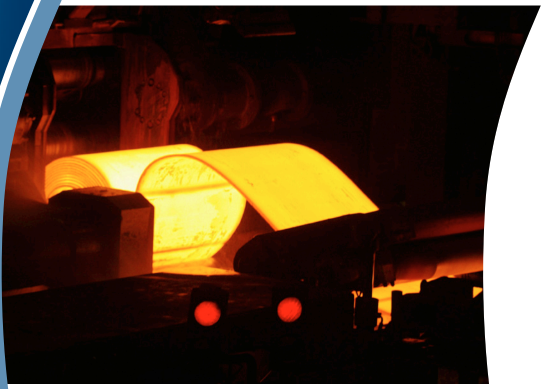
ECO-DESIGN PACKAGE

COMPOSITE FLOORING SYSTEMS



EUROFER
The European Confederation of Iron and Steel Industries

ABOUT EUROFER AND THE ECO-DESIGN PACKAGE

The European Confederation of Iron and Steel Industries, EUROFER, is committed to advancing sustainable development throughout the European steel industry.

This Eco-Design Package has been developed to promote the environmental credentials of steel and provide downstream users with environmental performance information. It demonstrates:

- the importance of life cycle considerations during product development
- the closed loop, material to material recycling of steel
- the availability of steel life cycle inventory data and information on the steel industry's sustainability development

This document follows the key philosophies of Eco-Design as described in ISO 14062 "Environmental Management - Integrating environmental parameters into product design and development".

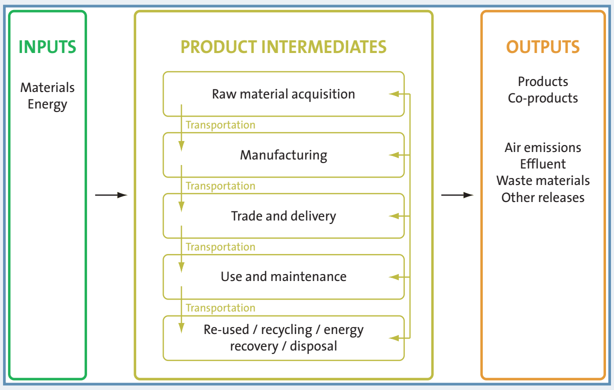


Figure 1: Scope of a life cycle consideration

In this Eco-Design package, life cycle considerations are integrated into the industry's product development and design environment. This provides product-specific environmental decision-making support for new and improved designs in early development phases and thereby assists with compliance of legislative requirements.

Discussions on Eco-design should be incorporated into the very early stages of product design to ensure optimum benefit to environmental, technical and economical performance.

COMPOSITE FLOORING SYSTEMS

This Eco-Design package focuses on the application of composite flooring systems.

In recent times the combined use of different materials within construction elements or even the mixture of construction methods within one structure has become more and more disseminated due to the remarkable advantages of such systems in view of economics and in reduced construction times. Different materials are consciously used at those locations within the structure where their specific advantages are enhanced. The most frequently applied combination of construction materials for buildings as well as bridges is that of structural steel and concrete.

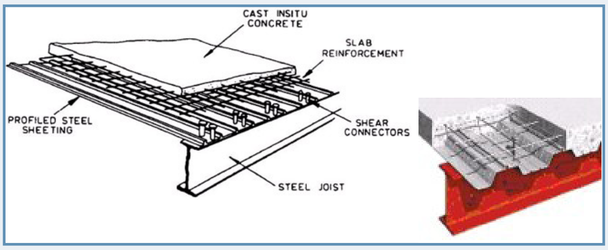


Figure 2: General schematic of a composite flooring system **/1/**

The composite flooring system is easily constructed by pouring light-weight concrete (LWC) onto a steel decking that has been laid across the steel joists/beams. Shear studs are fixed to the top flange of the beams through holes in the steel decking (they can either be bolted or welded onto the beam). Reinforcing steel bars are laid over the decking and the concrete is poured in situ. The large number of shear studs protruding into the concrete cause the underlying steel beams, decking and the concrete to act compositely as one unit (see figure 2), thereby greatly increasing rigidity and load carrying capabilities.

The analysed exemplary system for a composite floor comprises a standard surface area of a 7.5m x 7.5m floor grid, excluding columns. Figure 3 displays the final assembly phase of a composite flooring system when the concrete is pumped onto the steel decking.

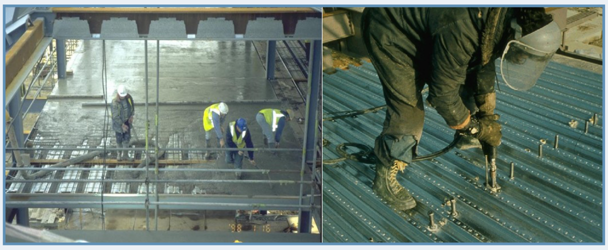


Figure 3: Assembly of a composite flooring system **/1/**

Composite flooring system (weight)

The weights of material required are calculated according to a typical application of a composite flooring system in an office building:

steel beams:	1229 kg
profiled steel sheet decking:	708 kg
steel reinforcing mesh and bars:	228 kg
steel shear studs:	24 kg
light-weight concrete:	9720 kg

The steel beams are 358mm high and the LWC floor slab has a height of 130 mm. The steel beams have an intumescent coating on three sides for fire protection purposes.

The floor design should conform to relevant European and national standards.

ECO-DESIGN OF A COMPOSITE FLOORING SYSTEM OVER ITS LIFE CYCLE

Identifying the most environmentally-sound product design alternative requires tracing the ecological effects of each choice.

Life Cycle Thinking / Assessment

According to ISO 14044 'Environmental management – Life Cycle Assessment – Requirements and guidelines', Life Cycle Assessment (LCA) provides a systematic approach to integrated environmental analysis. Emissions to air, water and soil, as well as resource intensity along a products' life cycle, can be analysed, aggregated and assessed.

The **Life Cycle Inventory (LCI)** phase represents the compilation and quantification of inputs and outputs for a given product system throughout its life cycle. The **Life Cycle Impact Assessment (LCIA)** phase involves interpreting and evaluating the magnitude and significance of potential environmental impacts on the basis of the LCI results.

For the 7.5m x 7.5m composite floor example, the impact on the environment is displayed in the table below, characterised by a number of these well-renowned LCI and LCIA categories **/2/**. For a selection of indicators, the impact is shown for each of the life cycle stages, as well as the total life cycle impact. Further information can be obtained from EUROFER. LCI data from IISI has been utilised for the various steel products, and where necessary, data from the GaBi 4 software and database is incorporated.

Environmental impacts	Units	Life cycle phases					Total
		Production		Use	End of Life		
		Materials	Processing		Scrap processing	Recycling	
Life Cycle Inventory (LCI)							
Primary energy demand	GJ	76.1	1.2		1.8	-20.4	58.7
Carbon dioxide (CO2)	kg	6838	72		370	-1968	5312
Life Cycle Impact Assessment (LCIA)							
Global warming potential	kg eq CO2	7001	74		380	-2003	5452
Acidification potential	kg eq SO2	21.7	0.7		1.1	-4.2	19.3
Eutrophication potential	kg eq PO4	1.7	0.1		0.1	-0.4	1.5
Photo-chemical oxidant formation potential	kg eq ethylene	4.7	0.1		0.08	-0.9	4.0

Production phase

The production phase for the composite flooring system covers steel and concrete production (materials), manufacturing and transportation (processing). The LCI results show that the contribution from transport and product manufacturing is significantly less than that for material production.

The steel in the composite flooring system accounts for 70% of the overall primary energy demand and 60% of the overall CO2 emissions. The amount of steel and concrete used can be optimised using different steel deck profile designs, depending on the load and span requirements. Overall, the production of steel is generally characterised by highly resource efficient production stages, with minimal potential for further improvement, and additional benefits of steel further demonstrated in the product's use phase.

Composite flooring offers significant reductions in the volume and quantity of materials used in construction. The use of steel decking eliminates the need for temporary formwork and the interaction between the decking and concrete minimises the volume of concrete required offering consequential benefits in overall frame weight and foundations.

Composite action between the flooring and the steel floor beams achieved with the use of shear studs can provide savings in beam weight of up to 50% and reductions in beam depth of up to 30% **/3/**. In addition to the direct reduction in the quantity of steel used, a consequential benefit in the reduction of materials used for the external envelope is made due to savings in beam depth, particularly for multi-storey construction.

These systems should be constructed in such a way so as to avoid scrap arising in the production phase. Additionally, as an alternative to normal concrete, it is possible to utilise the co-product from the steel-making process, blast furnace slag. The benefit of using this slag based material avoids the primary production of cement clinker.

Use phase

The flooring system is covered by a floor finish and casings, so a correctly constructed flooring system is durable for several decades without any maintenance and therefore no environmental burdens have been determined for the use phase. The availability of a wide range of advanced coatings ensures the long term protection of steel in buildings.

Fabric energy storage can be used to absorb excess heat inside buildings during the day which can then be removed by night time ventilation. Used effectively it can mean that mechanical cooling can be reduced or even eliminated. Studies have shown that composite floors can provide sufficient fabric energy storage in order to minimise air conditioning requirements in the building **/4/**.

End of Life phase

The End of Life phase includes demolition and separation of the composite flooring system as well as the recycling of steel scrap and concrete at the end of the product's life.

Of high importance for the end of life phase is the effective recyclability of steel without loss of material properties. It is therefore very important that these construction systems are designed in such a way that they have the ability to be dismantled effectively to maximise reusability and the recyclability of the system. Within the construction sector carbon steel materials are recovered with a recovery rate of 85 % or more **/5/**. The steel beams can also be reused, by being dismantled, which provides additional savings over recycling.

The End of Life is characterised by the additional burdens of preparing the residual material, and by the credit for the recovered material which can be used within a subsequent life cycle. Focusing on primary energy demand, this credit is 15.9 GJ (equivalent to 378 kg of 42.1 MJ/kg crude oil) for the recycled steel scrap and 4.5 GJ (equivalent to 107 kg of 42.1 MJ/kg crude oil) for the recovered concrete.

General information on material flows in steel making

Material flow analyses for steel products demonstrate that material-to-material recycling of post and pre-consumer scrap is already common practice. The fact that steel is 100% recyclable back into new steel products without loss of quality ensures that the material loop is closed.

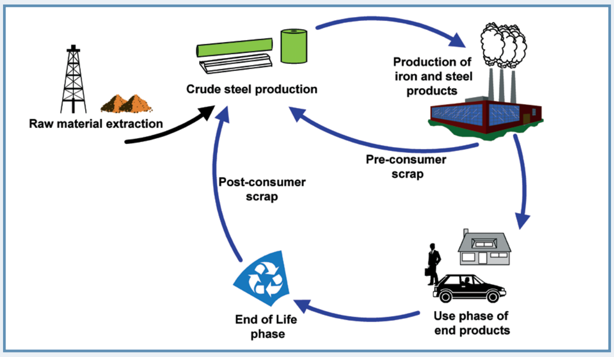


Figure 4: Flow of material through society **/6/**

Modern steel making is dominated by two principle process routes:

- **Iron ore-based production** where hot metal (pig iron) is produced by the reduction of iron oxide in the blast furnace, followed by refining in the basic oxygen furnace to produce steel. In the refining process, excess heat is produced, allowing steel scrap to be added to the melt.
- **Scrap-based production** where steel is produced by melting steel scrap in the electric arc furnace, sometimes followed by refining. Highly alloyed steel grades, like stainless steel and tool steels, are generally made from scrap. Alloying elements utilised, such as chromium and nickel, depend on the type of scrap used as well as from extra additions to the melt.

Energy efficiency has always been a priority within the steel industry and thus both process routes operate in a very energy efficient way. Continuous improvements to further develop this are ongoing **/7/**.

The recycling of scrap closes the loop of the material (steel) flow in the steel production process. Input of steel scrap to the production process can be up to 100 %, depending on the steel production process route. Europe recycles 101 million tonnes of steel scrap per year, which represents 54% of total steel production **/8/**. This saves 190 million tonnes of CO2 emissions which is equivalent to saving CO2 emissions generated by 34 million households **/9/**.

Steel product information

Hot dip galvanised coil (HDG) is made by passing cold rolled coil, in a continuous process, through a molten zinc bath to achieve a protective coating with a typical thickness of 0.02mm on both sides. The zinc layer provides corrosion protection to the steel substrate. HDG coil is used to make the profiled steel decking sheets as well as many other construction products. Typical thickness ranges for steel decking are between 0.8 and 1.2mm.

Steel sections include hot rolled I-beams, H-beams, wide-flange beams, and sheet piling. These products can be found on the market for direct use and can be used in construction, multi-story buildings, bridge trusses, vertical highway supports, and in riverbank reinforcements etc.

Rebar (Reinforcing Bar) is hot rolled steel. It can be found on the market for direct use or is further processed into finished products by the product manufacturers.

Rebar and reinforcing mesh is used to strengthen concrete in highway and building construction and is also used in floors to prevent the concrete from cracking and increase fire performance.

Further information

Steel products used within the construction industry support existing legislation. It is also necessary that relevant country-specific guidelines are followed. Further information may be gained from other environmental publications such as Environmental Product Declarations or environmental assessment schemes. The use of steel in such construction products will assist in achieving the requirements specified by these various guidelines.

Eurofer has LCI data available for HDG coil, steel sections, rebar steel and other steel products, together with the methodology report and advice on use of the data and product applications. Contact lca@eurofer.be or visit www.eurofer.org.

Further information relating to steel in the construction industry can be obtained from the following locations:

- The European Convention for Constructional Steelwork - www.steelconstruct.com
- Living Steel - online resource for information on residential steel matters - www.livingsteel.org
- Steel University - www.steeluniversity.org
- International Iron and Steel Institute, IISI - www.worldsteel.org.
- EUROFER - www.eurofer.org

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