Disclaimer

This sheet is intended for designers, specifiers and other members of construction project teams wishing to reuse this building material or product. It is part of a collection of sheets aimed at bringing together the available information to date that is likely to facilitate the reuse of building materials and products.

This sheet has been produced by Bellastock within the framework of the Interreg FCRBE project - Facilitating the Circulation of Reclaimed Building Elements, supported by the entire project partnership. Sources of information include the experience of reclamation dealers and involved project partners, lessons learned from exemplary projects, available technical documentation, etc.

The sheets have been produced between 2019 and 2021. As the reclamation sector is evolving, some information, notably regarding pricing and availability, may change over the time. When the text refers to European standards, it is up to the project team to refer, if necessary, to their national implementations and local specificities.

It is important to note that the information presented here is not exhaustive or intended to replace the expertise of professionals. Specific questions are always project related and should be treated as such.

The complete collection of sheets (including the introductory sheet) is freely available from different reference websites (a.o. opalis.eu, nweurope.eu/fcrbe, futureuse.co.uk).

Non-exhaustive directories of dealers in reclaimed building materials are available on www.opalis.eu and www.salvoweb.com.

Interreg FCRBE partnership: Bellastock (FR), the Belgian Building Research Institute / BBRI (BE) , Brussels Environment (BE), the Scientific and Technical Center of Building / CSTB (FR), Confederation of Construction (BE), Rotor (BE), Salvo (UK) and University of Brighton (UK).

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Iconography

Figure 1 : BENOIT J, SAUREL G, BILLET M, BOUGRAIN F, LAURENCEAU S, ADEME, BELLASTOCK, CSTB, *REPAR#2 Le réemploi passerelle entre architecture et industrie,* mars 2018, p108.

Introduction

This set of sheets ("*1.90. Concrete pavers and slabs resulting from the transformation of concrete construction elements", "2.91. Concrete shear wall" and "2.92. Concrete rubble resulting from the transformation of concrete construction elements*) aims to present several possibilities for the reuse of cement concrete elements.

This sheet introduces the basic precepts. It endeavours to describe the material in general. It then identifies the main families of elements with potential for reuse. The other sheets study in more detail the ways of reusing specific elements.

In general, this set of sheets covers the constituent elements of the structure and the building's envelope.

Material description

Cement concrete (called "concrete" in the rest of the documents) is a composite material, obtained by mixing:

- *sand*
- *gravel*
- *cement* (composed of limestone and crushed clay, fired at a very high temperature and then crushed)
- *water*

The proportions are variable depending on the intended use. Adjuvants can be added to its formulation to give it specific properties (e.g. setting or hardening accelerator or retarder, modification of workability, etc.).

Concrete has good compressive strength but not tensile strength. To overcome this, it is often coupled with steel. We then talk of reinforced concrete.

Today, second only to water, concrete is the most consumed material, with three tonnes per year used for every person in the world [1].

Concrete as we know it and use it today is the result of experiments and technological developments that have mainly taken place over the last century. The intense period of reconstruction that followed the Second World War was decisive for the concrete industry: countless inventions and construction methods arose. These developments were supported by countries, which aimed to achieve efficiency gains and savings. In France, this is the time when the "large complexes" were built, giving pride of place to concrete poured in place or prefabricated. During this period, those involved in construction specialised in concrete masonry. More recently, high-performance concretes have appeared incorporating new components such as fibres in their formulation.

Behind a single term there are a multitude of concrete types and applications. However, it is possible to establish a few broad categories:

→ According to the concrete types

- **Reinforced concrete** is the most common form in which the steel/concrete combination is found. This is a concrete which includes steel reinforcements, the arrangement, sections, distribution, anchors, and adhesion of which differ according to the forces to be taken up.
- **Fibre-reinforced concrete** (or fibre concrete) is concrete in which fibres have been incorporated (stainless steel, propylene, spun glass, carbon, etc.) which make it possible to create a mesh that increases the cohesion and resistance capacities of the concrete.
- **Prestressed concrete** is concrete to which a permanent compressive force is applied before it is put into service, so that it is not subjected to tensile forces once in service. This compressive force is obtained by the tensioning of reinforcements, after the pouring of the concrete (post-stress) or before the pouring (pretension).

→ According to the installation techniques

- **Precast concrete**: these are components produced outside their final location (in the factory, in the workshop, near the construction work or on a prefabrication area) then assembled on site. The elements are linked by a keying and concreting system which ensures the consistency and stability of the whole. Many prefabrication processes have emerged. The regular use of prefabricated concrete elements became widespread after World War II, in a context of large-scale reconstruction. Prefabrication is still used today, but in a more targeted way (façade panel, structural elements, etc.).
- **Concrete poured-in-place**: concrete cast in formwork by gravity. Depending on the size and context of the site, concrete can be produced in a concrete batching plant at the foot of the site or on a dedicated site. There is standard reusable formwork and custom formwork in the case of a complex shape. Depending on the position of the building element cast in place and its structural role, it will be more or less scrapped.

Today, concrete is not a material that can be found on the reclamation market. Some suppliers of reclaimed materials offer manufactured concrete pavers, slabs or roofing tiles, but not elements from the actual structure of the buildings. To date, steps to reuse concrete elements have therefore been carried out on the initiative of sponsors and designers. Nevertheless, the recovery and dealer networks of concrete elements are likely to develop in the future.

At this stage, several experiments have already demonstrated the possibility of reusing concrete elements from demolished buildings, for the same use or for other applications (*see sheets "1.90. Concrete pavers and slabs resulting from the transformation of concrete construction elements', "2.91. Concrete shear wall" and "2.92. Concrete rubble resulting from the transformation of concrete construction elements*). These different experiences highlight a range of possible reuse solutions, which are all alternatives to recycling (i.e. crushing concrete into aggregate).

[1] *Gagg (2014), Cement and concrete as an engineering material: An historic appraisal and case study analysis, Engineering Failure Analysis, Volume 40, p. 114-140.*

Do not confuse!
Concrete reuse and recycling

Once purged of its reinforcements and any coating, concrete is an inert material. On a good number of sites, the demolishers expose the concrete frames which are then demolished. The resulting rubble is crushed to make recycled aggregates. Depending on their quality and grain size, they can be used in road or backfill applications. Some aggregates can be incorporated into the production of new concrete - but only to a limited extent.

All of these approaches correspond to recycling practices. Reuse, unlike crushing, involves reuse of a building element while preserving its formal integrity, technical and architectural qualities as much as possible.

Identification of concrete elements that can be reused in construction (typological description of constituents)

The reuse of concrete is an ambiguous notion, which is why we rather speak of the reuse of concrete elements. A good knowledge of construction methods is necessary to determine the feasibility of reuse and target possible future uses.

In practice (*see figure 1*), the majority of the most commonly used elements in concrete constructions can be reused:

→ *Posts*: elongated, vertical load-bearing elements. They mainly take up the compressive forces transmitted vertically from the upper floors to the ground through the foundations. The most common sections are square, rectangular, circular, or I-sections.

→ *Beams*: long pieces whose function is to transfer loads (mainly vertical) to supports. They have standard rectangular sections and are reinforced so as to take up bending moments (longitudinal steel bars) and shearing forces (frames).

→ *Walls*: these are vertical structural surface works. They mainly support vertical loads. Due to their great rigidity, walls are also used to take up horizontal stresses (wind, earthquake). A concrete wall is considered as such when its length is at least equal to 4 times its thickness.

→ *Concrete floors*: these are load-bearing horizontal surface elements, mainly subjected to bending. A distinction is made between slabs with unidirectional spans and slabs with bidirectional spans. These floors are found in three main groups: solid slabs, ribbed slabs and special (mixed) floors. A slab is an element whose smallest dimension in its plane is greater than or equal to 5 times its total thickness. They are usually reinforced with welded mesh.

→ *Façade panels*: flat and relatively thin material of uniform thickness. These elements are used for filling most of the time and have no structural role.

Tip!

To understand the possibilities of reusing concrete elements, it may be useful to conduct an investigation into the history of the building from which they originate as well as its historical construction context. The analysis of archival documents, files of works executed and works on the history of construction makes it possible to identify and better understand the construction processes used. In addition to this documentary study, visual observation in the field, possibly supplemented by surveys, is essential in assessing and completing the analysis.

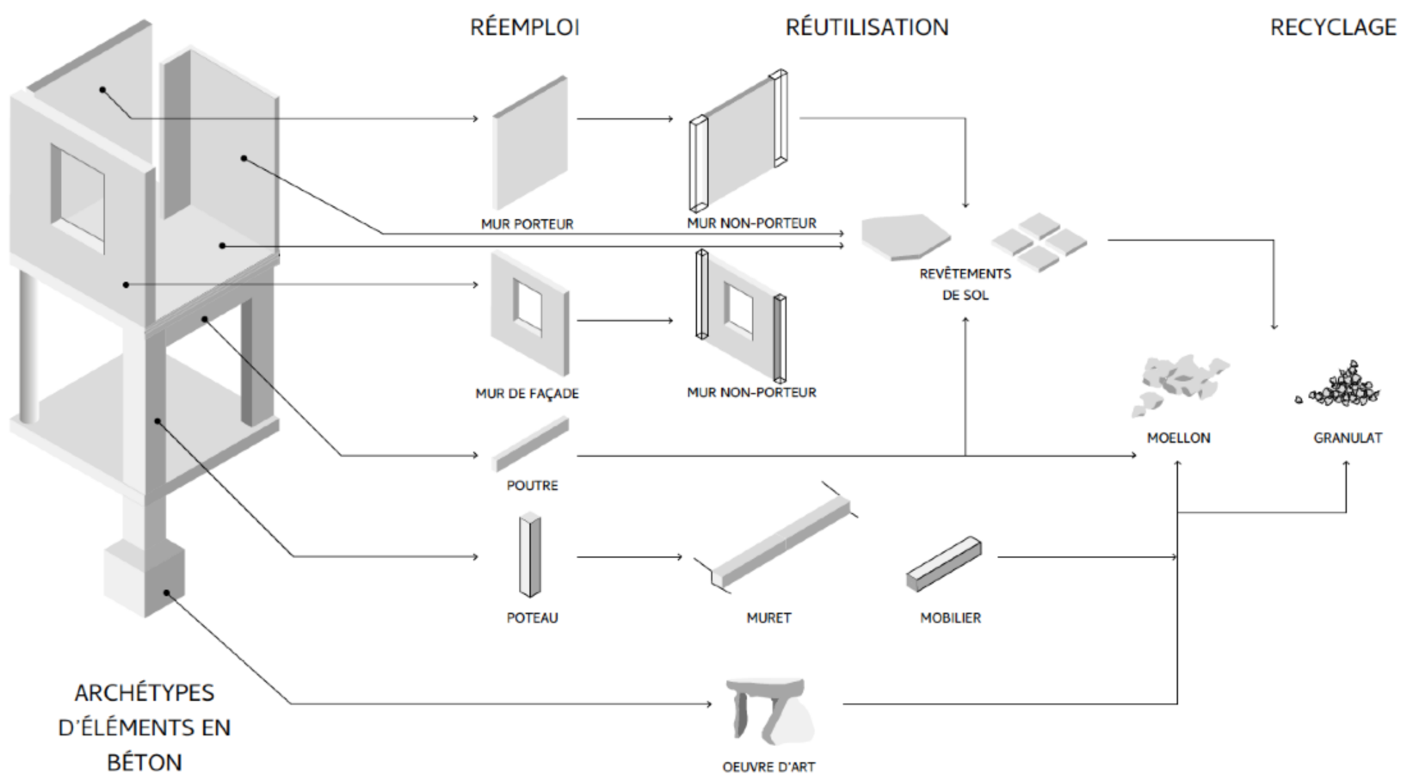

Figure 1: Main re-use and re-purposing possibilities for concrete elements

Main properties of reclaimed concrete elements

Whatever element one wishes to re-use, and whatever the new expected use, the basic characteristics to be understood to allow the sizing studies of future structures are:

→ *For concrete:*

- The physico-chemical composition.
- The compressive strength class. The tensile strength.
- The exposure class (linked to region, altitude and exposure to bad weather).
- The dimensions.

→ *For steel*:

- Mechanical properties: yield strength, tensile stress, relative elongation of tensile steel and modulus of elasticity.
- The dimensional characteristics: the position of the reinforcements, the diameter of the bars, the nature of the steel and the coating.

All the properties of reclaimed concrete must comply with the requirements applied to new concrete.

The diagnosis and more or less thorough analysis of the properties go towards deciding on the size according to the context of the project and the intended use. Over-sizing or downgrading of materials can be a design strategy to address knowledge gaps about the properties or deterioration of a building element.

Grading of concretes can be done by iteration, for example by carrying out measurements on site to obtain information on the hardness. A visual diagnosis makes it possible to identify the condition of the surfaces. The diagnostic tools and methods used by designers/specifiers working in the contexts of heritage concrete buildings can be called upon as part of a reuse process.

Calculations and main standards

→ *Design standards*: national regulations and Eurocodes.

→ *Installation standards*: standards and good practice on a national level (e.g.: NIT, DTU, etc.) and the standard EN 13670: Execution of concrete structures.

→ *Product standards*: relating to precast concrete products (structural and non-structural).

→ *Test standards*: in the case of reuse, mainly concerns test standards related to determining the properties of hardened concrete.