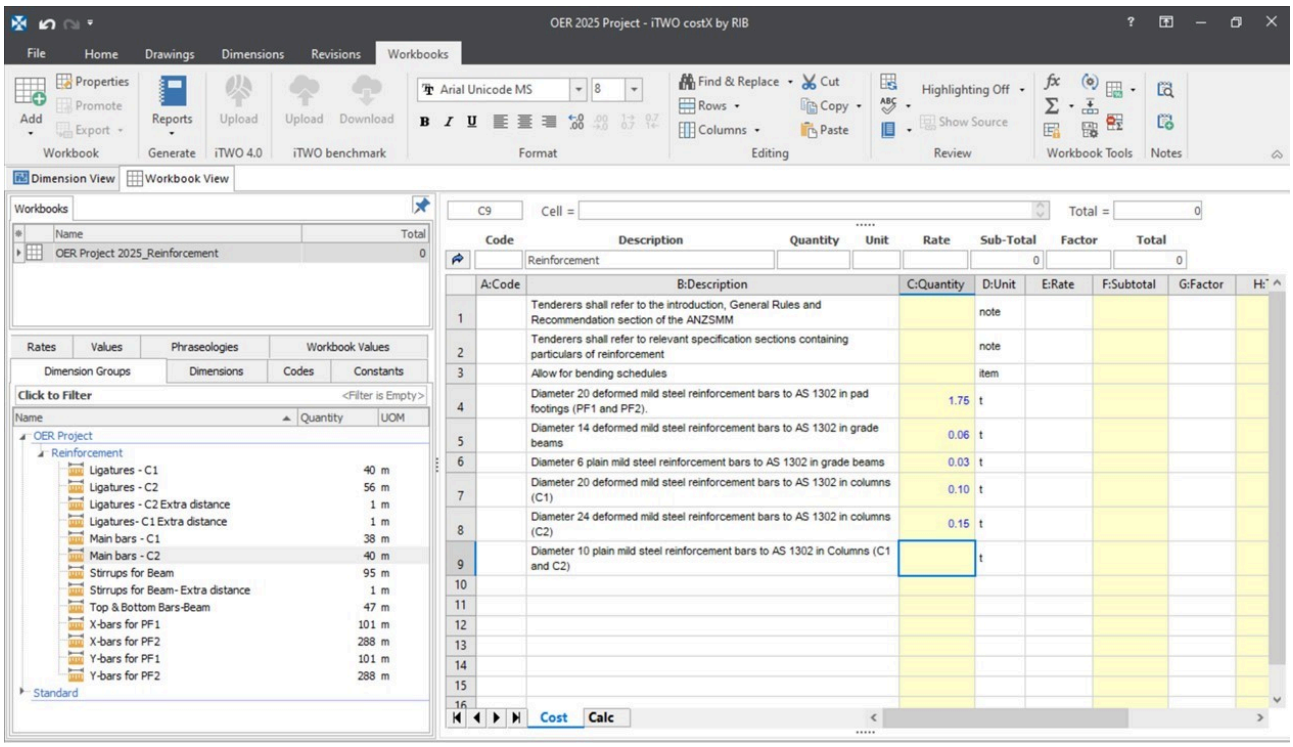


Figure 5.68: Screenshot of selecting C2 description to add quantities in the second level using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

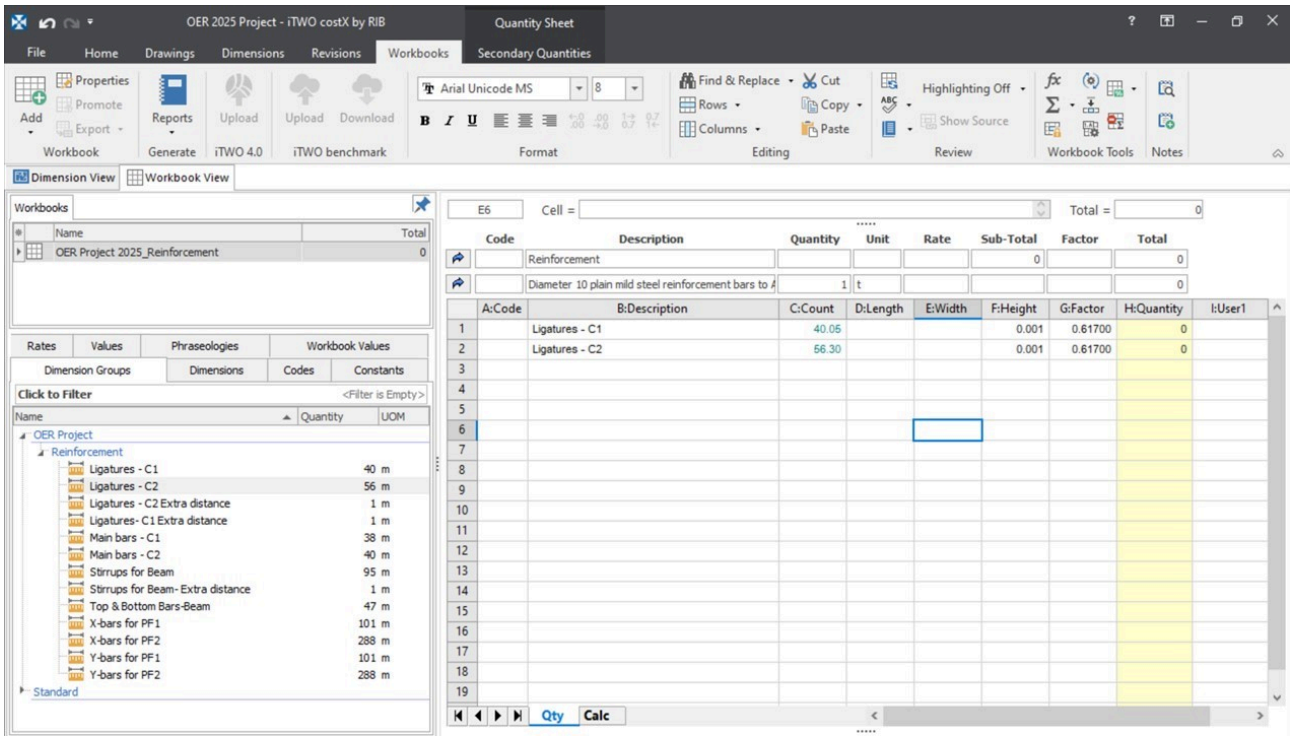


Figure 5.69: Screenshot of adding quantities of ligatures to the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

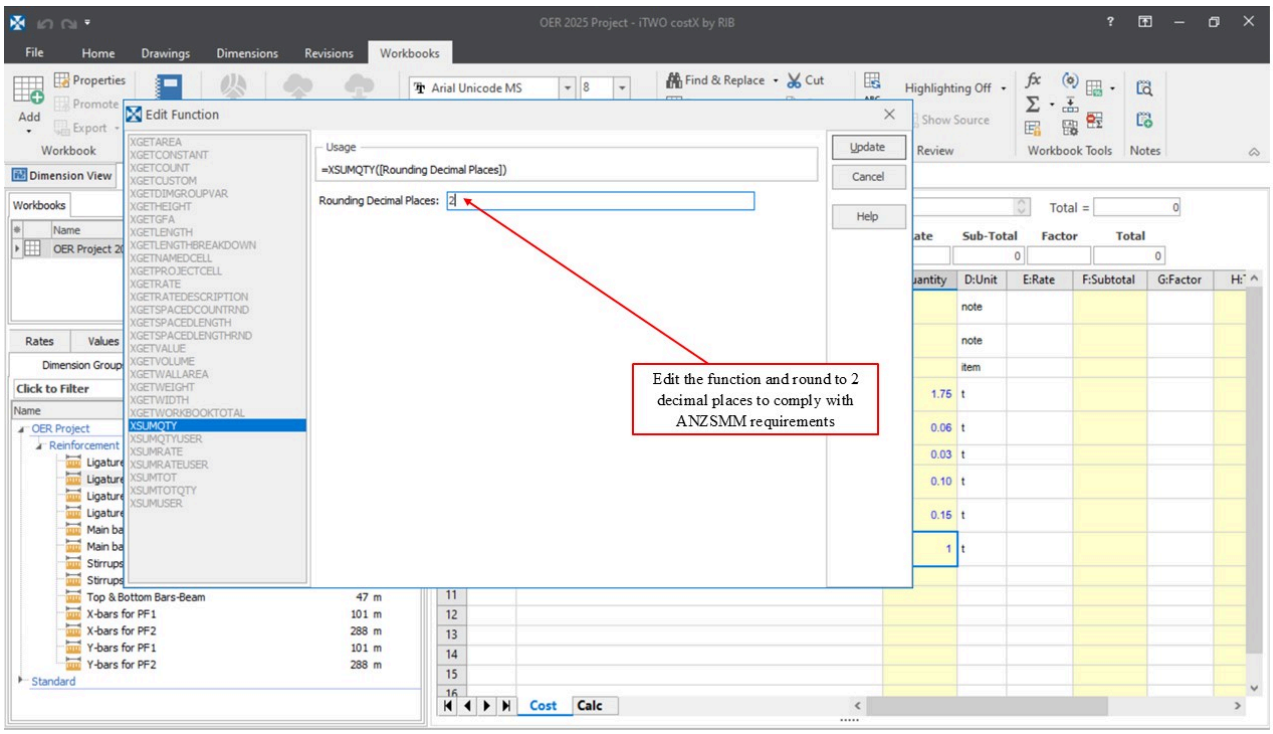


Figure 5.70: Screenshot of editing functions to round up values using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

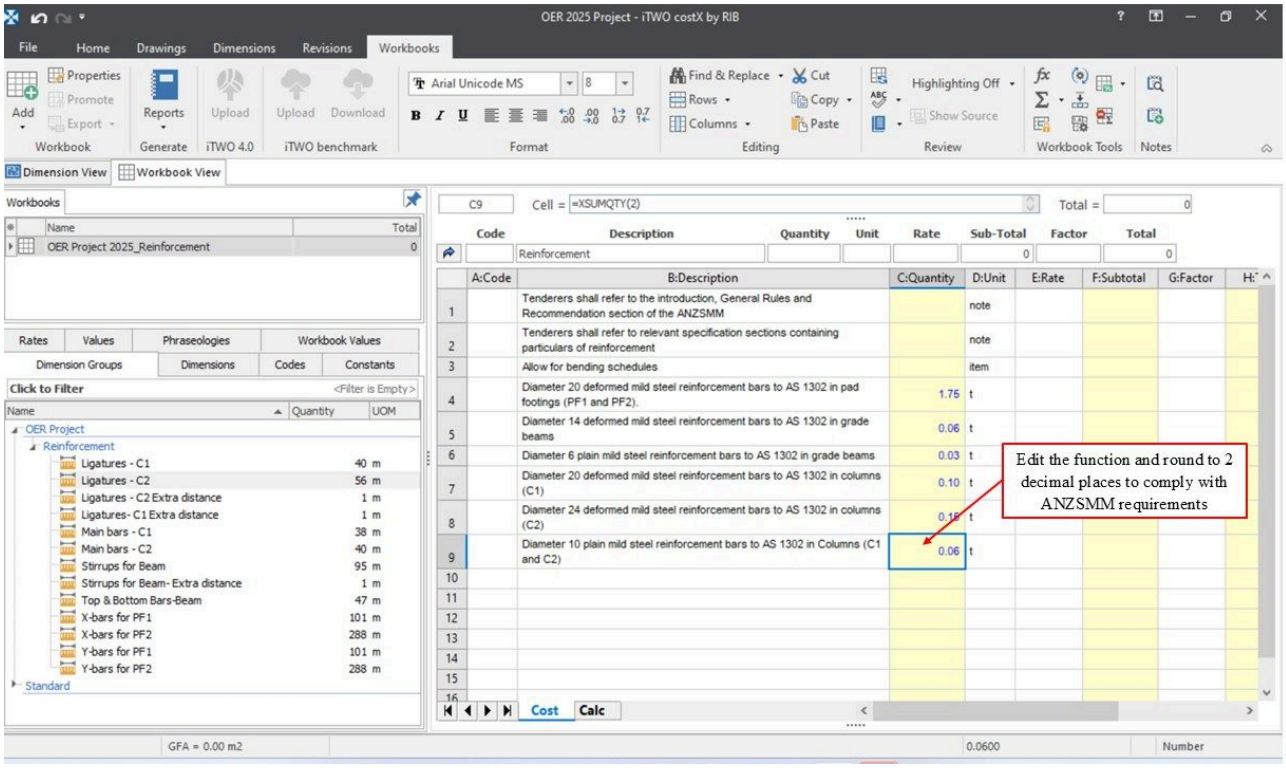


Figure 5.71: Screenshot of rounding up values using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Generate reports (Figure 5.72).

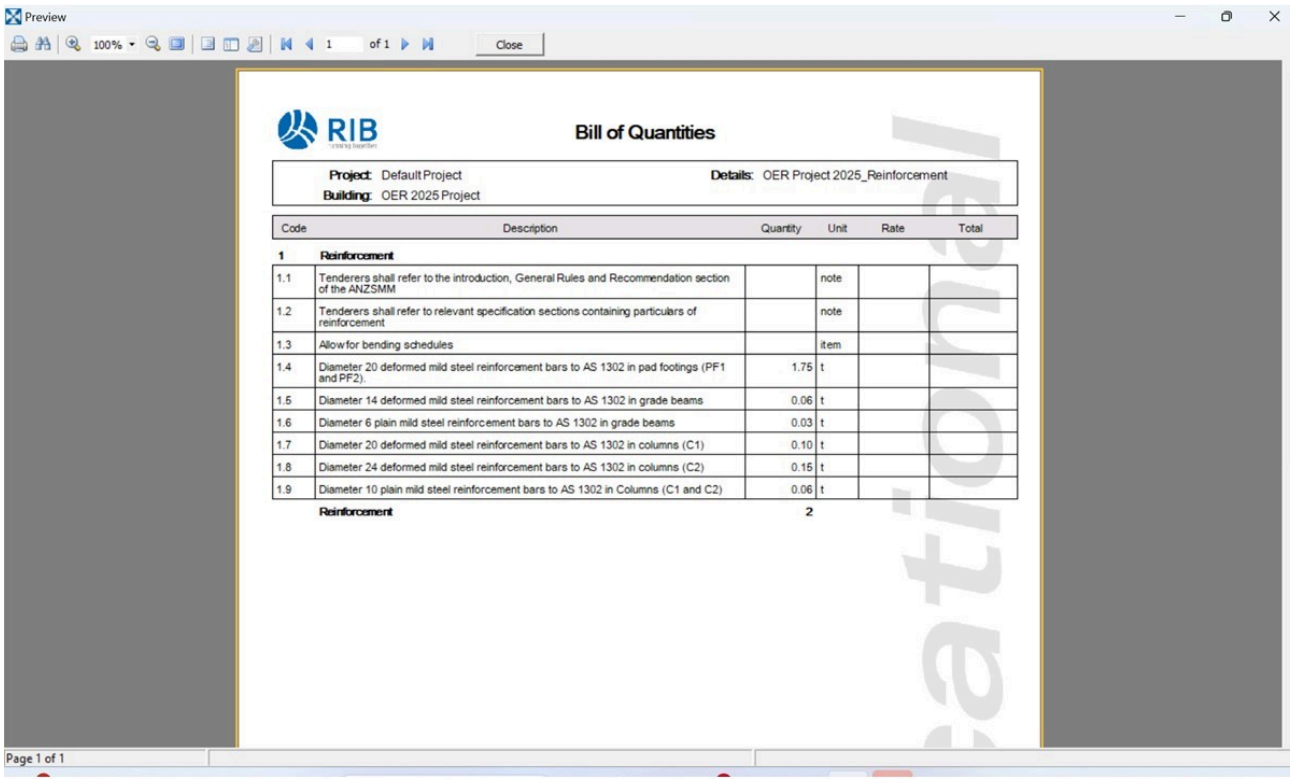


Figure 5.72: Screenshot of generated report for pad footings, beam and column reinforcement using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

CHAPTER 6: MEASUREMENT OF MASONRY

6.1 OVERVIEW

While there are numerous masonry items, this section specifically focuses on walls, piers, and damp-proof courses, detailing their technical specifications, the relevant measurement rules, and the measurement process using CostX software.

6.2 TYPES OF MASONRY WALLS

This section outlines the technical details related to masonry walls, piers, and damp-proof courses. When measuring masonry work, it is essential to specify the type and quality of materials, the bonding method, pointing or jointing techniques, and the mortar composition in the item descriptions.

There are various types of masonry walls, including solid walls, cavity walls and veneer walls, as illustrated in Figure 6.1.

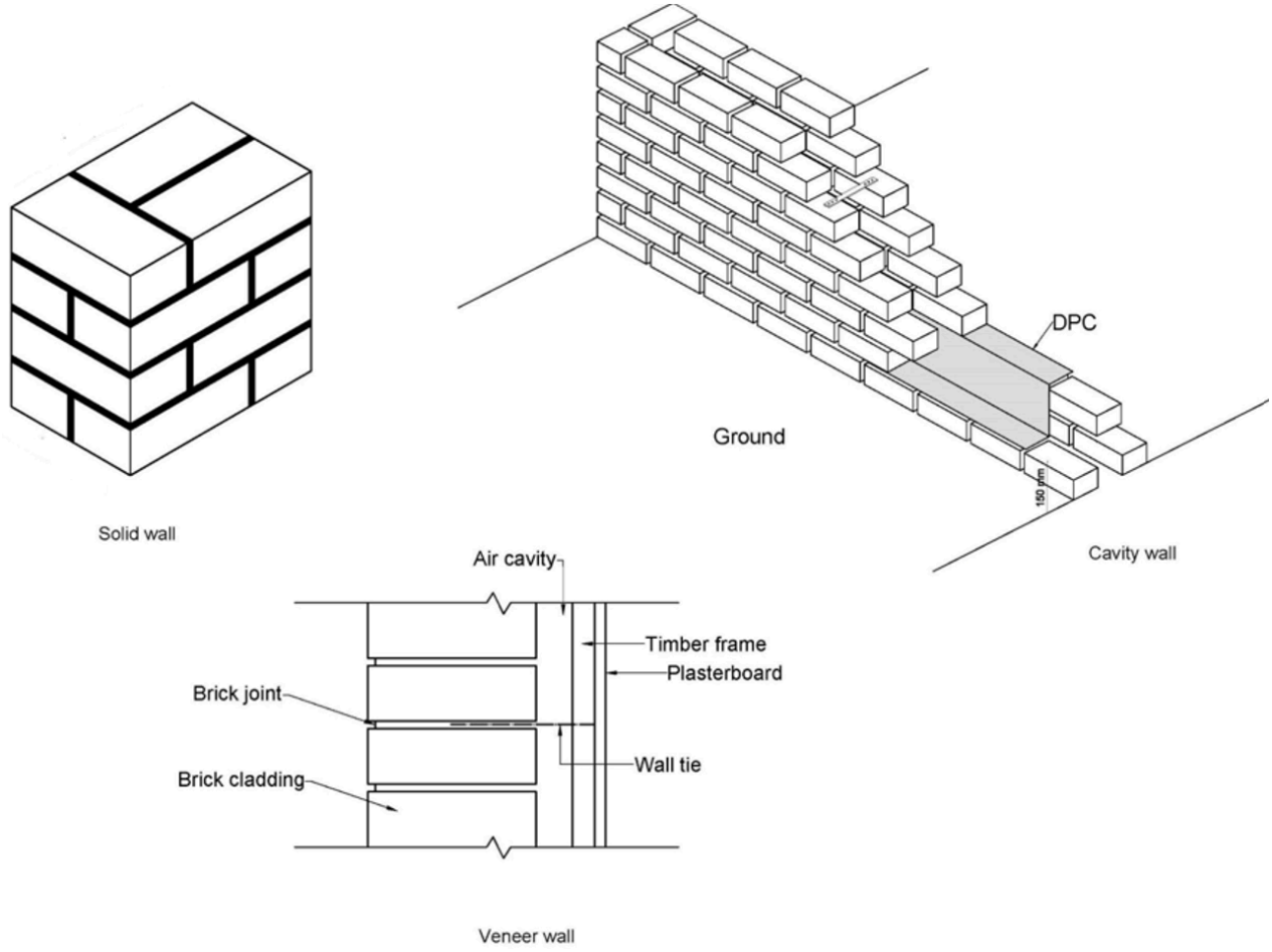


Figure 6.1: Types of masonry walls (Source: Created by Amirreza Aminalavije)

When measuring different types of masonry walls, it is essential to accurately identify their dimensions and thicknesses.

The standard size of a brick is 230 mm in length, 110 mm in width, and 76 mm in height as illustrated in the image below (Figure 6.2).

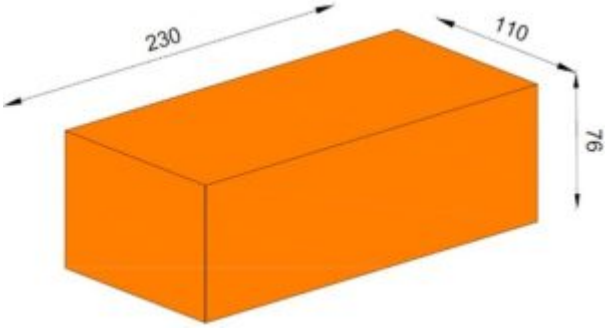


Figure 6.2: Standard brick dimensions (Source: Created by Amirreza Aminalavije)

Typical brick wall thicknesses (excluding finishes) are 110 mm for a half-brick wall and 230 mm for a one-brick wall.

In masonry construction, a 10 mm mortar joint is added to these dimensions. For example, the overall height of a brick including mortar is 86 mm as demonstrated in the calculation below:

76 mm (brick height) + 10 mm (mortar) = 86 mm

Blocks are generally available in three standard thicknesses: 90 mm, 140 mm, and 190 mm as shown in Figure 6.3. They commonly measure 390 mm in length and 190 mm in height. The following images show examples of some blocks:

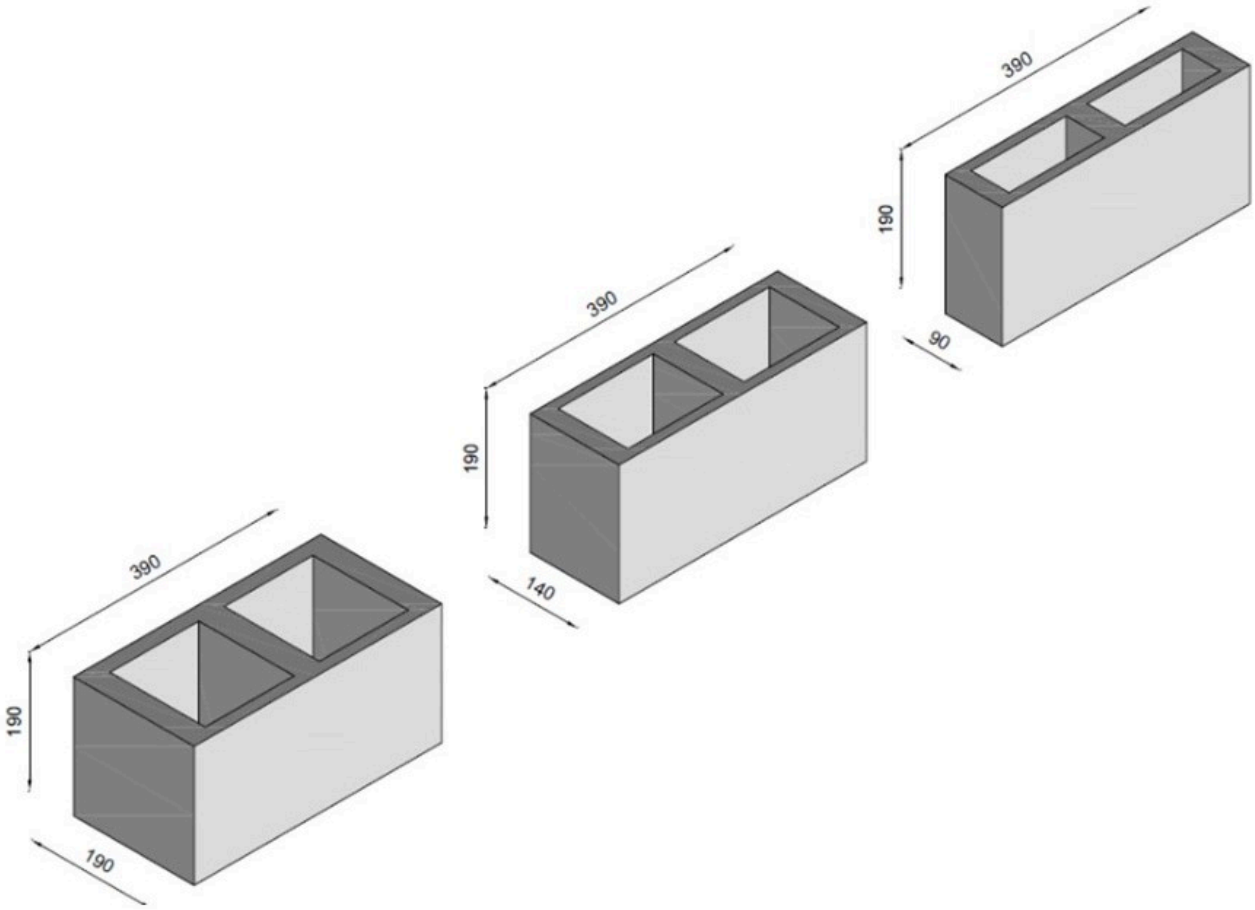
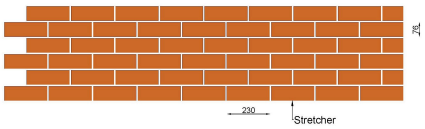
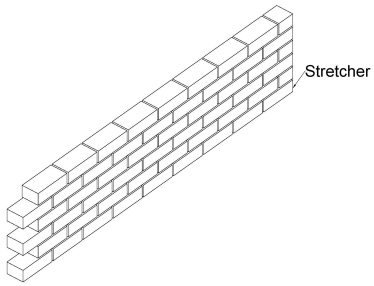
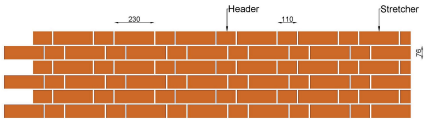
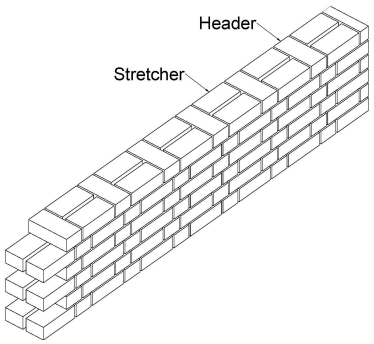
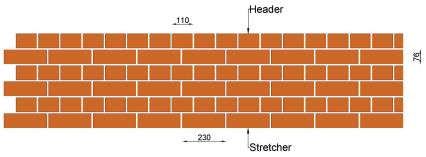
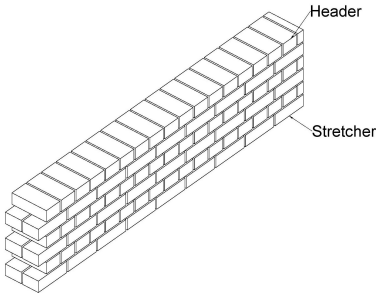


Figure 6.3: Standard block dimensions (Source: Created by Amirreza Aminalavije)

There are various bonding patterns used in masonry walls. Table 6.1 illustrates the most common brick bonding patterns. Depending on the wall thickness and the desired aesthetic, the appropriate bonding pattern can be selected. Generally, stretcher bond is used for 110 mm walls, while Flemish or English bond is commonly employed for 230 mm walls.

Figure 6.4 outlines the most common types of joints used in masonry construction. These bonding patterns are used in facing brick walls, where the bricks are exposed on the surface.

Table 6.1: Masonry bonding patterns (Source of images: Created by Amirreza Aminalavije)

Brick Bonding Pattern	Description	Elevation	Isometric View
Stretcher bond	Only the longest side of the bricks (the stretcher face) is visible in the masonry work.		
Flemish bond	Stretchers and headers are arranged alternately within each course		
English bond	Alternating courses of stretchers and headers are used in the construction of the masonry wall.		

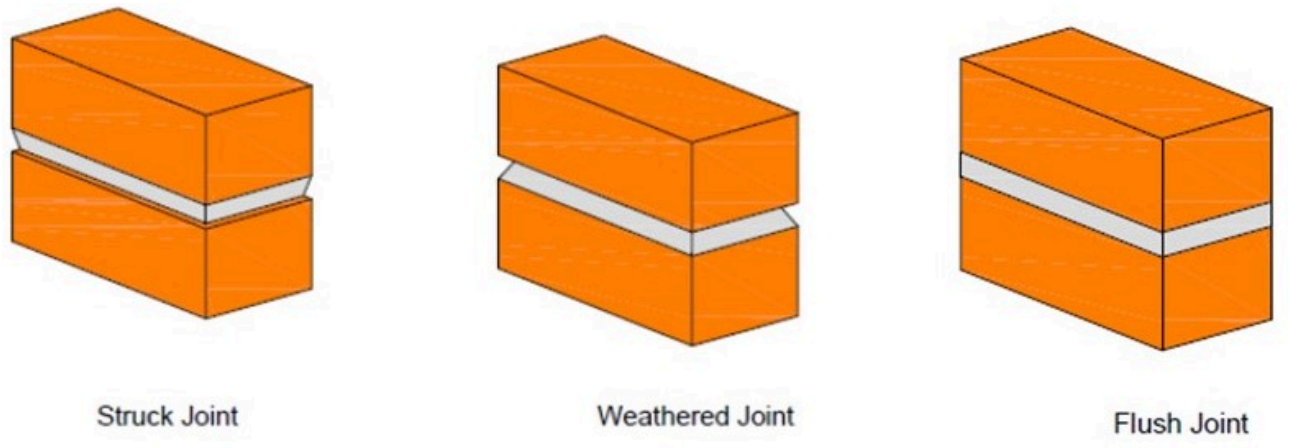


Figure 6.4: Types of joints (Source: Created by Amirreza Aminalavije)

Table 6.2 outlines the mix proportions by volume as specified in AS3700-2001. Depending on the type of wall and construction requirements, the mortar composition will be selected.

Table 6.2: Mix proportions by volume

Type	Cement	Lime	Sand
1	1	N/A	5
2	1	N/A	4
3	1	1	6
4	1	N/A	5
5	1	0.5	4.5
6	1	N/A	4

Piers

According to standards, piers are defined as masonry walls where the plan length is less than or equal to four times the wall thickness, except where this is due to openings, as illustrated in Figure 6.5.

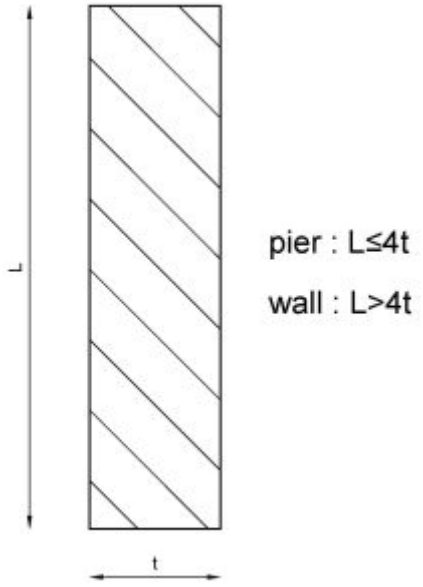


Figure 6.5: Pier classification (Source: Created by Amirreza Aminalavije)

Damp proof course

The damp-proof course (DPC) acts as a barrier to prevent water from rising through masonry walls. According to Australian standards, the DPC should be installed at least 150 mm above ground level. Figure 6.6 illustrates how it is placed in a masonry cavity wall.

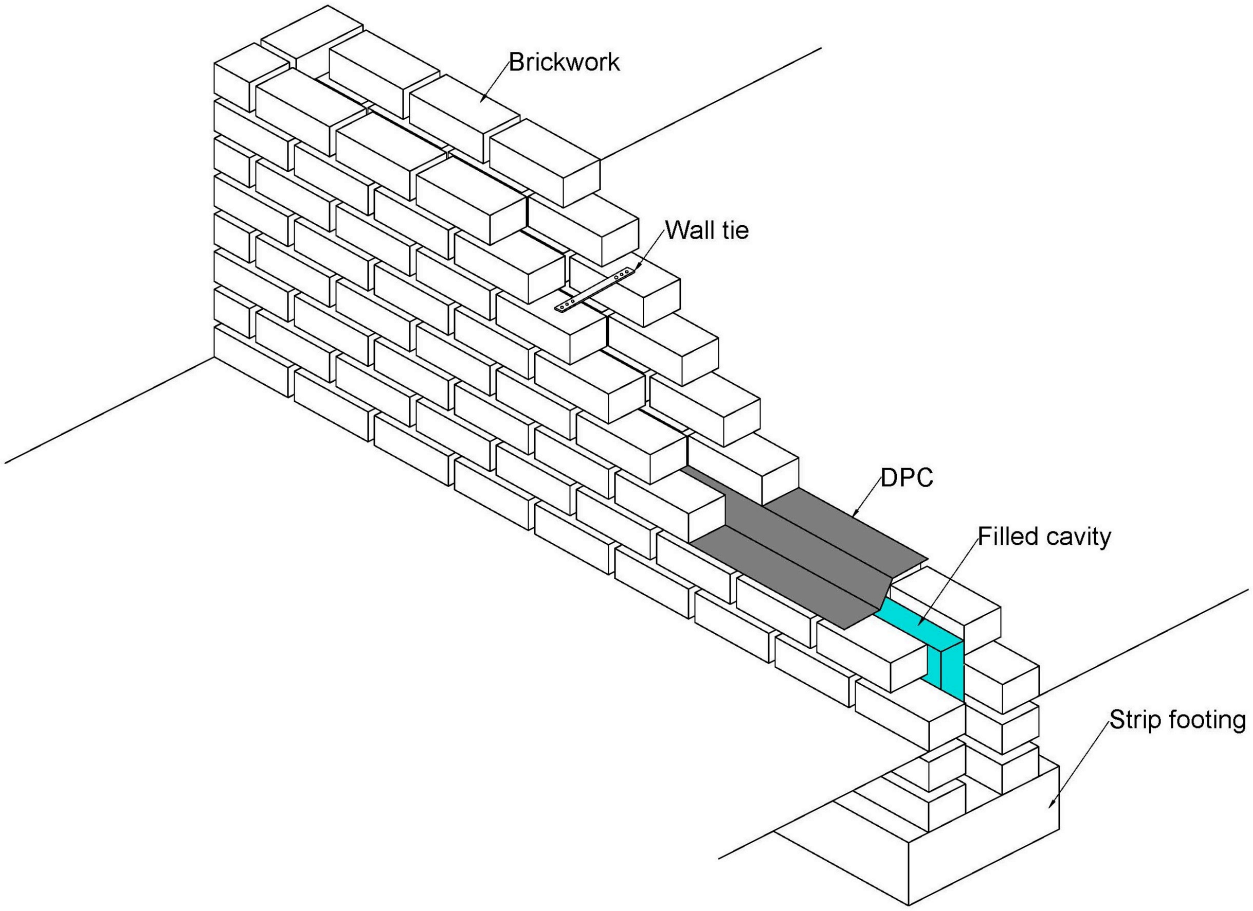


Figure 6.6: DPC in a cavity wall (Source: Created by Amirreza Aminalavije)

6.3 MASONRY MEASUREMENT RULES AND SAMPLE DESCRIPTIONS

The measurement rules for masonry are outlined in Section 12 of the ANZSMM. The "Information to be Included" table within this section contains both preamble notes and preamble items relevant to masonry works. The preamble notes direct tenderers to refer the Introduction, General Rules, and Recommendations section of the ANZSMM, along with relevant specification sections detailing the requirements for masonry work. The preamble items refer to provisions for samples, sample panels, and the conduct of tests. According to the standard, the unit of measurement for masonry walls is m^2. Wall measurements include the closing of cavities at the ends of hollow walls, jambs of openings, and wall ties in solid walls with two or more skins.

When writing descriptions, it is important to specify the masonry type, quality of materials, mortar composition, bonding method, and pointing or jointing techniques in the description.

When measuring masonry walls, deductions must be made for features such as string courses, sills, lintels, corbels, and other similar elements. However, according to Rule 3.4 in the Introduction, General Rules and Recommendations section of the ANZSMM, no deductions are required for openings with an area less than 1 m^2. For example, if there is an opening in a masonry wall measuring 1 m long and 0.5 m wide, this area (1 m × 0.5 m = 0.5 m^2) is less than 1 m^2 and therefore does not need to be deducted from the quantity of masonry measured.

Masonry work should be classified according to the type of bricks or blocks used, their sizes, colours, textures, bonding patterns, and finishes. Furthermore, masonry work should be classified by levels, and where consecutive floors have identical layouts, they may be grouped together by identifying the levels accordingly.

As per the standard, when measuring facing walls, it is necessary to measure two full courses below the finished ground level, unless otherwise specified in the contract documents.

Table 6.3 provides sample descriptions for various types of masonry walls.

Table 6.3: Sample descriptions of masonry walls

	Type of Wall	Description
1	110 mm facing brick veneer wall	110 mm thick facing brick wall comprising 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar, pointing to one side with weathered joint fixed to timber frame stud work.
2	90 mm block wall	90 mm thick block wall comprising of 390 × 90 × 190 mm blocks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar sand mortar.
3	230 mm common brick wall	230 mm thick brick wall comprising of 230 × 110 × 76 mm common bricks to AS4455, laid in English bond pattern using (1:1:6) cement lime sand mortar.
4	110 mm skins of brick cavity wall	110 mm thick skins of cavity wall constructed with common brick wall comprising of 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar.

According to ANZSMM, there are two types of piers: attached and isolated.

- Attached piers are measured in m^2. Only the projecting portion is measured, with the thickness stated in the description.
- Isolated piers are measured in linear metres (m), and their cross-sectional dimensions must be clearly described in the description.

The following table outlines sample descriptions for both attached and isolated piers.

Table 6.4: Sample descriptions of piers

	Type of Pier	Description
1	Attached	110 mm thick facing brick pier comprising 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar, pointing to one side with weathered joint.
2	Isolated	390 mm × 390 mm sized isolated piers comprising 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar, pointing to one side with weathered joint.

DPC and flashings are measured in m^2 when the girth exceeds 1 m. If the girth is less than 1 m, the unit of measurement is linear metres (m). The girth must be specified in 250 mm stages, such as:

- Less than 250 mm
- 250–500 mm
- 500–750 mm
- 750 mm to 1 m.

It is also essential to indicate the orientation and location, such as whether the item is horizontal, vertical, or located in a jamb, head, sill, or similar item.

The following is a sample description of a DPC:

"0.2 mm gauge polythene damp proofing course to walls, horizontal, lapped 150 mm joints sealed with pressure sensitive tape."

For a comprehensive understanding of the applicable measurement procedures and pricing considerations, readers are advised to refer to Section 12 of the ANZSMM.

6.4 MEASUREMENT PROCESS FOR MASONRY USING COSTX SOFTWARE

Using the provided floor plan and sections (Figures 6.7 and 6.8), measure the 230 mm and 110 mm solid walls, 110 mm brick veneer walls, piers, and DPC. Assume a floor-to-ceiling height of 3,000 mm for all elements. The window height is 1,300 mm, and the door height is 2,100 mm. All dimensions are in millimetres.

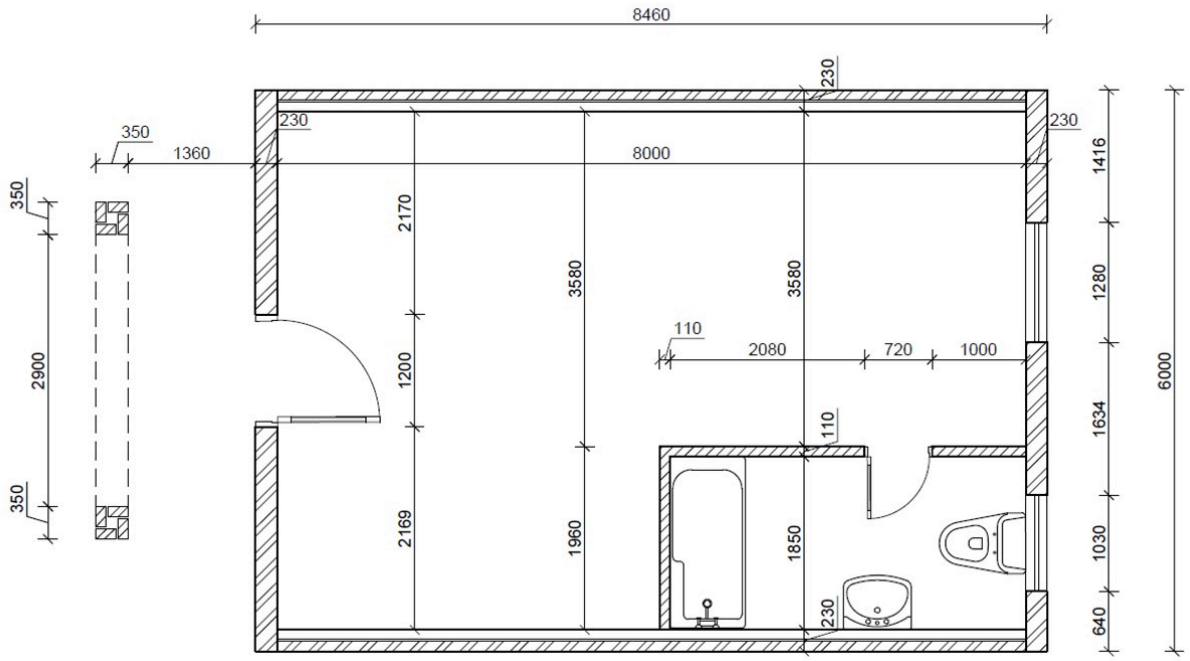


Figure 6.7: Wall plan of the masonry measurement drawing (Source: Created by Amirreza Aminalavije)

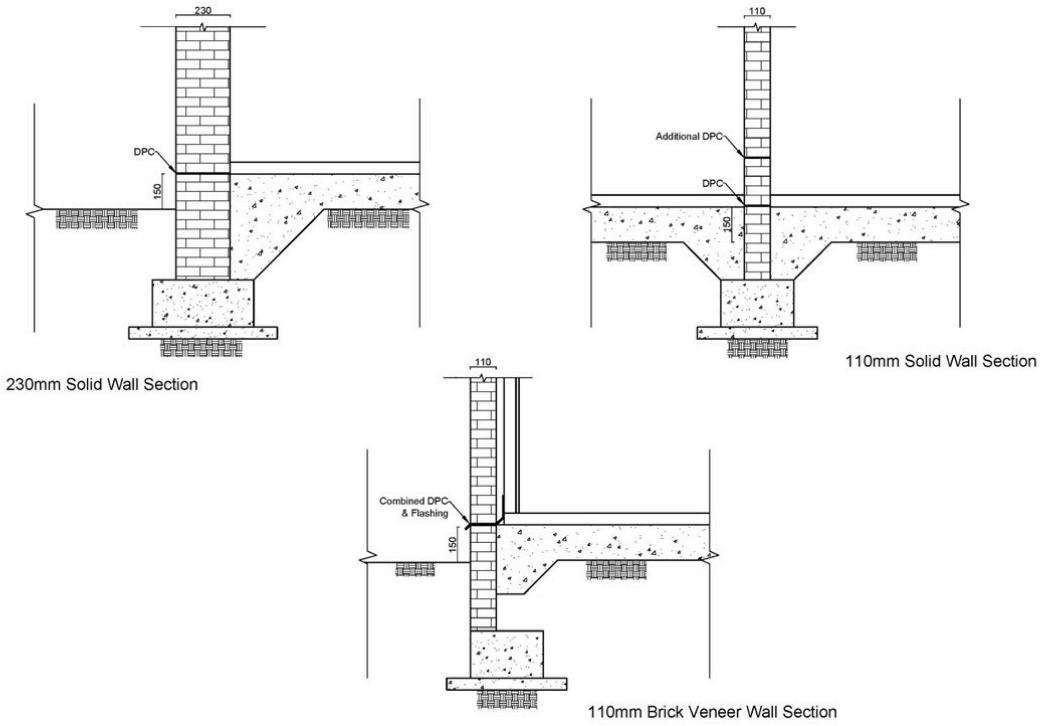


Figure 6.8: Wall sections of the masonry measurement drawing (Source: Created by Amirreza Aminalavije)

Step 1: Open CostX and create a new building. Name the building as "Masonry Measurement" and select the Default Project as the project. Set the default height to 3 m as shown in Figure 6.9.

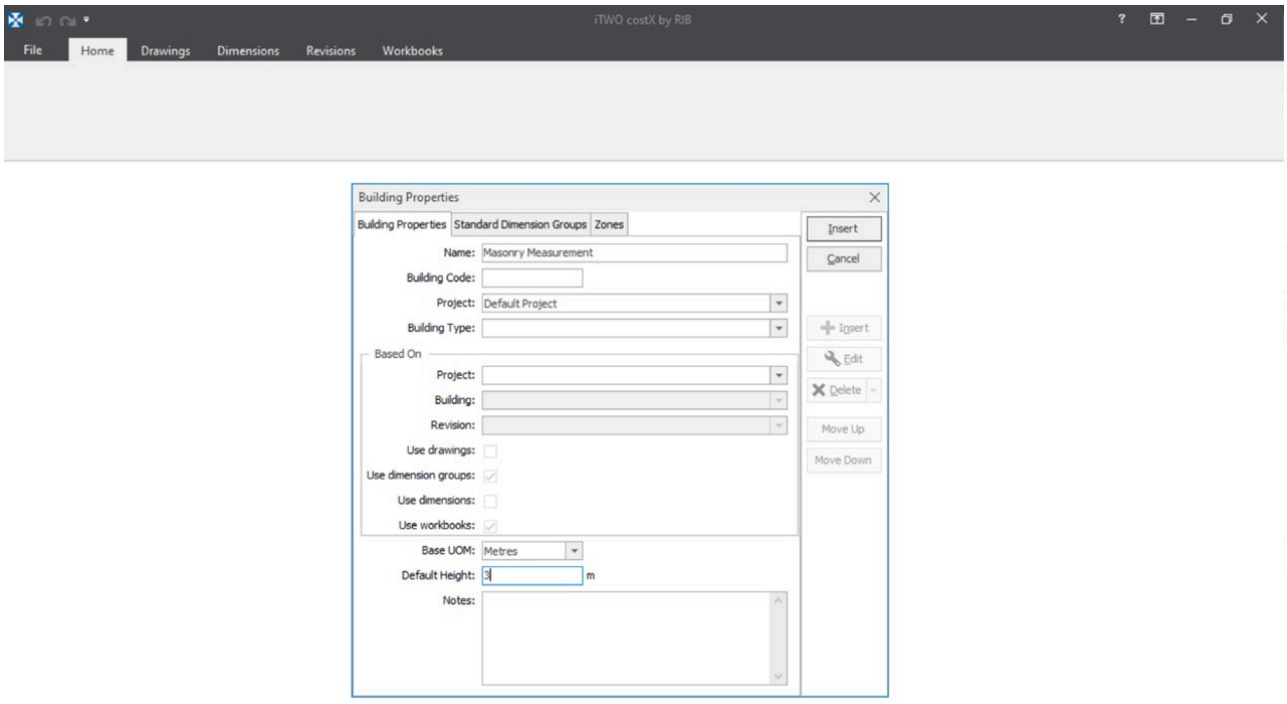


Figure 6.9: Screenshot of creating a building using CostX software using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 2: Click on the Drawings tab and then select Add Drawings to import the wall plan into CostX as shown in Figure 6.10.

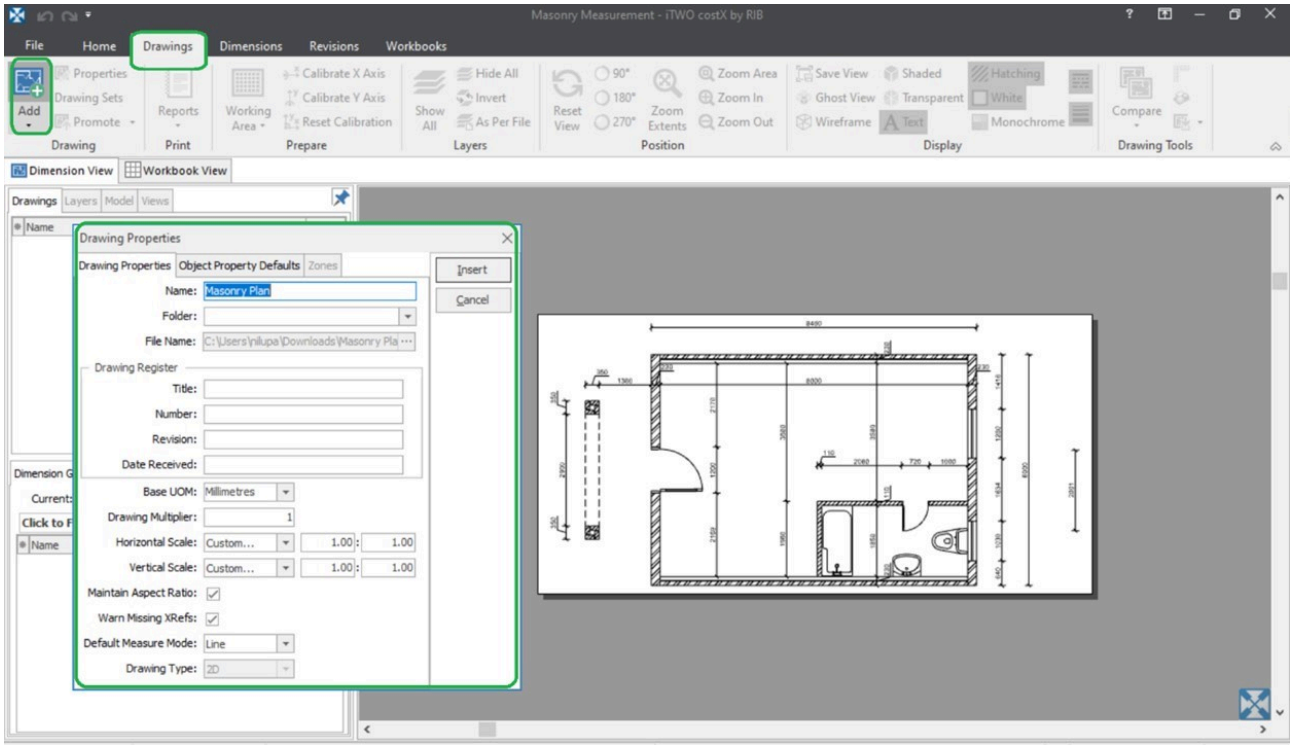


Figure 6.10: Screenshot of inserting the wall plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 3: Calibrate the drawing using the known X and Y dimensions, as shown in Figure 6.11 and Figure 6.12. It is recommended to use the longest dimension for calibration to minimise the accumulation of errors. The X-axis was calibrated using the 8,460 mm dimension marked on the plan, while the Y-axis was calibrated using the 6,000 mm dimension indicated on the drawings, as shown in the image below. To calibrate both axes separately, make sure to untick "Apply factor to Y axis"; otherwise, the X-axis calibration will also be applied to the Y axis.

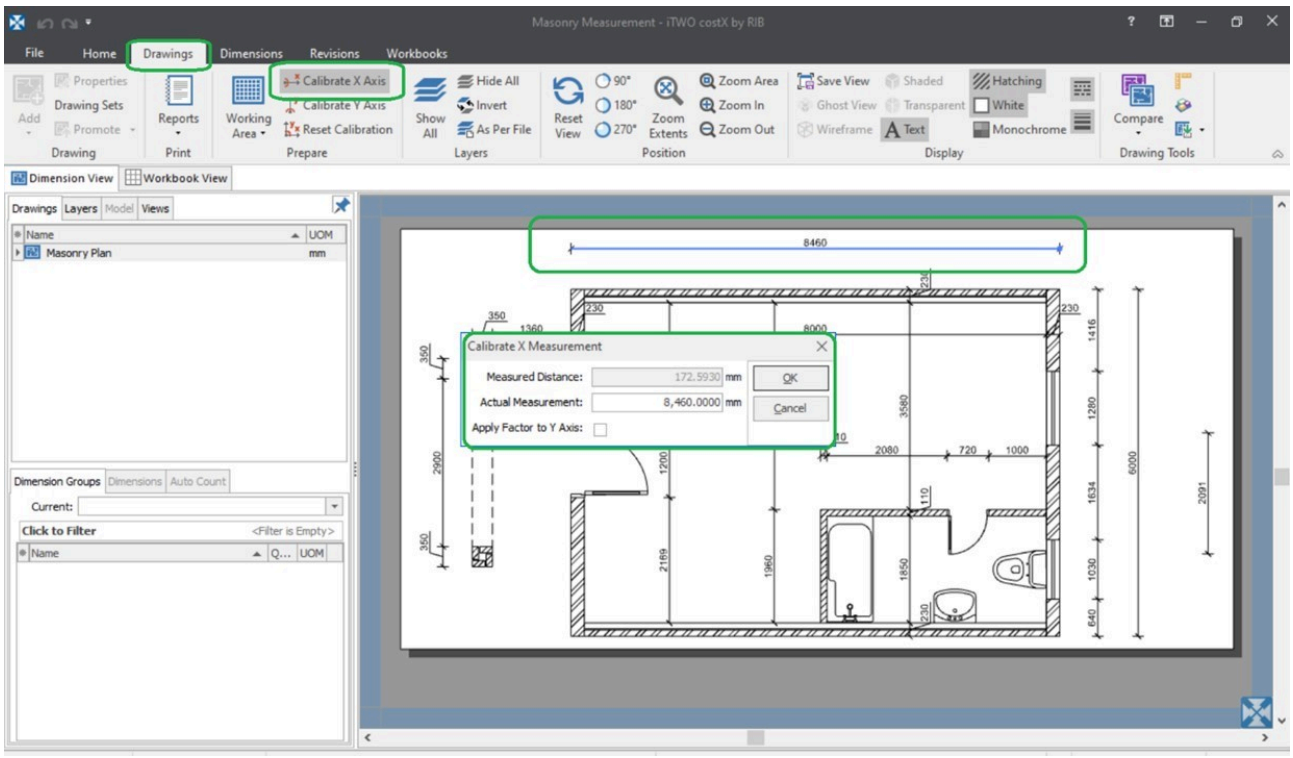


Figure 6.11: Screenshot of calibrating X axis of the wall plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

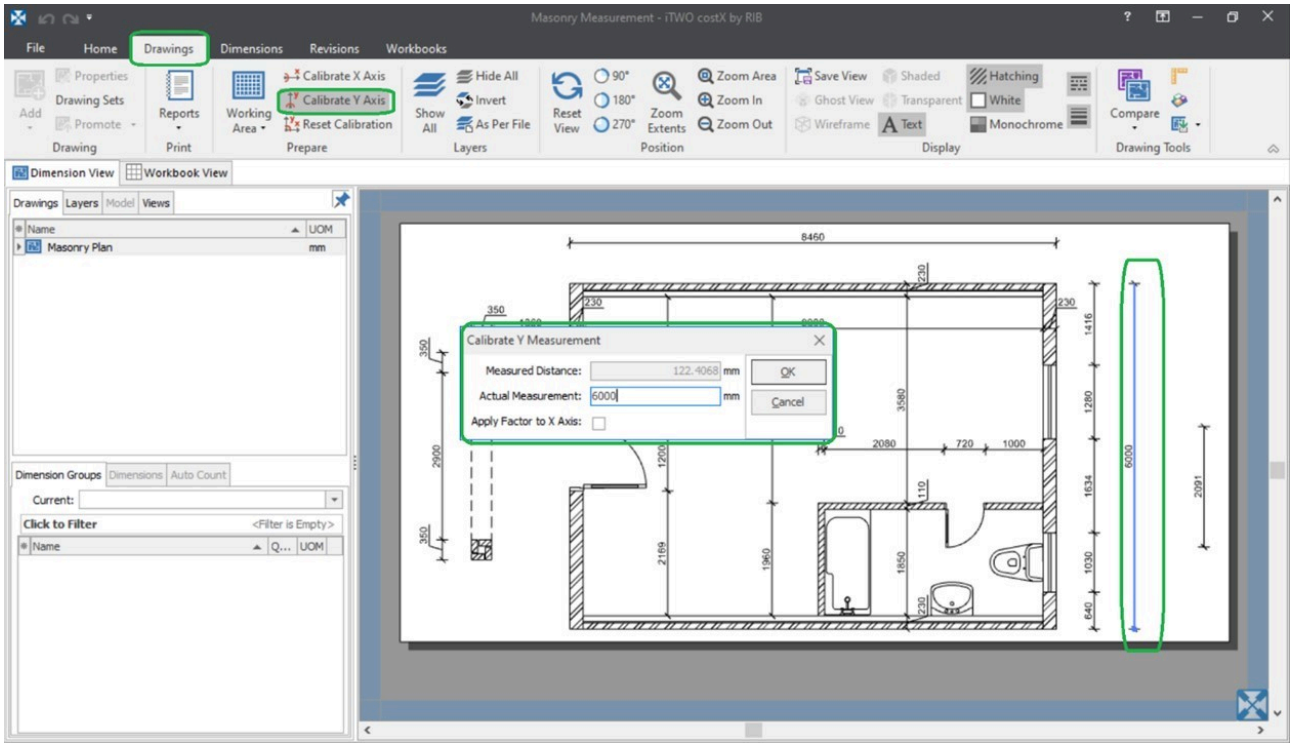


Figure 6.12: Screenshot of calibrating Y axis of the wall plan using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 4: Create a dimension group to measure the 230 mm brick walls as illustrated in Figure 6.13. Add a folder named Masonry. Walls are measured in square meters; therefore, set the measurement type to Length and the default display to Wall Area.

Since the default height was set to 3 m when creating the building (Step 1), this height will be automatically applied. If you need to adjust the height, you can do it in the Height field within the dimension group.

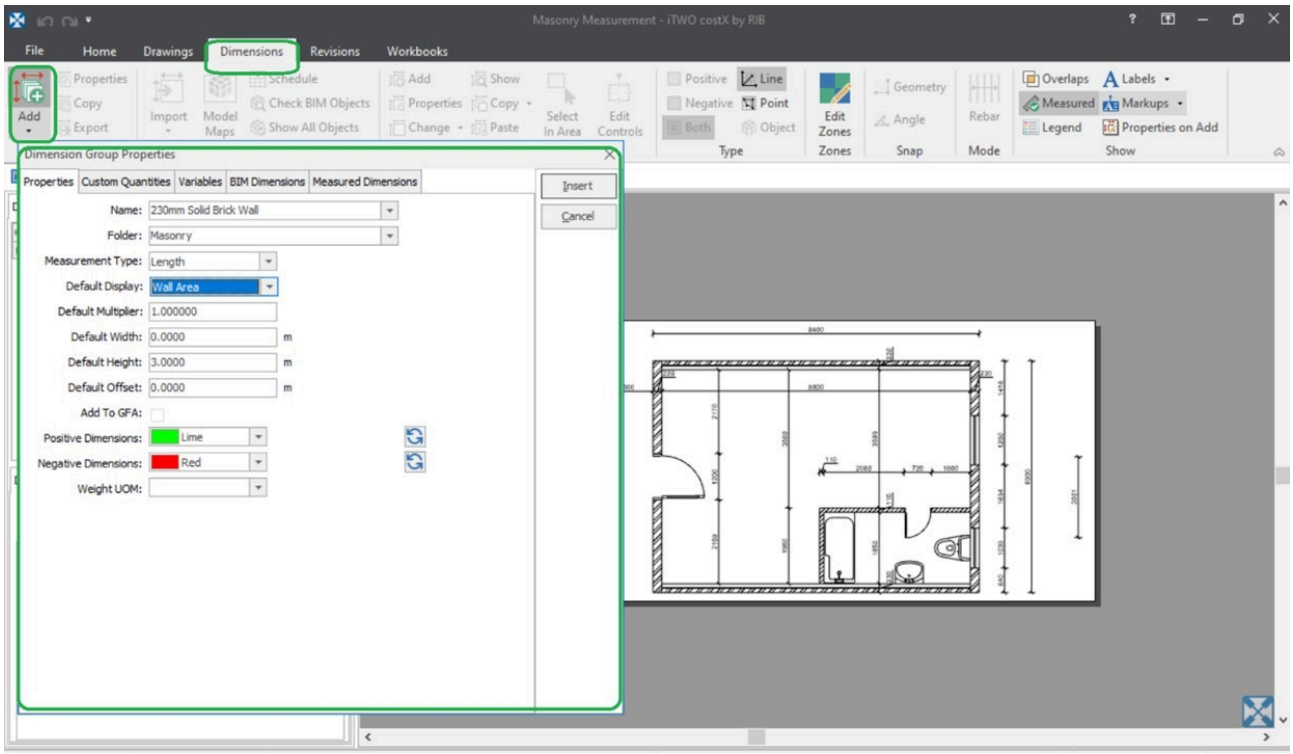


Figure 6.13: Screenshot of creating a dimension group to measure a 230 mm thick brick wall using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 5: Using the Point method, select the wall lengths corresponding to the 230 mm wall, as illustrated in Figure 6.14.

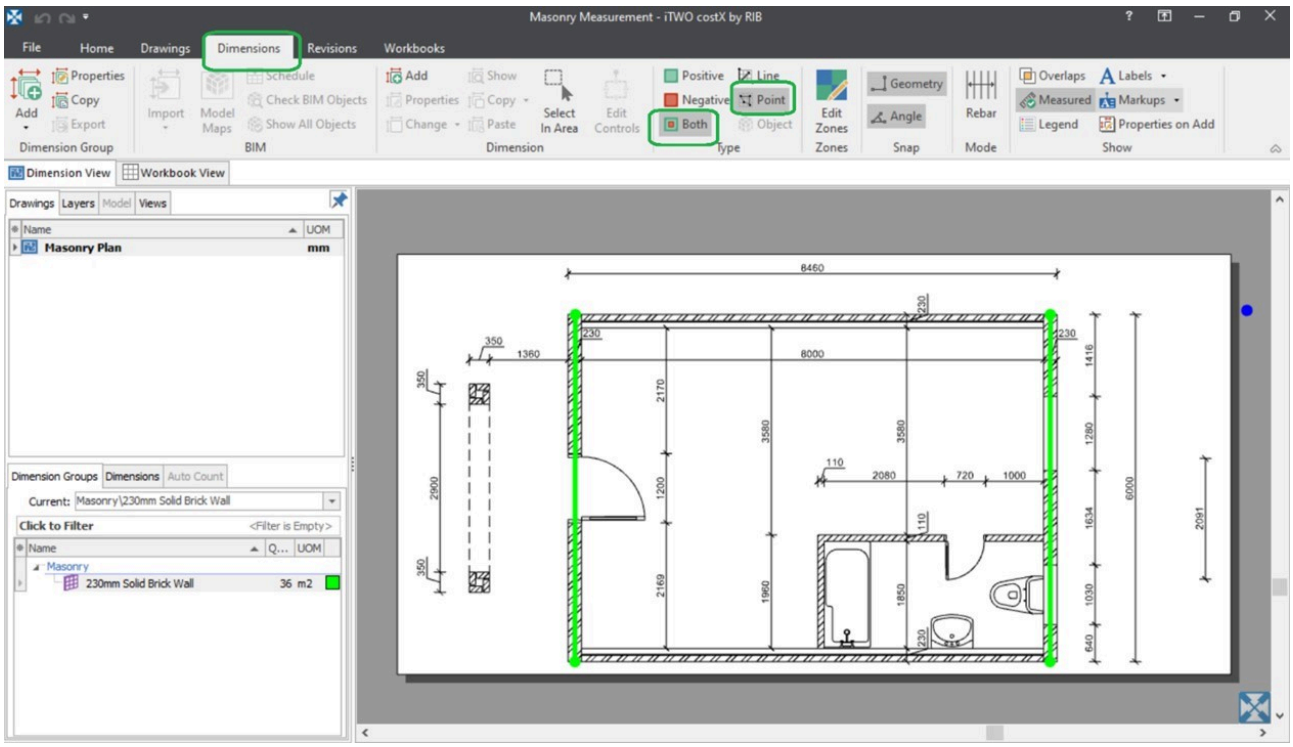


Figure 6.14: Screenshot of measuring 230 mm thick brick walls using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 6: Using the Point method, introduce door and window openings as negative dimensions as illustrated in Figure 6.15.

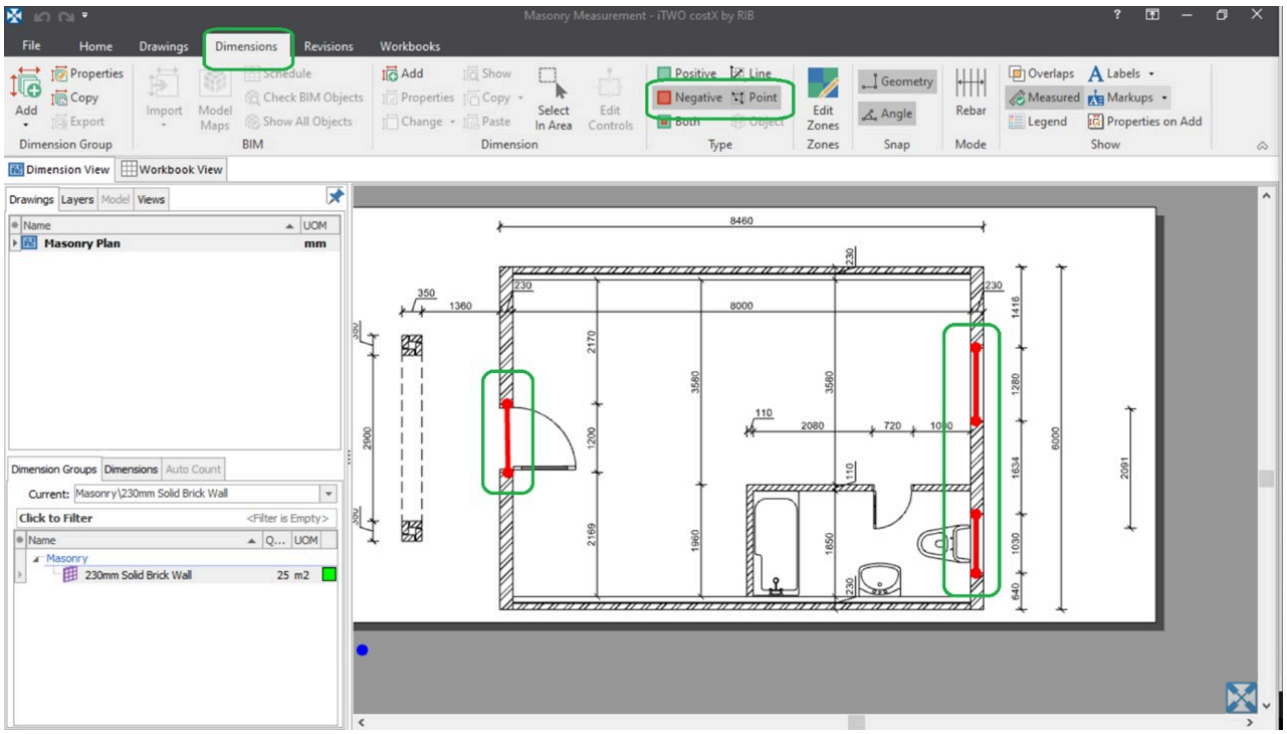


Figure 6.15: Screenshot of door and window deductions from 230 mm thick brick walls using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 7: Adjust the heights of these negative dimensions by right-clicking on the measured deductions on the plan, as the default height (3 m) was originally applied to them. Figure 6.16 shows how this adjustment is made for a door – apply the same process to the windows.

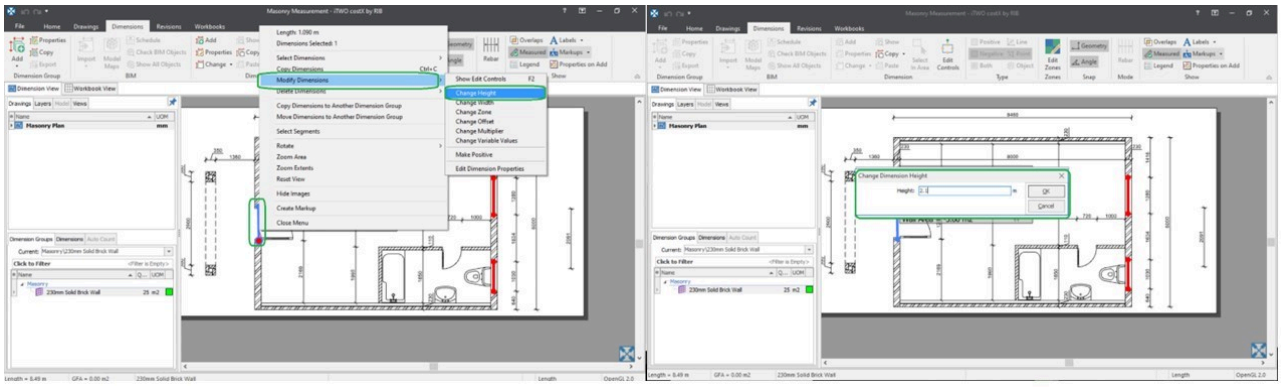


Figure 6.16: Screenshot of applying the correct heights for door deduction from 230 mm thick brick walls using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 8: Repeat steps 4-6 to measure the 110 mm brick veneer walls, selecting positive and negative quantities as appropriate, as shown in Figure 6.17.

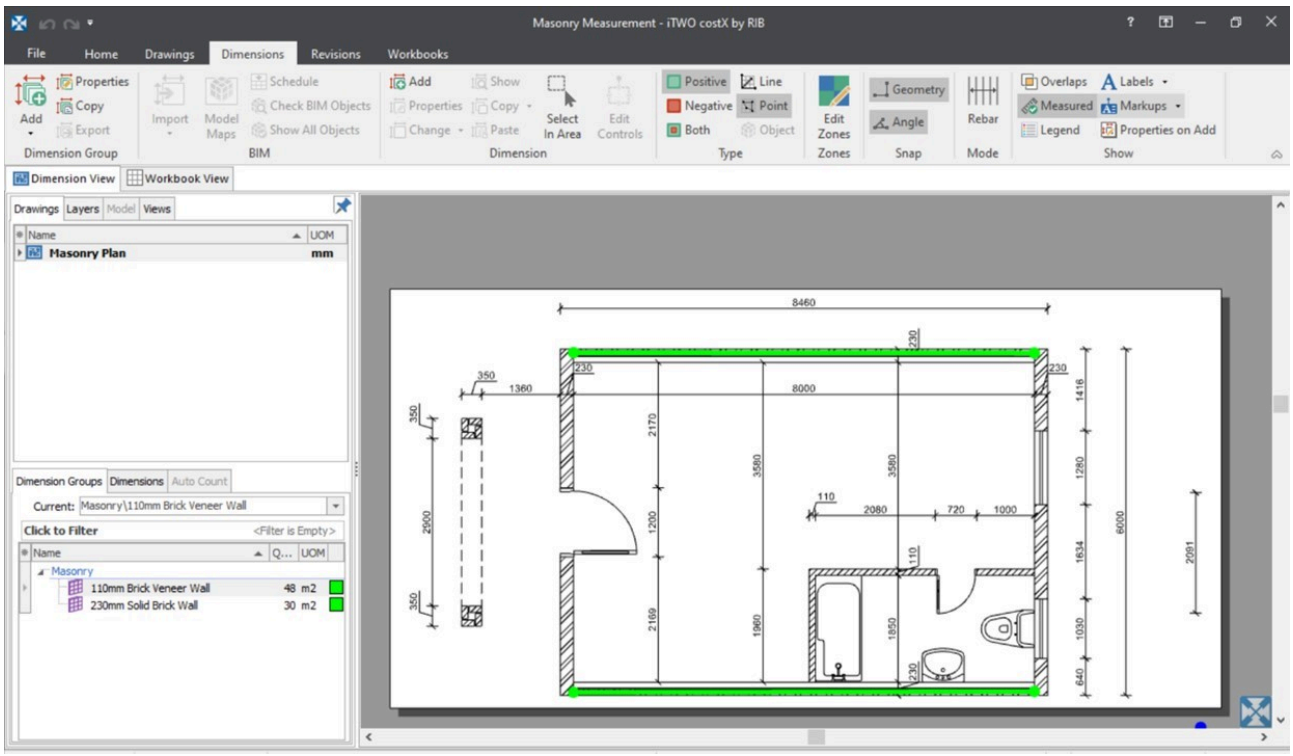


Figure 6.17: Screenshot of measuring 110 mm thick brick veneer walls using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 9: Repeat steps 4-6 to measure the 110 mm solid brick walls, selecting positive and negative quantities as appropriate, as illustrated in Figure 6.18.

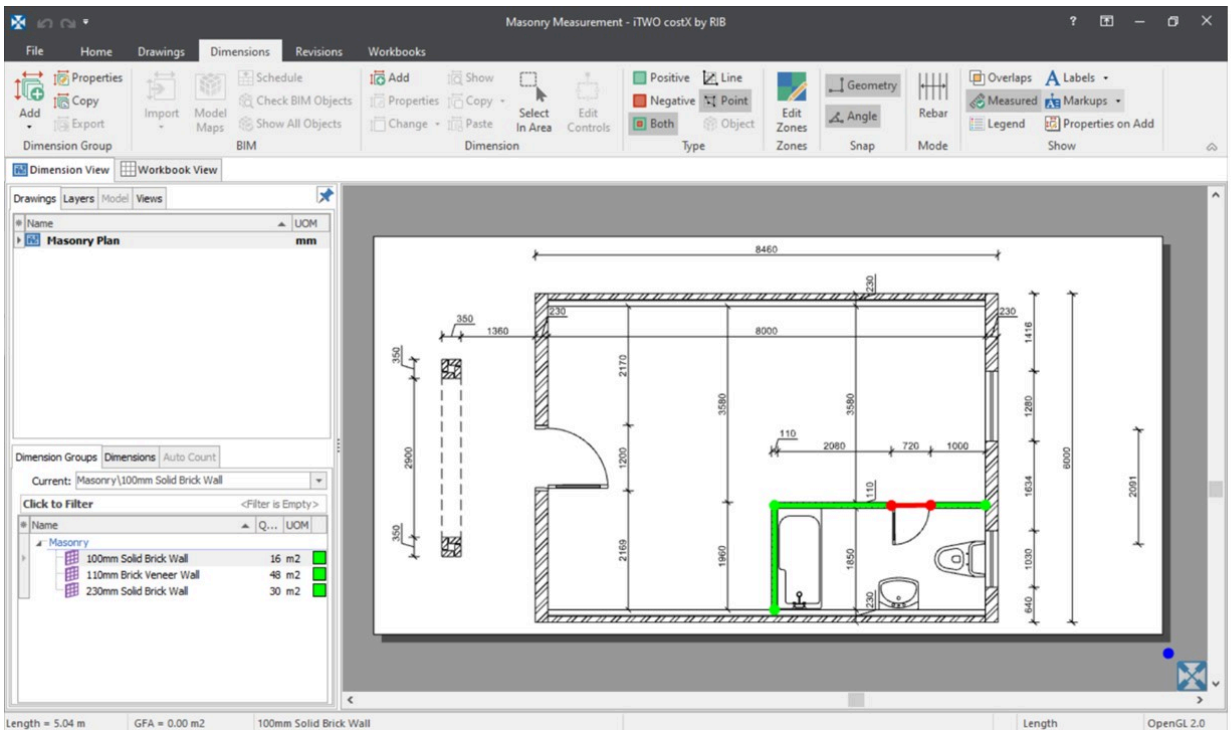


Figure 6.18: Screenshot of measuring 110 mm thick brick walls using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 10: To view the measured dimension in three-dimensional (3D) view using the 3D function on the drawing tab as shown in Figure 6.19. Please note that the windows are offset 1 m from the floor level in the 3D view.

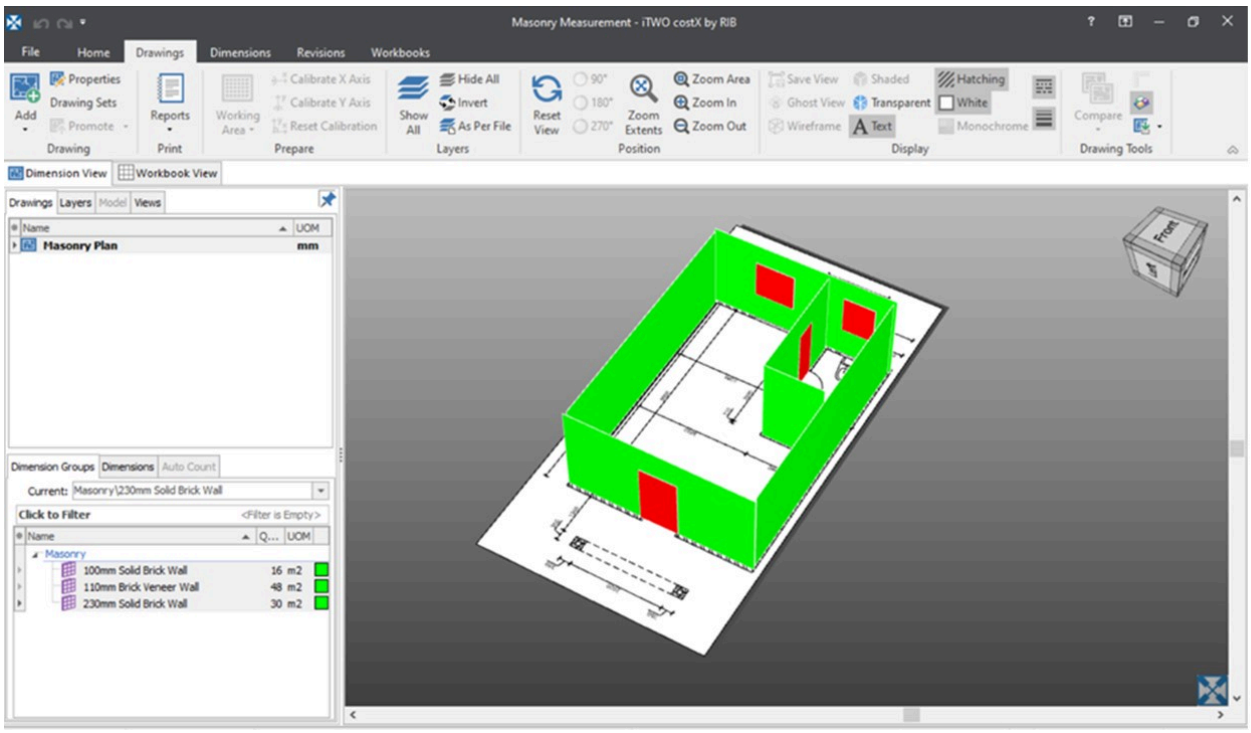


Figure 6.19: Screenshot of 3D view of measured walls using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 11: Create a dimension group to measure brick piers. Apply the rule outlined in Section 6.2.1 to determine whether the element should be classified as a wall or a pier, and check whether the pier is attached to a similar masonry wall or isolated. As the pier is not connected to a masonry wall, it is considered isolated and should be measured in linear meters. Accordingly, the measurement type and default display should be set to "Count", and the height should be specified in the dimension group settings.

Step 12: Click on the brick piers to count them as shown in Figure 6.20. The height will be transferred to the workbook when the quantities are transferred in Step 17.

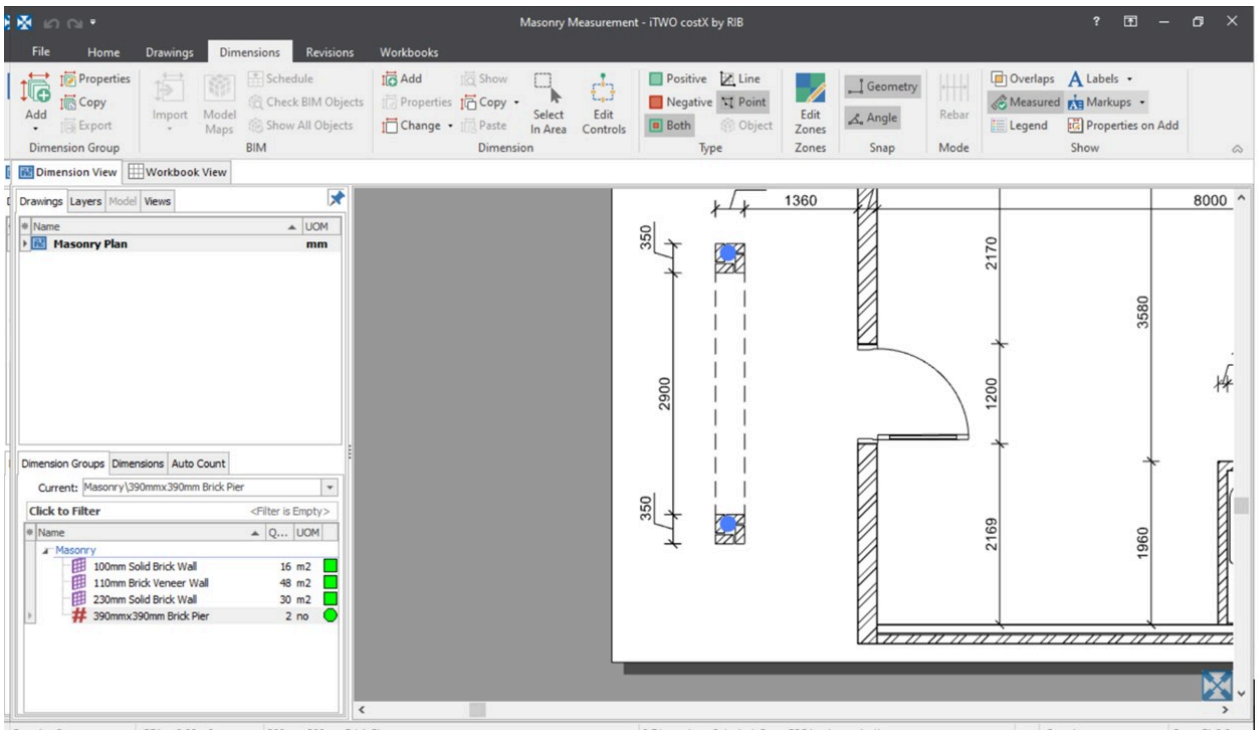


Figure 6.20: Screenshot of measuring 110 mm brick piers using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 13: Create a dimension group to measure DPC. DPC is measured in linear meters when the girth is less than 1 metre. Therefore, the measurement type and default display should be set to "Length".

Step 14: Using the Point method, select the wall lengths as shown in Figure 6.21, since the DPC will be laid along these walls as shown in sections in Figure 6.8.

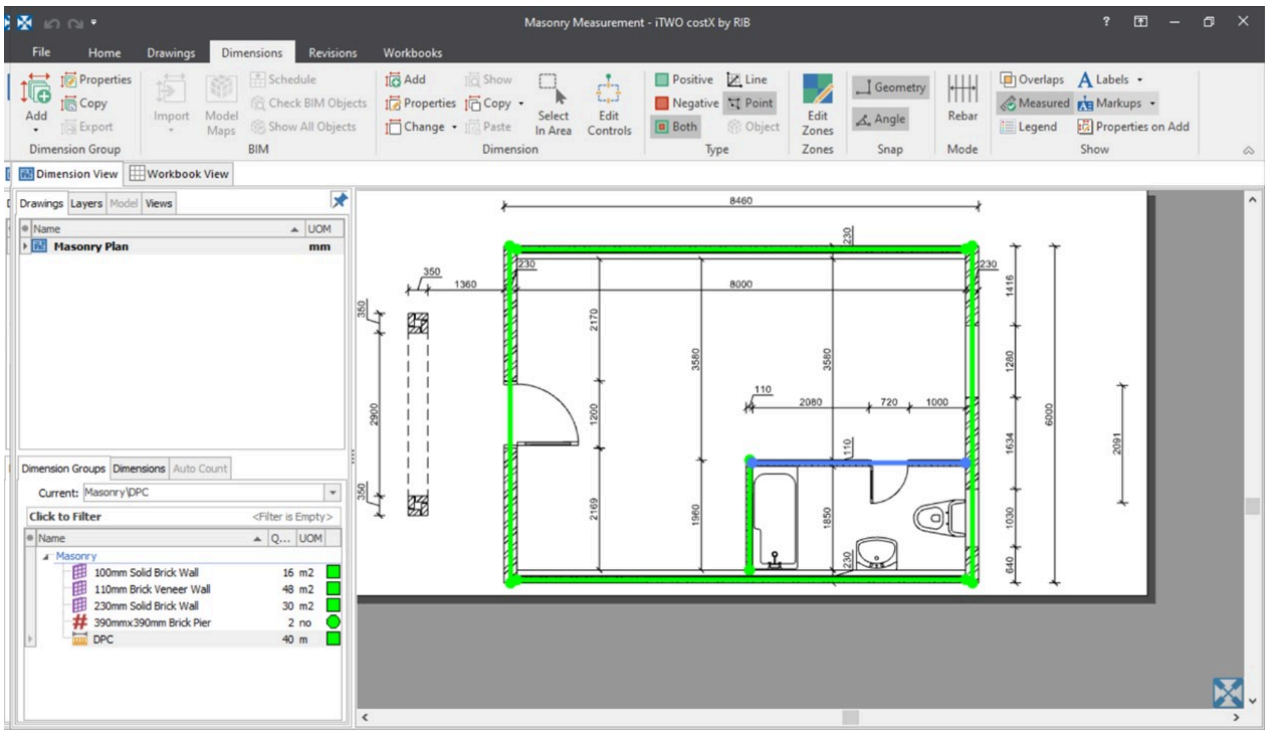


Figure 6.21: Screenshot of measuring DPC using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 15: Create a workbook. In the first level, set the heading as "Masonry" as illustrated in Figure 6.22

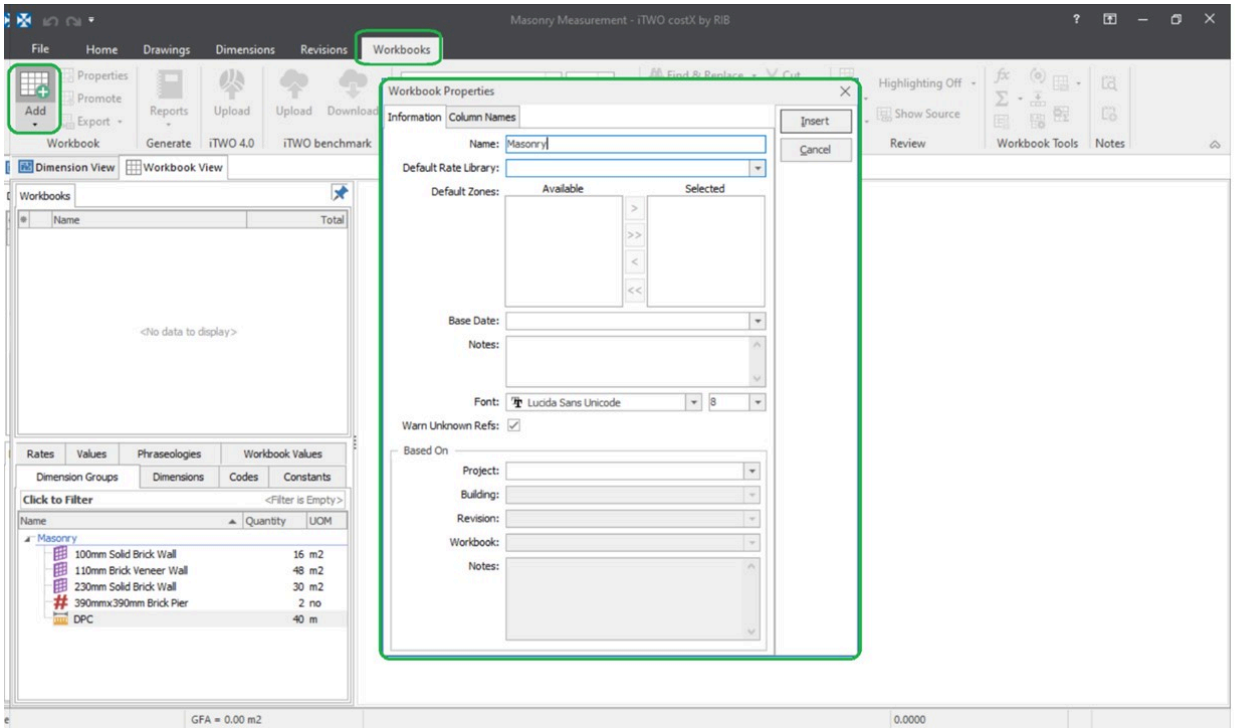


Figure 6.22: Screenshot of creating a workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 16: Double-click the number associated with the "Masonry" heading, then include the descriptions and UOM as specified in Table 6.5.

Table 6.5: Masonry descriptions

	Item	Description	UOM
1	Preamble note	Tenderers shall refer to the Introduction, General Rules and Recommendations section of the ANZSMM.	Note
2	Preamble note	Tenderers shall refer to relevant specification sections containing particulars of masonry works.	Note
3	Preamble note	Tenderers shall refer to the measurement and prices clauses of the masonry section in ANZSMM.	Note
4	Preamble item	Allow for samples of masonry materials as specified.	Item
5	Preamble item	Allow for testing of masonry materials and similar as required.	Item
6	230 mm Solid Brick Wall	230 mm thick brick wall comprising of 230 × 110 × 76 mm common bricks to AS4455, laid in English bond pattern using (1:1:6) cement lime sand mortar.	Square meters
7	110 mm Brick Veneer Wall	110 mm thick common brick wall comprising 230 × 110 × 76 mm common bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar, fixed to timber frame stud work.	Square meters
8	110 mm Solid Brick Wall	110 mm thick brick wall comprising of 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar.	Square meters
9	390 mm × 390 mm sized Isolated Brick Piers	390 mm × 390 mm sized isolated piers comprising 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar, pointing to one side with weathered joint.	Linear meters
10	DPC	0.2 mm gauge polythene damp proofing course to walls, horizontal, lapped 150 mm joints sealed with pressure sensitive tape, girth is less than 250 mm.	Linear meters

Step 17: By double-clicking each quantity cell, transfer the measured quantities by dragging them from the dimension groups, as shown in Figure 6.23.

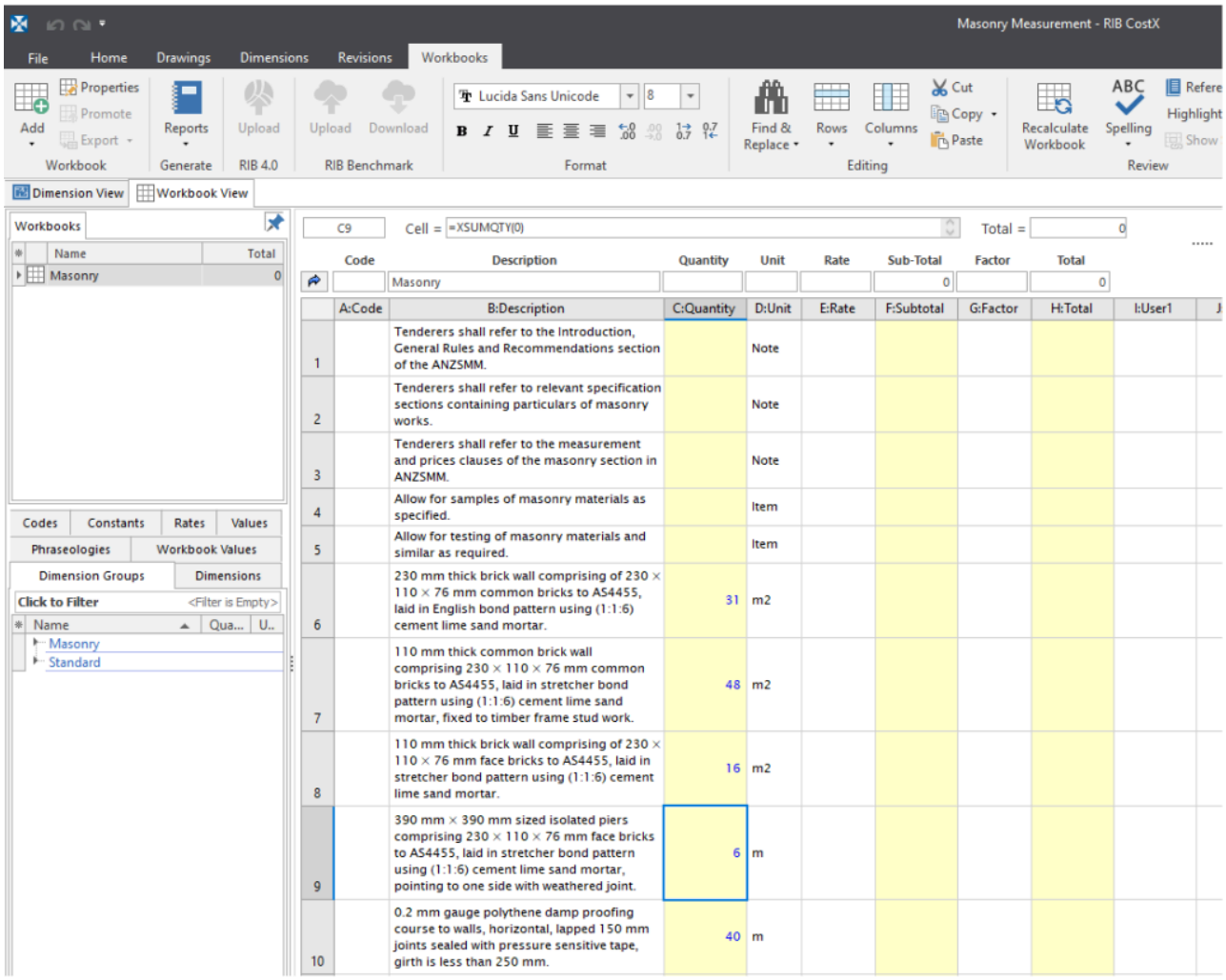


Figure 6.23: Screenshot of transferring the measured quantities to the workbook using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

Step 18: Generate the BQ using CostX software by selecting "Report" and then clicking "Print Workbook to Report" as illustrated in Figure 6.24.

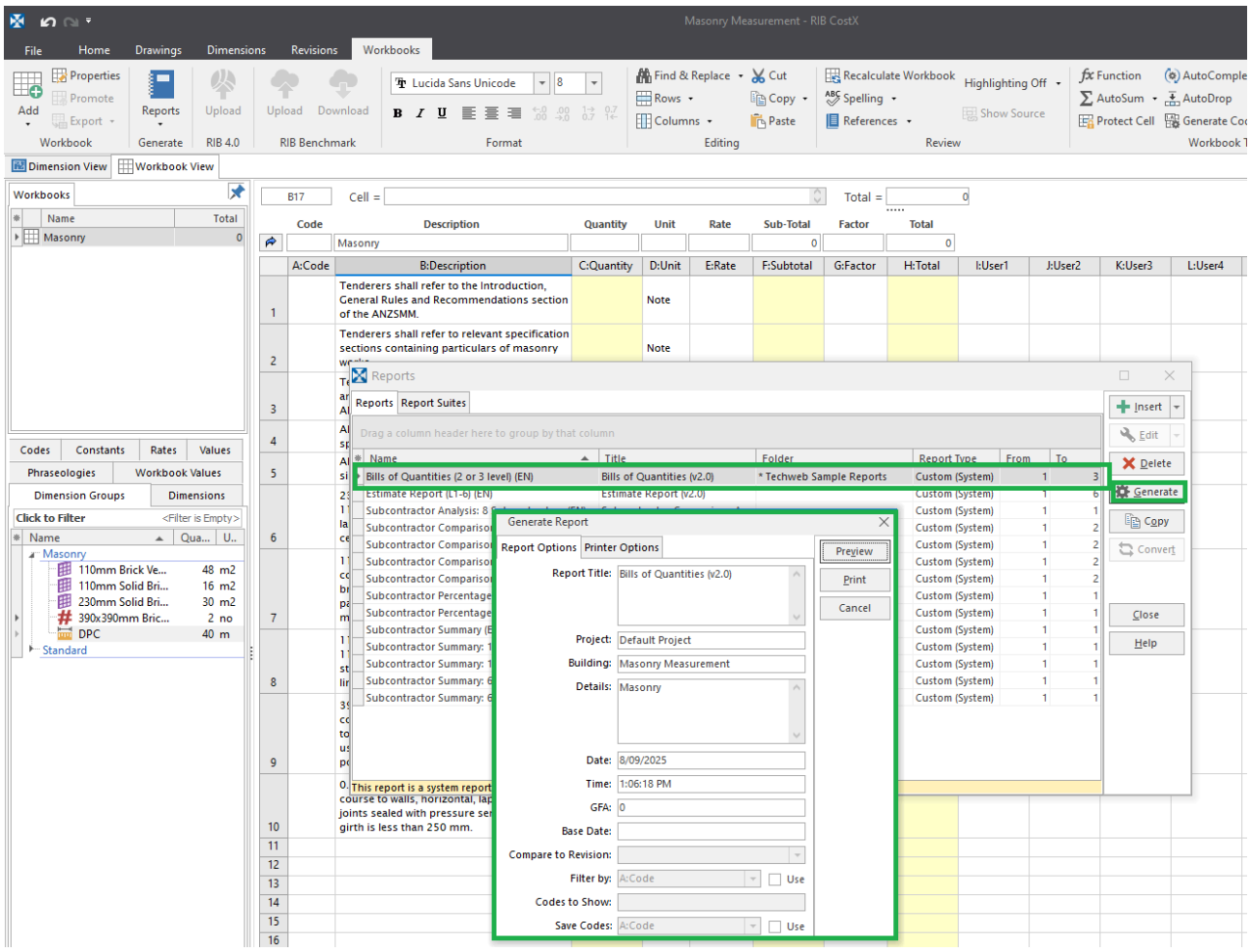


Figure 6.24: Screenshot of selecting report type and name using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

The final BQ for the masonry work is presented in Figure 6.25.al BQ for the masonry work is presented in Figure 6.25.

Default Project
Masonry Measurement
Masonry

Item	Description	Quantity	Unit	Rate	Amount
1	**Masonry**				
A	Tenderers shall refer to the Introduction, General Rules and Recommendations section of the ANZSMM.		Note		
B	Tenderers shall refer to relevant specification sections containing particulars of masonry works.		Note		
C	Tenderers shall refer to the measurement and prices clauses of the masonry section in ANZSMM.		Note		
D	Allow for samples of masonry materials as specified.		Item		
E	Allow for testing of masonry materials and similar as required.		Item		
F	230 mm thick brick wall comprising of 230 × 110 × 76 mm common bricks to AS4455, laid in English bond pattern using (1:1:6) cement lime sand mortar.	31	m2		
G	110 mm thick common brick wall comprising 230 × 110 × 76 mm common bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar, fixed to timber frame stud work.	48	m2		
H	110 mm thick brick wall comprising of 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar.	16	m2		
J	390 mm × 390 mm sized isolated piers comprising 230 × 110 × 76 mm face bricks to AS4455, laid in stretcher bond pattern using (1:1:6) cement lime sand mortar, pointing to one side with weathered joint.	6	m		
K	0.2 mm gauge polythene damp proofing course to walls, horizontal, lapped 150 mm joints sealed with pressure sensitive tape, girth is less than 250 mm.	40	m		

Figure 6.25: Screenshot of generating the BQ using CostX software used with permission from RIB Software (Source: Created by Authors). Any modifications or re-use beyond the context of the handbook requires permission.

CONCLUSION

This handbook has presented the measurement process for selected building trades, specifically groundworks, concrete, formwork, reinforcement, and masonry, using CostX as a digital on-screen measurement tool. Trade descriptions were developed in accordance with standard methods of measurement, and unpriced bills of quantities for these trades were generated using the software.

Students and other users can apply the framework introduced in Chapter 1, along with the examples provided in Chapters 2 to 6, to measure these trades across various building projects. Moreover, the same framework can be extended to other building elements, such as finishes, which are not explicitly covered in this handbook. Although CostX was the primary tool used in this handbook, the procedures outlined are adaptable to other digital measurement platforms.

Finally, it is important to note that this handbook is designed specifically for building projects. For infrastructure projects, separate handbooks are required to demonstrate appropriate measurement procedures tailored to those contexts.

The Authors,

December 2025

FEEDBACK AND CONTACT

We value your input to help improve this resource. If you have feedback, suggestions, or wish to report your use of this handbook, please share your thoughts through our dedicated feedback form. Your contributions ensure this material remains relevant and useful for all readers.
Deakin University Open Education Resource (OER) adoption, adaption and feedback form!

VERSIONING HISTORY

This page provides a record of changes made to this textbook. Each set of edits is acknowledged with a 0.01 increase in the version number. The exported files for this toolkit reflect the most recent version.

If you find an error, please contact opened@deakin.edu.au

Version	Date	Change	Details
1.01	January 2026	First Edition – Published on the Council of Australasian University Librarians (CAUL) Open Educational Resource Collective network.	This network was retired in 2026.
1.02	March 2026	Published on the Deakin eBooks network.	Due to retirement of original hosting network, OER was transitioned to the Deakin Open eBooks network.