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Low-carbon classification of concrete in Finland

In the past few years, the reduction of carbon oxide emissions has started to play a significant role in construction. The underlying reason for this is the general need to curb the impacts of climate change, but revised regulations as well as economic pressures also contribute to the decarbonisation drive. The future impact of the EU taxonomy on the carbon dioxide emissions of construction is also a factor not to be ignored.

The Construction Act currently being drafted in Finland will require a special climate assessment to be drawn up for new buildings and refers to a limit value for carbon dioxide emissions to be set for the building at the building permit stage. In addition to the energy use of the building, the scope of analysis also covers carbon dioxide emissions from the manufacture of building products.

Another source of pressure for decarbonisation is the EU Emissions Trading System (ETS). So far, the economic impacts of ETS have been minor in the construction sector. Cement manufacturers, for example, have been provided part of the emission rights for free and the price of emission rights has remained low. However, a change has already occurred, with free emission rights becoming scarcer all the time and the price of emission rights on a steep upward climb. The annual cost effect of emissions trading will exceed EUR 100 million in the concrete business in Finland.

Taxonomy is also a part of the equation, as it steers the investors' interest toward sustainable investment objects. For example, a construction project of a larger scale could be left without financing if it is not considered to meet the requirements of sustainable development.

The carbon dioxide emissions of building products are usually presented in the Environmental Product Declaration (EPD). The EPDs also present several other indicators, in addition to carbon dioxide emissions. Environmental Product Declarations are required to be subjected to an external verification. If the number of different product variations is high, as in ready-mixed concrete production, for example, an EPD is a laborious and expensive way to present the carbon dioxide emissions of the product.

In Finland, a system for classification of concrete has been adopted as a useful tool alongside EPDs. The classification is modelled on a corresponding classification system used in Norway. BY Low-carbon classification has been developed to provide a system for the classification of concrete types based on carbon dioxide emissions. (BY= Concrete Association of Finland.) If carbon dioxide emission data is all that is needed, the classification provides the same information as an EPD. The classification also facilitates the selection of a low-carbon concrete at the design stage. The objective is for BY Low-carbon classification to become the established national system in Finland for declaring the carbon dioxide emissions of different types of concrete and for classifying concrete types based on their carbon dioxide emissions. BY Low-carbon classification offers a

system for the reliable calculation of carbon dioxide emissions for concrete and the values provided by it are comparable.

The BY Low-carbon classification system is run by the Finnish Concrete Association (Suomen Betoniyhdistys ry). The classification system was developed in the years 2021 and 2022 in collaboration between the Finnish Concrete Association, the Association of Concrete Industry in Finland (Betoniteollisuus ry) and Aalto University. The classification system also includes dedicated calculation software. The background report of the method updated once a year presents the principles applied to classification as well as the specific emissions used in the calculations for raw materials, transport and energy.

Principles of Low-Carbon Classification

BY Low-carbon classification is a voluntary, national classification system for the declaration of the CO₂ emissions of concrete. BY Low-carbon classification provides a harmonised method, independent of brands, for the declaration of the carbon dioxide emissions of concrete. Being analogue with concrete strength classes, the classification system facilitates the specification of low-carbon concrete types at the building's design stage. The ultimate objective of the classification system is to reduce the carbon dioxide emissions resulting from concrete manufacture.

Concrete types are assigned into classes depending on the associated carbon dioxide emissions. The classification system covers a total of 16 different concrete types and a total of 5 different low-carbon classes. The classification is assigned separately for each concrete mix and concrete station. Concrete manufacturers can assign the concrete mix recipes of their choice to low-carbon classes, provided the emission value of the mix meets the classification requirements.

Low-carbon classes are indicated as GWP.NN, where GWP stands for Global Warming Potential and NN indicates the emission level in comparison with the reference level. Thus, GWP.85, for example, indicates that the carbon dioxide emissions of the concrete are no higher than 85% of the reference level. The reference level is given for each concrete type as the average emission level of Finnish concrete manufacturers in 2021. Low-carbon classes have an emission level that is lower than the reference level. Table 1 shows the BY low-carbon classes. The reference level (GWP.REF) is also a low-carbon class, indicating a class where the GWP emissions are equal to the average emission level of the concrete type in question.

The principles of Environmental Product Declarations (EPD) are applied to the calculation of emissions, although there are some differences. Unlike the EPDs, only GWP_{total} emissions are calculated for the classification and only life cycle stages A1...A3 of the EPD are considered. The calculation is based on the mix design of the concrete type. In addition to raw materials and their transport, the consumption of electrical and heating energy required in the manufacture of concrete is considered. The waste generated in the production of concrete is taken into account as well.

The emission values of the classification only refer to the concrete, whereas reinforcement of concrete structures, transport of concrete or concrete products or worksite activities, for example, are excluded. The emission value of the concrete can be utilised in the emission calculations of

buildings. However, it shall be borne in mind that the emission value only covers the concrete. The emission value of concrete is not comparable with the GWP values indicated in the EPDs of precast concrete elements, for example, because the latter also include the reinforcement as well as emissions from the manufacturing process of the product.

The assignment to a low-carbon class does not invalidate other requirements that apply to concrete. Strength and durability properties (such as exposure classes), for example, must be fulfilled regardless of the low-carbon class. It should be noted, however, that the selection of a low-carbon concrete also affects the other properties of the concrete, such as strength development.

Table 1. Concrete types included in BY Low-carbon classification and limit values for low-carbon classes. The values are GWP_{total} values and include modules A1...A3. The values are given in kg (GWP_{total}) / m^3 of concrete.

CONCRETE QUALITY	Ref.level				
	GWP.REF	GWP.85	GWP.70	GWP.55	GWP.40
C20/25	210	180	145	115	85
C25/30	230	195	160	125	90
C30/37	255	215	180	140	100
C35/45	285	240	200	155	115
C45/55	320	270	225	175	130
C50/60	340	290	240	185	135
C30/37 - Air-entrained	290	245	205	160	115
C35/45 - Air-entrained	330	280	230	180	130
C45/55 - Air-entrained	375	320	265	205	150
C50/60 - Air-entrained	395	335	275	215	160
C30/37 P0	270	230	190	150	110
C30/37 P30	300	255	210	165	120
C35/45 P0	300	255	210	165	120
C35/45 P30	330	280	230	180	130
C35/45 P50	340	290	240	185	135
C45/55 P50	375	320	265	205	150

The calculation of GWP emissions is primarily carried out using the BY Low-carbon calculator. Other verified calculation tools approved by Finnish Concrete Association can also be used. The values used for the specific emissions of raw materials, transports and energy are predetermined product-specific values which cannot be changed by the user. This ensures the maximum reliability and comparability of the calculations. The method is open to all the concrete raw materials used in Finland. New raw materials entering the market will be added in the calculation software on request. Reliable emission data, such as a verified EPD, is required on new materials.

Low-carbon classification for designer and client

The designer or the client can choose to select a low-carbon class for an individual structure or project. When a low-carbon class is selected, attention shall be paid to the availability of the classes and the effects the low-carbon class has on the properties of the concrete, in particular.

When choosing to go for a low-carbon approach, large concrete volumes should be implemented using a concrete type assigned to a low-carbon class. This will maximise the reduction obtained in emissions. Smaller concrete items included in the project, if any, can be implemented using concrete of a higher emission class or with no emission classification without causing any significant impact on the total emissions.

The application of classification of individual structures is recommended, but at the design stage it is sensible to conduct more extensive analyses. With a low-carbon approach in a project, it shall be ensured that it is possible to manufacture all the concrete structures included in the project using a concrete type of the selected low-carbon class. This needs to be assessed separately in each case. Alternatively, some of the structures can be excluded from the classification. It can be difficult to achieve the lower emission classes with some concrete types. Similarly, the number of producers who can supply concrete of the most stringent emission classes can be limited. If the structure is exposed to high stress on durability, the exclusion of such structures from low-carbon classification is usually the expedient option.

Low-carbon classification for concrete manufacturer

Low-carbon classification of concrete makes certain requirements on concrete manufacturers:

- Calculation of emission values for each mix recipe
- Certification of concrete station according to requirements of BY Low-carbon classification
- Accounting of concrete mix recipes with low-carbon classification

Concrete manufacturers have to calculate with the BY Low-carbon calculator the emission value for each concrete type based on the mix recipe data. The calculator produces a low-carbon report which indicates the low-carbon class of the concrete (e.g., GWP.70). The concrete then also fulfils higher low-carbon classes, e.g., GWP.REF and GWP.85. Other verified calculation tools approved by the Finnish Concrete Association can also be used.

For the classification, the concrete manufacturer must obtain certification for low-carbon concrete. The low-carbon classification certificate is granted based on an initial inspection. Later inspection visits include random sample inspections of batch reports, comparing them with the low-carbon calculation of each concrete type.

Concrete manufacturers are required to maintain accounts of the concrete mixes that have low-carbon classification. The accounts must show the date by which the calculation is to be repeated. The BY Low-carbon class must be indicated in the product code of the concrete type, e.g., C30/37 – #16 mm – S3 - XC3,4, XF1 – 50 v – GWP.85.

If significant changes take place in the concrete mix, raw materials or conditions, the concrete manufacturer must repeat the calculation and check the classification according to the new calculation. In any case, the calculation must be repeated every two years.

Low-carbon classification does not entail any changes in the quality control of the concrete manufacturer or in the technical requirements laid down for the concrete. The concrete manufacturer must verify that their quality control covers also low-carbon concrete types in a balanced and uniform way.

Effects of classification on concrete properties

The low-carbon class affects the properties of the concrete and this must be taken into consideration in the planning of concrete works and preparation of schedules. It is advisable that the suitability of a low-carbon concrete to the application in question is discussed with the concrete supplier.

In the lower emission classes, the proportion of admixtures in the binders increases. In practice, this means slower strength development for the concrete. Mould-stripping will be delayed, or alternatively, more efficient heating of the structure and/or use of accelerators is necessary. The effects are the most notable when using the lowest emission classes in cold conditions. Slower strength development can have significant effects on the construction process.

Availability of classified concrete types

The availability of low-carbon classes is a factor that must be considered if selecting a low-carbon class. The availability of the classes varies according to the concrete type. Lower emission classes are more difficult to achieve with air-entrained concrete and the most difficult with concrete types designed for infra construction. Availability also varies by region, with a wider selection available in the Helsinki region and other towns and cities than in the rural areas.