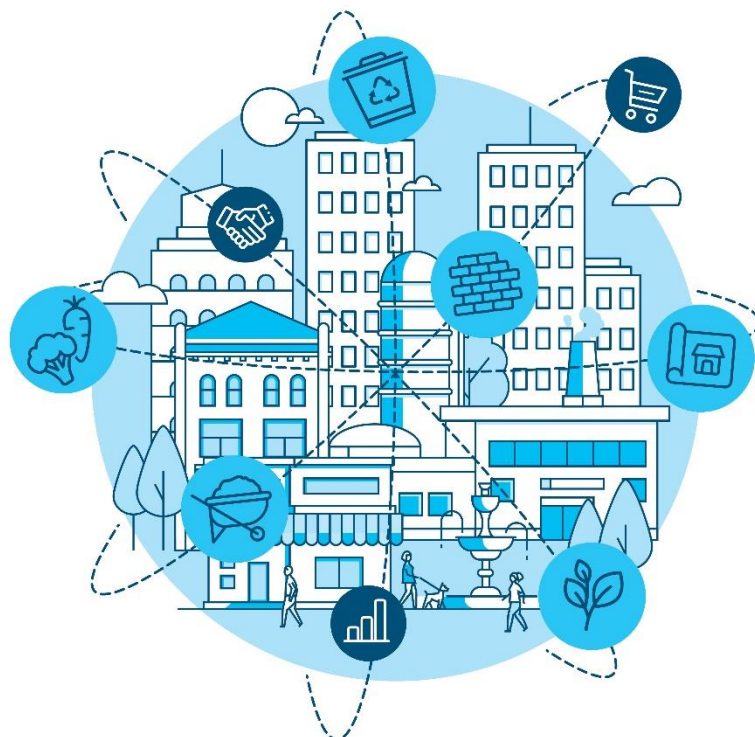





# CityLoops Guide for Pre-demolition Audit

Xamk, Finland and Capital Region Denmark, Denmark



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Abstract	This CityLoops guide for pre-demolition audit gives guidance to implement an identification of hazardous materials and an inventory of the non-hazardous materials and reusable products before a building will be demolished. The guide is based on mainly to the guidance of the Finnish Ministry of the Environment (Wahlström et al. 2019a).
Keywords	Pre-demolition audit; reuse; recycling; recovery; CDW management;
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# Foreword

The EU funded project No. 821033 Closing the loop for urban material flows (CityLoops) from October 2019 to September 2023 brings together six ambitious European cities to demonstrate a series of innovative tools and urban planning approaches, aimed at closing the loops of urban material flows and increasing their regenerative capacity. The cities are Apeldoorn (The Netherlands), Bodø (Norway), Mikkeli (Finland), Høje-Taastrup (Denmark) Roskilde (Denmark), and Seville (Spain). The cities will implement specific demonstration projects, including demonstration and evaluation of methodologies and instruments for promotion of Circular Economy focusing on flow of building materials. Among a number of tools and instruments for the support of the demonstration projects, tools for screening procedures and tool for selective demolition will be developed and tested. The screening involves a detailed assessment of buildings and materials with respect to hazardous materials and potential recycling before demolition. In Mikkeli, the draft of CityLoops a Pre-demolition audit guide has been developed based on the Finnish guidelines in cooperation with Apeldoorn, Høje-Taastrup, Roskilde and Capital Region Denmark. In addition to the Pre-demolition audit guide a guide for selective demolition will be developed separately. The two guidelines are presented in two separate complementary documents with cross-references to provide an integrated tool for implementation of circular economy in the construction industry.

This guide is based on the guidelines of the Finnish Ministry of the Environment (Wahlström et al. 2019a): Pre-demolition Audit – A Guide for Authors written by Margareta Wahlström, Petr Hradil and Tuuli Teittinen from VTT Technical Research Centre of Finland Ltd and Katja Lehtonen from Ytekki Ltd. The Finnish guide expands the pre-demolition guide published by the European Commission in 2017 (European Commission 2016a).

The Finnish guide was translated in English with permission of the Ministry of the Environment, because it was seen as the newest and the most practical guideline for the Pre-demolition audit. Additionally, the reports published by the PARADE - Best practices for Pre-demolition Audits ensuring high quality Raw materials -project (Wahlström et al. 2019b, Wahlström et al. 2019c) were considered in the guide, especially related to the identification of hazardous materials. Practical experiences from using the Finnish pre-demolition audit guide were collected by interviewing consultants.

It should be noted that this version of the Finnish guide has been prepared with respect to the general needs and common praxis in the EU member states and use in the CityLoops demonstration projects.

We acknowledge Finnish Ministry of the Environment and PARADE-project for the very useful guidelines and the opportunity to use them in the CityLoops project. We also acknowledge Laura Majoinen and Ville Mäntylä from Ramboll Ltd and Katja Ahola from Xamk for the opportunity to interview you and use your experience in this guide.

The draft guide will be tested and evaluated during the implementation of the CityLoops demonstration projects in cooperation with the CityLoops partners, their consultants, contractors and other stakeholders.

# 1. Introduction

Construction and demolition waste account for the most voluminous waste flow in the EU (Eurostat. 2019). While most construction and demolition waste are recoverable, the general obstacle to the reuse and recycling of construction and demolition waste is the uncertainty regarding the validity of recovered materials and building elements. (Wahlström et al. 2019a)

Reuse or recycling of materials require planning and auditing before demolition in order to monitor and assess hazardous waste and reusable/recyclable elements. This audit should be done well in advance of the demolition, and should identify hazardous materials, list non-hazardous materials, and provide recommendations for their handling, following the waste hierarchy of prevention, re-use, recycling, recovery, and disposal.

Different actors are involved in the process: construction clients initiating the demolition and construction project, contractors responsible for demolition work and waste management, experts who conduct pre-demolition audits, and waste managers who provide waste collection and treatment services.

This CityLoops guide for pre-demolition audit is based on the guidelines of the Finnish Ministry of the Environment published in 2019, which expands the pre-demolition guide published by the European Commission in 2017 (European Commission 2016a). The Finnish guide provides information on the best practices for the assessment of construction and demolition waste flows, or the pre-demolition audit, conducted before a building or a structure is demolished or repaired. The guide aims to facilitate and further the recovery of materials and building structures for reuse and recycling without compromising the safety measures and practices laid down in the EU Construction and Demolition Waste Management Protocol. According to the EU Construction and Demolition Waste Management Protocol: (European Commission 2016b, according to Wahlström et al. 2019a):

- All demolition, repair and construction projects must be well designed and managed to reduce environmental and health impacts and, simultaneously, to generate significant material savings.
- A pre-demolition audit must be carried out for all demolition or repair projects in which, in addition to harmful substances, other materials resulting from demolition are surveyed in advance.
- Authorities must decide on the threshold for conducting a pre-demolition audit.

- A pre-demolition audit takes full account of the local market for construction and demolition waste, as well as for reusable and recyclable materials.
- The individual conducting a pre-demolition audit must be a qualified expert.

The Finnish guide covers waste generated by demolition and repairs, excluding soil resulting from excavation and dredging. The target group of the guide includes: (Wahlström et al. 2019a)

- The owner or holder of a property embarking on a construction project.
- An expert conducting a pre-demolition audit.
- Construction professionals (including renovation and demolition contractors) and waste management, waste transport and recycling companies.
- Local, regional, national and EU-level authorities
- Bodies responsible for the quality assurance of buildings and infrastructure

The Finnish guide supports the objective of the EU Waste Framework Directive (2008/98/EC) which aims at the reusing or recycling 70% of construction and demolition waste by 2020. Performing a pre-demolition audit plays an important role in the management of construction and demolition waste.

## **2. Need for a pre-demolition audit**

### **2.1. Identification of hazardous materials and products**

Identification of hazardous materials is needed for safe and correct removal of contaminants and proper waste management. Identification of hazardous materials gives information on the recyclability and reusability of the waste and materials and also helps to secure high quality of reusable and recyclable materials during the demolition. (Wahlström et al. 2019b)

Presence of asbestos in constructions needs special attention in buildings built before 1995. The use of asbestos has since 1994 been banned in almost all European member states. Most countries have common legal requirements for asbestos inventory prior to demolition. Wastes containing asbestos are classified as hazardous waste and waste management need to fulfil the legislative requirements (e.g., licencing for removal of asbestos from construction, packaging, and disposal). (Wahlström et al. 2019c)

Other hazardous substances have requirements related to waste management or hazardous substances can limit the recyclability of construction materials. Wastes containing hazardous substances are classified as hazardous primarily based on the European list of waste or the

waste status must be assessed based on hazardous properties (content of the hazardous substance compared to hazardous waste classification and substance-specific limit values). EU regulations set special requirements for waste defined as hazardous waste (e.g., shipment, landfilling, and treatment). (Wahlström et al. 2019c)

It is recommended that the presence of all hazardous materials listed in Annex 1 that are found at the site to be demolished or renovated be assessed in the identification of hazardous materials report.

## **2.2. Inventory of the non-hazardous materials and reusable/recyclable products**

An inventory of the non-hazardous materials and reusable products is voluntary, but it is recommended that it will be performed for all objects to be demolished. While the owner of the property or its holder may carry out an inventory of the non-hazardous materials and reusable products, it is recommended that an external expert be used. If the individual performing the hazardous materials survey also has sufficient competence to carry out an inventory of the non-hazardous materials and reusable products, it is recommended that he be used to carry out such a survey (Wahlström et al. 2019a).

## **2.3. Timeliness of a pre-demolition audit**

If the building is not demolished immediately after the pre-demolition audit has been carried out, the audit should be updated as necessary if significant changes are made to the structures or use of the building.

# **3. Steps of a pre-demolition audit**

A pre-demolition audit consists of an identification of hazardous materials and products and an inventory of the non-hazardous materials and reusable products.

Pre-demolition audit	
<p><b>Identification of hazardous materials and products</b></p> <p>Hazardous substances: what, where, concentration</p> <p>Recommendations for the methods of demolition</p> <p>Recommendations for treatment of hazardous waste</p>	<p><b>Inventory of non-hazardous materials and reusable products</b></p> <p>Estimated amount of non-hazardous materials</p> <p>Estimation of the products potential for reuse, recycling, or recovery</p> <p>Recommendations for demolition and treatment</p>

Figure 2 - The content of the pre-demolition audit (Source: Wahlström et al. 2019a).

An identification of hazardous materials and products aims to: (Wahlström et al. 2019a)

- identify and locate building materials containing harmful substances.
- make recommendations before demolition on removal methods for construction materials containing contaminants.
- make recommendations on the treatment of waste containing hazardous substances.
- prepare an estimate of the volume of hazardous waste to be generated during demolition.

An inventory of the non-hazardous materials and reusable products aims to: (Wahlström et al. 2019a)

- recognise reusable and recyclable materials and building elements and to give recommendations for how to handle them.
- produce a comprehensive list of non-hazardous waste and their quantities in order to promote separate collection and material recovery.
- provide information required by the owner of the building or authorities, such as estimates of the value of the materials and building elements, their technical condition, environmental benefits to be obtained through the reuse or recycling of materials, or any additional study or research needs.



A pre-demolition audit consists of the following steps (Figure 3): (Wahlström et al. 2019a)

- a documentation study (gaining familiarity of the documents on the object of demolition) (chapter 5).
- a field study (chapter 6).
- an assessment of the quantity and quality of the non-hazardous materials and reusable/recyclable products.
- a preparation of recommendations for the handling of the non-hazardous materials and reusable/recyclable products.

It is also recommended, that a pre-demolition audit include an investigation of opportunities for use of the reused/recycled materials in new structures/buildings.

A written report must be produced on the pre-demolition audit (see chapter 7 Reporting and recommendations). If necessary, an identification of hazardous materials may be reported as a separate report.

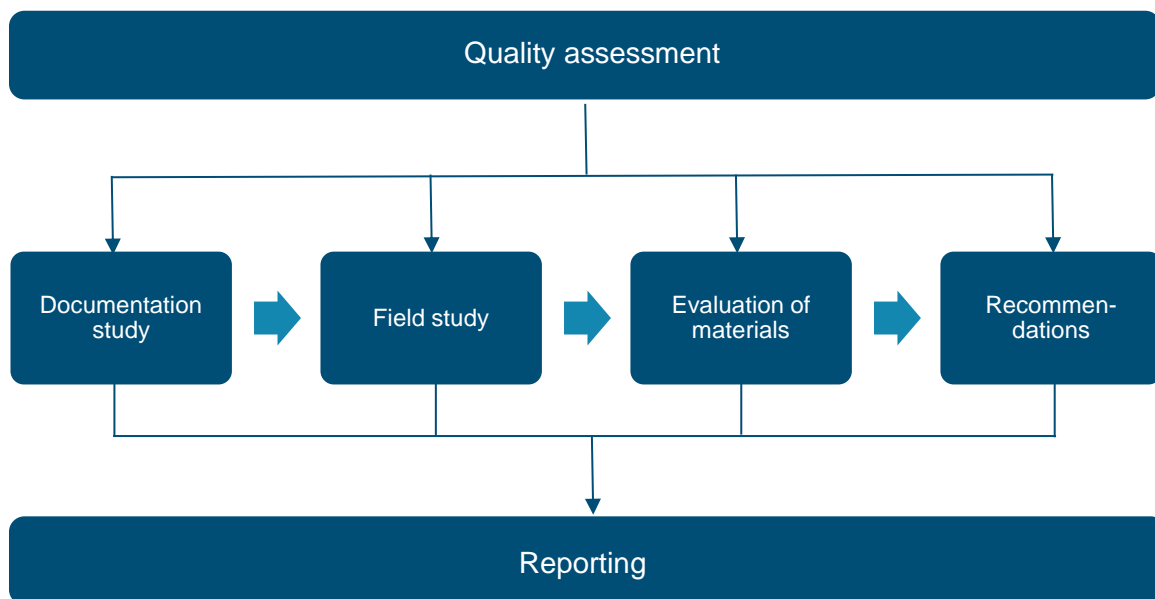


Figure 3 - Steps of the pre-demolition audit process (Source: Wahlström et al. 2019a)

## 4. Documentation study

### 4.1. Objective of the documentation study

It is a good to thoroughly review the documents and construction documents on the site to be demolished before visiting the site or during the visit. It is recommended to examine at least the technical drawings and material lists included in the design documents of the building or in more recent building documents. (Wahlström et al. 2019a)

The purpose of the documentation study is to: (Wahlström et al. 2019a)

- produce the first estimate of the materials, their quantities and potentially harmful substances contained in them.
- determine the age of the building or a structure and the type of construction, and to find out the types of joints between the materials and structures.
- find out about the construction methods and materials typical of the time the building to be demolished was constructed and about its location.
- describe the environment of the site and access to it.
- plan the scope of the field study.

It is also recommended, that a documentation study include an investigation of opportunities for use the reused/recycled materials in new structures/buildings.

### 4.2. Source documentation

Typical source documentation used in the survey include drawings and reports obtained from the construction authorities or the owner of the building or structure. It is also recommended that the involved parties familiarise themselves with the repair plans of the property and their implementation if they are easily available. All sources used in the survey are to be appropriately listed in the reporting on the pre-demolition audit. (Wahlström et al. 2019a)

#### **Design and repair documents**

The most important documents concerning the object to be demolished or renovated are: (Wahlström et al. 2019a)

- architectural plans and technical drawings.
- documents of completed construction or repair work.

The documents listed above contain information that is useful in the planning of a field study and the preparation of a pre-demolition audit. They provide information on the time of construction, the dimensions of the building, the building type, its composition, main construction materials, the location of machinery and equipment, and facilities that are hidden or difficult to access. (Wahlström et al. 2019a)

### **Documents related to the use and maintenance of the building**

Familiarisation with the documents related to the use and maintenance of the property that is subject of the pre-demolition audit will enable the involved parties to collect information at the site on the possible storage and use of hazardous products, which may have contaminated other materials. Information related to the condition and maintenance of the building can be collected from the building's operating and maintenance instructions, condition assessment, condition inspection or the condition inspections of building elements. (Wahlström et al. 2019a)

It is a good to review the available documents on the use of the building to be demolished or its parts in order to detect any changes in the original floor plan, materials or coatings. (Wahlström et al. 2019a)

### **Other documentation**

It is also recommended to consult the available instructions and literature provided by national/local construction organisations in order to identify the potential presence of harmful substances at the site as well as any commonly used building materials, construction systems and joining methods typical of the age, type and location of the building.

Available registers of waste management services and reusable building elements and brokering services for recycled materials can be used to identify waste treatment options and potential resellers of recovered construction materials. In the future, the CE marking of building materials may possibly provide information on harmful substances contained in them. Additional information on the recyclability of materials, their reusability and environmental footprint can be collected from building environmental certificates (e.g., DGNB, LEED and BREEAM), for example. (Wahlström et al. 2019a)

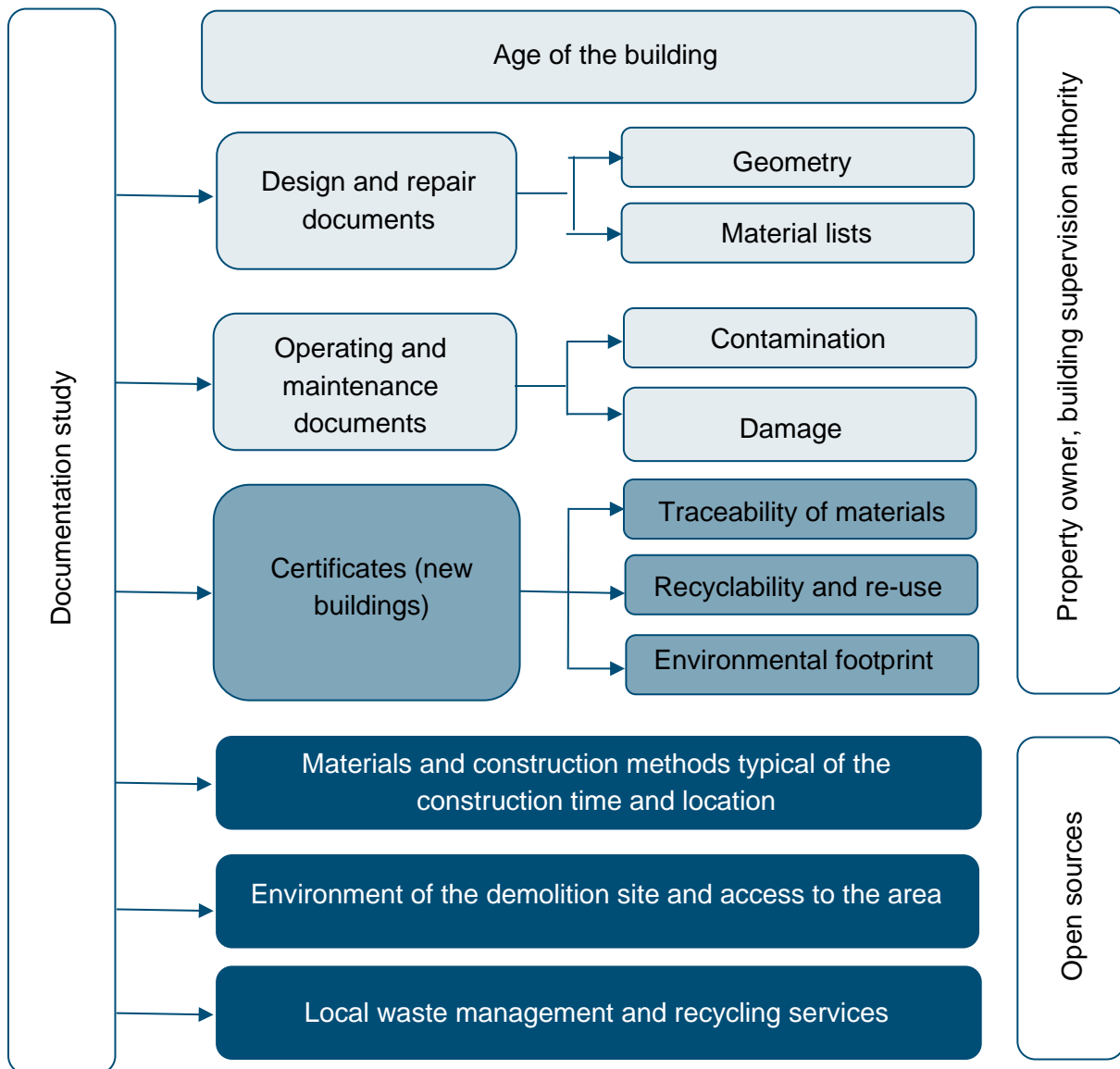


Figure 4 - The content of the documentation study (Source: Wahlström et al. 2019a)

## 5. Field study

### 5.1. Objective of the field study

A field study is a prerequisite for a pre-demolition audit. A field study should be carried out in order to assess the condition of the materials and to make recommendations for their handling. A field study aims to: (Wahlström et al. 2019a)

- assess the conformity of design documents and other source documentation with the actual situation,
- analyse potentially hazardous substances and to collect material samples for laboratory testing,
- anticipate risks and observe exposure of materials and building elements to hazardous substances,
- determine the current technical validity of the building and building materials and collect material samples for the assessment of technical validity,
- identify and mark reusable parts.

It is also recommended, that a documentation study include an investigation of opportunities for use the reused/recycled materials in new structures/buildings.

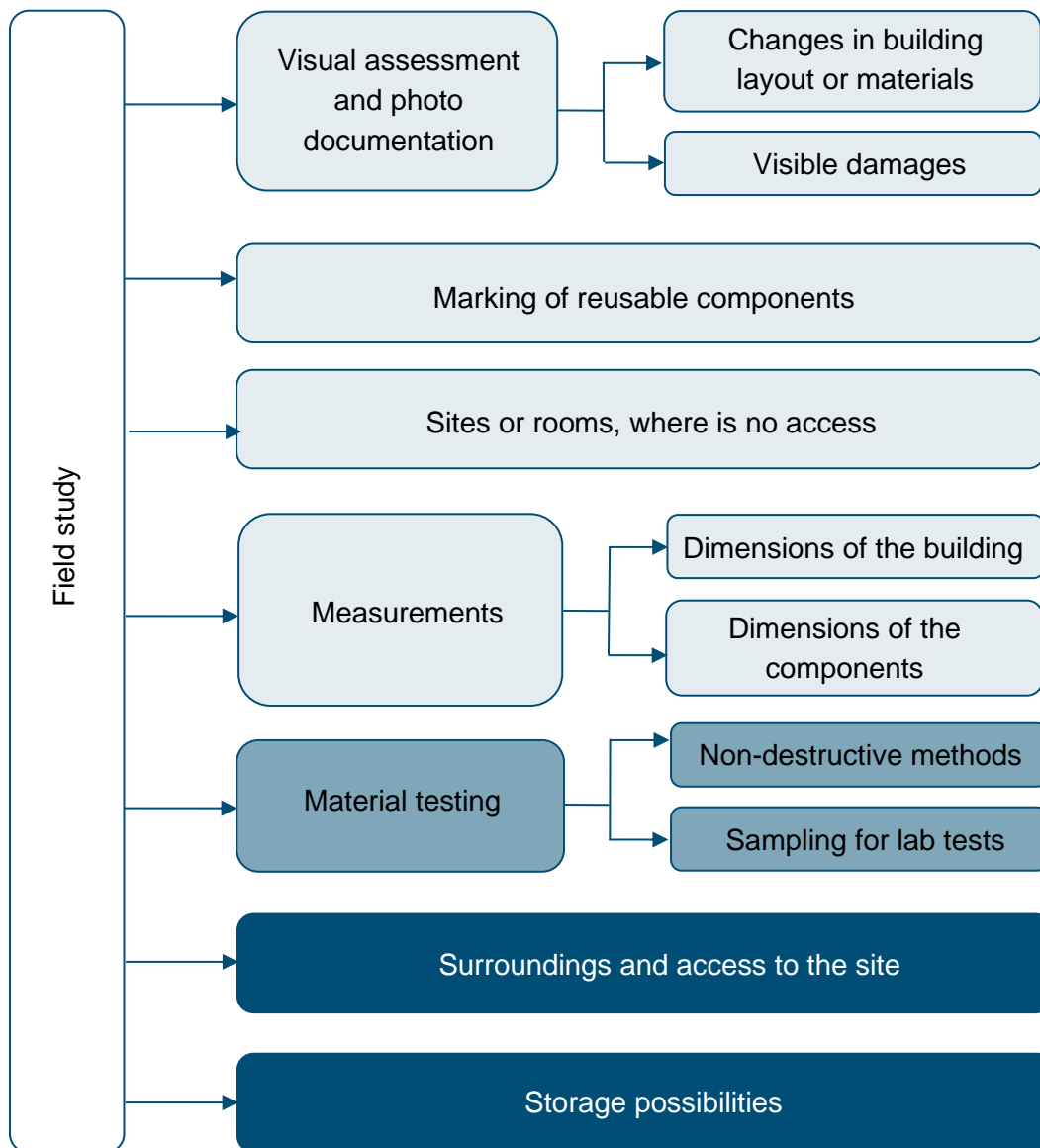


Figure 5 - The content of the field study (Source: Wahlström et al. 2019a)

## 5.2. Steps of a field study

In a field study, the building or structure is assessed and inventoried visually. If necessary, samples are taken for analysis. A field study should be conducted in a systematic way, and the recommended approach is to carry it out in four stages: (Wahlström et al. 2019a)

- general on-site analysis of the building,
- a general assessment of the type and location of materials to be demolished in order to prepare for the next stage with suitable equipment,

- a detailed study, measurements and on-site inventory of materials,
- sampling and the analysis of samples to determine the quality of the materials, possible contamination and deterioration.

A pre-demolition audit report includes a description of the field study detailing the sampling and measurement methods, the sampling points and the results of the analyses.

### **Visual evaluation and photography**

The visual assessment of the building to be demolished identifies the different structures and technical systems and materials of which they consist. Special attention should be paid to materials that may look very similar, for example, in complex layers where another material may be covered by another layer. It is recommended that charts be drawn, notes be taken, and photographs be taken of elements of the object to be demolished and include them in the report. (Wahlström et al. 2019a)

It must be ensured that all materials that can be examined are identified. With regard to cladded surfaces, it is important to remove a small portion of the coating to ensure that the materials beneath the coating are as expected. (Wahlström et al. 2019a)

It is recommended to use systematic mapping of the locations, e.g., starting from the top of the building or from one end to another end of the building. Same system can be utilized in numbering of samples.

- Roof material (brick, tiles, plates etc.)
- Roof bearing construction (timber, steel profiles etc.)
- Roof insulation (mineral wool, glass wool, paper wool)
- Walls (brick, concrete, etc.)

### **Marking of reusable components**

Structural elements intended for demolition and reuse, such as reusable doors or windows, must be visibly marked and their location must be indicated in the construction plan or construction design plan (such as in paper or electronic drawings or in the BIM system). Such markings should be unique (e.g., a number, a bar code or an RFID identifier) so that the original location of each structural element will be known after demolition. (Wahlström et al. 2019a)

### **Measurements at the demolition site**

If necessary, the external and internal interior dimensions of the object to be demolished must be checked. Internal cavities, water leaks and the composition of composite materials must be identified, if necessary, by using suitable, non-destructive methods. (Wahlström et al. 2019a)

### **Assessment of materials**

If the information on demolition materials recommended in Annex 1 and 2, such as the concentrations of hazardous substances or material technical characteristics, is not assessed in on-site inspections, they must be obtained through appropriate methods. (Wahlström et al. 2019a)

### **Identification of hazardous materials**

The auditor must have sufficient knowledge and experience to identify all hazardous materials and to fulfil all the legal requirements for the waste management. This is based on expert knowledge and experience regarding what type of hazardous substances can be expected in buildings/construction of a certain age, use, with certain types of materials, etc. Several guidance documents with information on period for use of certain materials have been published in different countries. (Wahlström et al. 2019c) The use of hazardous substances in building materials and the periods when certain materials have been used, varies between countries and it is important to use only local information.

The field survey can be done in a destructive or non-destructive manner. A destructive audit can consist in opening of false ceilings and walls, opening of technical shafts, making a hole in wall and floor coverings or (partial) disassembly of technical installations (e.g., ventilation ducts). (Wahlström et al. 2019c)

Photos are taken from every hazardous waste material present in the building and from each location where these materials exist. Locations of hazardous materials are marked to the drawings.

Samples for laboratory analysis can be taken by surface sampling for identification of hazardous substance in coating or by drilling in order to get information of hidden materials under surface. Annex 3 gives information about standardized test methods for testing. National or regional legislation must be checked for requirements concerning laboratory analyses and methods. (Wahlström et al. 2019c) The measured or estimated concentrations of hazardous substances are compared to national threshold limits for non-polluted materials or limits for hazardous waste classification. (Wahlström et al. 2019b) Also quality and analysis requirements for e.g., utilizing concrete waste as aggregate in new concrete structures has to be taken into account when planning material recycling.

For some substances, harmful substances can be measured on site, for example, using a portable XRF device. The reliability of field measurements must be checked by using a



sufficient number of laboratory samples. (Wahlström et al. 2019a) More information about portable analysers is listed in Annex 3.

A risk evaluation must be performed for every asbestos containing waste material present in the building: the nature and type of the material (bound asbestos or not), the state of the material (damages, weathering), location of the material, the impact of removing the asbestos containing material, etc. (Wahlström et al. 2019c)

Safety and health measures are important in the field study. If materials containing hazardous substances are suspected to be present in the building to be demolished, the field study should follow appropriate practices and protective measures (e.g., asbestos demolition work).

### **Other studies**

The surrounding area must be examined from the viewpoint of the following aspects: (Wahlström et al. 2019a)

- nearby areas that may be affected by the demolition work (in particular, noise and dust)
- access to the site by vehicles
- any temporary storage areas for materials, building elements and movable property recovered on the property to be demolished.

## **6. Reporting and recommendations**

### **6.1. Content of the pre-demolition audit report**

The author of the pre-demolition audit report is to draw up and sign the final report of the pre-demolition audit. The final report may contain sections prepared by different experts. For example, if different consultants carry out the Identification of hazardous materials and the inventory of the non-hazardous materials and reusable products, the studies can be reported separately. (Wahlström et al. 2019a)

The recommended content of the pre-demolition audit report is: (Wahlström et al. 2019a)

- basic information about the project
- summary of the documentation study

- summary of the field study (e.g., description of the research methods, sampling points and information on the representativeness of measurements and sampling)
- factors of uncertainty (e.g., premises with no access, etc.) that may be relevant to the reliability of quantity and quality data.
- recommendations for further examination during demolition work
- Inventory of materials (see Annex 1 and 2)
  - notification of hazardous waste
  - notification of reusable building elements
  - notification of non-hazardous waste (including recyclable materials)
  - recommendations for the handling of materials (including recycling)

Pre-demolition audit report can also include information about opportunities for reuse components and materials.

Finnish Ministry of Environment has published a separate pre-demolition audit reporting form (an Excel file), where the quantity information on the pre-demolition audit is to be collected and which is part of the pre-demolition audit report:

[https://www.ymparisto.fi/fi-FI/Rakentaminen/Uudet\\_oppaat\\_rakennusten\\_kestavaan\\_purka\(52764\)](https://www.ymparisto.fi/fi-FI/Rakentaminen/Uudet_oppaat_rakennusten_kestavaan_purka(52764))

## 6.2. Material inventory

The inventory of materials and building elements is a result of conducting a pre-demolition audit. An inventory is typically based on a documentation study and a field study. It is recommended that the presence of all hazardous substances listed in Annex 1 in the structures and building materials to be demolished be assessed in the identification of hazardous materials report. It is recommended that at least the non-hazardous waste listed in Annex 4 be reported in the pre-demolition audit report. (Wahlström et al. 2019a)

A pre-demolition audit report should include at least the following information: (Wahlström et al. 2019a)

- material type and hazardousness as classified according to the European List of Wastes
- volume of materials expressed in tons, cubic meters or other relevant units of measurement.

The holder of waste, its processor, its consignee, its end-user or the construction authority may require additional information such as: (Wahlström et al. 2019a)

- List of building elements/materials to be demolished and recommended for reuse, recycling and recovery. Materials from these elements/materials should not be excluded from the demolition materials list.
- Location of waste materials and building elements at the site in order to ensure that demolition work can be carried out as efficiently and safely as possible.
- Recommendations for waste treatment.
- Information on the quality and value of the demolished materials and building elements and on the environmental benefits obtainable from their reuse or recycling.

Annexes 1 and 2 contain a recommendation for information to be provided on demolition materials.

## 6.3. Recommendations for material treatment

Decisions on the treatment of demolished materials must be taken as shown in Figure 6.

The pre-demolition audit report can be supplemented with recommendations for how waste management should be arranged at the demolition site. Issues to consider may include: (Wahlström et al. 2019a)

- recommendations for the safe removal of hazardous waste
- recommendations for demolition methods that further the recycling of building materials and occupational safety and health.
- identification of potential treatment options for different waste streams (reuse, recycling, energy recovery, backfilling/earth construction and disposal) and an estimate of the proportion of each treatment option. Different alternatives can be proposed for each material group or waste stream.
- proposals for sorting operations to be carried out at the demolition site.

Opportunities related to recycling of typical CDW materials according to the EU waste hierarchy are given in Table 1. More guidance for selective demolition and reuse/recycling/recovery of materials is given in the separate CityLoops Draft Selective Demolition Guide.

Additional recommendations may be made for waste treatment outside the demolition site, e.g., the most environmentally friendly methods of recovery or the location of potential waste treatment plants.

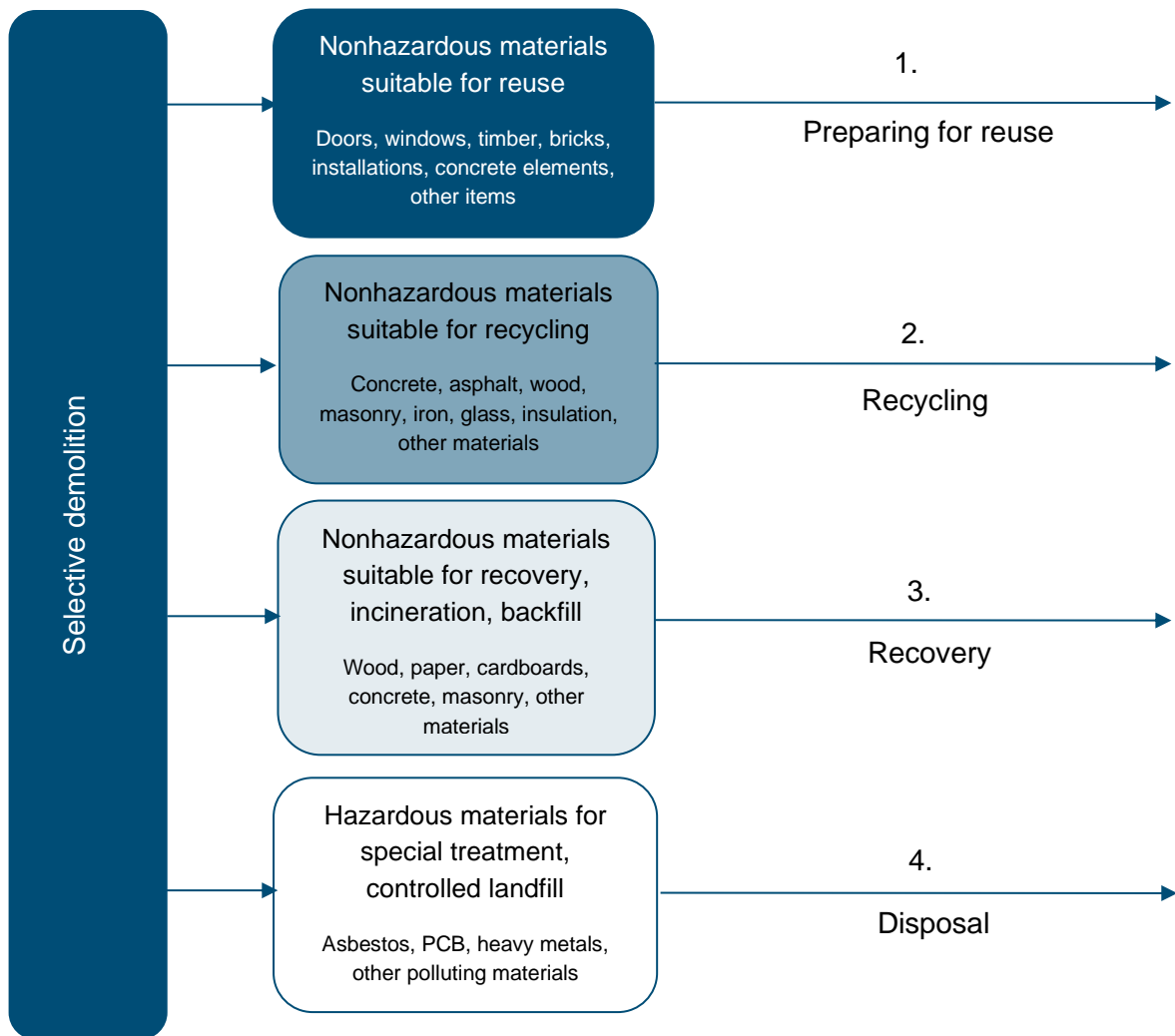


Figure 7 - Decision-making on materials and waste management

Table 1 - Typical CDW materials and related opportunities for recycling according to the EU waste hierarchy. The list includes requirements of demolition and handling on-site (CityLoops Selective Demolition Guide 2021).

CDW FRACTION	1. PREP. FOR REUSE	2. RECYCLING	3. RECOVERY	4. DISPOSAL	COMMENTS
Concrete	Concrete elements and structures. Careful dismantling.	Crushed concrete, for aggregate in new concrete or unbound road materials.	Crushed concrete for backfill. Fines 0-4 mm from crushing.	Fines 0-4 mm from crushing.	Crushed concrete must be pre-crushed on-site, max. size typical 400 mm.
Masonry	Reuse of bricks and roof tiles.  Careful dismantling and handling.	Crushed masonry for road materials.	Crushed masonry for backfill.	Plaster and mortar from masonry.	
Wood	Reuse of timber.  Reuse of doors and window frames.	Shredding for chip boards etc.	Shredding for landscaping.  Incineration.		
Metal	Reuse of construction steel.	Scrap iron and metals. Melting at steelwork.			Traditional handling of scrap materials.
Glass	Reuse of windows and plane glasses.	Melting for new glass or insulation materials.		Poor, dirty glass.	Recycling and recovery of glass need careful cleaning.
Gypsum	Reuse of cardboards.	Recycling of gypsum.	Recovery for other purposes.	All kinds of gypsum.	

## 7. Finnish experiences on performing a pre-demolition audit

In Finland, new guidelines of Ministry of the Environment for pre-demolition audit (Wahlström et al. 2019a) were published in November 2019. After a year, a pre-demolition audit has been

carried out in accordance with the new guide for an estimated 8-12 cases so there is still relatively little experience on performing pre-demolition audit according to the new guidance.

### **Experiences of Ramboll Finland Ltd**

Ramboll Finland Ltd. participated in piloting Finnish pre-demolition audit guide and excel form for reporting. Development Manager of Sustainable Development, Laura Majoinen and project manager Ville Mäntylä from Ramboll Finland Ltd were interviewed for their experiences on pre-demolition audit in November 2020. Laura Majoinen also had presentation on the same topic in webinar organized by Miksei, Mikkeli, Xamk and Esedu in 9.12.2020. Laura Majoinen has been involved in four pre-demolition audit projects.

The purpose and content of the pre-demolition audit is still variable in Finland. Pre-demolition audit can include only identification of hazardous materials, inventory of demolition waste or it can include inventory of reusable products depending on the case. Pre-demolition audit typically always consider the demolition materials of load-bearing structures and complementary structures such as partitions, doors and windows. However, practices and the content of reports still vary, for example, depending on whether machinery and equipment are included in the demolition survey. There are also varying practices in how surface materials, floor coverings, lower roof materials, HVAC parts and furniture are counted as part of the demolition material quantities. (Majoinen 2020) Assessing waste and material amounts has seen relatively simple to do and Ramboll Finland Ltd. has developed own model for this purpose. However, the estimation of the volumes of e.g., furniture and building technology devices is time consuming and therefore their volumes are not typically included to the report. (Majoinen & Mäntylä 2020)

The criteria and channels for reuse are not yet well established in Finland. There is variation in practices, how to assess the re-use potential and condition of materials as well as pathways through which these materials or components could be utilized. At the moment the demand for demolition materials and components in Finland is low. Materials/component listed as reusable has been e.g., doors, windows, equipment and devices. For now, e.g., wall elements have not been listed as reusable products in projects performed by Ramboll Finland Ltd. because the interior part of the “sandwich” elements is typically not seen reusable due to microbial damages but there have been discussions on how different materials could be used more efficiently in the future. Ramboll Finland Ltd. also participate in the project, where health, safety and validity aspects are further developed. (Majoinen & Mäntylä 2020)

Planning of reuse is key factor for increasing reuse of materials. It is good to plan reuse arrangements before ordering a pre-demolition audit from a consultant. For instance, could the materials be marketed in a digital marketplace? Is there some new building or renovation site where materials could be utilized? Or is there any other reuse idea? A workshop on planning reuse of materials has been tested at two ongoing pre-demolition audit cases of Ramboll Finland Ltd. In these cases, reusable materials and equipment were first screened at very generous level and numbers were only roughly estimated. The information will be used in

workshop, where the customer's various organizations and other stakeholders draw up a more detailed reuse plan. After this, the list of reusable materials will be refined, and more accurate measurements will be made. (Majoinen 2020)

Pre-demolition audit should be strongly integrated into other demolition planning. It is advisable to carry out a pre-demolition audit in connection with the descriptions and documents required to apply for a demolition permit. Expertise of a demolition designer and surveyor performing identification of asbestos and other hazardous materials should be used also in identification in reusable/recyclable materials (if different experts are used). It is important that the pre-demolition audit is carried out sufficiently (for example, a year) before the actual demolition work, so that there is enough time to include the results of the demolition survey to the follow-up documents (e.g., procurement). (Majoinen 2020)

In conclusion, pre-demolition audit (identification of reusable/recyclable materials) and material reuse are still new procedures in Finland. Different approaches need to be tested to find out the best practices to ensure that the purpose, content and criteria of the pre-demolition audit are similar from one project to another and that the reuse and recycling of materials can be increased. (Majoinen 2020)

### **Experiences of ReUse project**

South-Eastern Finland University of Applied Sciences (Xamk) tested the pre-demolition audit process in ReUse-project in three buildings (student residential building, apartment house and school). Lecturer Katja Ahola was interviewed for the experiences in January 2021.

In the first survey, the collection of weight and density data for quantitative calculation of material masses required a lot of work. However, in later projects the calculation of material quantities was easier. On the other hand, the work was slowed down by insufficient source material of buildings. The uncertainty of the audit increases the more variables have to be assessed. (Tykkä et al. 2020)

The reuse of concrete wall elements was recommended e.g., in noise barriers. Otherwise, the sites contained relatively little reusable material (in tonnes): doors, windows, furniture, sanitary furniture, staircase and railings, yard tiles, door and window fittings. (Tykkä & Ahola 2020) Reuse of brick wall pieces was also tested in the project.

Also in ReUse project, low demand of demolition materials was seen as challenge for materials reuse. There are many doubts and uncertainties related to e.g., impurity and condition of materials. In addition, the property owner or constructor may not have resources or time to remove or market reusable demolition materials. Reuse of materials is still new aspect in Finland and changing current practices requires time and work. (Ahola 2021, Tykkä et al. 2020) However, many projects are ongoing in Finland to increase and develop reuse and recycling of demolition materials.

# 8. Terms and definitions

## 8.1. Basic terms

### The CityLoops value chain

To structure the tools and the demonstration projects of the CityLoops project, a value chain has been developed for common approach and concerted actions aiming on circular economy (CE) in the construction sector.

The elements of the value chain are presented in Figure 1 showing:

- Old building after end-of-life demolished producing construction and demolition waste (CDW).
- Transformation of materials from waste subjected under the waste legislation to resources or secondary materials.
- New building built with secondary materials, substituting natural materials.

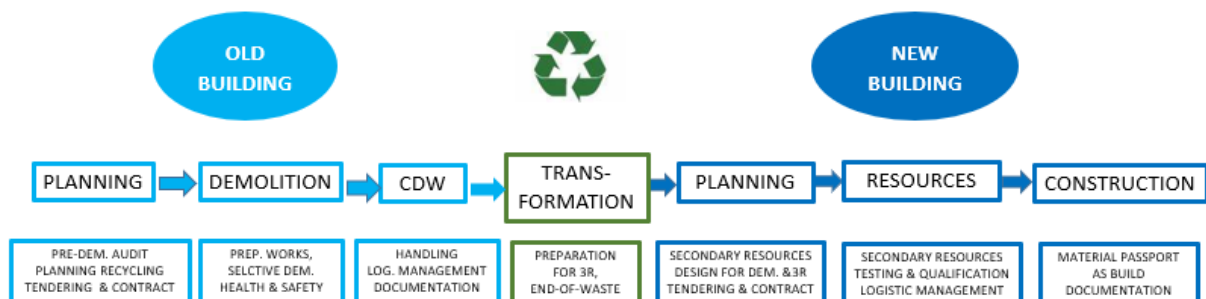


Figure 1 - The value chain of CityLoops. The guide for pre-demolition audit is a planning tool for selective demolition, handling of CDW and transformation of the waste materials to resources.

Traditional demolition and recycling are focused on the demolition process and handling of the CDW materials for the lowest price without specific consideration the use of recycled materials. CDW management with respect to CE must consider the optimal opportunities for recycling with respect to economy as well as environmental protection and sustainability.

The value chain starts with planning of demolition:

- Pre-demolition audit including monitoring and assessment of hazardous waste and opportunities for recycling.



- Planning recycling of the CDW materials including assessment of the potential market.

**The quality management of the demolition process** is a process initiated and organised by the owner of the building or structure that covers all the phases related to the demolition project, starting with the planning of the project and ending with the preparation of documentation and the reporting on the demolition work (Wahlström et al. 2019a). The quality management also include utilization of the transformed CDW to resources in new constructions according with the value chain (Figure 1).

**A pre-demolition audit**, which covers both an **identification of hazardous materials and products**, as well as an **inventory of the non-hazardous materials and reusable/recyclable products**, is an important part of the demolition process including quality management. The aim of a pre-demolition audit is to carry out and document a quantitative and qualitative assessment of material flows before demolition or repair of a building or structure is performed. In addition to taking an inventory of hazardous and non-hazardous waste and reusable materials and building elements, a pre-demolition audit may include recommendations for handling such materials and elements, for example. (Wahlström et al. 2019a)

**Identification of hazardous materials and products** is part of the pre-demolition audit. Identification of hazardous materials and products identify and locate building materials containing harmful substances and provide recommendations for the demolition and handling of such materials. (Wahlström et al. 2019a)

**An inventory of the non-hazardous materials and reusable/recyclable products** is part of the pre-demolition audit. An inventory of the non-hazardous materials and reusable products evaluates the amount of non-hazardous waste generated during demolition work, identifies reusable and recyclable materials and building elements, and makes recommendations for how to treat them. (Wahlström et al. 2019a)

**A transfer document** is a document or a set of documents (according to the regulations of the member states) that the waste holder must produce for construction and demolition waste when the waste is handed over to the waste transporter. The waste holder must ensure that the transfer document(s) will accompany the waste throughout the transport process and will be given to the consignee of the waste. (Wahlström et al. 2019a)

**Selective demolition** means removal of materials from a demolition site in a pre-defined sequence to maximize recovery and recycling performance. (European Commission 2018)

**The waste hierarchy** generally lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g., energy recovery; and (e) disposal. (Waste Framework Directive 2008/98/EC)

*Re-use* means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived.

*Recovery* means any operation the principal result of which is waste serving a useful purpose by replacing other materials, which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II sets out a non-exhaustive list of recovery operations.

*Recycling* means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.

**A notification of construction and demolition waste** is a written or electronic notification of the quality and quantity of waste. A notification of building and demolition waste is to be attached to an application for a permit for or a notification on the construction and demolition of a building or its part. The information contained in the pre-demolition audit report can be used in the preparation of a notification on construction and demolition waste required in connection with the building and demolition permits. The contractor is responsible for the planning of waste management at the site (waste sorting and the storage of sorted waste in accordance with the national/local waste legislation. (Wahlström et al. 2019a)

## 8.2. Actors

**The property owner or property holder** is usually the developer/buyer of the demolition or renovation project. The owner or holder of a property embarking on a construction project initiates a pre-demolition audit process. The owner or holder of the property is responsible for the accuracy of the information on the quality and quantity of materials and hazardous substances. In the performance of the demolition contract, the responsibility for organising waste management should be agreed upon, i.e., who is the owner of the waste under the contract. The ownership of reusable elements should also be agreed upon. (Wahlström et al. 2019a)

**The client/buyer** is a person or organisation that starts a construction project or another party that guides and supervises the construction project. The client may obtain from consultants and designers the design and expert services required for the application for a demolition permit. (Wahlström et al. 2019a)

**The contractor (demolition contractor)** carries out the demolition work. The contractor normally prepares a tender in accordance with the Invitation to tender on the basis of the plans and reports drawn up of the demolition site. In the early stages of the demolition project, the contractor is responsible for drawing up a detailed demolition plan, having it approved by the client and, upon request, also presenting it to the authorities that grant the construction permit.

The contractor is responsible for the planning of waste management at the site (waste sorting and the storage of sorted waste according to legislation). (Wahlström et al. 2019a)

An **expert** conducts a pre-demolition audit on behalf of the property owner. Where qualification requirements allow, the same consultant may perform the identification of hazardous materials and products, which is to be included in the pre-demolition audit report and the inventory of the non-hazardous materials and reusable/recyclable products. (Wahlström et al. 2019a)

**The consultant conducting the identification of hazardous materials and products** must have sufficient competence in performing asbestos and Identification of hazardous materials (e.g., certified specialist). Conducting an identification of hazardous materials surveys and studies requires special expertise, training or at least extensive experience in and in-depth familiarity with the relevant instructions and regulations. (Wahlström et al. 2019a)

**The consultant conducting the inventory of the non-hazardous materials and reusable /recyclable products** must have a sufficient competence on demolition work and surveys corresponding to the object of the procurement, as well as on the promotion of circular economy in demolition work and knowledge of waste legislation. The owner of the property may also carry out the inventory of the non-hazardous materials and reusable products himself, but it is recommended that an external expert be used. (Wahlström et al. 2019a)

**The waste manager** provides waste collection, transport, treatment and brokering services. (Wahlström et al. 2019a)

**The owner or/and building control authority** receives a report on the quality and quantity of construction and demolition waste generated, grants the construction and demolition permit and supervises construction projects in its capacity as an authority. (Wahlström et al. 2019a)

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# Annex 1: Identification of hazardous materials

It is recommended that all hazardous substances listed in Table 2 and their possible presence in the structures and building materials, as well as any hazardous substances separately specified by the property owner or its holder, are taken into account in the identification of hazardous materials. It is a good idea to state separately in the report that all the substances listed in Annex A have been taken into account in the identification of hazardous materials, if one has been done. In addition to hazardous substances, it is also advisable to record any microbial-damaged materials in the report if they are detected by visual evaluation. (Wahlström et al. 2019a)

*Table 2 - Hazardous substances and materials to be taken into account in the survey, as well as examples of building materials in which hazardous substances may occur. (Source: Wahlström et al. 2019a)*

HAZARDOUS SUBSTANCE OR MATERIAL	EXAMPLES OF BUILDING MATERIALS THAT MAY CONTAIN HAZARDOUS SUBSTANCES	EXAMPLE OF A WASTE CODE
Asbestos	insulators (fire, heat and sound insulators), pipe insulators facade joint fillers facade coating bituminous-based paints for sheet metal roofs bituminous felt for roofs bituminous binders for roofs waterproofing materials for wet areas asbestos cement sheets (interior cladding boards, ceiling boards) vinyl tile adhesive flexible vinyl mats ceramic tiling mortar rendering mortars skirting boards for floors with acrylic flooring sealants	08 01 17* 17 02 04* 17 03 01* 17 03 03* 17 06 01* 17 06 05* 17 04 09* 17 09 02* 17 09 03*
PCB	paints (vinyl paints, chlorinated rubber paints and cyclized rubber paints, concrete floor paints, balcony deck paints) joint sealants ((joints between prefabricated units) heat-resisting glass and glazing sealants capacitor oil for electrical equipment	08 01 17* 17 06 05* 17 09 02* 17 09 03*

PAH & creosote	tar-based, coal tar-based and bitumen tar-based paints	08 01 17*
	bitumen board and roof insulating board	17 02 04*
	damp-proof membranes, vapour barrier materials, capillary breaks and insulating material for electrical cables	17 03 01*
	chimneys (soot)	17 03 03*
	creosote-impregnated wood	17 06 01*
		17 06 05*
		17 04 09*
Hydrocarbons, oils	oil leaks e.g., on floors	17 09 03*

Harmful metals	pressure-impregnated wood (arsenic, copper, chromium)	08 01 17*
	electronics	17 02 04*
	lamps (energy-saving bulbs, fluorescent lamps, mercury vapour lamps)	17 06 05*
		17 09 02*
	old paints (lead, cadmium, zinc, etc.)	17 09 03*
Brominated flame retardants	cellular rubber insulator	17 06 03*
	EPS - in the base floors of buildings	17 09 03*
	XPS insulating materials	
	electronics	
	fibreboard insulating materials	
Phthalates	vinyl coatings (DEHP: 13-19 %)	17 02 04*
	vinyl wallcovering	17 09 03*
	cables	17 04 10*
	adhesive	
	varnish	
	roof membranes	
	sealed glazed units	

The following information is recommended to be included in reporting on hazardous substances and materials containing these dangerous substances: (Wahlström et al. 2019a)

- **Material:** A material containing a hazardous substance(s).
- **Amount of material:** An estimate of the amount of waste containing a hazardous substance, based on measurements and calculations.
- **Concentration of a hazardous substance:** Concentration of a hazardous substance in material/waste, if known.
- **Location of material:** A description of the location of waste containing a hazardous substance.
- **Additional information and instructions for demolition:** Recommendation for safe removal of waste containing a hazardous substance.
- **Recommended treatment/disposal:** Recommendation for treatment/disposal of waste containing a hazardous substance.

Finnish Ministry of Environment has published a separate pre-demolition audit reporting form (an Excel file), where the quantity information on the pre-demolition audit is to be collected and which is part of the pre-demolition audit report:

[https://www.ymparisto.fi/fi-FI/Rakentaminen/Uudet\\_oppaat\\_rakennusten\\_kestavaan\\_purka\(52764\)](https://www.ymparisto.fi/fi-FI/Rakentaminen/Uudet_oppaat_rakennusten_kestavaan_purka(52764))

The “Identification of hazardous materials” sheet summarises the results and observations from the Identification of hazardous materials report on materials containing hazardous substances.



# Annex 2: Reusable, recyclable and other demolition materials to be reported in the pre-demolition audit report

## Reusable building blocks and materials

It is recommended to list separately the reusable elements in the inventory of the non-hazardous materials and reusable products report. For reusable parts, it is recommended to provide the following information: (Wahlström et al. 2019a)

- **Building element or material:** Building element or material suitable for reuse, e.g., windows, doors, door planks, bricks, tiles, timber, etc.
- **More detailed description:** A more detailed description of the building element or material, e.g., manufacturer and type.
- **Volume:** Number of elements or other suitable unit of measure (e.g., total area or total length)
- **Dimensions:** Dimensions of the building element or material to be demolished with sufficient accuracy
- **Location:** Description of the location of the material or element(s) in the building
- **Additional information:** E.g., condition of the material, its quality, purpose of reuse, instructions for demolition or the monetary value of the elements/material, if known.

Finnish Ministry of Environment has published a separate pre-demolition audit reporting form (an Excel file), where the quantity information on the pre-demolition audit is to be collected and which is part of the pre-demolition audit report:

[https://www.ymparisto.fi/fi-FI/Rakentaminen/Uudet\\_oppaat\\_rakennusten\\_kestavaan\\_purka\(52764\)](https://www.ymparisto.fi/fi-FI/Rakentaminen/Uudet_oppaat_rakennusten_kestavaan_purka(52764))

The "Building elements" sheet reports building elements and materials which, according to the surveyor, have reuse potential and which, therefore, should be recovered intact and for which a new use should be found. This will reduce the amount of waste generated.

## Recyclable and other demolition materials

The demolition materials report must also indicate materials at the demolition site (non-hazardous demolition waste) that are not expected to have any reuse value. It is recommended that at least the demolition materials listed in Table 3 be reported.

*Table 3 - Other demolition materials to be reported*

DEMOLITION MATERIAL	WASTE CODE	DESCRIPTION
Concrete waste	17 01 01	Concrete (dry and fresh), concrete tiles and elements
Brick waste	17 01 02	Bricks
Tiles and ceramics	17 01 03	Ceramic tiles and other ceramics
Mixed concrete waste	17 01 07	Concrete waste containing bricks and ceramic tiles
Wood waste	17 02 01	Timber, wooden furniture
Glass waste	17 02 02	Glass, glass fibre, glass enamels
Plastic waste	17 02 03	Plastic membranes, plastic sheets, plastic tubes, plastic laminates, plastic furniture, mixed plastic waste
Asphalt waste	17 03 02	
Roofing felt waste	17 03 02	
Metal waste	17 04 07	Miscellaneous metals
	17 04 01	Copper, bronze, brass
	17 04 02	Aluminium
	17 04 03	Lead
	17 04 04	Zinc
	17 04 05	Iron and steel
	17 04 06	Tin
Insulants	17 06 04	Insulation materials such as mineral wool, glass wool, eco wool
Gypsum waste	17 08 02	Gypsum-based construction materials such as plasterboards
Mixed construction waste	17 09 04	Other miscellaneous construction and demolition waste

It is recommended, that the following information be provided on recyclable and other demolition materials:

- **Volume:** Estimated mass, volume or other suitable unit of measurement. If no waste in question is generated, its volume is to be marked as zero.
- **Location:** A description of the location of the material at the site.
- **Recommended treatment method:** A recommendation for how the material should be treated (recycling, recovery as energy, landfilling and disposal).
- **Additional information and instructions for recovery and demolition:** For example:
  - Technical characteristics: Assessment or measurement of the technical suitability and other available information on the technical condition of the material.
  - Value: The monetary value of the material, if known.
  - Environmental footprint of the material: (If known)
    - a) carbon footprint of the material
    - b) energy consumption during material production
    - c) reference to the Environmental Product Declaration (EPD) of the material

Information on the material's environmental footprint can be used in the assessment of the environmental benefits that can be obtained from the material's recycling or reuse.

# CITYLOOPS

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and bio-waste, where seven European cities are piloting solutions to be more circular.

Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), Porto (Portugal) and Seville (Spain) are the seven cities implementing a series of demonstration actions on CDW and soil, and bio-waste, and developing and testing over 30 new tools and processes.

Alongside these, a sector-wide circularity assessment and an urban circularity assessment are to be carried out in each of the cities. The former, to optimise the demonstration activities, whereas the latter to enable cities to effectively integrate circularity into planning and decision making. Another two key aspects of CityLoops are stakeholder engagement and circular procurement.

CityLoops started in October 2019 and will run until September 2023.



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