Place and Functions Identity at Piazza Ghiberti in Florence

School of Architecture Entrance Building

Building virtual architectures for real

As we know buildings are made of thousands of parts: components, elements and materials assembled, and in many cases produced, in that special factory that is the construction site. A place very different from the manufacturing factories where climate and weather, variable site conditions, and operators that never repeats the same organization make constructions as a very high turbulent process, and architectural building as an unpredictable product.

STRUCTURAL & TECHNOLOGICAL MODEL

Final design deliver and project assessment

ASSIGNMENT GUIDE 03

Since the '50 many studies are trying to streamline the construction process and to rationalize its organization in order to achieve reliability and quality.

But modeling such a complex and variable phenomena is very difficult also because the construction scenario is changing dynamically and increasing its complexity. Adopted models and criteria are now under a deep reconsideration because the digital revolution is now offering new opportunities but also requires radical changes in all the processes.

Computation design, and more specifically the parametrical approach, are new powerful tools that allow to speed up production and to give full control on design. But these changes require a radical rethinking on the way designers draw: designers are now asked not to draw lines but objects with specific attributes and parameters. We need a deep understanding of architectural elements' ontology and their relationships because we are not anymore drafting graphics but simulating the process of a real construction.

In reference to what said before, the final assignment will aim to represent the virtual construction of a building as a real, using objects previously understood in their physical characteristics, and organized for their attitudes.

This final task will complete previous assignments in order to realize a unique document to be bound in a single UNI A1 document. Keep in mind that this document must be paginated in landscape (horizontal) format. The sheet format with the customized title block will available for downloading on the course website.

UNIVERSITÀ DEGLI STUDI FIRENZE
Scuola di Architettura

Index

To realize the final document students must respect the following sheets index and organize information in three sections:

- *Identification and Localization*
- *Ontology*
- *Quantity Estimation*

* * *

00. Main Cover

Title, student's name, and a representative picture of the project.

01. The Place. Site Analysis and Environment Assessment

In this sheet is required to synthesize what elaborated in previous assignments and to extract all the meaningful elements related to the Place, recognizing aspects of strength, weakness, opportunities, threats, and showing them as attribute data that may influence the new construction or be influenced by it. The goal is to define the suitability of the Place for the programmed building; how its futures can affect the building and how it could enhance the quality and contribute to the site's sense of place. For a more extensive explanation please refer to the relative assignment guides.

02. The Program. Project Goals, Space Program, and Budgeting

In this sheet is required to synthesize what elaborated in previous assignments in order to present the main goals of the project and an overall quantitative estimation about spaces and costs. Referring to the Assignment Guide #02 this sheet must contain:

- *Concept*, a diagramatic/pictorial representation about the identity, architectural references and the main goals of the project;
- *Space Program*, preliminary list of the functional spaces as had been defined in the early phases of the project using spreadsheet and bubble graph;
- *Budget*, a parametric cost estimation based on the total amount of square meters coming from the Space Program and the research on the cost of similar architectural examples.

03. Internal Cover. The virtual model

It is required to describe criteria by which the architectural objects were organized, the adopted coding system, graphic symbols, and the official references for cost estimation. For the latter it is suggested to adopt the official cost list of the Regione Toscana (http://prezzariollpp.regione.toscana.it), but be free to adopt any other list of your convenience.

Using the official cost from Regione Toscana you can also consistently use their coding system with the following adaptations:

A03 Demolitions
A04. Excavations
A05. Backfills
A06. Foundation and underslab drainage
B02. Formworks
B03. Steel and rebars
B04 Concrete
B07. Bearing walls
B08. Slabs
C01. Not bearing walls
C02. Interiors walls and ceiling
C03. Roofs
D01. Thermal insulation
D05. Waterproofing
E01. Plasters
E02. Pavements
E03. Finishing
E05 Screeds
F04 Painting and coatings
F05 Pluvial works
F06. Sewer

Products (P)
P70. External doors and windows
P71. Internal doors and windows

According with this coding system we can have for a "solaio a lastre (tipo predalle) con lastre in cemento armato vibrato …" the following number: B08.021.003 where the last terns of numbers are related to the type and subtype (021.003) and the first to the family (B08).

If you intend to adopt another classification system (uniclass, omniclass,…) or their adaptation, please refers to the contents of Classroom Lectures and describe it extensively.

For notes and other specifications «Sheet notes»/ «Note Block» from Revit can be conveniently used.

04. Site preparation and Ground work

Identification and localization

A03. Demolitions

1. Photo of the actual situation showing nature and localization of demolitions.
2. Graphical representation and calculation in m3 of demolitions

A04. Excavations

3. Schematic plans and sections or 3D view with dimensioning showing excavations needed for foundations and the realization of the underground floor integrated by analytical calculation in volume. If you are using continuous beams or isolated plinths with joists, keep in mind the excavation should extend its surface around 1 meter from the foundation profile. Furthermore, consider that depth must be increased by about 50 cm to contain gravel and / or leveling cement lean.

4. Site plan with structural grid referred to some existent cornerstones or other fixed objects in the construction site in order to allow a correct displacement of the building. Remember to close each triangulation or specify angles if needed.

Quantity Estimation

According with descriptions in «Identification and localization» a calculation in volume is required for:

- Demolitions
- Excavations

For this assignment students are not required to describe and estimate *A05.Backfills*

05. Foundations

Identification and localization

A06. Foundation and underslab drainage - B02. Formworks - B03. Steel and rebars - B04 Concrete

1. 3D visualizations or schematic plans of the foundation floors with labels referring each families and types of adopted foundations. Structural walls and/or other solutions for consolidations of the building area are also required.

Current families/types of foundations and consolidation works could be:

- foundation wall
- reverse beam
- isolated plinth
- flat plate
- beam-and-slab
- plate with pedestals
- foundation on piles
- bulkheads

Ontology

Students are required to describe each families/types related to foundations with their main label and labels of each product elements (P_) if the foundation is a composite type. Represent them using 3D sections or 2D sections integrated by photos and/or drawings with some technical specifications from manufacturing firms or examples.

Current functional elements of foundation could be:

- base and sub base foundation
- reinforced concrete footing
- reinforced concrete elements (beam, plinth, wall,...)
- tiebacks (for bulkheads)

Other types and sub-types should be defined in relation to the percentage of rebars as described in figure.

Quantity Estimation

According with descriptions in «Identification and localization» students are required to produce:

1. Bill of quantities obtained from analytical calculation or from BIM scheduling related to each product elements (P_) forming the foundation types.

Product elements (P_) normally used in foundation are:

- gravel (for sub-base foundation)
- formworks (to contain the concrete casting)
- lean concrete (for base foundation)
- reinforced concrete that can be distinguished in different categories in relation to resistance, durability, ...

In order to simplify the estimation students are asked to use a parametric approach based on concrete quantity. Type of concrete for foundation, taken from Prezzario Regione Toscana is the item **01.B04.005.001** with the following characteristics:

- Strength Class: C 25/30 (C28/35)
- Exposure class: XC2- Wet and rarely dry
- Slump class: S3-medium high workability

Students have to run an analytic computation of concrete in volume and to determine steel rebars weight (01.B03.001.005) and formworks surfaces (01. B02..002.001) in relation to it using a parametric approach *(> see PART II)*. As a result, and in order to facilitate calculations, students can use concrete types F, G, H *(> see PART II)*.

6. Structures

Identification and localization

B02. Formworks - B03. Steel and rebars - B04 Concrete - B07. Bearing walls

1. 3D visualization of the structural system (here, 2D drawing are NOT allowed!) with labels referring to the adopted families and types. Be careful not to include slabs in this section.

Current in-situ reinforced concrete structural families/types could be:

- bearing walls and beams
- bearing walls and plates
- posts and beams (mono or bi directional)
- columns and plates

Ontology

Students are required to describe each families/types related to structures with their main label and labels of each product elements (P_) if the element is a composite type.
Students must represent them using 3D sections or 2D sections integrated by photos and/or drawings with some technical specifications from manufacturing firms or examples.
Current families/types of the structural system could be:

- pilasters
- girders (horizontal, vertical, shaped..)
- joist (to connect the main beams or as a shearing element)
- bearing walls
- slab and plates

For a parametric estimation other types and subtypes should be defined in relation to the percentage of rebars as described in Part II of this document.

Quantity Estimation

Product elements (P_) normally used in structural system to estimate are:

- steel rebars
- concrete
- formworks

As in Foundation even in Structures students have to provide analytic computation in volume of concrete and a parametric estimation of steel rebars and formworks.
In this case we can consider two types of concrete with the following distinguished characteristics as described in Prezzario Regione Toscana:

- **01.B04.006.005** strength class C32/40, exposure class XC3-low humidity, slump class S3-medium high workability;
- **01.B04.006.001** strength class C28/35, exposure class XC3-low humidity, slump class S3-medium high workability.

For steel rebars (01.B03.001.005) and formworks (01.B02.002.002) quantification students can follow instructions provided in Part II of this document and use the «virtual» concrete types A, B, C, D, E.

07. Slabs

Identification and localization

B08. Slabs

1. 3D visualization or 2D drawing of roof slabs, intermediate internal slabs, and ground slabs with labels referring to the adopted families and types

Current reinforced concrete or precast slab families/types could be:

- flat slab
- hallow slab
- waffle slab

Many other variations in relationship to the used materials and methods of production (for example: in-situ or precast) can be possible.

Ontology

Students are required to describe each families/types related to slabs with their main label and labels of each product elements (P_) if the type is a composite type.
Students must represent them using 3D sections or 2D sections integrated by photos and/or drawings with some technical specifications from manufacturing firms or examples.

In most cases, do NOT label the product elements (P_) because many slabs are normally supplied as an integrated component. Anyhow a description of the constituent parts off the slab is required.
Vice versa, if the chosen slab is an in-situ concrete work the product element is required in the same manner of the structural sheet.
Current functional elements of slabs could be:

- structural deck
- formwork and or voidform
- structural screed
- joists

In this system you can include labels of each component materials but do NOT include here quantity estimation of elements that belong to other building system such as *Finishing (E03)*, *Pavements* with their bedding and/or bonding/adhesive layer, screed to fall or leveling that are not bearing screed *(C02)*, Air control, vapor barrier, and thermal insulation layers *(D01)*.
All these elements have to be estimated in their appropriate sheet (*09. Rooms and indoor finishing*).

Quantity Estimation

According with descriptions in «Identification and localization» students are required to produce:

1. Bill of quantities obtained from analytical calculation or from BIM scheduling related to each product elements (PR_) forming the structural core of each slab types.

Pay attention because inside the same typology of slab differentiations types can derive from a different thickness of the structural screed (such as 4 cm, 6, cm.,...). For this reason use a consistent coding system specifying different thicknesses as subtypes (the last tern of numbers in Regione Toscana coding system)

As mentioned before for slabs supplied as a completed component the quantity estimation of its core element is NOT required. The quantity estimation should be run computing the surfaces of each type without the analytical estimation of its components/elements.
For in-situ concrete slab analytical estimation, students must follow the direction illustrated in the Structure chapter.

08. Interior not bearing walls

Identification and localization

C02. Interiors walls

1. 3D visualization system or 2D views/plans with labels referring to the adopted families and types of the interiors walls.

A very limited list could be:

- monolithic
- multilayer
- movable partition

Ontology

Students are required to describe

each families/types related to interior not bearing walls with their main label and labels of each product elements (P_) if the element is a composite type. Students must represent them using 3D sections or 2D sections integrated by photos and/or drawings with some technical specifications from manufacturing firms or examples.
Current functional elements of these family could be:

- structural core
- closure elements
- internal layers for insulation purpose.
- surfaces finishing

Quantity Estimation
Students must produce bill of quantities for each component materials or products.
Product elements (P_) normally used in not bearing internal walls system that sudents need to estimate are:

- hallow clay
- bricks
- studs and framing
- plasterboards/gypsum panels
- self bearing panels
- air gap and/or other materials for insulation purpose
- plaster/coating
- painting, ceramic tiles, marble, wood,..for finishing

To run this estimation students can decide to apply the parametric or analytic technique using BIM technology as described in Part II of this document.

09. Interior finishing and rooms

Identification and localization
In this sheet, students are required to estimate pavements, ceiling and skirting/wall base. Even for this elements is possible to run the parametric approach or the analytic one using Building component schedule or Component material schedule.
In the latter case the elements identification concern used materials or products. In the first case, identification concern room or space types where products and materials are previously identified.

Ontology
For this task students are, first, required to define types of pavements, ceiling and skirting/wall base and their component materials with their main label and labels of each product elements (P_) if elements are composite types.
Students must represent them using 3D sections or 2D sections integrated by photos and/or drawings with some technical specifications from manufacturing firms or examples.

Functional elements that can be combined to create different pavement types are:

- finishing elements
- bedding and/or bonding/adhesive layer
- screed to fall or leveling that are not bearing screed (C02)
- air control, vapor barrier, and thermal insulation layers (D01).

Current functional elements that can be combined to create different ceiling types are:

- hangers
- frames and profiles
- ceiling boards and closure elements
- internal layers for insulation purpose.

In the analytic approach the subsequent step required to draw each pavement, ceiling and skirting using the predefined types and label them with their codes (identification).

Vice versa, in the parametric approach (that we suggest) is NOT required to draw any pavements, ceiling and skirting because it is possible to use the room/space types as a key element.
In this second case, students are therefore required to define rooms/ space types that result from the combination of the adopted ceilings, pavements and skirting.
To speed up all the operations a powerful technique is «Room Style» that allows to automatically assign types of floors, ceilings and baseboards. (see video tutorials on course website).

Quantity Estimation
As written before students can use analytic or parametric approach to estimate pavements, ceiling, and skirting quantities.
For the first one, BIM technologies offer the Component materials scheduling where all the materials can be sorted, extracted and computed.

In the second one BIM technologies offer the Room/Space scheduling that is a little more complex to manage but able to speed up the drawing process.
For this second procedure students need to create the Room schedule database with some field adaptation as explained in the classroom lectures.
For a full description of fields that need to be created refers to the paragraph *11. Cost estimation and project assessment*.
In this case, the required fields in integration of the functional aspects are:

- id progressive number (XYY= where X refers to the floor level and YY to the progressive number in each floor)
- perimeter (automatically calculated)
- area (automatically calculated)
- type of pavement
- type of ceiling
- type of wallbase/skirting

After that and room/space identification, students can sort and extract quantities for each type of rooms/ spaces and calculate the amount of pavements, ceiling based an area field and skirting on perimeter.
The last operation required to export data in microsoft excel in order to have the total amount of each component.

10. Stairs - Detail

In this sheet students are asked to represent at the detailed scale one stair of the building at their own choice.

Identification and localization
3D visualization system or 2D views/ plans with the call out showing where the stair is located.

Ontology
Students are required to describe each families/types forming the analized stair. Students must represent them using 3D sections or 2D sections integrated by photos and/or drawings with some technical specifications from manufacturing firms or examples.

Current functional elements that can be assembled to create a stair are:

- stringers
- risers
- treads
- railings

Quantity Estimation

Students are required to produce:

1. Bill of quantities obtained from analytical calculation of each elements of the stair.

For in-situ concrete stair, students must follow the direction illustrated in the Structure chapter.

11. Cost Estimation and Project Assessment.

This is the conclusive sheet where students are asked to present an evaluation of the final project concerning the following aspects:

- compliance with goals, concepts, and budgeting defined in the Program (Sheet 02);
- compliance with space program pointing out dimensional differences and space relationships

For the first aspect, students are required to use graphs, spreadsheets, diagrams and short commentaries. In particular, it must be calculated the final cost of the project and the differences with the budget estimated in the initial stages. In addition, other assessment elements must be calculated such as:

- cost comparisons and cost incidence of each item/family;
- charts and diagrams showing the synthetic composition of cost;
- average unit cost by surface.

To facilitate the execution of this part, a specific guide and a collaborative spreadsheet will be available on line.

For the second part related to functional aspect, students are asked to produce the functional layout with net surface quantification of each department including circulation areas. For this task students are invited to use BIM Room and functional department scheduling. Here are the sequence of activities to produce a functional layout in BIM software:

- create the room database;
- define appropriate fields as summarized in the list below;
- label rooms on each floor;
- assign consistent colors according to each department;
- extract department schedule surface;
- for each floor and the total;
- place legends and schedules on each floor drawing;
- For a detailed explanation of this procedure, see video tutorials in the course website;

Other useful information about room scheduling is also contained in Part II of this document.

Suggested fields for Room schedule database

- id progressive number (XYY where X refers to the floor level and YY to the progressive number in each floor);
- name (name of the room such as office, stairs, corridor, wc, library, ...)
- department (functional identification of similar rooms by functions such as: students area, administration, recreation, … and mandatorily, circulation.)
- perimeter (automatically calculated)
- area (automatically calculated)
- program area (estimated area defined in the program assignment. If the program had been carried out by macro areas/departments you can only enter the total value of individual departments)
- difference between actual and program area (a calculated field subtracting area from program area. If the program had been carried out by macro areas you can only consider differences in the total surfaces departments
- type of pavement
- type of ceiling
- type of wallbase/skirting
- room style (optional, if you choose to operate assigning automatically floors, ceilings and wall base. To learn how to operate using «Room Style» check the videotutorial out in the course website)

PART TWO ASSIGNMENT GUIDE 03

How to manage Scheduling on BIM: reinforced concrete example

1. Cost estimation and Scheduling

Strategies and levels of details in cost estimation.

Building cost estimation is part of project deliverables. It comes in different levels of detail in relationship to the development of design phases. It starts from the early phases, with a general estimation for client use, and ends with an analytic cost estimation for tendering and contracting.

During the project development we can have continuous activities related to cost estimation where the main goal is to give awareness and cost control to designers and to support their decision making.

We can distinguish two strategies to accomplish this task: the parametric approach, where estimations are developed as a percentage/incidence of an element to a reference item, and the analytic approach where estimations are developed for each component material, building component, or functional system. In most cases a mix of them is used.

Scheduling and its organization.

In any strategies, schedule is the format and the tool as well to determine building quantities and costs.

Organized as a spreadsheet, schedule should contain identification elements and code, a short description (a more extensive descriptpions are in other specific deliverables such as technical specification, instructions, ...), localization, quantification, unit cost and final cost estimation.

The preliminary and fundamental data to acquire are quantities which has to be calculated in a consistent unit such as sqm, cbm, kg, ...

Following the two previous strategies, schedule can be created an managed using component materials or building components, articulated in hierarchical order.

In our assignment we can use our own coding system or refer to some international/local standard.

Internationally, a good classification system is the UNICLASS expecially for Building Elements (such as roof, pavements, ...), Functional System (such as timber roof, framing, ...)

Instead, for more analytical estimation mainly based on component materials (or products such as tiles, concrete, steel…), a good system can be the Prezziaro Regionale Toscana.

For our assignment and according with BIM ar-

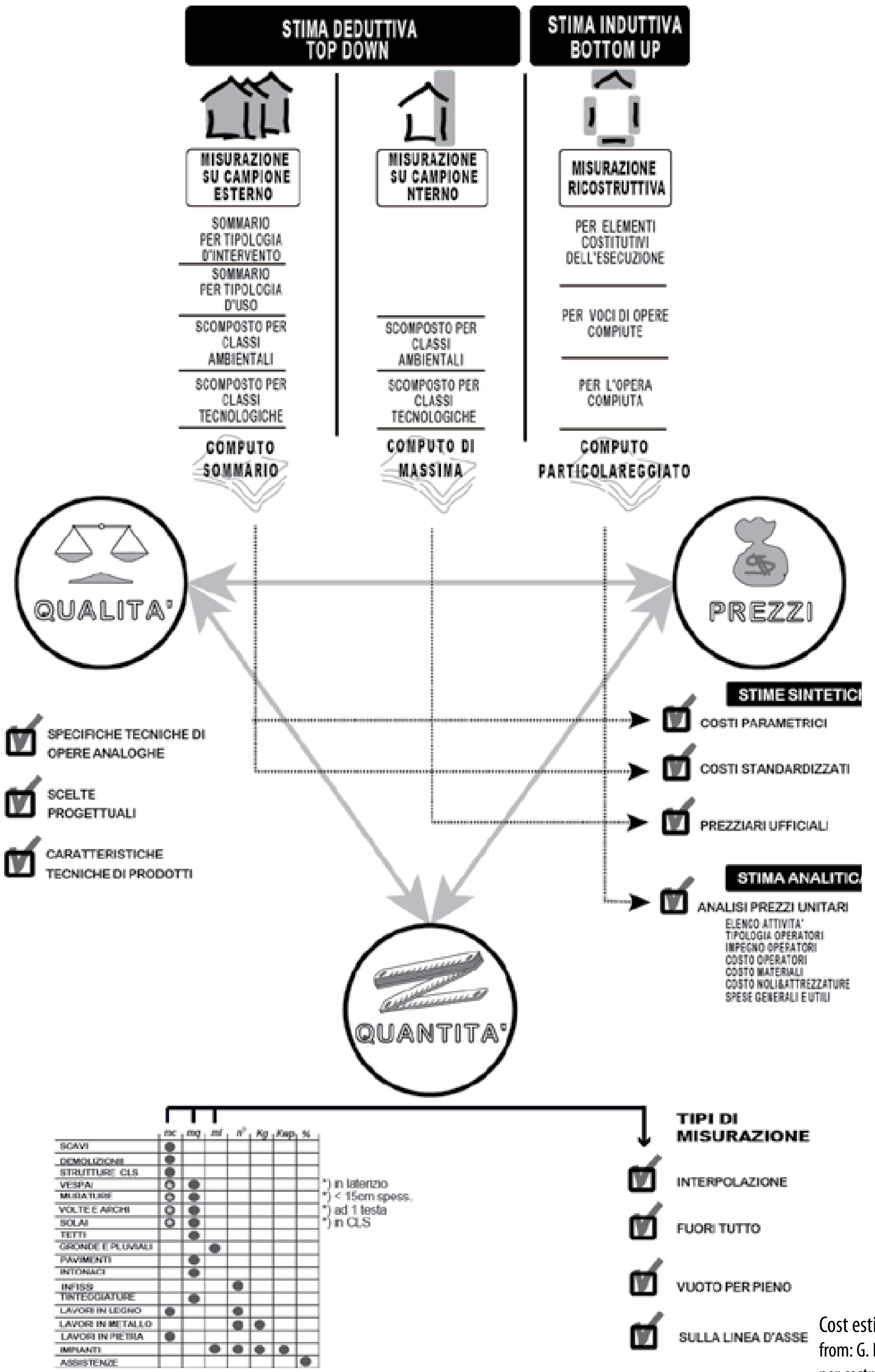
CODE	Group	Sub group	Section	Object	
EF_20	20				Structural elements
EF_20_05	20	05			Substructure
EF_20_10	20	10			Frames
EF_20_20	20	20			Beams
EF_20_30	20	30			Columns
EF_20_50	20	50			Bridge abutments and piers
EF_25	25				Wall and barrier elements
EF_25_10	25	10			Walls
EF_25_30	25	30			Doors and windows
EF_25_55	25	55			Barriers
EF_30	30				Roofs, floor and paving elements
EF_30_10	30	10			Roofs
EF_30_20	30	20			Floors
EF_30_60	30	60			Pavements
EF_30_70	30	70			Bridge decks
EF_35	35				Stairs and ramps
EF_35_10	35	10			Stairs
EF_35_20	35	20			Ramps

Uniclass classification, 2015

ticulation we can use the following:

- Building Component (equivalent to building elements and types)
- Component Materials (equivalent to products and materials).

As wrote before, a syntetic identification of the adopted classification has to be placed in the sheet 03. *Internal Cover. The virtual model.*



Cost estimation in costruction, from: G. Ridolfi (2015), Progetto e contratti per costruire, Aracne, Roma

Detailed descriptions, localizations, quantifications and cost estimations, using consistent scheduling, must be placed in each sheets devoted to the technological analysis of the building components (S04 04. *Site preparation and Ground work*, 05. *Foundations*, 06. *Structures*,…).
The final summary of the cost, arranged for components materials and building components (depending on the type of estimation) and charts should be placed in last sheet 11. *Cost Estimation and Project Assessment*.

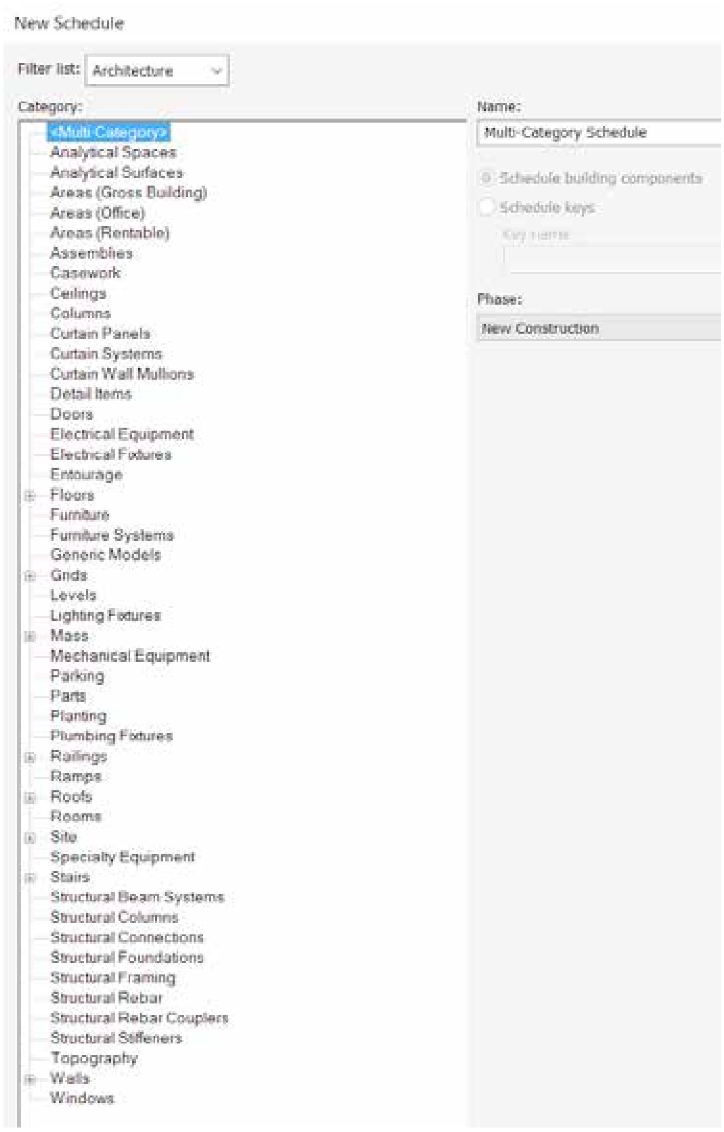
2. How to work with BIM scheduling.

In the following pages we can analyse how to work with BIM scheduling.

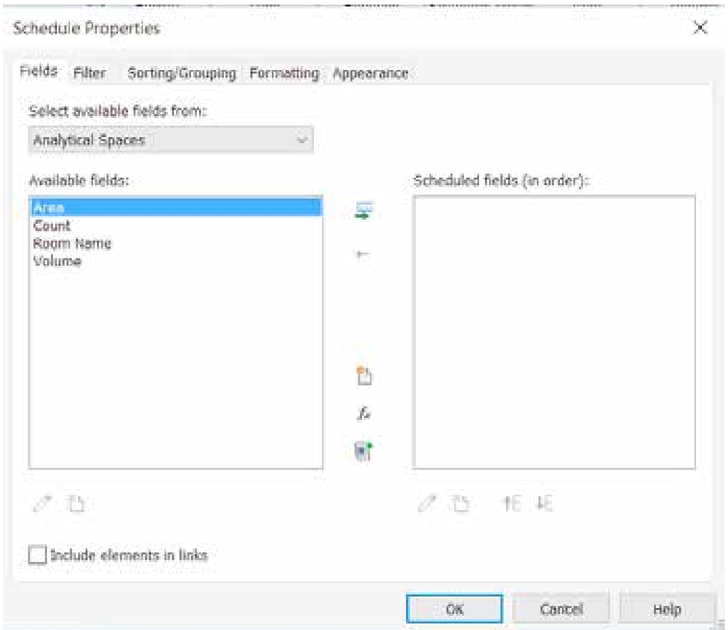
In BIM it is possible to extract information through two different kinds of schedules: Schedule Quantities or Material Takeoff; in other words, schedules organized by Building Components or by Component Materials. We will use both strategies to estimate different part of the building.

Analytic estimation

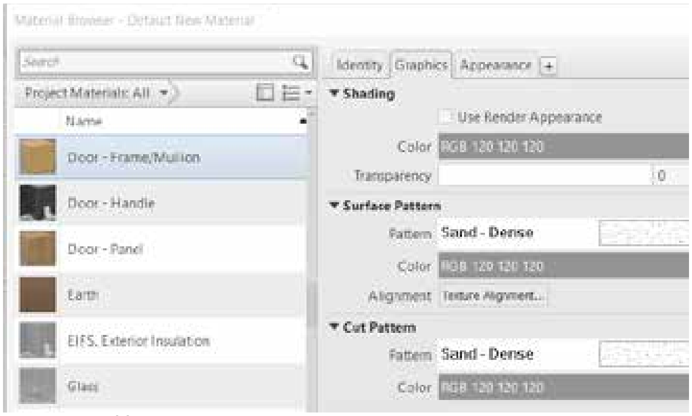
In Material Takeoff Schedule (Revit) and Element Schedule (Archicad) the key element is component material. It is an analytic way to compute and required a full detailed specification about the material usage in each part of the construction.
As we said before, a component material represents a record in BIM logic. A record that we can populate with many different kind of information, and sort/read using appropriate fields.
In our assignment we need to define this information/attributes:



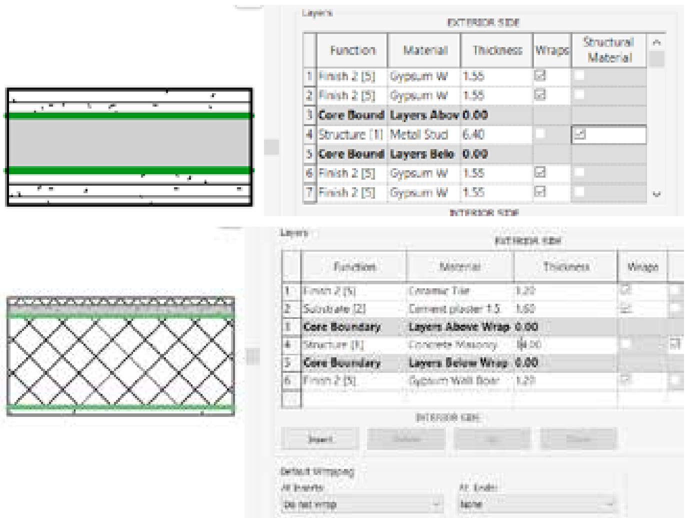
Revit 2016, Family categories



Revit 2016, Family categories



Revit 2016, Adding new material



Revit 2016, Creating new building component: Wall

- ID number (automatic calculated)
- Code (extracted from assigned material attributes)
- Component material name (extracted from assigned material attributes)
- Area (automatic calculated)
- Volume (automatic calculated)
- Unit cost (extracted from assigned material attributes)
- Unit of measurement converter
- Sub-total cost (a calculated field)

This is the most common used schedule for the final detailed cost estimation and required that each part of the building is drafted specifying what kind of material is made.

Parametric estimation

In Schedule Quantites (Revit) or Component Schedule (Archicad) the key element is building component (BIM types or building families such as wall, foundations,…). This kind of schedule doesn't return material quantities but building elements and for these reason, such as in Revit, it involved less attributes and a limited extraction data options. In this case material computation can be produced having assigned each building component and a certain percentage of its components.

Schedule: Multi-Category Material Takeoff - FINISHING ROOM.rvt

<Multi-Category Material Takeoff>

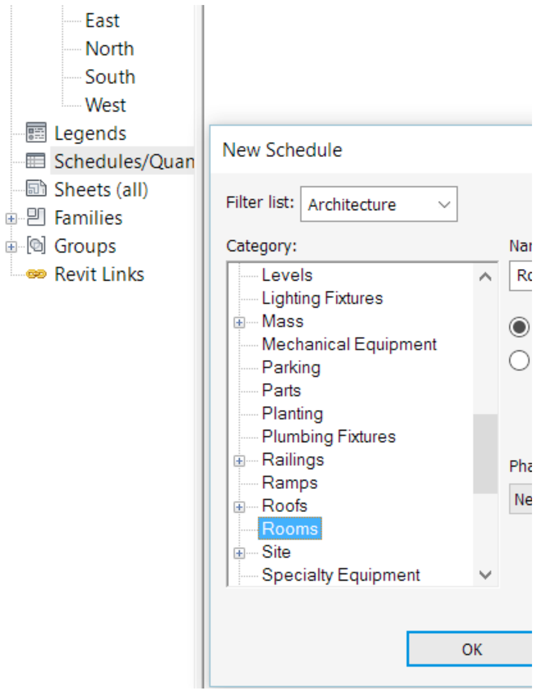
A	B	C	D	E	F	G	H	I	J
Category	Cost	Count	Family	Family and Type	IfcGUID	Material: Area	Material: As Pai	Material: Volum	Material: Name
Air									
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-pls		55 m²	No	2.74 m³	Air
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-pls		56 m²	No	2.81 m³	Air
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-til		45 m²	No	2.23 m³	Air
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-pls		26 m²	No	1.32 m³	Air
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-til		20 m²	No	1.00 m³	Air
						202 m²		10.10 m³	
Brick, Common									
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		60 m²	No	4.79 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		104 m²	No	8.30 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-pls		55 m²	No	5.59 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-pls		56 m²	No	5.73 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		129 m²	No	10.32 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-til		45 m²	No	4.56 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		24 m²	No	1.89 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-pls		26 m²	No	2.69 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: EW 102-85-brk-til		20 m²	No	2.04 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		41 m²	No	3.26 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		16 m²	No	1.26 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		20 m²	No	1.60 m³	Brick, Common
Walls		1	Basic Wall	Basic Wall: IW-xx-xx-gyp-pls		101 m²	No	8.04 m³	Brick, Common
						695 m²		60.07 m³	
Cement plaster 1.5 cm									
Walls		1	Basic Wall	Basic Wall: IW-XX-XX-pls-til		39 m²	No	0.63 m³	Cement plaster
Walls		1	Basic Wall	Basic Wall: IW-XX-XX-pls-til		14 m²	No	0.23 m³	Cement plaster
Walls		1	Basic Wall	Basic Wall: IW-XX-XX-pls-til		15 m²	No	0.24 m³	Cement plaster
Walls		1	Basic Wall	Basic Wall: IW-XX-XX-pls-til		17 m²	No	0.27 m³	Cement plaster
						85 m²		1.36 m³	

Revit 2016, Material Takeoff sorted by building components

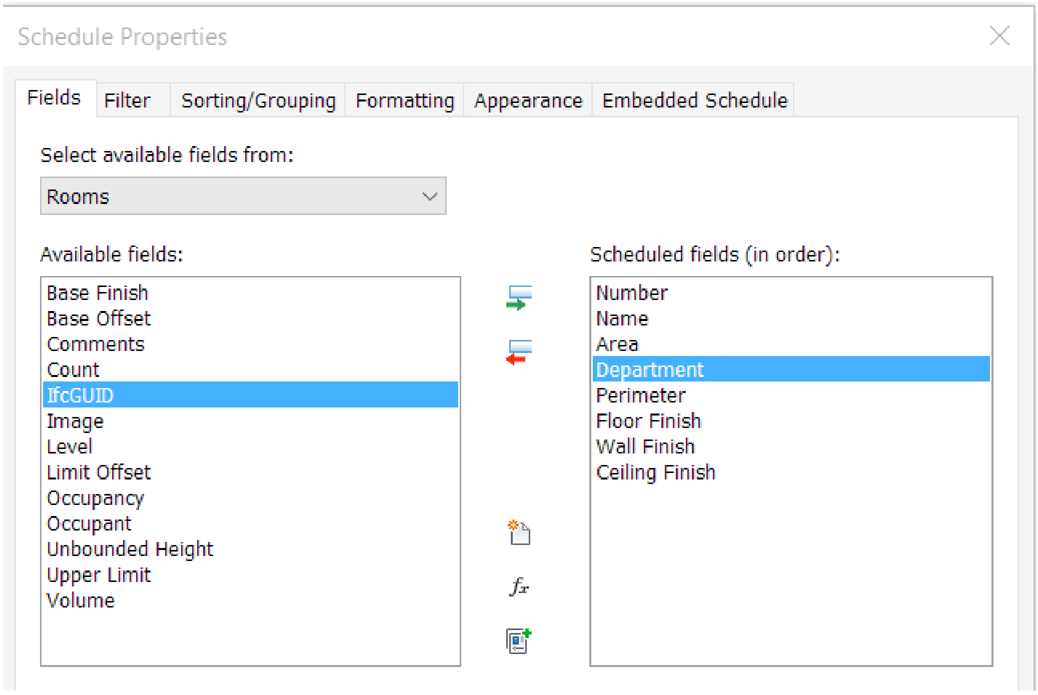
3. Instructions to create schedules

To manage building elements scheduling and cost estimation follow these steps:

1. create materials adding new items to the default Project material stack;
2. assign all the attributes you need to material starting from name/code, unit cost. For other advanced applications, physical properties and graphical representation are also available;
3. create building components duplicating and renaming existent BIM types (walls, columns,…). For analytic schedules we need to articulate and to specify all the layers is made assigning to them materials and thickness. Instead, for a parametric estimation building elements can be drafted using a single generic layer because the generic material is made can be split in others component materials and evaluated subsequently using some defined percentage/ratio. For this second procedure it is previously necessary to define the reference material and the percentages of all the other materials that realize the building element such as % of steel and formworks in the volume of reinforced concrete elements;
4. draw each building element using the appropriate building component (BIM types) previously defined;



Revit 2016, Choosing Room schedule



Revit 2016, Assigning Fiedls to room schedule

<Room Schedule Buildign components-CEILING>

A	B	C	D	E	F	G	H	I	J	K	L	M
ID	Name	Department	Level	Floor Finish	Wall Finish	Ceiling Finish	Area	program area	diff by program	unit cost	unit	item cost
C01												
1	Room		Level 1	F01	W01	C01	5 m²	40 m²	35 m²	100	1 m²	538.5
C01: 1							5 m²	40 m²	35 m²			538.5
C02												
101	living	housing	Level 1	F02	W03	C02	49 m²			50	1 m²	2445.64875
102	bed	housing	Level 1	F01	W02	C02	25 m²	16 m²	-9 m²	50	1 m²	1252.246938
103	office	housing	Not Placed			C02	Not Placed	12 m²		50	1 m²	
C02: 3							74 m²	28 m²	-9 m²			3697.895688
C04												
104	wc	housing	Level 1			C04	4 m²	9 m²	5 m²	70	1 m²	278.31475
C04: 1							4 m²	9 m²	5 m²			278.31475
Grand total : 5							83 m²	77 m²	31 m²			4514.710438

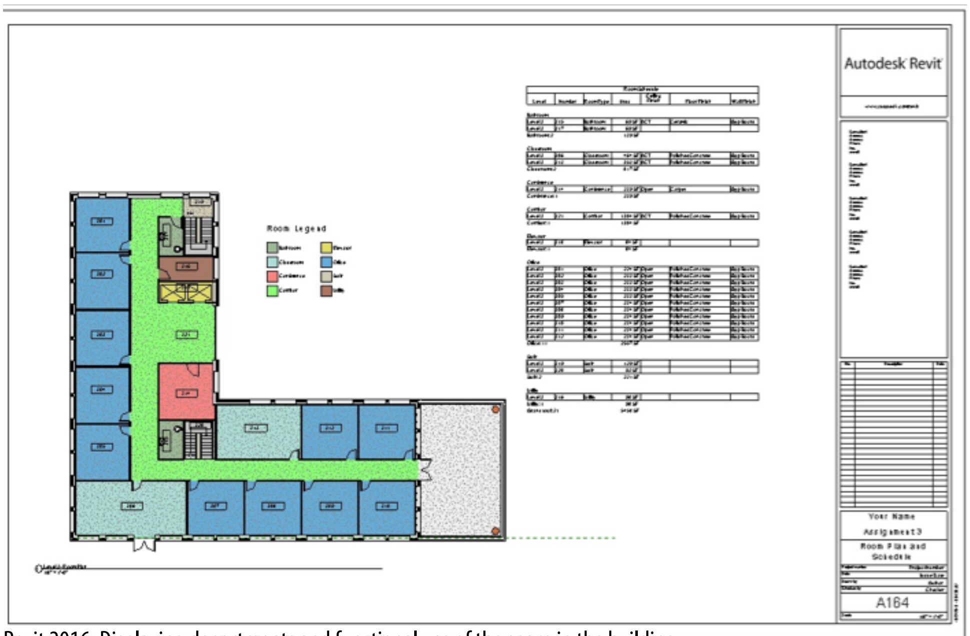
Revit 2016, Room schedule sorted by ceiling types. Note the calcuated field Diff by program that allows to calcultate differences from program and actual area of each room and department

5. create schedule for different building elements or components material;
6. sort the database by building components or component materials in order to have a consistent organized quantification;
7. set sub total of quantities and costs in formatting schedule in order to obtained the total estimation of each material component type;
8. In case of parametric estimation, export the database in excel in order to get all the component materials from the applied generic material in relationship to the defined percentage or ratio. Finally apply the unit cost in order to have their total estimation.

Room schedule

A particular component schedule is the Room Schedule. It is mostly used for functional space description and to evaluate the functional composition of the building. It is also used in the final detailed deliverables to specify room finishing extracting data of pavements, wall finishing, ceiling, skirting.

In our assignment we agree to use Room scheduling for functional description (see Sheet 11) and eventually to estimate floor finishing, ceiling and skirting (see Sheet 09).



Revit 2016, Displaying departments and functional use of the space in the building

4. Reinforced Concrete cost estimation through a parametric approach.

The following part is a reference for reinforced concrete cost estimation that wil be developed using a parametric approach.

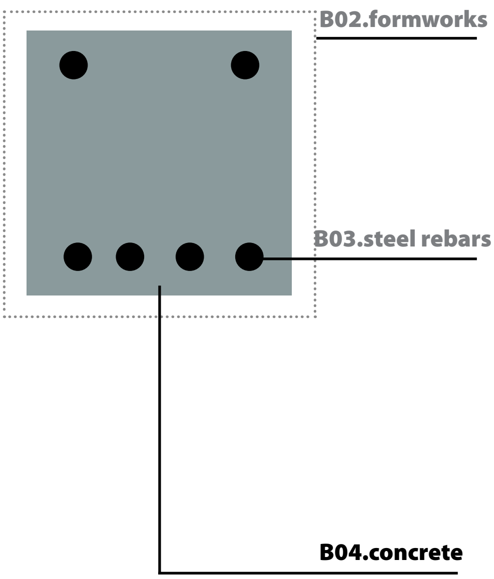
To approach this task parametrically, we can use clusters or BIM styles applied to materials. In other words, we have to create a virtual material incorporating different class of concrete, different percentage of steel and different percentage of formworks: the three materials that define the reinforced concrete product.

Concrete component styles
To simplify, for concrete material we assume the following attributes differentiations:

- three class of strength (C32/40, C28/35, C25/30,
- two class of exposure (XC3, XC2)
- one class of slump (S3).

From their combinations and in relationship to the building components strength requirements we can select three concrete component materials that can be used in different building components (01.B04.005.001, 01.B04.006.001, 01.B04.006.005) Steel rebars is one of the three material (or category of works) which contribute to the realization of the reinforced concrete component material.

COMPONENTS MATERIALS ITEMS



TYPES OF CONCRETE MATERIAL IN BUILDING ELEMENT			
concrete types	01.B04.006.005	01.B04.006.001	01.B04.005.001
	C32/40-XC3-S3	C28/35-XC3-S3	C25/30-XC2-S3
Horizontal Beam	■		
Vertical Beams	■		
Pilasters	■		
Walls	■	■	
Joists		■	
Foundation Beams			■
Plinth			■
Base			■
Plate			■

01.B04.005.001 getto in opera di calcestruzzo ordinario, classe di esposizione ambientale XC2, esposto a corrosione da carbonatazione, per ambiente bagnato, raramente asciutto. Classe di resistenza caratteristica C25/30 - consistenza S3 ***108,90644 €/m3***

01.B04.006.001 getto in opera di calcestruzzo ordinario, classe di esposizione ambientale XC3, esposto a corrosione da carbonatazione, per ambiente con umidità moderata. Classe di resistenza caratteristica C28/35 - consistenza S3 ***114,88357 €/mc***

01.B04.006.005 getto in opera di calcestruzzo ordinario, classe di esposizione ambientale XC3, esposto a corrosione da carbonatazione, per ambiente con umidità moderata. classe di resistenza caratteristica C32/40 - consistenza S3 ***122,56844 €/m3***

Types of concrete and their applications on building components

2016 / FI

Codice regionale: **TOS16_01.A03.001.001**

Tipologia: TOS16_01 - NUOVE COSTRUZIONI EDILI: I prezzi sono relativi a una nuova costruzione di edilizia civile di circa 5000 mc vuoto per pieno, e si riferiscono a lavori con normali difficoltà di esecuzione.

Capitolo: A03 - DEMOLIZIONI: eseguite con qualsiasi mezzo ad esclusione delle mine, compresi gli oneri per le opere provvisionali quali le puntellature, i ponti di servizio anche esterni fino ad un'altezza di m 2,00 e quant'altro necessario ad effettuare la demolizione a regola d'arte, compresi l'accatastamento nell'ambito del cantiere e/o il carico, trasporto e scarico agli impianti di smaltimento autorizzati del materiale inutilizzabile, esclusi i costi di smaltimento e tributi, se dovuti.

Voce: 001 - Demolizione totale o parziale di fabbricati

Articolo: 001 - con struttura portante in pietrame o mattoni e solai in legno, in ferro, in latero-cemento, eseguita con mezzi meccanici, in qualsiasi condizione di altezza

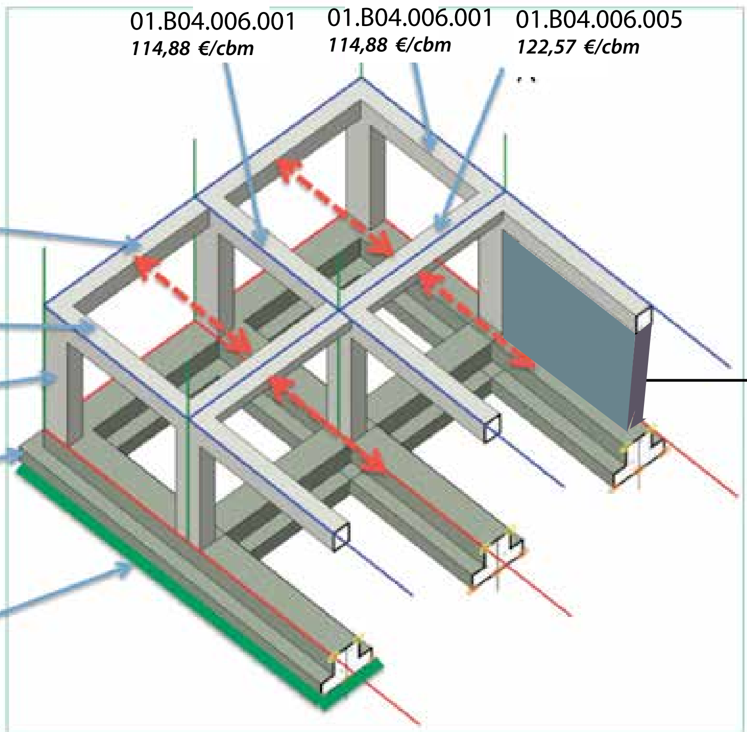
Prezzo a m³ € 12,17648

Analisi

Codice	Elemento di analisi	Unità di Misura	Quantità	Prezzo Unitario	Importi parziali	Importi
TOS16_AT.N01.001.205	Macchine per movimento terra e accessori - Escavatore cingolato con attrezzatura frontale o rovescia con massa in assetto operativo di 20000 KG - 1 mese	ora	0,02	€ 20,41667	€ 0,40833	
TOS16_AT.N01.001.902	Macchine per movimento terra e accessori - Consumo carburanti, oli e altri materiali - macchine movimento terra da 10.000 kg a 25.000 kg - oltre 126 CV	ora	0,02	€ 30,00000	€ 0,60000	
TOS16_AT.N01.002.006	Accessori per demolizioni - Martellone oleodinamico completo di supporto e perni di fissaggio, punta o scalpello da	ora	0,02	€ 4,50000	€ 0,09000	

Codes and technical descriptions from Preziario Ufficiale Regione Toscana

CONCRETE TYPES

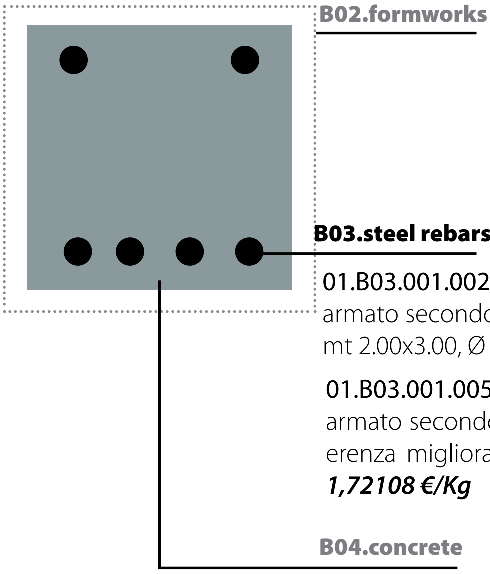


Concrete types localization

Steel rebar component style.
As discussed before, we want to estimate the reinforced concrete material in a parametric way and, as a consequence, we need to define the relations between the reference material (concrete) and the dependent material (steel).

For this referentiation we need, first, to convert the amount of concrete (cbm) in those of steel (Kg). We can use the percentage relation assigning different quantity of steel and, as a result, we can obtain different kind of virtual steel component. For semplification sake we can assume five concrete materials styles deriving from considerations about the strenght requirements of different building components and how the percentage of steel can affect the perfomance of reninforced concrete . So even considering the same product (01.B03.001.005) we can have the following 5 component materials that corrispond to different quantity of steel:
A-275 kg/m3;
B-173 kg/m3;
C-118 kg/m3;
D-0 kg/m3.

COMPONENTS MATERIALS ITEMS



01.B03.001.002. Fornitura e posa in opera di acciaio per cemento armato secondo le norme UNI in vigore. rete elettrosaldata formato mt 2.00x3.00, Ø 6 mm, maglia 20x20 ***1,4269 €/Kg***

01.B03.001.005 Fornitura e posa in opera di acciaio per cemento armato secondo le norme UNI in vigore. barre presagomate ad aderenza migliorata (solo nell'ambito di progettazione preliminare) ***1,72108 €/Kg***

TYPES OF STEEL REBARS MATERIAL IN BUILDING COMPONENTS

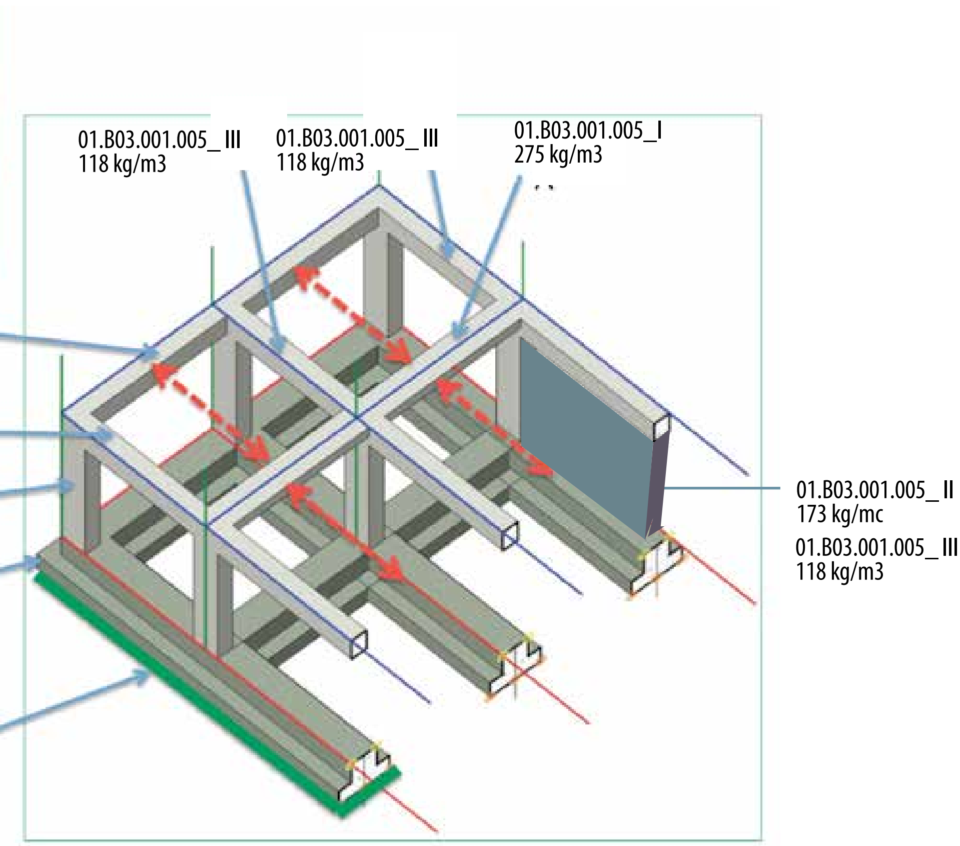
Types of Steel rebars	01.B03.001.005 I	01.B03.001.005 II	01.B03.001.005 III	01.B03.001.005 IV	01.B03.001.005 V
% of rebars, weight, and cost in relation to concrete volume	3,5% (275 kg/m3) 473,45 €/m3	2,2% (173 kg/m3) 297,60 €/m3	1,5% (118 kg/m3) 202,91 €/m3	1% (78,6 kg/m3) 135,27 €/m3	without rebars 0 €/m3
Horizontal Beam	■				
Vertical Beams		■			
Pilasters	■	■			
Walls		■	■		
Joists			■		
Foundation Beams			■		
Plinth			■	■	
Base				■	■
Plate			■	■	

Types of steel rebars and their applications on building components

These quantities are obtained applying different percentage of volume multiplied for the steel density (7860 Kg/cbm)*

*°) Remember that density is different from specific weight where the second one is related to the force P=mass*acceleration > 9,81 Kg ml/s2> 9,81N.*
As a consequence the specific weight of steel is 7800 kg/cbm = 77106,6 N/cbm> 77,1066 kN/cbm

STEEL REBARS TYPES



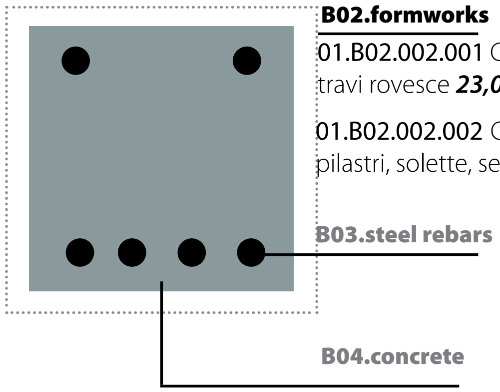
Steel rebars types localization

Fromwork component styles.
For a parametric estimation also formworks need some conversions. First, we need to transform the cbm of concrete (the reference material) in sqm through wich formworks are normally estimated.

For this transformation we need to consider the building components and their geometry. In fact building components required different kind of works (such as shoring) and involve different exposed surfaces.
These considerations bring, in their average, to the values contained in figure on the other page.

The five type of formworks and their applications in the building component are syntehsized below.

COMPONENTS MATERIALS ITEMS



B02.formworks

01.B02.002.001 Casseforme di legno. per opere di fondazione, plinti, travi rovesce ***23,03626 €/m2***

01.B02.002.002 Casseforme di legno. per opere in elevazione travi, pilastri, solette, setti e muri ***28,33512 €/m2***

TYPES OF FORMWORKS MATERIAL IN BUILDING COMPONENTS					
Types of formworks	01.B02.002.002_ a	01.B02.002.002_b	01.B02.002.002_e	01.B02.002.001 _c	01.B02.002.001 _d
quantity of formworks and cost in relation to concrete volume	78,5 sqm/m3 240, 85 €/m3	7 sqm/m3 198,35 €/m3	11 sqm/m3 202,91 311,69 €/m3	5 sqm/m3 115,18 €/m3	0,2 sqm/m3 4,61 €/m3
Horizontal Beam					
Vertical Beams					
Pilasters					
Walls					
Joists					
Foundation Beams					
Plinth					
Base					
Plate					

Types of formworks and their applications on building components

L	B	H	Cbm	Sqm	sdm/cbm	% covering	SQM/CBM	SQM/CBM average	Type
Horizontal Beam									
0,3	1	1	0,3	2,6	8,66667	88%	7,626667		
0,4	0,7	1	0,28	2,2	7,85714	82%	6,442857	**6,912063492**	**b= 7**
0,4	0,6	1	0,24	2	8,33333	80%	6,666667		
Vertical Beam									
0,3	0,5	1	0,15	1,6	10,6667	81%	8,64		
0,4	0,4	1	0,16	1,6	10	75%	7,5	**7,602222222**	**b= 7**
0,4	0,6	1	0,24	2	8,33333	80%	6,666667		
Pilaster									
0,5	0,5	4	1	8	8	90%	7,2		
0,4	0,4	4	0,64	6,4	10	90%	9		
0,35	0,35	4	0,49	5,6	11,4286	90%	10,28571	**8,521428571**	**a =8,5**
0,4	0,6	4	0,96	8	8,33333	90%	7,5		
0,35	0,6	4	0,84	7,6	9,04762	90%	8,142857		
0,3	0,6	4	0,72	7,2	10	90%	9		
Wall									
0,35	1	4	1,4	10,8	7,71429	87%	6,711429		
0,3	1	4	1,2	10,4	8,66667	88%	7,626667		
0,25	1	4	1	10	10	90%	9	**8,59452381**	**a =8,5**
0,2	1	4	0,8	9,6	12	92%	11,04		
Joist									
0,2	0,3	1	0,06	1	16,6667	80%	13,33333		
0,3	0,3	1	0,09	1,2	13,3333	75%	10	**11,28777778**	**e= 11**
0,25	0,4	1	0,1	1,3	13	81%	10,53		
Foundation beam									
0,4	0,6	1	0,24	2	8,33333	60%	5		
0,5	0,5	1	0,25	2	8	50%	4	**4,65**	**c= 5**
0,4	0,8	1	0,32	2,4	7,5	66%	4,95		
Plinth									
0,6	0,6	1	0,36	2,4	6,66667	70%	4,666667	**4,973333333**	**c=5**
0,6	0,5	1	0,3	2,2	7,33333	72%	5,28		
Base									
0,35	10	1	3,5	20,7	5,91429	3,50%	0,207	**0,20%**	**d=,2**
Plate									
0,35	10	1	3,5	20,7	5,91429	3,50%	0,207	**0,20%**	**d= ,2**

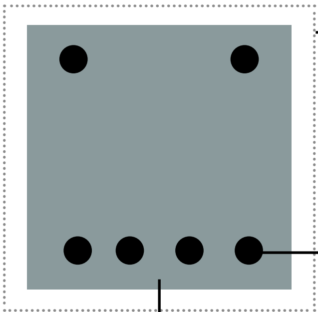
Formwork style definition according to shapes and building components

Reinforced concrete component styles.
Combining types of concrete, steel and formworks we are now able to define the reinforced concrete components.
Even here for a simplification sake we can restrict the total amount of types.
The result of these combinations are shown in figure where clusters (material styles) are eight in total.

These materials with their specific codes can be now created and applied to each building component before to start to draw them.
Remember these materials are virtual materials that need to be computed in a separated way in order to extract for each of them the related quantities of steel rebars and formworks.

Also you have to remember that this is a parametric estimation for steel rebars and formworks based on some semplifications in order to have a more detailed quantification even if the proiect is not completed.

COMPONENTS MATERIALS ITEMS



formworks

01.B02.002.001 Casseforme di legno. per opere di fondazione, plinti, travi rovesce ***23,03626 €/m2***

c – 5 sqm/m3 115,18 €/m3
d – 0,2 sqm/m3 4,61 €/m3

01.B02.002.002 Casseforme di legno. per opere in elevazione travi, pilastri, solette, setti e muri ***28,33512 €/m2***

a – 78,5 sqm/m3 240, 85 €/m3
b– 7 sqm/m3 198,35 €/m3
e – 11 sqm/m3 202,91 311,69 €/m

steel rebars

01.B03.001.002. Fornitura e posa in opera di acciaio per cemento armato secondo le norme UNI in vigore. rete elettrosaldata formato mt 2.00x3.00, Ø 6 mm, maglia 20x20 ***1,4269 €/Kg***

01.B03.001.005 Fornitura e posa in opera di acciaio per cemento armato secondo le norme UNI in vigore. barre presagomate ad aderenza migliorata (solo nell'ambito di progettazione preliminare) ***1,72108 €/Kg***

I – 3,5% (275 kg/m3) 473,45 €/m3
II – 2,2% (173 kg/m3) 297,60 €/m3
III – 1,5% (118 kg/m3) 202,91 €/m3
IV – 1% (78,6 kg/m3) 135,27 €/m3
V – without rebars 0 €/m3

concrete

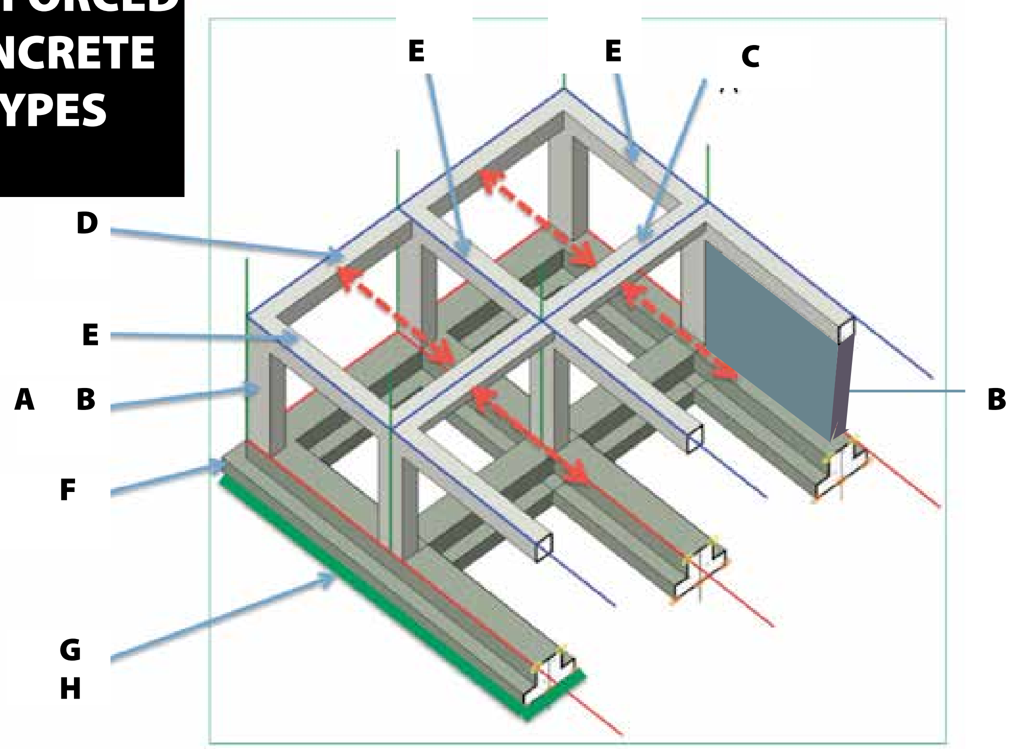
01.B04.005.001 getto in opera di calcestruzzo ordinario, classe di esposizione ambientale XC2, esposto a corrosione da carbonatazione, per ambiente bagnato, raramente asciutto. Classe di resistenza caratteristica C25/30 - consistenza S3 ***108,90644 €/m3***

01.B04.006.001 getto in opera di calcestruzzo ordinario, classe di esposizione ambientale XC3, esposto a corrosione da carbonatazione, per ambiente con umidità moderata. Classe di resistenza caratteristica C28/35 - consistenza S3 ***114,88357 €/mc***

01.B04.006.005 getto in opera di calcestruzzo ordinario, classe di esposizione ambientale XC3, esposto a corrosione da carbonatazione, per ambiente con umidità moderata. classe di resistenza caratteristica C32/40 - consistenza S3 ***122,56844 €/m3***

Types of materials used for reinforced concrete component material

REINFORCED CONCRETE TYPES



Reinforced concrete types localization

TYPES OF REINFORCED CONCRETE MATERIALS IN BUILDING COMPONENTS								
TYPES OF REINFORCED CONCRETE	**A** 836,87 €/mc	**B** 661,02 €/m3	**C** 794,37 €/m3	**D** 618,52 €/m3	**E** 558,64 €/m3	**F** 623,51 €/m3	**G** 359,36 €/m3	**H** 113,52 €/m3
type of concrete steel formworks	01.B04.006.005 I a	01.B04.006.005 II a	01.B04.006.005 I b	01.B04.006.005 II b	01.B04.006.001 III e	01.B04.005.001 III c	01.B04.005.001 IV d	01.B04.005.001 V d
Horizontal Beam			■					
Vertical Beams				■				
Pilasters	■	■						
Walls		■						
Joists					■			
Foundation Beams						■		
Plinth						■		
Base							■	■
Plate							■	

Types of reinforced concrete and their applications on building components