Sustainable Use of Natural Resources In Construction Works: a Case Study of Social Housing.

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Conference proceedings

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Conference chair
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Preface

Sarajevo Green Design Foundation together with University of Mostar and University of Dzemal Bjedic and city of Mostar hosted a 3rd international Green Design Conference 04-10 October 2017 in Mostar. This year's Green Design Conference was also a part of International Green Design Biennale (a seventh international Green Design event in Bosnia and Herzegovina). The conference is organized in collaboration with **EU Horizon 2020 'Buildings as Material Banks'** Project and aimed at addressing the many inter-related aspects of green design of cities, buildings and products, from urban strategies to social cohesion, design for reconfiguration and reuse design for change, sustainable energy strategies. Beside EU BAMB consortium Conference is organized in collaboration with University of Twente from Enschede the Netherlands ,ZUYD University of applied science from Heerlen the Netherlands and Green Council form Sarajevo, Bosnia and Herzegovina.

The emphasis of the conference is on innovative design and engineering methods that will contribute to the process of redefining the quality of life in cities and rethinking the way we create, make and use artifacts and resources that will enable circular economy and circular built environment. Unique feature of the conference was its attempt to bring together scientist, creative and production industry together and involve them in multidisciplinary debate during the town hall meetings and evening keynote addresses. Innovation in sustainable construction has been presented through papers addressing new design approaches, new tools and methods that will support transition towards circular resource use and circular economy as well as case studies addressing new product development and development of BIM frameworks for circular world of construction.

Conference topic integrates issues from green cities, transformation of cities and mobility to spatial adaptability and flexibility of building systems, BIM, Heritage, up to material productivity, bio based construction and energy saving. Development of the research agenda with respect to conference topic deals with issues such as, life cycle performance of buildings, design methodology and protocols for reversible buildings / buildings as material banks, BIM, systems development, reuse, renewable materials, 3D manufacturing, and development of performance measurement tools. Major themes that have been covered by conference proceedings addressed topics as Reversible Buildings, Building Information Modeling, Green Cities and Green Materials and Technologies.

Elma Durmisevic, GDC2017, Conference Chair

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Sustainable Use of Natural Resources In Construction Works: a Case Study of Social Housing

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Abstract

Optimizing the use of resources in the building process is a current problem and is also highly regarded in the latest European legislation. The problem can be tackled by minimizing waste production, promoting waste recovery and transforming waste into resources. In this work has been experimented the elaboration of a building project, for the social building intended use, which can be realized in all aspects in accordance with current regulations and which uses products containing materials from recycling. It relates to the methodology applied and the results obtained and the difficulties encountered in the development of the project.

Keywords:
Natural resources, Building Process, Social Housing, Recycled material, Environmental certification

1 INTRODUCTION

The largest contribution to the total production of special wastes in Italy is given by the construction and demolition sector, with a percentage referring to the 2014-2015 two-year period, equal to 41.1% of total wastes produced. Hazardous wastes attributable to the construction sector account for 8.6% of the total product.

The construction and demolition sector is described by the Ateco reference codes for the classification of economic activities from 41 to 43 and constitute the national version of the European Nomenclature Nace Rev. 2, Statistical Classification of Economic Activities in the European Community, published in the Official Journal on December 20, 2006.

These official data, contained in the Report prepared by the Higher Institute for Environmental Protection and Research (ISPRA) [1], relate to the production of special wastes for the economic activity, according to the Ateco 2007 classification, for the 2014-2015 two-year period.

Regulation 305/2011 of the European Parliament and of the Council of 9 March 2011 lays down the harmonized conditions for the marketing of construction products; in Annex I, lists the basic requirements for construction works and in point 7, refers to the sustainable use of natural resources.

The use of resources, under this Regulation must guarantee the reuse or recyclability of construction works and materials, the durability of the same and the use of environmentally compatible raw and secondary raw materials.

In Italy, as in Europe, waste production has progressively increased as a result of economic progress and increased consumption. The diversification of production processes has also led to the diversification of waste types with increasingly negative effects on the environment. The considerable amount of produced waste combined with the difficulties of disposal and the increase in relative costs have led to an ever-increasing interest in recycling, i.e. the ability to recover some fractions of waste, re-inserting them into production cycles in the form of secondary raw materials . Recycling is the foundation for sustainable development and helps to reduce the cost of waste disposal in landfills or incinerators.

The European Community itself, with Directive 2008/98/EC, in adopting a new strategy for a more rational waste management and policy, has attached great importance, not only to the prevention and safe disposal of waste, but also to actions increase recycling and re-use.

Member States are required to commit themselves to ensuring that recyclable materials do not end up in landfills, and this means that by 2020 recycling of urban waste will increase by at least 50% in weight.

Decision n. 1386/2014/EU of the European Parliament and of the Council on a general EU action program on the environment by 2020 "Living well within the limits of our planet", or simply "Seventh Environmental Action Program" "(7th PPA), sets out some of Europe's priority objectives for 2020, including improving the sustainability of EU cities.

The objectives are based on the principle of "polluter pays" and are set with a clear long-term vision for 2050 where prosperity and healthy environment are based on a waste-free circular economy in which natural resources are managed in a sustainable manner .

The roadmap (COM (2011) 571) to an efficient resource-based EU is based on the actions undertaken by the flag-ship Initiative and completes, defining what elements need to be addressed and outlining their 2020 priorities. These elements are oriented towards the transformation of the economy towards an efficient use of resources and concern:

- sustainable consumption and production;
- turning wastes into a resource;
- support for research and innovation;
- harmful subsidies for the environment and prices properly defined.

The Roadmap distinguishes, then, the behaviors to follow depending on the different types of resources and key areas. In particular, in the section on improving the construction and use of buildings, the stage set by the Commission states that: "*by 2020 the renovation and* *construction of buildings and infrastructure will be made to high resources efficiency levels* ", specifying that "*70% of non-hazardous construction and demolition waste will be recycled*."

In this respect, the approach to the management of construction and demolition waste in Europe differs widely among the various Member States, in fact, from the synthesis data contained in the document (Background Paper) prepared at the workshop "Improving management of construction and demolition waste" [2] it appears that a group of nine Member States (Austria, Belgium, Estonia, Germany, Hungary, Luxembourg, Malta, the Netherlands and Spain) has already achieved this sustainability goal, while the other group of nine (Croatia, Cyprus , Czech Republic, Denmark, France, Italy, Lithuania, the United Kingdom and Slovenia) is showing good recovery rates, with values between 50% and 70%, and finally the group of the remaining ten Member States (Bulgaria, Finland, Greece, Ireland, Latvia, Poland, Portugal, Romania, Slovakia and Sweden) is still far from this goal, which is likely to preclude the possibility of meeting the target set by the European Commission for 2020.

From the analysis of the European Union's regulatory documents and guidelines, two possible strategies emerge:

- the recovery of waste products or materials from C & D or other (output) through careful planning of the demolition and proper management of materials and products of existing building;
- the design of the building system that involves the use of environmentally-friendly materials and products (inputs), as products derived totally or partly from material recovery operations.

This would result in a sustainable resource management strategy that suggests reconnecting the two extremes of product life and transforming what is considered a waste in a resource so as to push the economy from a linear model (" take, produce, use and throw ") [3] to a circular one [4]. The purpose is to keep the value of good within the economic system as long as possible, even at the end of its life cycle, through the reuse of all or part of the components and materials that make up it so to reduce both resource consumption and waste production at the same time.

The European Commission [5] has long supported the efficient use of resources in the various industrial sectors (including those involved in the realization of construction products) by promoting sustainable and innovative industrial processes that use, for example, sustainable raw materials or operate industrial symbiosis [6], a system by which waste or by-products from an industry become production factors for another.

The inputs of this phase are therefore the primary raw materials, including renewable ones, which even in a circular economy will always play an important and sometimes irreplaceable role, and secondary raw materials or by-products, coming from both internal recovery to the same, or analogous, industrial process and from other economic sectors, even completely outside the building world. Outputs, however, correspond to manufacturing waste, to be identified as by-products or waste, and to finished construction products, which can be distinguished in their many different forms.

This paper addresses the design strategy of the building system oriented to the use of environmentally friendly materials and products (inputs). The aim is to experiment with the design of a building for social housing, which can be realized in all aspects in accordance with current regulations and that it uses products containing recycled materials available in the market with the purpose of calculating the recycled percentage used on the total volume of the technical elements used.

2 THE CASE STUDY

2.1 Territorial area

The case study is placed in the town of San Martino Buon Albergo, in the province of Verona (Figure 1), in a strategic position since it is the first municipality outside the Verona municipal boundary and at the same time is surrounded by greenery.

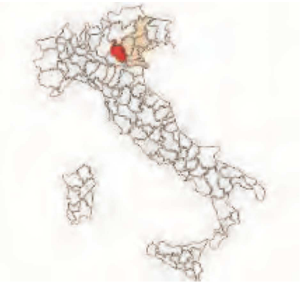


Figure 1: Localization of the Municipality of San Martino Buon Albergo in the Italian territory

At the morphological level, the municipality includes a flat territory to the south and a hilly land to the north (Figure 2). The intervention site is located east of the municipal area, in a residential area with prevalence of residential buildings. The area is well connected to the main road and is the location to an important sports center for the whole community.

Figure 2: Aerial photo of the intervention area (Source: www.gmaps.it)

2.2 Urban setting

In the extract of the Intervention Plan (IP) (see Figure 3) of the Municipality of San Martino Buon albergo, the area of interest appears to be a residential expansion with a concentration of building capacity.

Figure 3: Extract from PI of San Martino Buon Albergo with in red the area of intervention

These are parts of the territory that are not yet built or only partially built, with no primary urbanization, which the IP identifies as areas of residential expansion in which to apply the principle of urban equalization, which involves the activation of agreements between public and private entities in accordance with the meaning of Art. 6 of the Regional Law N. 11/2004, in order to ensure a balanced and functional growth for the new urban expansion. The intervention follows the prescriptions of the technical standards, which in art. 70, define the "City of Transformation" as the whole of the parts of the territory in which the process of transformation is carried out for the realization of the newly-built city and existing areas of the city which, disused and abandoned, are recovered under 'urban and functional aspect to urban contexts with retraining and reconversion actions. The operations of the "City of Transformation" are implemented with a public or private initiative plan (Piano Urbanitstico Attuativo - PUA) and must meet the urban standards specified in the technical standards.

The aim of the project is to realize the new urban layout between Borgo della Vittoria and Casette Marcellise, with particular regard to the road, the central nucleus of the new urban park and the enhancement of the services in the hamlet of Casette Marcellise. The Territorial Buildability Index is mc / sqm 0.75 as by PUA. Areas of unallocated selling Areas and Areas for enhancement of public services at Casette di Marcellise, such as the new square, the new public facilities and the adjacent green equipped area, are foreseen. The intended use is residential. The distance between the window walls should be at least 10 m and the distance from the minimum road clearance must be 5 m., as provided by DLgs n. 285/92 and DPR n. 495/92. In the PUA in force on the area of interest, the following information is given: Land area = 11,099.31 sqm; Maximum building height = 13 m; Maximum achievable volume = 33,849.75 mc. Finally, the area does not appear to be subject to constraints or particular vulnerabilities.

2.3 The design proposal

Looking at the residential environment present around the project area, it was decided, also in keeping with the PI guidelines, to build a Social Housing building that could accommodate different types of utilities. The built, horseshoe-shaped with a central courtyard, consists of 8 blocks (see Figure 4) for residential use and a building for the community.

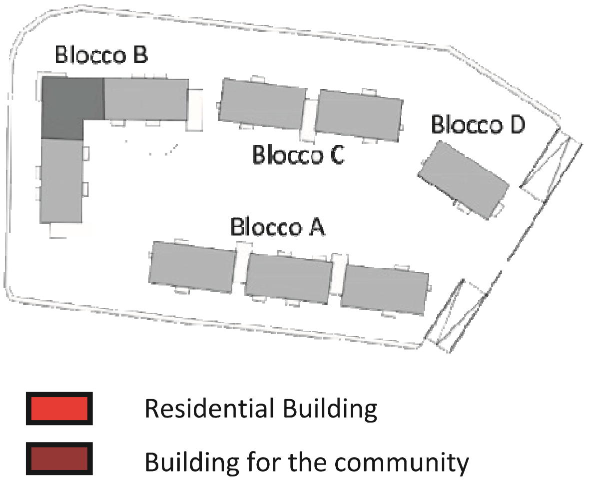


Figure 4: Schematic diagram of the layout of the designed buildings

The built-in volume corresponds to 26,160 cubic meters divided into Blocks A (9,514 cubic meters), B (10.132 cubic meters), C (4,440 cubic meters) and D (2,074 cubic meters), and meets the limits set by the PUA.

The units located south of the lot in question (see Figure 5) are developed on three ground levels, while those located north on two levels, to allow more ventilation in the central court. It has also been left more open on the east side, as a green public area is planned.

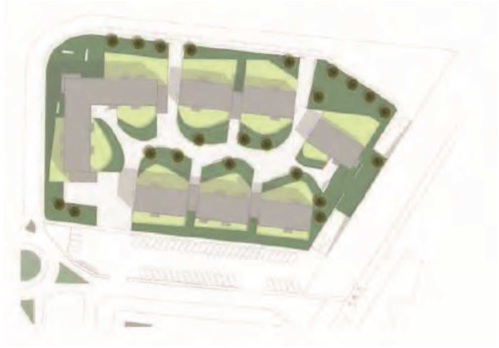


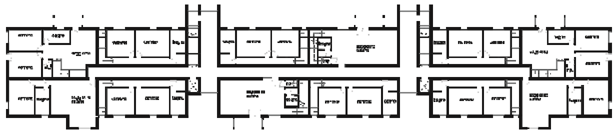
Figure 5: Project plan

Figure 6: Overview

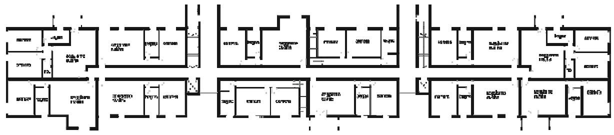
With the intention of accommodating different types of utilities, four types of apartments have been designed: two-room, three-room, duplex in two different variants (2 + 2 and C-shaped). There are small variations in sizes between the Block D and the others, due to a different structural mesh resulting from the position of the stairwell. In fact, this block is the only one to have the staircase contained inside it, while in other buildings it is inserted inside independent elements (see Figure 6).

Block A (Figure 7) provides for the construction of 26 apartments in the different types (12 two-room apartment , 2 type 2 three-room apartment, 8 duplex 2 + 2 and 2 duplex C-shaped); block B (Figure 8) provides the realization of 16 apartments (8 two-room apartment and 8 duplex 2 + 2); block C (Figure 9) provides the realization of 10 apartments (2 two-room apartments, 2 three-room, 4 duplex 2 + 2 and 2 duplex C-shaped); and Block D (Figure 10) of 5 apartments (2 two-room apartment, 2 three-room apartment and 1 duplex 2 + 2), for a total of 57 apartments. The basement is unique throughout the complex and there are garages, cellars and technical rooms. There are 60 garages as the housing units are 57. Furthermore, there is the possibility of making public parking (Figure 11) available in accordance with Regional Law 11/2004, which provides 2.5 square meters per inhabitant dedicated to public parking lots, and will fully meet the needs of 68 parking spaces, including two for disabled people.

Ground floor



First floor

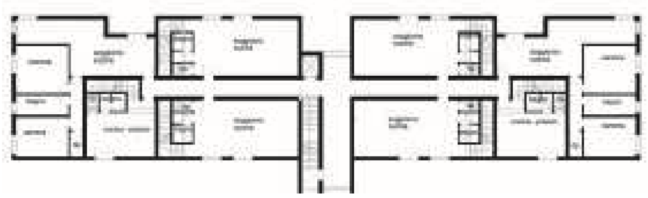


Second floor

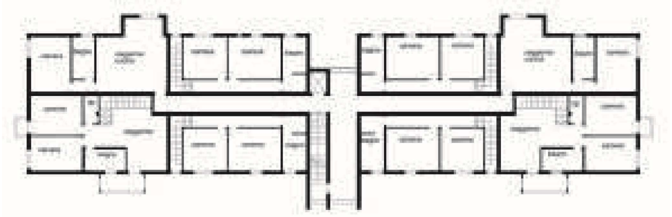
Figure 7:Block A diagram

Ground floor First floor Second floor

Figure 8:Block B diagram

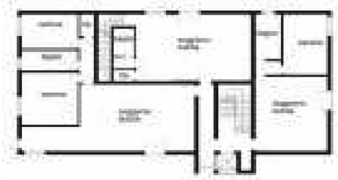


Ground Floor

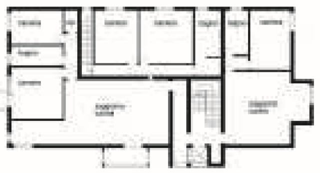


First Floor

Figure 9: Block C diagram

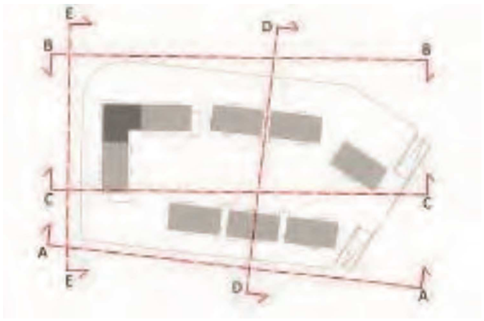


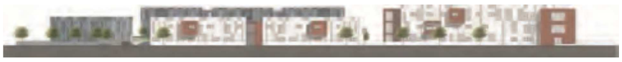
Ground floor



First floor

Figure 10: Block D diagram





Section B-B

Section D-D

Figure 11 Sections

2.4 Exterior spaces

Social Housing presumes the implementation of strategies designed to create a community and to foster integration through the use of common spaces and services among the inhabitants. For this reason, in addition to inserting a building for common activities, a green interior space has been designed to be a place of aggregation for users (Figure 12). Space is determined by a cyclopedestrian path which in turn widens at certain points to accommodate rest areas (Figure 13). The apartments on the ground floor are provided with a private green space, which is bordered by public greenery placed at a higher altitude (+1 m). This split off is due to the need for greater ventilation in the basement.

Figure 12: Project rendering

Figure 13: Project rendering

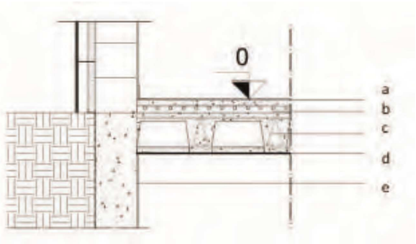
2.5 Technological choices

In order to achieve a good percentage of total recycled builds, it was considered appropriate to use a steel skeleton for this project.

The slab on the ground floor is a predalles type (Figure 14) with elements of Beton lightening, while the tops, and the flat cover, are made of the beams and the steel sheet system (Figura 15).

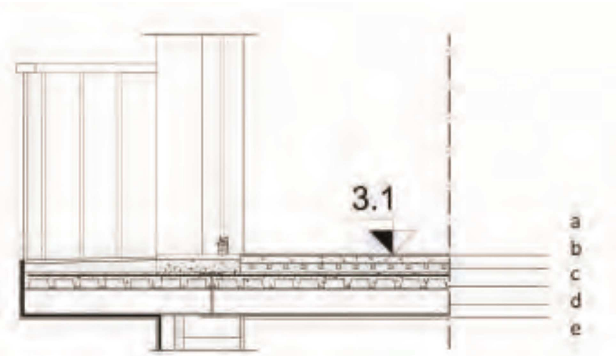
As for the perimeter walls (Figure 16), going from inside to outside, can be found the following stratigraphy: kerakoll plaster, Vibrapac vibropressed concrete blocks, Insulation of Maiano Companies, a layer of air, being provided a ventilated wall, Acquaboard di Siniat plates of exterior plasterboard and Kerakoll plaster finish.

Darkening systems with recessed concealed drapes have been conceived so as not to alter the elevation layout linearity. The internal partitions (Figure 17) are designed with plasterboard walls with a double insulating layer. Such solutions are used in all buildings of the complex.



a. finish layer: Caesar ceramic; b. plant integration layer and bedding screed; c. support layer: Predalles slab with Beton lightenings; d. finish layer: Siniat plasterboard; e. finish layer: Kerakoll plaster

Figure 14: Ground floor slab Predalles type detail



a. finish layer: Caesar ceramic

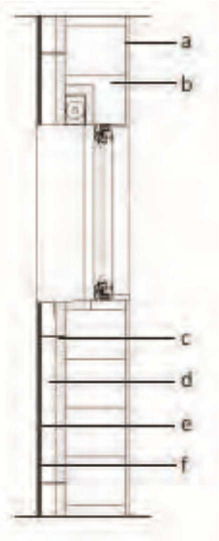
b. plant integration layer and bedding screed

c. support layer: slab with steel sheet and filling jet with electro-welded mesh

d. support layer: IPE 140 secondary beam

e. finish layer: Siniat plasterboard

Figure 15: Steel slab of the first floor detail



a. Internal finish layer: Kerakoll plaster

b. support layer: vibropressed concrete blocks

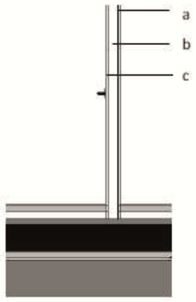
c. insulation layer: Syntherm panel

d. ventilation layer

e. external finish layer: AcquaBoard panel

f. external finish layer: Kerakoll plaster

Figure16: Perimeter wall detail



a. finish layer: Siniat plaster board

b. Internal finish layer: Syntherm panel

c. finish layer: Siniat plasterboard

Figure17: Internal partition detail

3 PROCEDURE FOR CALCULATING THE QUANTITY OF RECYCLED MATERIAL

The first addressed issue was to produce a catalog, though not exhaustive, of products on the Italian market for which the manufacturer declares the significant percentage of recycled content compiled according to the classification system identified in UNI 8290-1:1981- Residential Construction. Technological system. Classification and terminology, issued by the Italian National Unification Body. Many difficulties have been encountered in carrying out this activity as many companies do not declare the exact percentages of recycled content for their products. The reasons behind this situation is unknown, so it is supposed that production inputs are lacking in control or that little attention is paid to making this data available. The work was developed in the period January-June 2016 and 10 companies were identified for a total of 20 products.

The second issue addressed was the calculation of the amount of recycled material. For this purpose, have been taken into account the criteria used in the LEED [7] and ITACA [8] environmental certification systems.

The LEED evaluation system is structured in seven thematic areas organized into prerequisites and credits. For the purpose of the work, the section "Materials and Resources" has been analyzed. Regarding the content of recycled material, the certification system provides 2 points out of a maximum of 14 available. In the section in addition, all materials and construction products used in the project must contain a quantity of recycled material such that the sum of the post-consumption and half of the pre-consumption materials constitutes at least 10% or 20% of the total economic value, exclusively considering in the calculation the materials permanently installed in the project.

Also in this case, difficulties were encountered in knowing the value of % of the content of recycled material, since both the cost of the material and the exact percentages of pre- and post-consumption content are to be known as input data. Both of these data are not always released by companies or are not reported in a certified data sheets.

For this reason, it was considered more appropriate to carry out this analysis with the method proposed by the ITACA protocol; in fact, it is more simply based on volumes and percentages, partly inferable from project choices and partly from data provided by the manufacturer.

For this has been used the Itaca Protocol Reference Routine Procedure, UNI/ PdR 13: 2015 Environmental Sustainability of Constructin works – Operational tools for Sustainability Assessment, published on January 30, 2015, splitted into two sections and based on the ITACA Residential Protocol.

In the used Itaca protocol evaluation criteria for calculating the performance score of residential buildings are organized in "Criteria Sheets" and are grouped by reference category.

Specifically for the 'Resource Consumption' Assessment Area, and for the application of the evaluation criterion the B.4.6 'Recycled / Recovered Materials' criterion sheet has been taken into account [9]. This criterion sheet specifies the calculation method to be applied and the performance indicator to which it refers and which corresponds to the percentage ratio between the volume V_{rtot} [m^3] of recycled/recovered materials used in project (B) and the totality in volume V_{tot} [m^3] of the materials/components used in the test (A) according to the following formula:

$$Indicator_{ed} = V_{rtot}/V_{tot} \times 100$$

Particular attention should be given to note 7 of the B.4.6 criterion sheet specifying: "The percentage of recycled material R must express the sum of pre-consumption and post-consumption recycled content." The definitions of pre-consumption recycled content and post-consumption recycled content refer to UNI EN ISO 14021.In order to calculate the amount in percentage of recycled material present in the case study, it was decided to proceed with the study referring only to one block of the residential complex (Block D). The choice is relapsed to this building because it is the only one to be independent and it can be assumed that such simplification results in an extensible result to all the other blocks because they are designed with the same characteristics and with the same technological choices. Due to the limits imposed by the regulations, the basement has been designed entirely in concrete. For this reason only the part of the building out of the ground was taken into account for the calculation of materials. In any case, it has been attempted to limit as far as possible the use of concrete as it is a material that has limitations relative to the content of aggregates from recycling. It was therefore mainly used for the hoods and screeds and for the parapets of the external balconies. In order to improve the energy efficiency, the installation of thermal and photovoltaic solar panels is planned. To carry out the calculation quickly, the Revit program was used to model the building. The Recycled Content item has been added among the parameters attributed to each single material. With a simple spreadsheet, the V_{rtot} volume [m^3] of the recycled/recovered materials used in the design and determination of the volume V_{tot} [m^3] of the materials/components used in the operation was determined. Through the calculation, a percentage of 64% volumes of recycled material was reached (see Table 1).

Category	V_{tot} [m^3]	V_{rtot} [m^3]
Walls	298.57	155.37
Slabs	183.11	153.48
Pillars	1.8	1.8
Beams	1.47	1.47
Stairs	1.31	0.78
Doors	3.09	0.79
Windows	1.22	0.29
Total	490.57	313.98
Total Percentage	**64%**	

Table 1

4 CONCLUSIONS

In this work has been experiment the design of a project using products containing certain percentages of recycled material as declared by the manufacturer. The main aim was to demonstrate that it is possible to design a building for social use according to the current regulations and that it uses the classified products that are actually present on the market containing recycled material, reaching the 64% .

Many difficulties have also been reported, especially in finding information from companies that are willing to provide data on the content of recycled material for their products. To overcome this problem, it is suitable, therefore, that companies should be able to provide certification products that accompany a product even with recycled material content.

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