Steel beam

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 Rotor vzw/asbl 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).

The information contained in this document does not necessarily reflect the position of all the FCRBE project partners nor that of the funding authorities.

Steel beam

Material description

The Crystal Palace, a gigantic 92,000 m^2 glass and iron greenhouse built for the Great Exhibition in London in 1851, is one of the first demonstrations of the possibilities offered by the use of iron for the construction of large buildings. Incidentally, this building is also a prime example of the possibilities of reuse permitted by this method of construction. Originally located in Hyde Park, a contractual clause required its demolition once the exhibition was over. However, public opinion was against this sad fate. After many proposals, it was finally a certain Francis Fuller who bought the Crystal Palace. He had it dismantled carefully and completely reassembled in Sydenham (where it remained until it was destroyed by fire in 1936). The use of resistant parts, of relatively modest dimensions (the widest were cast iron beams 8 m long and weighing less than a ton) and the simplicity of the assemblies were key factors for the success of a such an operation.

Although steel has now replaced cast iron, the same principles of modularity, workability, strength and reversibility make steel structural elements good candidates for reclamation. This sheet deals more specifically with the reclamation of steel beams, as independent elements, generally used in the structural construction of buildings. It therefore does not directly address the reclamation of the following elements:

- cast iron, aluminium, stainless steel beams or in other metal alloys;
- other metal construction elements (i.e. tubes and hollow profiles, welded steel tubes, angles, castellated beams, sheet piles, etc.);
- partial or complete structures based on still assembled steel beams;
- beam fasteners (plates, ball joints, etc.).

Nevertheless, the general principles described in this document are likely to be a guide for the reclamation of some of these elements.

In general, steel beams are used as simple load-bearing vertical (e.g. column) or horizontal elements (e.g. beams, lintels, joists, etc.), or as elements assembled in a metal structure (e.g. frame, structure, etc.). Their inclusion in a construction is generally validated by a stability design office and, in the case of frames and structures, a specialized builder is responsible for the preparation and delivery of the elements. Girders can be distinguished according to several criteria:

→ *Composition*. Today, beams are generally produced in unalloyed structural steel, mainly composed of iron, with a carbon content of less than 2% and which contains a limited content of certain other elements (e.g. manganese, phosphorus, sulphur, silicon , etc.). The composition of the steel largely determines the physical and chemical properties of the beams. As such, steel beams should not be confused with their cast iron counterparts (old and more fragile due to a higher carbon content), aluminium (lighter, extracted from bauxite, possessing different material properties), stainless steel (which is another steel family characterized by a high chromium content) or other metal alloys.

→ *Production method.* Steel beams are finished products (or semi-finished if they still have to be machined) from the steel industry. They are traditionally classified as long and hot rolled products.

→ *Age of the elements*. The use of steel in construction has become widespread since the late 19th century. In general, it is considered that steel produced since 1970 complies with modern product specifications and calculation methods based on Ultimate Limit State (ULS) and Serviceable Limit State (SLS) testing.

→ *Steel grades and qualities*. A numerical classification system for the type of steel the beams are made from allows them to be differentiated based on their mechanical characteristics. In short, structural steels are designated by:

- the letter S ("structural")
- the minimum elastic limit in N/mm^2 (for a thickness of 16 mm)
- a grade referring to their "quality" (according to the specified value of fracture energy at impact bending: JR, J0, J2, K2).

The most common grades of steel used in the manufacture of beams are S235JR / S275JR / S355J2 (where S235JR stands for "structural steel with a yield strength of 235 N/mm^2 and a guaranteed minimum breaking energy of 27 Joules at 20° C"). There are also steels with high yield strength and steels with improved resistance to atmospheric conditions. There are equivalence tables which make it possible to characterize steels graded according to old standards.

The original technical documentation makes it possible to know the steel grade of the reclaimed beams. If this is not available, it is possible to request a physical and chemical analysis by an approved laboratory.

→ *Shapes and profiles*. Structural grade steel beams come in many standardized shapes and sizes. Common models are the profiles IPN, IPE, HEA, HEB, HEM, UPE and UPN (where the first letter refers to the section shape, *see Figures 1 to 3*). Their dimensions are standard and their respective masses and properties are fixed in standard EN 10365. The mechanical properties differ according to the profiles.

CE Marking

CE marking has been compulsory for new structural steels since 2014 and is addressed in standard EN 1090-1. The EN 1090-2 standard stipulates that elements not covered by the mentioned standards (such as reclaimed steel) can be used if their relevant properties are specified and indicated. In the case of reclaimed beams, it is relatively simple to refer to the specifications of European standards for new products in order to demonstrate the fitness for use of the elements. This process can make use of a visual estimate of the condition of the elements, charts showing the performance of new homologous elements, laboratory grade tests and a global strategy of oversizing the structures.

Steel beam

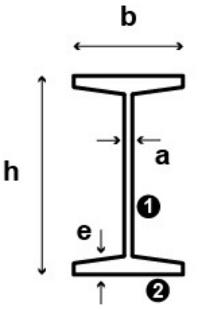


Figure 1. IPN profile (inclined flanges with variable thickness)

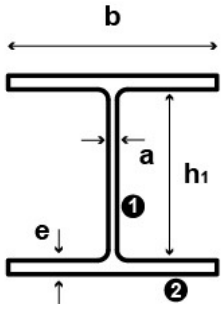


Figure 2. HEA profile (Parallel flanges)

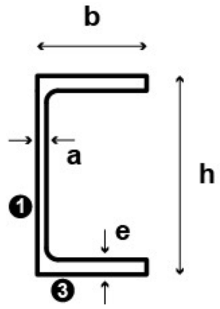


Figure 3. UPE profile

Figures 1 to 3: Common profiles of steel beams

1. "web".
2. "Flanges".
3. "Flanges".

a. Thickness of web
b. Width of flange
e. Thickness of flange
h. Depth of web (including flanges)
h1. Depth of web (excluding flanges)

→ *Surface finish*. Depending on the intended use, the beams may have undergone different treatments:

- *Untreated*: recognisable by their dark colour and rusty rolling scales. Untreated beams are often used for invisible applications.
- *Coated with an anti-corrosion primer*: these beams can be recognised by their reddish-brown surface and are often installed in a non-visible interior application or provided with a subsequent finishing coat (paint).
- *Hot-dip galvanised*: coated with zinc and/or iron/zinc alloys through immersion. The surface alloy thus creates a thicker anti-corrosion layer, with a matt surface, suitable for more demanding exterior applications.
- *Metalled*: having undergone thermal spraying of a metal or an alloy.
- *Coated with fire protection*: in the form of intumescent paint, flocking, etc. (n.b. some flockings are likely to contain **asbestos**, see § "Hazardous substances and precautions").
- *Other organic paints, powder coating*, etc. These processes provide lighter protection and colouring of the elements. Typical of visible interior applications.

Depending on the new intended use, the original finish may need to be cleaned by sandblasting, shot blasting or chemical dipping. These operations are subject to specific normative provisions.

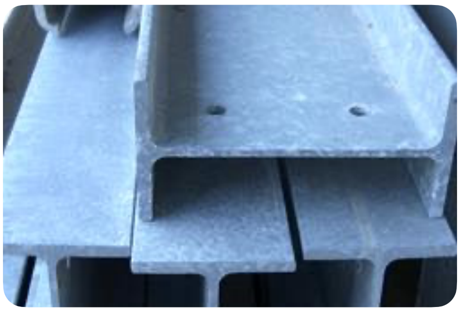
→ *Fixings*. Several fixing methods are to be found:

- Mechanical, by riveting or bolting, by means of accessory parts and junction elements (studs, bolts, rivets, plates, ball joints ...).
- Welds.
- Fixing in masonry.

Depending on the means used during removal, it is common to find certain accessories attached, as well as traces of the previous fixing method (e.g. remains of mortar, welded parts, reinforcements, junction elements, etc.).

Natural, untreated beams

Reclaimed IPE beams, with anti-corrosion protection treatment. © Opalis (Omgekeerd Bouwen)



Galvanised steel beams © lecoindupro

Flocked beams

Painted beams

Steel beam

Material reclamation

Recent steel beams are a standardised product. With good coordination, their careful disassembly for reclamation is usually easy. The beams thus dismantled are suitable for reuse on site or via professional channels of material dealers (who can also ensure the supply of reclaimed beams).

This sheet deals with the case where the beams are dismantled separately and reassembled independently, although it is also possible to recover complete structures or complete structural elements (trusses, etc.).

→ *Preliminary examination*. In practice, it makes it possible to identify and list reusable beams and to ensure the feasibility and profitability of removal with a view to reuse. In the case of isolated elements (such as lintels), an "expert eye" is often able to estimate the interest of a batch based on photos or by an on-site visit. When the objective is to recover a complete or partial metal structure, it is preferable to carry out an in-depth examination of the batch and of the elements taken separately (general and detailed plan, surveys, etc.). In all cases, the points of attention relate, among others, to:

- the general condition of the elements/batch: quantities, dimensions of the elements, nature and condition of the surface coating, presence/absence of holes and reinforcements, visible damage, etc.;
- the installation method (i.e. bolts, rivets, welds, fixing), the condition of the assemblies and the dismantling of the elements;
- the commercial interest linked to careful removal, depending on the model and quantity of beams, and on logistical arrangements, particularly in terms of lead time, working time, implementation of safety measures, handling, transport, etc.

→ *Documentary research and checking the quality of the steel*. Before proceeding with the actual removal, it may be necessary to determine the general characteristics of the building and the beams which constitute it, in order to ensure their suitability for dismantling and reuse. This involves identifying the conditions of use of the material and finding information from the building archives, from the original architects, engineers and/or contractors, or from other local sources. This information may relate to:

- *the building*: date of construction, plans, geographical location, type of use and stresses (e.g. corrosive conditions, seaside), possible disasters (e.g. fires, floods, earthquakes, impacts), etc.
- *the beams*: technical sheet of the elements (e.g. type of profiles, grade and quality of the steel, type of coating), their function (e.g. column, beam, lintel, etc.), stresses (e.g. inside/outside, corrosive atmosphere, nature of the loads), possible repairs, etc.

→ *Removal*. As it relates to the structure and may involve working at height, the careful disassembly of steel beams requires good coordination to ensure worker safety and maintain the integrity of the beams.

→ To guarantee the traceability of the elements, it is strongly recommended to carry out their individual identification by means of a physical marking (preferably on the core, by means of labels or markers resistant to wear, erasure. and to light).

→ The elements assembled by bolting can be dismantled mechanically, or by cutting as close as possible to the connections in order to maximise the length of the recovered elements. A few points to note:

- Bolts can plastically deform under stress. These deformations should be closely observed during dismantling, to limit the risks of breakage and instability.
- Welds can suddenly fail. The removal of joints with critical welds requires the constant assistance of a lifting device to relieve the load on the joints.
- The beams must not fall to the ground.

→ *Cleaning and sorting.* On site or in the workshop, the beams recovered are generally sorted by grade and given a rough cleaning. They are freed from mortar residues and the accessory elements that may interfere with transport and handling are completely or partially removed (reinforcements, connecting elements, etc.). The beams showing some deformation or suspicious traces are eliminated from the batches intended for reclamation.

Restrictions

Different reference documents (see § "Did you know") agree on the fact that elements meeting the following conditions ***should not be reclaimed:***

- *Girders having been subjected to extreme point loads, strong impacts or fires.*
- *Girders subject to fatigue, that is to say a weakness acquired by a metal having undergone excessive stresses which locally modify its internal structure. This phenomenon manifests itself through the appearance of cracks (before breaking). This can be caused by repeated impact or vibration cycles. These conditions of use are quite rare in the building industry, but they can be found, for example, in lift shafts, overhead cranes, road bridges, railway tracks, etc.*
- *Girders coming from extreme applications (e.g. subjected to radioactivity, etc.).*
- *Girders showing a significant loss of their cross section due to corrosion (one of the documents sets the limit at 5% of the thickness of the element). This scenario is mainly encountered on buried beams or those subjected to a high humidity level.*
- *Girders showing visible (or suspected) signs of plastic deformation.*
- *Girders produced before 1970 because their composition probably does not correspond to contemporary steel standards. Their fitness for use can nevertheless be established, subject to carrying out specific analysis and tests.*

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→ *Operations*. While some beams can be reused as is after a rough cleaning, others may require additional operations such as:

- *Cutting*: Girders can easily be cut to a specified length. The processes used (e.g. cutting, shearing, cutting, water jet cutting, flame cutting, etc.) must meet the requirements in terms of dimensional tolerances, maximum hardness and symmetry of the edges.
- *Machining*: the beams can be machined in the workshop to meet the needs of the future project (tapping, welding of additional elements, bending, notching, drilling, etc.). It is not always necessary to remove old welded joints, stiffeners, corner bars, etc. Making new bolt holes and other holes is possible, provided they are made at a sufficient distance (usually 100mm) from existing bolt holes and other holes. All machining operations must meet the specifications applicable to new steel beams (e.g. EN 10034 for I and H beams).
- *Finishing*: the corrosion/fire protection (if present) may have been damaged during removal. Consequently, the performance of the original coating may be compromised and no longer correspond to the required level for the envisaged new use. Refer to the standards in force and carry out additional tests to determine the initial performance of the original coating if necessary (*see § "Characteristics and fitness for use"*).
  - Some original coatings may contain dangerous substances (e.g. lead, asbestos, *see § "Hazardous substances and precautions"*).
  - It is not advisable to rely on original fire protection coatings as they are often sensitive to moisture and strongly related to the original shape, location and application of the element prior to its disassembly.
  - If the application of a new surface coating is envisaged, it is advisable to determine the nature of the original coating, to proceed with its appropriate removal (e.g. sandblasting, shot blasting, chemical dipping) and to respect the installation conditions and preparation of the new coating (the normative specifications to be respected are generally the same as for new steel beams).
  - One-off repairs to the old coating may be necessary due to damage caused by removal and/or by operations linked to the reclamation of the element (e.g. cutting, welding, etc.). Compatibility of repair products should be ensured.

Tip: batch formation!

If tests are required to grade the performance of the steel or the beams, it is advisable, during removal, to group the identical elements into clearly defined batches.

The grouping criteria can be the type of coating, the shape and size of the elements, or their original application (interior/exterior, corrosive environment, load level, etc.).

This technique makes it possible to facilitate the subsequent sampling of the batches as well as the interpretation of the test results.

Recovered beams with welded connections
© Gebruikte bouwmaterialen Weert

Deterioration of the original coating
© Gebruikte bouwmaterialen Weert

Distorted corners
© Gebruikte bouwmaterialen Weert

Installation for cutting beams
© Opalis (Wolter Bouwmaterialen)

Cut beams
© Opalis (Wolter Bouwmaterialen)

Rework of beams
© Opalis (Général Métal Réédition)

→ *Handling and storage*. Due to their heavy weight (the density of steel is 7850 kg/m³), beams are generally handled with suitable lifting gear. For long elements, it is advisable to use several lifting points. It is best to properly protect the lifting points, especially if a maintenance of the coating is envisaged. Steel elements can be stored outdoors, without protection against moisture or frost. However, it is advisable:

- to avoid storing the elements directly on the ground, in order to limit corrosion,
- to avoid creating water accumulation areas on the beams,
- to provide sufficient support points to avoid deformation,
- to store the elements in distinct batches, correctly listed (*see box "Tip: batch formation!"*).

→ *Transport and delivery.* All necessary precautions must be taken during transport and delivery (fixing, loading and unloading material, etc.). Due to the size and weight of the elements, transportation can be quite expensive. Therefore, many professional suppliers of reclaimed beams prefer to avoid transportation and storage costs by selling the beams directly from the dismantling site.

Storage of beams by profile and shape © Opalis (Sarl Perrin)

Storage of reclaimed steel beams, coated with corrosion protection (in red) and uncoated (rust and white paint) © Gebruikte bouwmaterialen Weert

Storage of recovered beams on wooden supports © Opalis (Premys Ferrari)

Inspiration

Several inspiring projects demonstrate that the reuse of metal structures on the scale of entire buildings is a practice that is not only possible but also interesting from an environmental and economic standpoint. The success of these projects is generally based on a combination of factors such as collaborations with specialist suppliers, the mobilization of design offices to analyse the properties of the beams and an innovative approach in demonstrating their fitness for use

→ *https://projectsites.vtt.fi/sites/progress/cases.html*

Bedzed Project (2002), Hackbridge (UK). Reuse of 95 tonnes of steel © Bill Dunster Architects, ZedFactory

https://library.uniteddiversity.coop/Ecological_Building/BedZED-Toolkit-Part-1.pdf

Applications and installation

Reclaimed steel beams are suitable for a wide variety of applications. They can be reused for structural and non-structural purposes, both indoors and outdoors.

More demanding applications may require careful determination and/or checking of material properties (*see § "Characteristics and fitness for use"*). Reclaimed steel beams are generally not suitable for extreme applications, where technical performance is exploited to the maximum, and where the margin of error is extremely small (e.g. structural applications subject to high stress or fatigue, applications requiring high deformability, seismic applications, etc.).

For structural applications, it is advisable to involve stability engineers early enough in the design process to, on the one hand, determine the appropriate beam types based on the preliminary design and, on the other hand, develop the design correctly based on available profiles, including conservative assumptions needed for structural design, oversizing, etc.

The assembly of reclaimed steel beams is done in the same way as for new beams. When welding, the carbon equivalent value (CEV) of the profiles must clearly be taken into account. This value indicates the weldability of the beams. In particular, it is determined by the chemical composition of the steel. If necessary, the carbon equivalent can be determined through destructive and/or non-destructive tests (*see § "Characteristics and fitness for use"*).

Depending on the application, account must be taken of the relevant standards, good practice and applicable execution standards (e.g. EN 1090-2: "Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures").

Some suppliers of reclaimed materials are able to provide information on the origin of the beams, their dimensions and the type of profile, but more rarely on their technical characteristics. The lack of information or certification of the material must then be compensated by conservative assumptions on the technical characteristics of the steel (e.g. compensation measures, safety factor, oversizing, etc.) and/or through additional tests.

Depending on the intended use, the designer/specifier may need to specify his expectations regarding the following characteristics:

→ *Types and dimensions*. In order to increase the chances of finding suitable elements from professional suppliers, it is advisable to specify as wide a range as possible of beam types and profiles that can be used in the design. Often, it is sufficient to specify a minimum length rather than an exact length, as the profiles can easily be cut to the desired length afterwards.

→ *Condition*. Salvaged steel does not often look the same as new steel. There may be bolt holes or other holes in the elements, as well as welded fittings, stiffeners, corner bars, etc. These marks are usually not a problem per se and can be left as is. If necessary, a limit can be placed on the size and/or location of the existing (bolt) holes. Girders with bolt holes and other holes, or traces of surface rust, are generally suitable for reuse, but may have limitations with respect to the addition of new holes and their section characteristics.

→ *Finishing*. As discussed in the "*Material Reclamation*" section, it is not advisable to rely on the original coatings and it is often preferable to apply a new coating, in accordance with the requirements of the new use.

→ *Quantity*. To increase the likelihood of meeting the available supply in the reclamation market, the designer/specifier may choose to split the batch into smaller batches, or appoint a third party company to collect the elements. It is advisable to leave the possibility of supplementing the batch of reclaimed beams with new elements at key points of the construction and/or to supplement the quantities found.

Most of the reclaimed building materials are sold as is. The sales conditions may however contain specific guarantees specific to the material (*for more information, see the introductory sheet*).

Inspiration

NTS Building (2017), Thirsk (UK). Reuse of structural steel beams © Cleveland Steel and Tubes (CST)

https://www.steelconstruct.com/wp-content/uploads/CS01-NTS-building-Thirsk.pdf

Characteristics and fitness for use

Steel is a very durable material with very limited deterioration of its technical characteristics during use and under normal conditions. To assess the fitness for use of reclaimed steel beams, and depending on the field of application envisaged, it is often necessary to know certain characteristics of the elements (*see table below*).

Depending on the intended uses, the project team - and in particular the stability design office - assesses whether tests are necessary to determine and verify the mechanical properties and chemical composition of the steel in the reclaimed steel beams. Grading of certain properties may require destructive testing on a sample or non-destructive testing on each separate element. The extrapolation of the results to include the whole batch must be validated by an appropriate sampling method and statistical approach.

The quantity of samples required and the nature of the tests to be carried out can have an impact on the economics of the project, which should therefore be anticipated. A few remarks about this:

- Yield strength, maximum tensile strength, toughness and chemical composition are standardised for steel beams manufactured after 1970. **Knowing precisely the grade and steel quality of the beams to be reused largely determines the quantity and nature of the tests that will be necessary to justify their fitness for use**. As such, it is therefore useful to consult the technical data sheets and the original execution documents. Most of the time, if this information is known, a simple visual inspection of the components can be sufficient to determine their fitness for reuse. If this information is not available, the use of grade tests should be considered in view of the requirements of the new application.
- Structural buildings are classified into **three normative consequences classes** (abbreviated to CC, "consequences classes") according to the consequences of the collapse of the structure and the loss of human life. These are coupled with **execution classes** (EXC), which regulate the level of execution, quality assurance and inspection and testing (see Eurocode EN 1090-2: 2018). Buildings in higher performance classes have more requirements to determine and/or verify the technical characteristics of structural elements.
- The principles of oversizing in the **design**, the use of additional safety factors and/or the adoption of minimum values for certain characteristics can also reduce the need for in-depth testing. Sometimes, however, it will be more economical to demonstrate certain characteristics through tests in order to get the most out of beam performance.
- The execution of the steel and beam grade tests is entrusted to approved laboratories which have the appropriate infrastructure and which can guarantee the correct sampling of batches, analysis and interpretation of the results obtained.
- Several practical manuals offer concrete methodological procedures to support the reclamation of steel beams. These documents indicate, among other things, which tests are necessary for which types of applications, on how many samples must be carried out and whether or not they must be carried out statistically (*see § "References"*).

Characteristics	Comments
Dimensional characteristics (length, width, thickness)	These characteristics are closely linked to the degree of sorting of the recovered elements. A careful visual examination accompanied by simple measurements is often sufficient to evaluate them. The cross section dimensions of steel beams have generally been standardized since the 1970s (see EN 10365 for hot rolled U, I and H sections).
Dimensional tolerances and geometry	The cross-sectional tolerances and geometry of the beams are specified in various European standards (EN 10034 for I and H sections). A visual or detailed examination of the batch is often sufficient to estimate them.
Toughness/impact resistance	Toughness (or resilience) is the ability of steel to absorb energy and to deform plastically under sudden impacts or forces without breaking or cracking. This characteristic depends on the steel grade and the ambient temperature. It is often specified in technical documentation (for example by the initials JR in "S 275 JR") for steels manufactured after 1970. This property should be taken into account for specific and demanding applications, generally in an outdoor environment and when the temperature is very low. For interior steels which are not subjected to fatigue, a conservative assumption is often sufficient (i.e. the JR quality, the lowest quality, as defined in standard EN 10025, can be estimated without testing). In some cases, however, it is useful to prove, by means of destructive testing (Charpy test), that the steel has better toughness than this minimum value.

Characteristics	Comments
Mechanical resistance • Yield strength • Tensile strength • Elongation at break	The **yield strength** indicates the maximum load beyond which the material is deformed permanently (one says then that it enters the "plastic" zone). **Tensile strength** refers to the maximum load that an element is able to take before failing and then breaking. These characteristics depend on the nominal thickness of the elements and are indicated by the steel grade. For example, a steel beam (16 mm thickness) with steel grade S275 indicates that its yield strength is 275N/mm². This same indication makes it possible to establish that its maximum tensile strength is around 370 - 530 N/mm². When this information is not available, it can be established by grade tests: • **Destructive tensile tests** on a representative sample (for a batch of reclaimed beams, the degree of reliability increases with the number of samples, see EN ISO 6892-1). Tensile testing can also determine **elongation at break**, which refers to the ability of the material to elongate before breaking (when subjected to a tensile load) and which is an important property to know in some specific applications. • **Non-destructive hardness tests**, using a portable hardness tester. Under certain conditions (test protocol), the measurement of the hardness of steel allows to estimate the yield strength as well as the tensile strength of elements by means of tabulated values (see EN ISO 18265). These characteristics are also used to model the behaviour of beams under bending, compressive, shear stresses etc.
Reaction to fire	Steel is considered a non-combustible material (Euroclass A1), which does not emit heat or smoke. However, it quickly loses its strength and rigidity in the face of the high temperatures reached during a fire. Ambient heat can deform steel members and cause structural instability. Class A1 only concerns steel and is not applicable to beam coatings. It is therefore necessary to know the reaction to fire of the finishing products used (e.g. paint, etc.)
Fire resistance	Specific fire requirements are determined by national regulations. These requirements depend, among other things, on the use of the premises (for example: private or community housing, emergency exits, terraces on flat roofs, etc.), by the building's height, but also on the ability of users to evacuate the premises in the event of fire (senior citizens' residence, hospital, etc.). At a European level, the classification of the fire resistance of different building elements is described in standard EN 13501- 2. It is expressed by a period of time Rf (in minutes) during which a construction system satisfies the criteria of stability (R), flame tightness (E) and thermal insulation (I). To this end, the construction elements or systems are generally dimensioned and designed according to Eurocode standards to meet national requirements. In the case of structural steel elements, depending on the application, it will mainly be a question of delaying the temperature rise, in order to maintain the bearing capacity of the structure as long as possible: • either by oversizing the elements (thicker elements take longer to heat up); • or by applying a fire-retardant coating to the steel surface (e.g. plates, intumescent paints, mortar flocking, etc.) • or by encasing the structural steel elements in concrete.
Suitability for welding - "weldability"	In the absence of precise information, an analysis of the chemical composition of the steel and a metallurgical examination may be necessary to determine the weldability of the steel. The chemical composition can be determined non-destructively by optical emission spectroscopy (mobile or laboratory equipment) or destructively by taking a sample (cutting one end or taking shavings by drilling). The metallurgical examination (microscopy) is carried out by sampling and makes it possible, among other things, to grade the steel structure, the steel grain size and the purity.
Sustainability	This characteristic mainly concerns the state and nature of the protective anti-corrosion coating. When used outdoors, the steel must be properly protected in accordance with the standards in force. In an indoor or non-corrosive atmosphere, no special requirements are necessary.

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In some special cases, other characteristics should be assessed, for example:

→ Contraction needs for certain types of connections/assemblies

→ Limits on internal lack of continuity or cracks in areas to be welded

→ Behaviour at high temperatures (creep test)

→ Fatigue behaviour (torsion, rotary bending, repeated impact tests)

→ Thickness requirements.

Portable hardness tester © PCE Instruments France

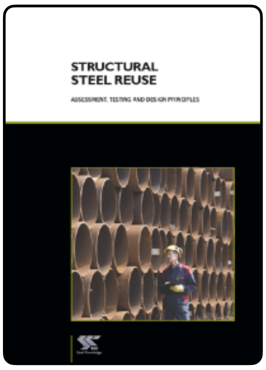
Références

EUROPEAN RECOMMENDATIONS FOR REUSE OF STEEL PRODUCTS IN SINGLE-STOREY BUILDINGS (ENG)

https://www.steelconstruct.com/wp-content/uploads/PROGRESS_Design_guide_final-version.pdf

Guide for the reuse of steel elements in single-storey constructions. The document describes different reuse scenarios and provides concrete guidelines for the design and calculation of structures based on salvaged steel elements.

Written by members of a project consortium within the framework of the PROGRESS project (PROvisions for GREater reuse of Steel Structures), funded by the RFCS (Research fund for coal and steel).



STRUCTURAL STEEL REUSE / ASSESSMENT, TESTING AND DESIGN PRINCIPLES (ENG)

https://steel-sci.com/assets/downloads/steel-reuse-event-8th-october-2019/SCI_P427.pdf

A specific guide which establishes guidelines for the assessment of fitness for use, testing and design of reclaimed steel structures.

Produced by the Steel Construction Institute, UK, but applicable to countries that have adopted the Eurocode series of standards.

STRUCTURAL STEEL ELEMENTS INTENDED TO BE REUSED IN STRUCTURAL APPLICATIONS (FR)

https://www.bbsm.brussels/wp-content/uploads/2021/06/annexe-20-WP6-fiche-produit-application-elements-de-structures-acier-de-reemploi-application-structurale.pdf

Guide established within the framework of the BBSM project (Le Bâti Bruxellois Source de nouveaux Matériaux) with guidelines on the reuse of steel elements, where the guidelines as described in "STRUCTURAL STEEL REUSE / ASSESSMENT, TESTING AND DESIGN PRINCIPLES" are checked against the Belgian and Brussels context, and more specifically the general reuse protocols as established in the same project.

DIAGNOSTIC AND PERFORMANCE EVALUATION METHODOLOGY FOR THE RE-USE OF STEEL FRAMING ELEMENTS (FR).

Fondation Bâtiment Énergie (FBE), 2020.

http://www.batiment-energie.org/doc/70/FBE-ECB-enjeu-A-ossature-V9.pdf

Steel beam

Availability

HEA, HEB and IPE profile beams, and to a lesser extent IPN and HEM, are commonly found in small and medium quantities on the reclamation market, mainly from demolition contractors who also have a stock of reclaimed materials. As an indication, the following table gives an idea of the availability of reclaimed steel beams (elements of the same type, of variable length, ~ 4 to 6 m):

Frequent	1 - 5 elements
Occasional	5 - 20 elements
Rare	20 - 100 elements

Often, large quantities of reclaimed beams are taken directly and sold from the deconstruction sites in order to limit the costs associated with transport and storage. It is therefore advisable to make contact fairly quickly (at the start of the project) with specialised companies in order to maximise the chances of coming across an available offer.

Find specialised businesses

salvoweb.com

salvoweb.com opalis.eu

Indicative prices (excl. tax)

The price of re-used steel elements can fluctuate significantly depending on the development of the raw material market (especially the demand for recycled steel). The table below provides an indication for various reclaimed beam profiles (price per linear metre, prices observed in 2021).

HEA profiles:	HEA 100 : 18 €/ml HEA 200 : 40 €/ml HEA 300 : 75 €/ml
HEB profiles:	HEB 180 : 50 €/ml HEB 220 : 70 €/ml HEB 300 : 120 €/ml
IPE profiles:	IPE 120 : 10 €/ml IPE 240 : 26 €/ml IPE 360 : 50 €/ml

Hazardous substances and precautions

A *lead* diagnosis may be necessary to detect the presence of old anti corrosion lead coatings (red lead) on the steel beams. Theoretically, red lead was banned in Europe around 1990. The diagnosis can be carried out either using a commercially available lead test kit, or by sending a sample of the paint to the laboratory or by having this test carried out by a professional. In this case, it is strongly recommended to strip and/or repaint using a specialised operator. It is strongly advised against using a heat gun, sander or sandpaper to remove lead paint. Chemical stripping will be preferred, with adequate health and environmental provisions.

AMIANTE

The reclaimed steel beams may have been coated with *asbestos* present in the old fire protection flockings. It is therefore advisable to remove the beams after the asbestos removal work, and in all cases, to inquire about the asbestos diagnosis if available.

Embodied carbon (Cradle to gate - production A1-A3)	kg CO_2 eq./kg
INIES database (FR)– (CTICM collective data)*	1.41
INIES database (FR)– Generic data **	4.76
IBU database (DE) - individual data (EPD bauforumstahl e.V.) ***	1.74
ICE database (UK) ****	1.55

** Indicative value for 1 kg of load-bearing steel beam element (column, girder, girt, joist, etc.) or structural element (purline, constituent element of a metal truss, etc.), ensuring the performance prescribed in the project design phase, for a reference lifetime of 100 years, a Young's modulus (elasticity) equal to 210 GPa, and steel grades S235, S275, S355 and S460 (defined in standard NF EN 10025).*

*** Indicative value for 1 kg of load-bearing vertical steel element as a frame element for a reference service life of 100 years.*

**** Indicative value for 1 kg of structural steel (sections and plates). It covers steel products of grades S235 to S960 rolled into structural sections, merchant bars and heavy sheets.*

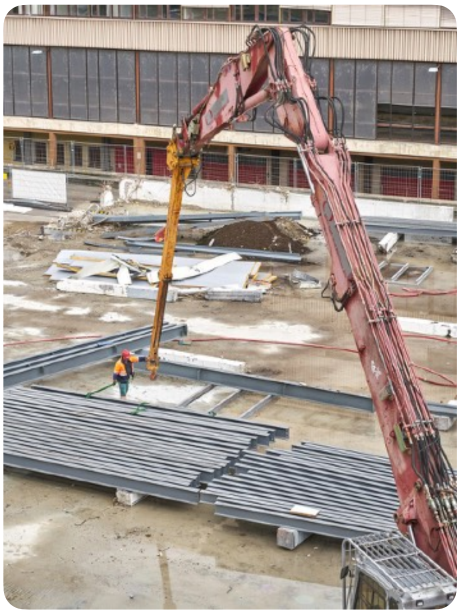
***** Indicative value for 1 kg of hot rolled steel profile. Steel sections include I-beams, H-beams, wide flanged beams, and sheet piles.*

The production of new steel beams has a considerable environmental impact, in particular linked to the supply of raw materials from the mining industry and/or the recycling of metals, as well as to the energy required to supply the steel making process. From this point of view, reclamation is a particularly effective strategy for extending the life of a steel component. According to the sources, reusing 1 ton of steel prevents the equivalent production of ~ 1410 to ~ 4760 kg of CO2 equivalent related to the manufacture of new steel (production phase only). This corresponds to the emissions caused by a small diesel car during a trip of ~ 8,400 to ~ 28,600 km.

Inspiration

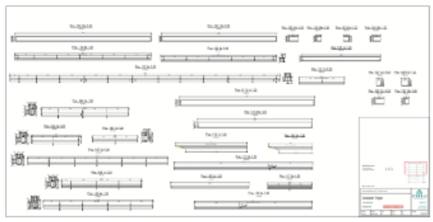
In 2021, the architectural firm Bauburo In Situ allowed the integration of steel structural elements into a project in Winterthur (Switzerland). Most of the beams (60 t) come from the deconstruction of a 15-year-old structure and other deconstruction sites (10 t). In the absence of precise information on the quality of the steel, the firm and engineers assumed the lowest quality, and used compensatory measures for the design of the structure (e.g. doubling the number of secondary beams). No tests were carried out and surface repairs and additional treatments were applied only occasionally. Fire resistance was obtained by casting the beams in concrete. The design of the new building was largely guided by the availability and dimensional characteristics of the batches recovered. The alterations to the beams were as minimal as possible, most of the connections were used as is. © Martin Zeller, Baubüro in situ ag (https://www.insitu.ch/projekte/196-k-118).

Beam reclamation



Beam reclamation

Beam reclamation



Inventory of elements

Installation of beams

Installation of beams

Installation of beams