Recycled aggregates and REACH

1. Introduction

Recycled aggregates (part of "recovered aggregates" in ECHA-documents) constitute the largest volume of recycled materials in Europe. They are safe and soundly used for instance in road construction. In many Member States use is subjected to environmental testing (leaching testing). Recycled aggregates meet all limit values that apply and do not pose an environmental risk.

Several Member States have end-of-waste criteria which apply to recycled aggregates. When recycled aggregates cease to be waste, they are automatically subject to REACH regulation. Recycled aggregates however are articles and therefore exempted from the obligation of registration (note: natural aggregates (minerals) are in general exempted, see Annex V of the REACH regulation). This paper explains why recycled aggregates should remain considered as articles.

2. Production of recycled aggregates

The properties of recycled aggregates are determined by the input material, the type of machinery used and the processing conditions. The input materials to a crushing process are varied, such as crushed hardened concrete, mixed inert waste in various compositions e.g. ceramic and brick and natural materials such as aggregate and railway ballast. By blending the various input materials, the aggregates produced can be tailored to the required aggregate properties. For instance, by adjusting the volume of "cubic" material such as railway ballast, important parameters such as flakiness (see below) can be controlled. Good waste acceptance enables a producer to tailor the properties of its products.

The type of crusher used, e.g. jaw or rotating crushers, determines the way the material is crushed during processing and hence important properties such as percentage of crushed & broken particles (see below). Similarly for the processing conditions applied such as rotating speed can determine the intensity of particle crushing and affect the properties that are required for the final specification/use.

3. One particle versus an ensemble of particles

Recycled aggregates are able to perform their function because each individual particle has shape characteristics such as elongation, cubic and roundness that determine the structural, load bearing capacity, stability of the total aggregates structure and compactness of concrete mixtures. Process parameters are adjusted in such a way that on average particles obtain the shape and surface that is required. Shape and surface of an individual particle may deviate from the perfect desired value, yet it is the overall shape and surface of the multiple ensemble of aggregate particles which determine the interlocking function and of the total aggregates bulk. The structural stability, compactness and this interlocking capacity of the particles determine the structural function of aggregates to a much greater degree than the chemical composition. In fact, due the many and varied chemical compositions of aggregates, chemical composition has little or no influence on the structural function of aggregates at all.

Recycled aggregates are not placed on the market as individual particles, but sold as multiple particles. The shape of each particle contributes to the total volume of particles and will affect the materials made from them. Although the shape and surface of one individual particle can not be exactly influenced during the process, its final shape and surface are such that they determine its function.

4. Quality of recycled aggregates

Aggregates are construction products as defined by the Construction Products Regulation (CPR). This means they are intended to be incorporated in construction works for specific uses. Aggregates have to fulfil precise requirements, specifications and properties for each specified use. These properties (according to the Mandate M125 issued by the Commission) are detailed by CEN/TC 154 – Aggregates and the harmonized standards developed under CEN/TC 154 e.g:

- EN 13242: Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction,
- EN 12620: Aggregates for concrete,
- EN 13043 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas.

CEN/TC 154 standards provide the following technical definitions used under the CPR:

- Aggregate: granular material used in construction. Aggregates may be natural, manufactured or recycled
- Natural aggregate: aggregate from mineral sources which have been subjected to nothing more than mechanical processing
- Manufactured aggregate : aggregate of mineral origin resulting from an industrial process involving thermal or other modification
- Recycled aggregate: aggregate resulting from the processing of inorganic material previously used in construction

Recycled aggregates meeting the requirements of any CEN/TC 154 standards are subject to the same performance requirements as other aggregates and are therefore fit for purpose. Their physical characteristics conform to the requirements of the appropriate standard for each particular end use. The conformity to EN standards includes testing of physical, geometrical and chemical properties, with the correct physical and geometrical properties such as grading (dimension/sizing), surface texture and shape being the most important. These are important as aggregates are required to interlock in both unbound and bound applications, thus achieving the load bearing capacity (sub-base) and strength (concrete). In addition, the shape is crucial to achieve a dense packaging of the aggregates bulk, respectively in the final product in order to minimise the binder content. Chemical testing for specific properties is only required where necessary.

The above has already been acknowledged by CEN/TC 154 in its resolution on 2008-09-23: *"The standards require that aggregates particles are produced with specified, defined and precise shape and surface characteristics. These characteristics determine the function of the aggregate to a far greater degree than its chemical composition."*

The following table summarizes the main properties which are relevant to assess the conformity of aggregates to CEN/TC 154 harmonized aggregate standards.

Important requirements for recycled aggregates

Tests for geometrical properties	Tests for mechanical and physical properties
Determination of particle size distribution	Determination of resistance to wear
Determination of particle shape – Flakiness Index, Angularity	Determination of the resistance to fragmentation
Percentage of crushed and broken surfaces	Determination of particle density

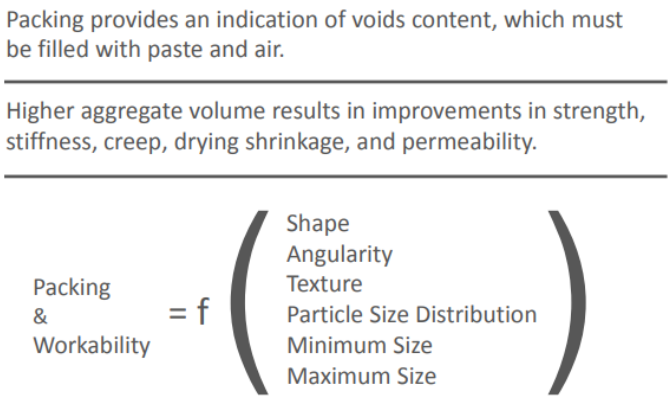
Shape and surface are explicitly the most important features of an aggregate, including recycled aggregates. They fully determine their performance. This can be understood by taking the following examples:

- Flakiness reflects the distribution of thin and elongated particles. This distribution can be influenced by designing the input material, the type of crusher and the process conditions e.g. speed of the crusher etc.
- Angularity, as demanded by CEN/TC 154 harmonized aggregate standards, reflects the angle at which individual particles stack. It is a measure of the ability to form a stable construction. The more angular particles in an aggregate product, the greater stability that can be achieved.
- Rounded particles will roll and lead to reduced stability. Angularity can be influenced by designing the input material and the type of a crusher and process conditions.
- The percentage of crushed and broken surfaces gives an indication of the volume of particles with crushed/broken edges. Crushed particles can be harder to compact, need more water when used in concrete, but provide better aggregate interlock. Rounded particles on the other hand provide a lower surface area, better workability, are easier to compact and provide and improved surface finish. It is up to the producer to design their product by adjusting input quality and process conditions to achieve the best material possible against the CEN/TC 154 harmonized aggregate standards and the required specification.

The importance of the properties mentioned above can be understood by taking the following example. Recycled aggregates are perfect substitute for natural aggregates in concrete. The shape of aggregates directly impact the density of concrete. The better aggregate packs together the denser the concrete. This directly affects the strength and water content of the concrete. The shape of aggregates is critical to the durability and strength of concrete, as a good aggregate interlock with low water demand will give good compaction and a denser concrete (see fig.1). Particles that are too flaky (long and thin) or elongated (long and slim) or both are less likely to provide a good aggregate interlock and will increase the water required producing weaker concrete. Aggregates containing both crushed and rounded particles (cubical and spherical) are more likely to produce stronger and more durable concretes with better aggregate interlock and a balance water demand.

It is needless to say that also other features of recycled aggregates are directly related to shape and surface of particles, such as density and permeability to water.

Figure 1. Effect of aggregate characteristics on packaging and workability of the final product.



5. Chemical composition

As stated previously, the suitability of recycled aggregates for a particular use is established by multiple characteristics. The fundamental chemical composition, which is typically inert, is not the predominant parameter which determines its use. It is irrelevant if particles are made up of either basalt, limestone, gravel, concrete or even bricks. The properties required relate to the hardness of particles and their shape that determine how recycled aggregates can be used and not their chemical composition which is typically inert.

The CEN/TC 154 harmonized aggregate standards do refer to some chemical properties, such as sulfur and sulfates. These substances can be harmful for the functioning of specific products such as concrete as they can affect the setting of the cement used but are of significantly less importance than the physical and geometric properties discussed earlier in this document.

Recycled aggregates are subject to environmental testing according to national regulations of the Member States. Regulations for health and safety at the workplace apply in the same way for all kinds of aggregates. Harm to human health and the environment can therefore be ruled out.

6. Conclusion

The performance, conformity and fitness for use of both recycled and primary aggregates are fully determined by their physical and geometrical properties. This goes for an individual particle as well for a bulk of particles.

By producing aggregates with the correct input material quality and using the correct equipment and process conditions, the physical and geometrical properties such as shape and surface texture can be tailored in order to achieve the specified properties for uses as described in the CEN/TC 154 harmonized aggregate standards against the intended use.

Chemical composition is of a very minor importance, if important at all. Recycled aggregates should therefore remain considered as an article in the sense of REACH regulation.

Attachment

Diagram taken from ECHA “Guidance on requirements for substances in articles”. Shape and design of recycled aggregates are unambiguously more relevant for its function than chemical composition. EU product standards but also assessment in practice of recycled aggregates focus on physical properties. As explained in this paper, physical and geometrical properties are determined by shape and surface. Chemical composition is irrelevant for the functioning of recycled aggregates.

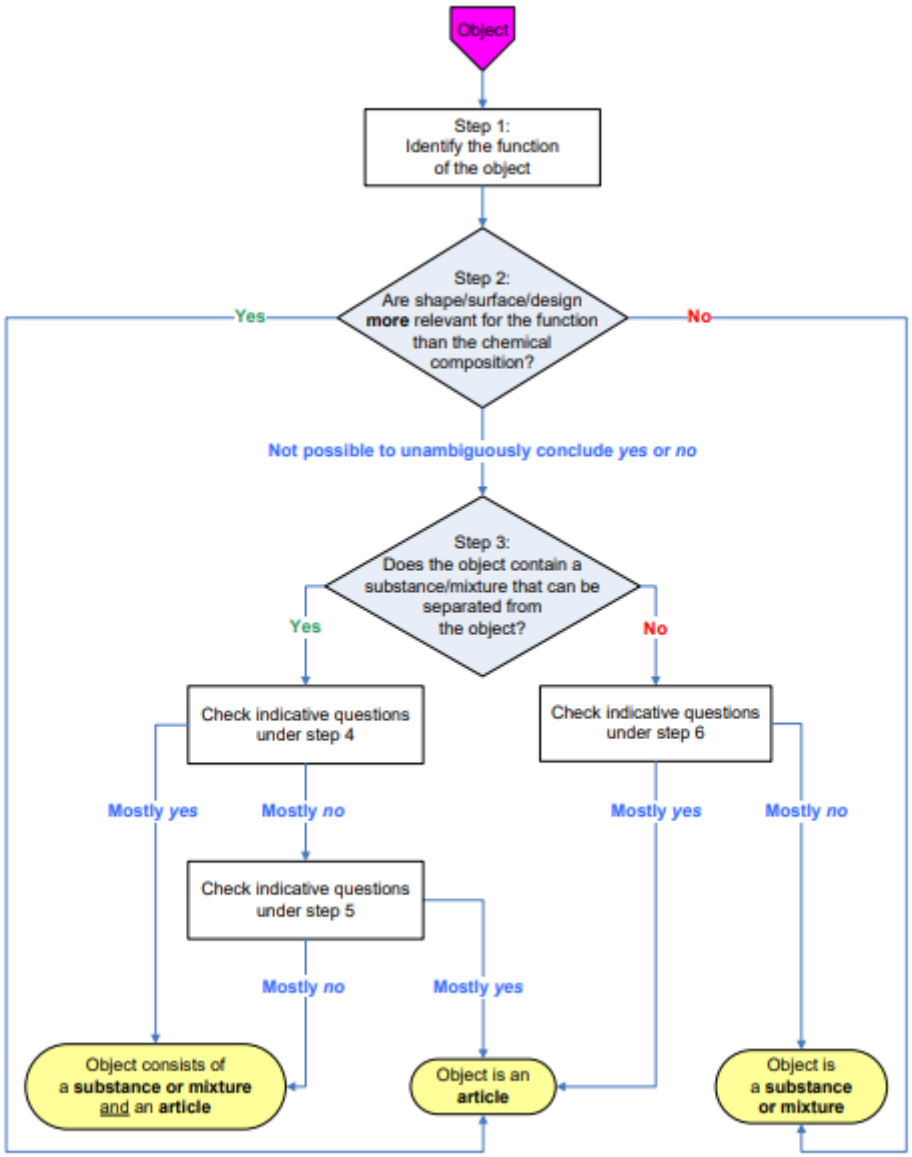


Figure 2: Decision-making on whether an object is an article or not

Aggregates Europe – UEPG represents the European Aggregates Industry since 1987, with Members in 25 countries. It is by far the largest non-energy extractive industry, covering a demand of 3 billion tonnes of primary and secondary aggregates per year, produced on 26,000 sites by 15,000 companies (mostly SMEs) across Europe. Our industry produces natural aggregates from quarries, sand & gravel extraction sites and from marine aggregates, it produces recycled aggregates from construction & demolition waste and manufactured aggregates from industrial processes such as steel slags or incinerated bottom ash.

The Fédération Internationale du Recyclage (FIR) represents the European recycling industry of Construction & Demolition Waste and of Incinerator Bottom Ash (IBA). It is the largest recycling industry of Europe. Together the members of FIR recycle more than 200 million tonnes of C&DW. Members of FIR have contributed to achieve full and high quality recycling in some of the EU Member States. More than 40 years of expertise is available to also assist other Member States to achieve these levels.

The European Recycling Industries' Confederation (EuRIC) is the umbrella organisation for the recycling industries in Europe. Through its 75 members from 23 European countries, EuRIC represents more than 5,500 large companies and SMEs involved in the recycling and trade of various resource streams. They represent a contribution of 95 billion EUR to the EU economy and 300,000 green and local jobs. By turning waste into resources, recycling reintroduces valuable materials into value chains over and over again. By bridging circularity and climate neutrality, recyclers are pioneers in leading Europe's industrial transition.

FEAD is the European Waste Management Association, representing the private waste and resource management industry across Europe, including 19 national waste management federations and 3,000 waste management companies. Private waste *management* companies operate in 60% of municipal waste markets in Europe and in 75% of industrial and commercial waste. This means more than 320,000 local jobs, fuelling €5 billion of investments into the economy every year.