SCRREEN2

This project has received funding from the European

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Start date: 2020-11-01 Duration: 36 Months

FACTSHEETS UPDATES **BASED ON THE EU FACTSHEETS 2020**

AGGREGATES

AUTHOR(S):

TABLE DES MATIÈRES

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AGGREGATES

OVERVIEW

Aggregates are granular materials used in construction. They are also referred to as 'construction aggregates' as they are a core element of a wide range of construction purposes in buildings and civil engineering structures. Aggregates may be used on their own in unbound condition as a structural material, e.g. road stone, armour stone, railway ballasts, or in bound condition with the addition of water, cement, bitumen or other binders to form construction products such as concrete, mortar, and asphalt. The most significant supply by volume is natural aggregates, i.e. crushed rock, sand & gravel. Natural aggregates are mineral construction materials from naturally occurring deposits, which have been subjected to nothing more than mechanical processing. Other types of aggregates are manufactured aggregates produced from wastes from other industries, and recycled aggregates produced from construction and demolition wastes.

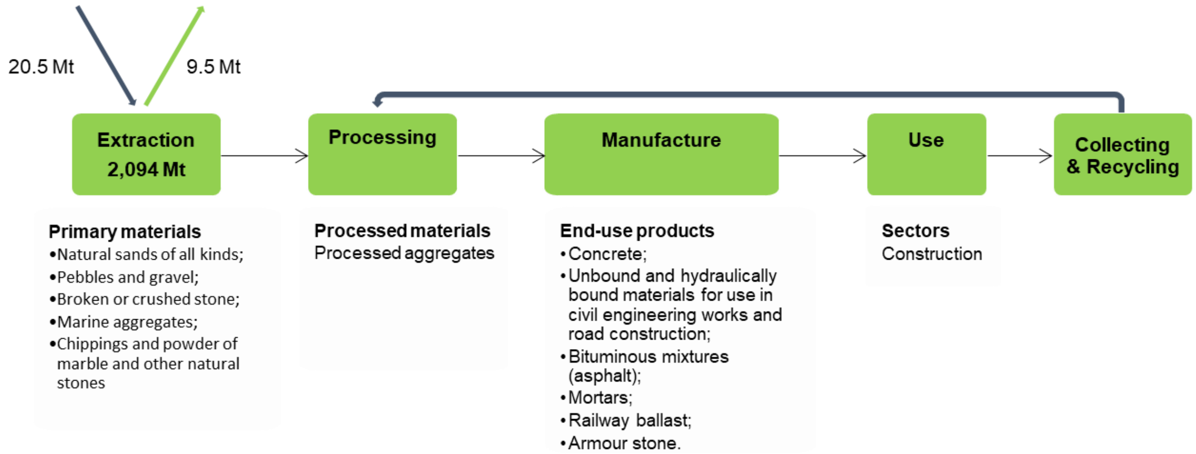

Figure 1. Simplified value chain for aggregates in the EU[1]

Table 1. Aggregates supply and demand in metric tonnes, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
4227 million tonnes	Russia 17% Germany 14% France 10% Turkey 9% Poland 7% UK 6% Italy 4%	2547 million tonnes	60%	Norway 60 UK 36%	0.6%

Prices: prices of aggregates increase regularly from 5€/tonnes in 2000 (5$) to 8€/tonnes in 2020 (10$)

Primary supply: the world production of aggregates is about 4.2 billion tonnes whereas the EU27 production is around 2.5 billion tonnes. EU27 is self-sufficient in aggregates since the import reliance is only 0.6%.

[1] JRC elaboration on multiple sources (see next sections)

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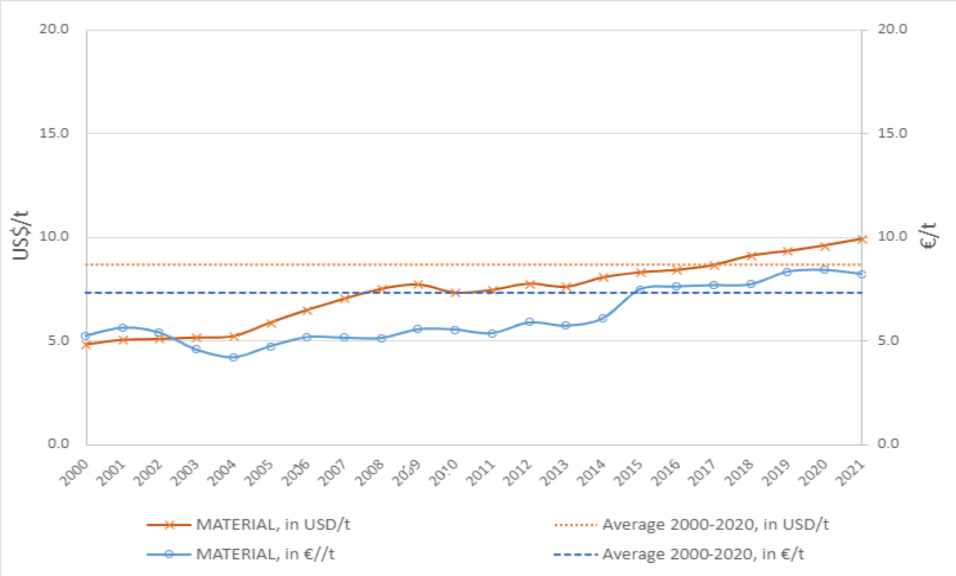

Figure 2. Annual average price of aggregates between 2000 and 2020 (USGS, 2021)[2].

Secondary supply: Recycled aggregates from construction and demolition waste (C&DW) are an important source of aggregate supply. Concrete, bricks, tiles and asphalt are the most commonly recycled C&D waste materials. Recycling reduces natural aggregates resource depletion and landfilling of waste. Concrete, the most used material in buildings, is often recycled at its end of life at demolition or construction sites close to urban areas. Unless transported in large volumes by rail or waterway, transportation in long distances (usually maximum 35 km) is not economically attractive. Environmental benefits of recycling diminish over longer distances as well (CSI, 2009; Ecorys, 2016).

Uses: The use of aggregates takes place entirely in construction related activities (UEPG, 2021). According to data provided by (BIO Intelligence Service, 2015) and (UEPG, 2018), in the EU 40% of the aggregates are directly used in construction works as structural (unbound) materials, 45% are used in concrete manufacture, 10% in asphalt products, and 5% in other products (railway ballast and armour stone).

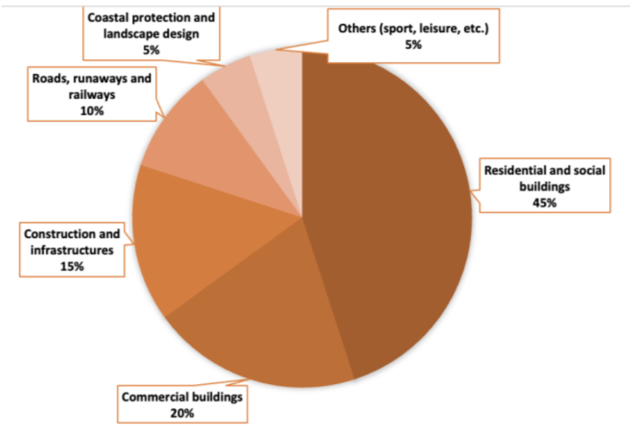

Figure 3: EU uses of aggregates

[2] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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Substitution: There is no substitute for aggregates

Table 2. Uses and possible substitutes

Use	Percentage*	Substitutes	Sub share	Cost	Performance
Residential and social buildings	45%	No substitutes			
Commercial buildings	20%	No substitutes			
Construction and infrastructures	15%	No substitutes			
Roads, runaways and railways	10%	No substitutes			
Coastal protection and landscape design	5%	No substitutes			

*Estimated end use shares of aggregates based on agreed outputs of SCRREEN Experts Validation Workshop (2022). Substitute ratings based on agreed outputs of SCRREEN Experts Validation Workshop (Dondi,M 2022).

Other issues: The main health hazard from aggregates is airborne dust generated during production, handling and use. Occupational exposure to respirable dust, particularly if it contains respirable crystalline silica, should be monitored and controlled. Repeated inhalation of excessive amounts of respirable silica may cause silicosis (Aggregate Industries 2021a, 2021b). In Europe, land-use conflicts and absence or complexity of aggregates policies are among the challenges for long-term and sustainable aggregates supply. The integration of mineral resources policies into land-use planning at different levels is a key factor for achieving responsibly sourced minerals. (SnapSEE, 2014; UEPG, 2022). European Standards, established from 1st January 2004 on, address the use of aggregates in concrete, mortar, asphalt, railway ballast, armourstones, etc. (MPA 2021). The EU is self-sufficient for aggregate materials, and no particular threats exist for what concerns social sustainability and security of supply.

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MARKET ANALYSIS, TRADE AND PRICES

GLOBAL MARKET

Table 3: Aggregates supply and demand (extraction) in metric tonnes, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
4227 million tonnes	Russia 17% Germany 14% France 10% Turkey 9% Poland 7% UK 6% Italy 4%	2547 million tonnes	60%	Norway 60 UK 36%	0.6%

The use of natural mineral construction materials such as sand, gravel, and crushed rock aggregates constitutes the biggest raw material flow through the economy. The global supply of aggregates is estimated at around 4.2 billion tonnes.

- The most significant supply by volume is natural aggregates. Natural aggregates are mineral construction materials from naturally occurring deposits, which have been subjected to mechanical processing.
- Other types of aggregates are manufactured aggregates produced from wastes from other industries, and recycled aggregates produced from construction and demolition wastes.

Aggregate resources are plentiful throughout the EU and the world. Reserves are determined mostly by land uses, proximity to consumption centres, and local environmental concerns.

The construction sector relies upon the supply of aggregates, which represents the most considerable tonnage of material consumed by this sector. Aggregates may be used on their own in unbound condition as a structural material, e.g., road stone, armour stone, railway ballasts, or in bound condition with the addition of water, cement, bitumen or other binders to form construction products such as concrete, mortar, and asphalt.

The aggregates industry follows the macroeconomic cycles and reacts to the levels of activity in the construction sector. Sand and gravel consumption increased in 2021, following the economic growth in construction (both in public and private sectors). Long-term increase in demand is driven by both public and private construction sector as well as major global infrastructure improvement. (USGS, 2022).

In terms of volume, aggregates are the materials used the most by the construction sector and account for the most substantial amount of solid material extracted globally (UNEP, 2019).

International trade is limited as aggregates are mostly consumed regionally because of the high costs of transport. It is estimated that less than 5% of global aggregates production moves across borders, in particular to countries that have less geological availability of suitable materials for aggregates in combination with strong demand for large development projects (e.g., Singapore) (UNEP, 2019). Gasoline price increases are likely to shorten the supply radius to aggregates consumers but will not have a significant repercussion on the global supply (SCRREEN2 workshop, 2022).

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UNEP (2019) highlights the potential for sand and gravel shortages in some parts of the world and the consequences of unregulated extraction. (SCRREEN2 workshop, 2022). Land use competition is considered a bottleneck for aggregates supply in the EU. Also, social conflicts may cause market supply shortages at local level. The war in Ukraine is not expected to have a significant impact on the EU market since the aggregates market is mostly regional (SCRREEN2 workshop, 2022).

EU TRADE

For this assessment, Aggregates is evaluated at both extraction and processing stage.

Table 4. Relevant Eurostat CN trade codes for Aggregates

Mining		Processing/refining	
CN trade code	**title**	**CN trade code**	**title**
25171010	Pebbles and gravel	25171020	Broken or crushed dolomite and limestone flux, for concrete aggregates, for road metalling or for railway or other ballast
		25171080	Broken or crushed stone, for concrete aggregates, for road metalling or for railway or other ballast, whether or not heat-treated (excl. pebbles, gravel, flint and shingle, broken or crushed dolomite and limestone flux)
		25174900	Granules, chippings and powder, whether or not heat-treated, of travertine, ecaussine, alabaster, basalt, granite, sandstone, porphyry, syenite, lava, gneiss, trachyte and other rocks of heading 2515 and 2516 (excl. marble)
		25174100	Marble granules, chippings and powder

Imports are consistently more than the exports in case of pebbles and gravel in last 5 years. There has been a fall in 2019 with a steady decrease in overall trade. The gap between import and export has started to widen since 2015 and it appears that export volume is yet to recover from Covid slowdown.

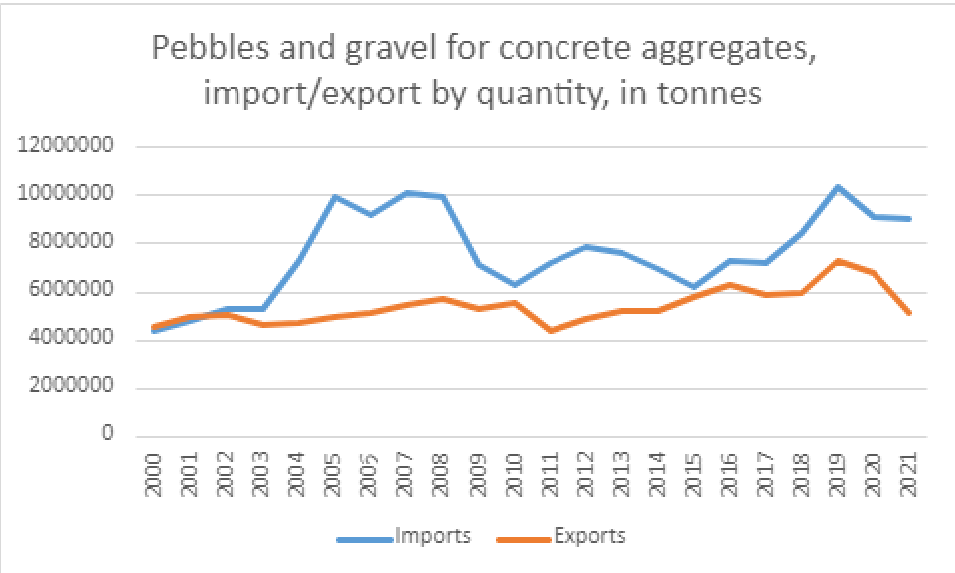

Figure 4. EU imports/exports of Pebbles and gravel (CN 25171010) from 2000 to 2021 (Eurostat, 2022)

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UK and Norway have been the major suppliers in the case of pebbles and gravel. However, contributions from Belarus have increased considerably over the past few years. Total import volume seems to have recovered and stabilised for the past year post-COVID fall in 2019.

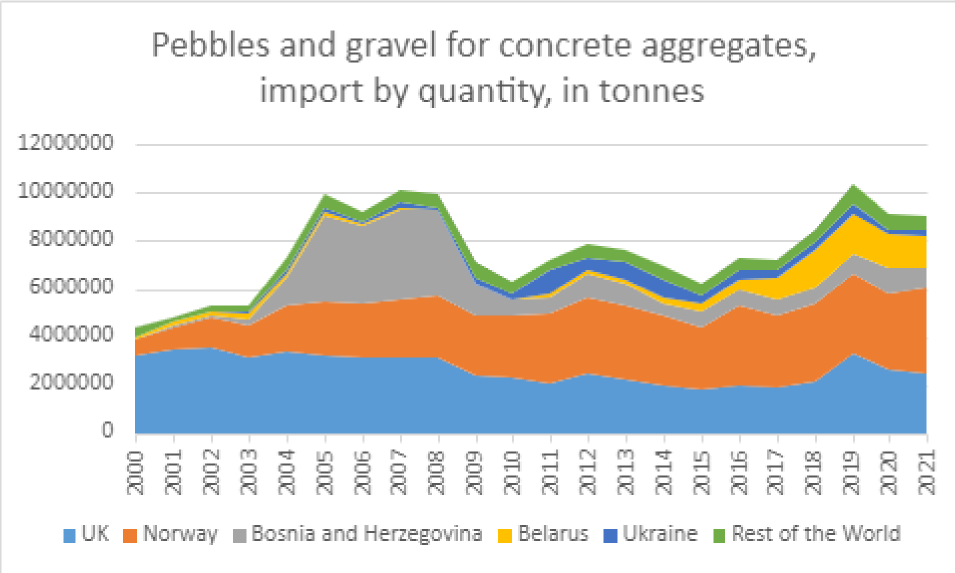

Figure 5. EU imports of Pebbles and gravel (CN 25171010) by country from 2000 to 2021 (Eurostat, 2022)

EU imports of broken and crushed dolomite and lime stone flux has been higher than the exports in past 5 years. There has been a fall in both import and export since last one year.

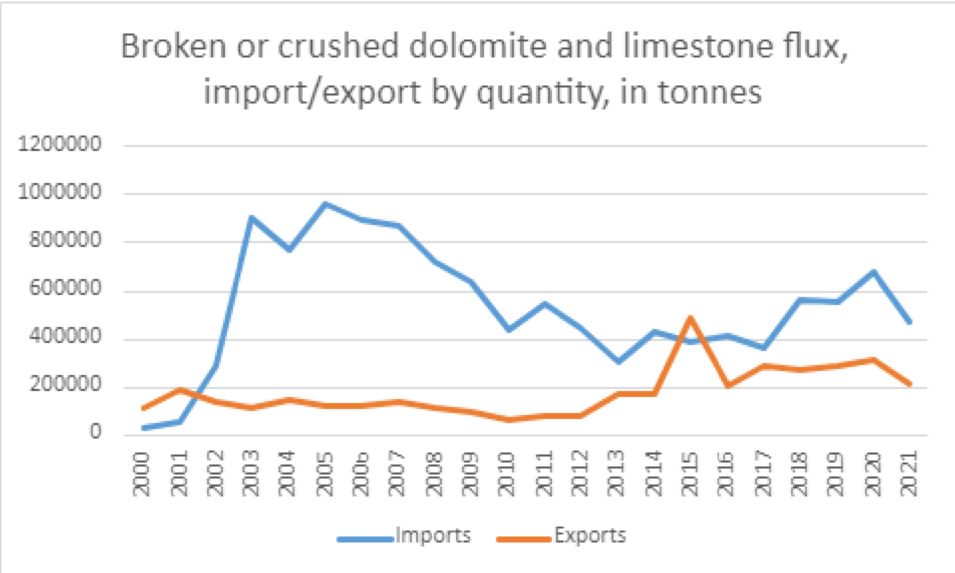

Figure 6. EU imports/exports of Broken or crushed dolomite and limestone flux (CN 25171020) from 2000 to 2021 (Eurostat, 2022)

Bosnia and Herzegovina is a consistent major supplier of broken or crushed dolomite and limestone flux for the EU. On the other hand, there has been a significant fall in contributions from Norway and UK since 2014.

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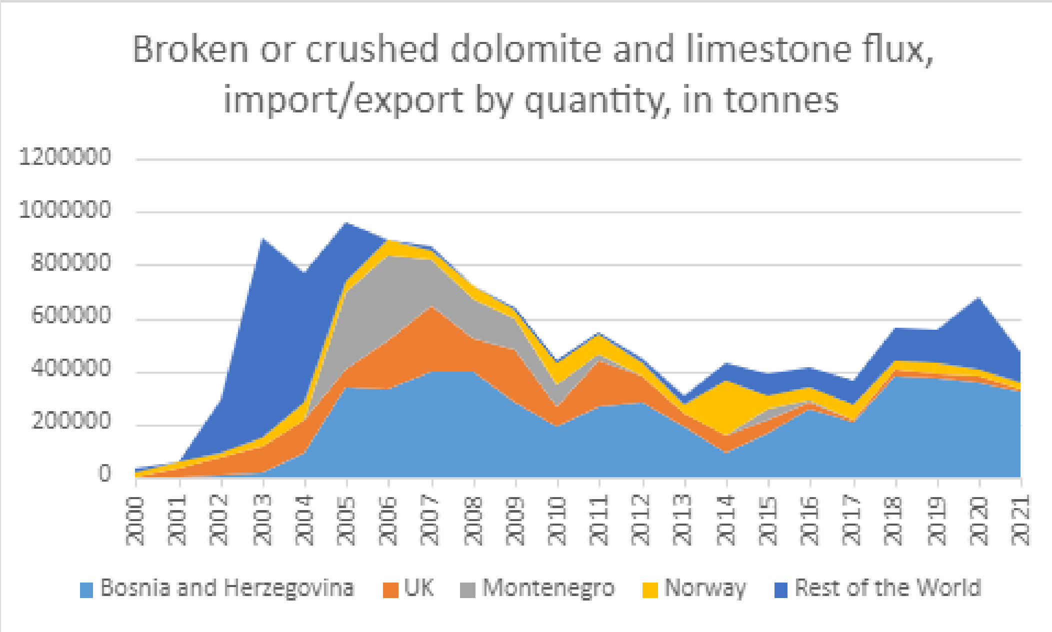

Figure 7. EU imports of Broken or crushed dolomite and limestone flux (CN 25171020) by country from 2000 to 2021 (Eurostat, 2022)

EU imports of broken or crushed stone for concrete aggregates has been significantly high throughout the last decade. However, there has been a slight increase in exports in 2020 combined with a fall in imports. The gap between imports and exports has been steadily increasing since 2013 but appears to have narrowed post-COVID since imports have continued to fall but exports have started to show growth.

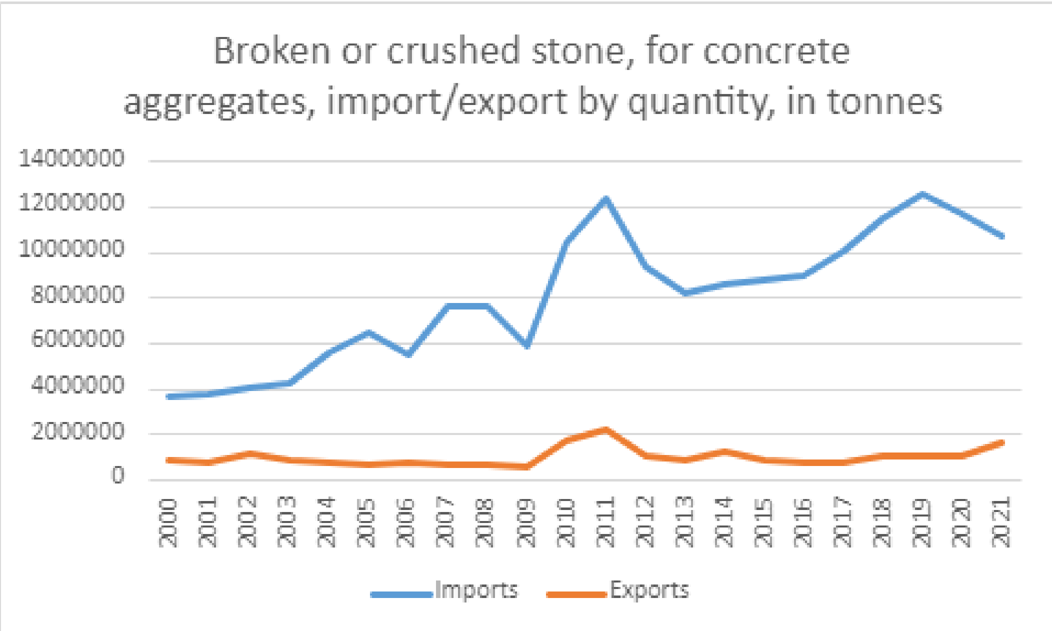

Figure 8. EU imports/exports of Broken or crushed stone (CN 25171080) from 2000 to 2021 (Eurostat, 2022)

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Norway and Switzerland continue being major suppliers of broken and crushed stone with little contribution from the rest of the world. A general decrease in supply is seen since 2019 from all sources.

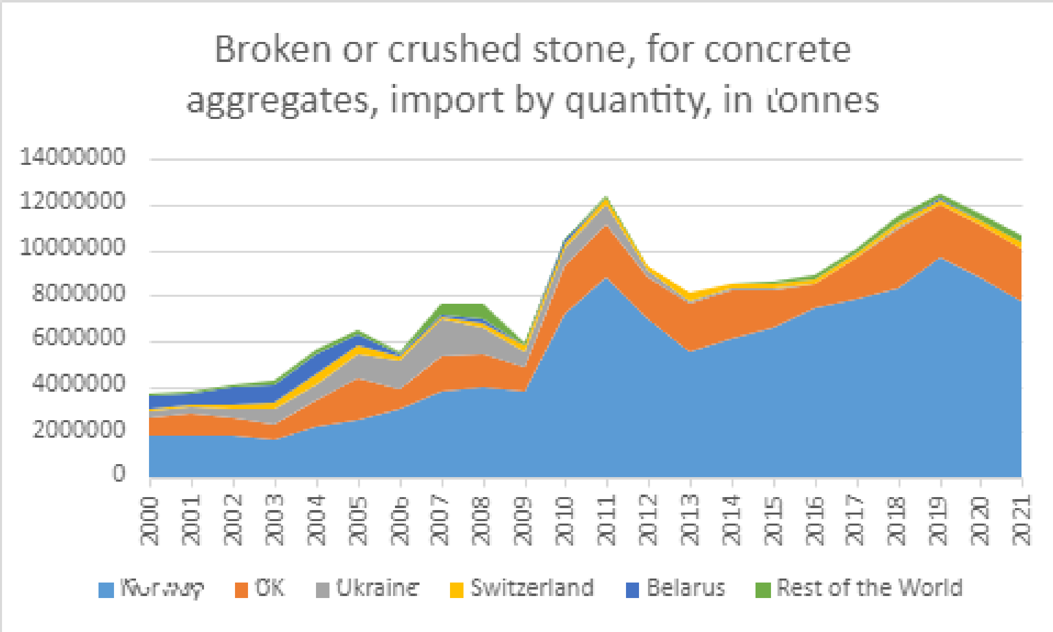

Figure 9. EU imports of Broken or crushed stone (CN 25171080) by country from 2000 to 2021 (Eurostat, 2022)

EU imports of marble granules, chipping and powder in considerably high throughout compared to the exports. In year 2018, there has been gradual fall in overall trade reviving finally in 2020.

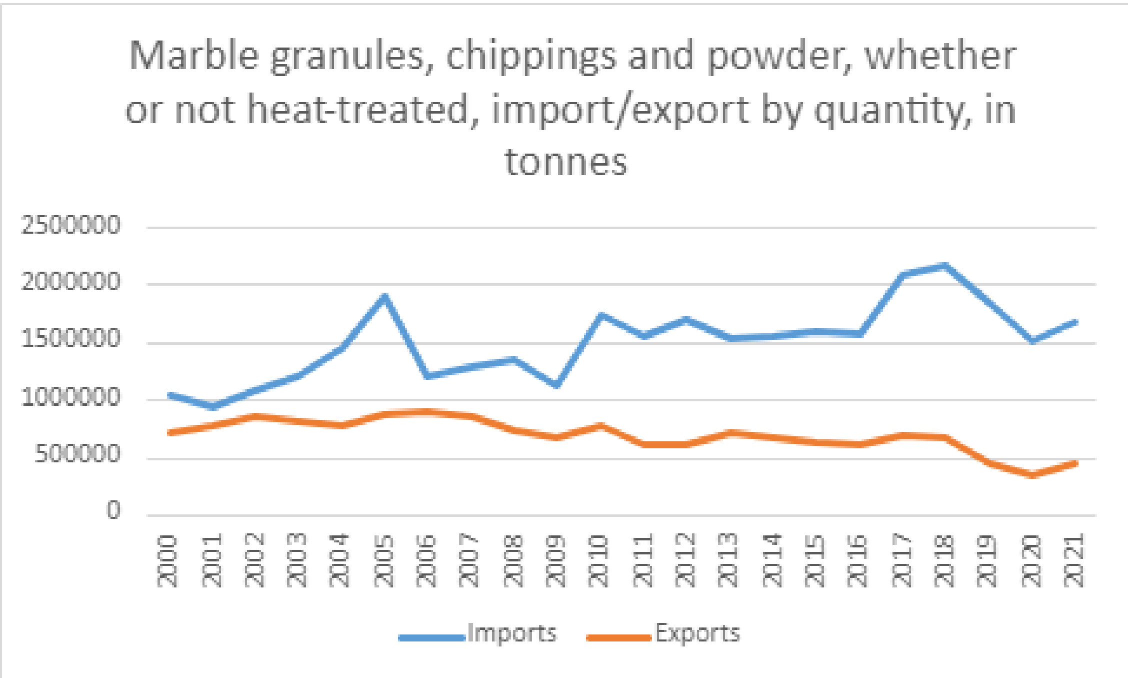

Figure 10. EU imports/exports of Marble granules, chippings and powder (CN 25174100) from 2000 to 2021 (Eurostat, 2022)

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Norway has been the largest supplier for marble granules, chipping and powder with a certain amount of contributions from Turkey as well. There is a gradual decrease in supply since 2018 from both these countries followed by a rise last year.

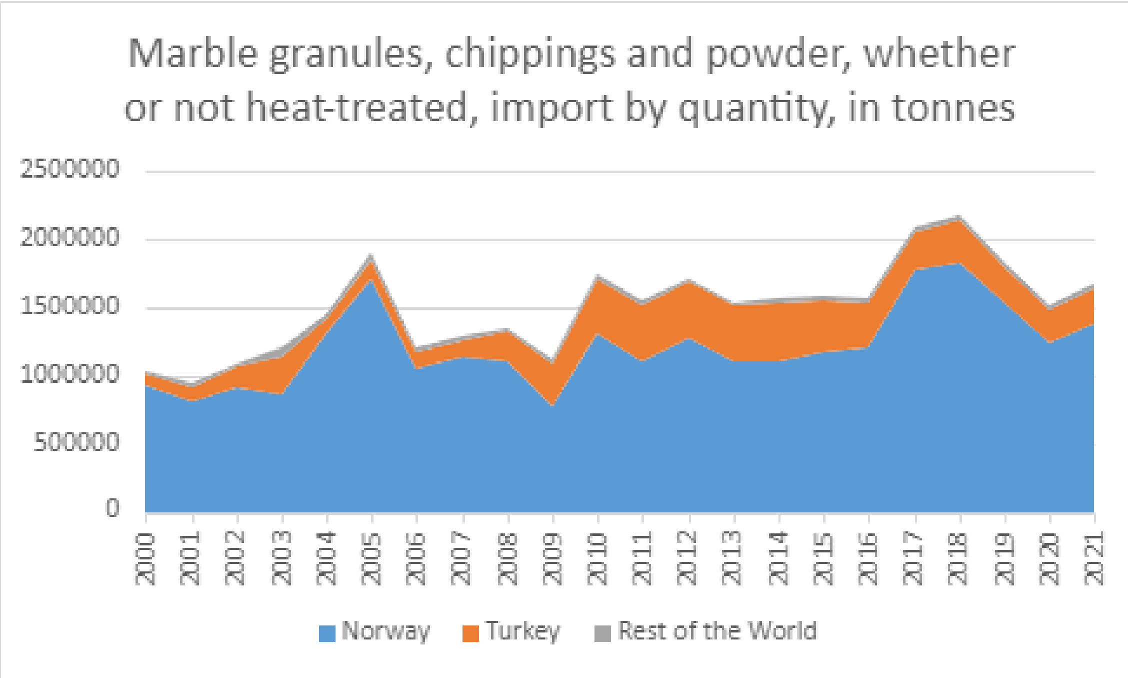

Figure 11. EU imports of Marble granules, chippings and powder (CN 25174100) by country from 2000 to 2021 (Eurostat, 2022)

EU27 is also an importer of granules, chippings and powders (CN 25174900) almost exclusively from Norway and UK. Until 2011 the total imports were around 8 billion tonnes but they decreased to 5 billion tonnes after 2011

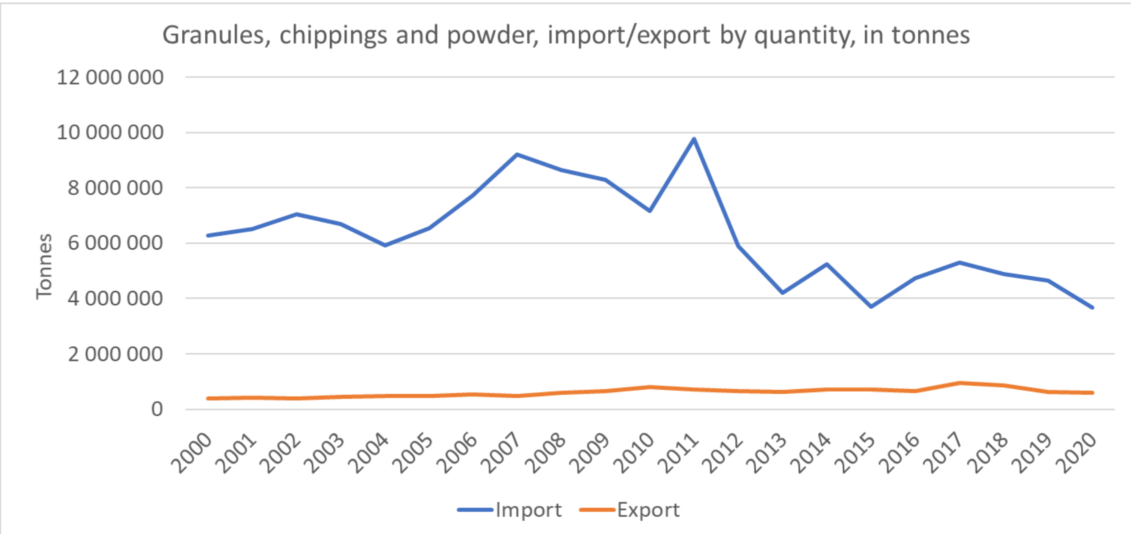

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Figure 12. EU imports/exports of Granules, chippings and powder, whether or not heat-treated, of travertine, ecaussine, alabaster, basalt, granite, sandstone, porphyry, syenite, lava, gneiss, trachyte and other rocks of heading 2515 and 2516 (excl. marble) (CN 25174900) from 2000 to 2021 (Eurostat, 2022)

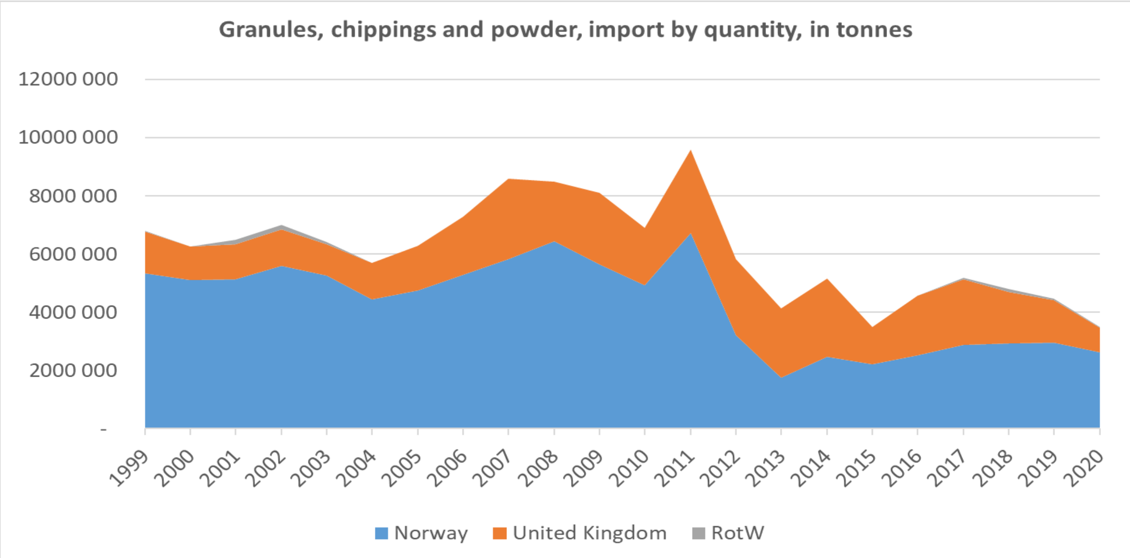

Figure 13. EU imports of Granules, chippings and powder, whether or not heat-treated, of travertine, ecaussine, alabaster, basalt, granite, sandstone, porphyry, syenite, lava, gneiss, trachyte and other rocks of heading 2515 and 2516 (excl. marble) (CN 25174900) by country from 2000 to 2021 (Eurostat, 2022)

PRICE AND PRICE VOLATILITY

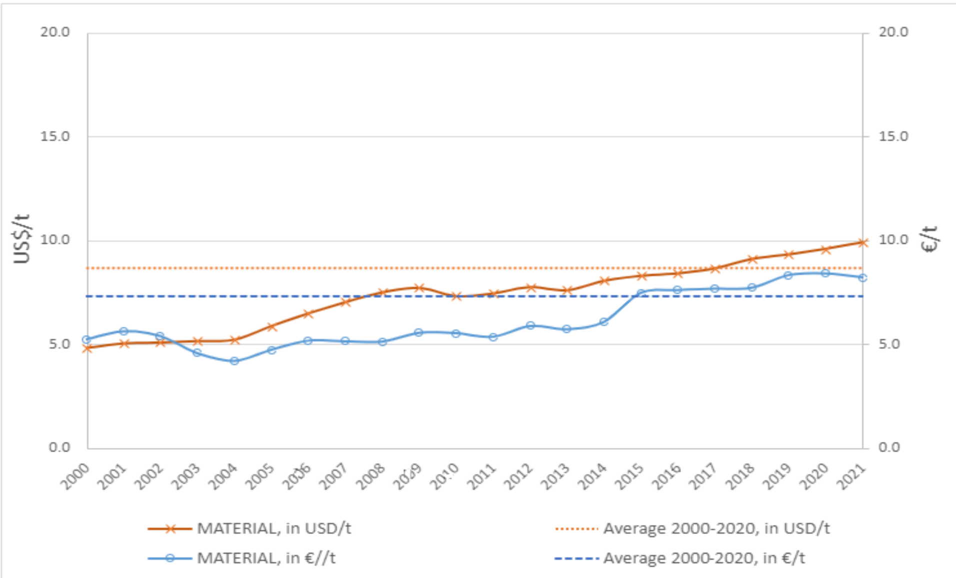

Figure 11. Annual average price of Aggregates (Sand and gravel) between 2000 and 2021, in US$/t and €/t[3]. Dash lines indicate average price for 2000-2021 (USGS, 2022)

[3] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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DEMAND

GLOBAL AND EU DEMAND AND CONSUMPTION

The use of mineral construction materials constitutes the largest raw material flow in the EU economy (European Commission 2018b). Aggregates EU consumption is assessed at extraction stage.

Aggregates extraction stage EU consumption is presented by HS codes CN 25171010 Pebbles and gravel for concrete aggregates, for road metalling or for railway or other ballast, shingle and flint, whether or not heat-treated, CN 25171020 Broken or crushed dolomite and limestone flux, for concrete aggregates, for road metalling or for railway or other ballast, CN 25171080 Broken or crushed stone, for concrete aggregates, for road metalling or for railway or other ballast, whether or not heat-treated (excl. pebbles, gravel, flint and shingle, broken or crushed dolomite and limestone flux), CN 25174900 Granules, chippings and powder, whether or not heat-treated, of travertine, ecaussine, alabaster, basalt, granite, sandstone, porphyry, syenite, lava, gneiss, trachyte and other rocks of heading 2515 and 2516 (excl. marble) and CN 25174100 Marble granules, chippings and powder, whether or not heat-treated. Import and export data is extracted from Eurostat Comext (2022). Production data is extracted from UEPG (2002-2021).

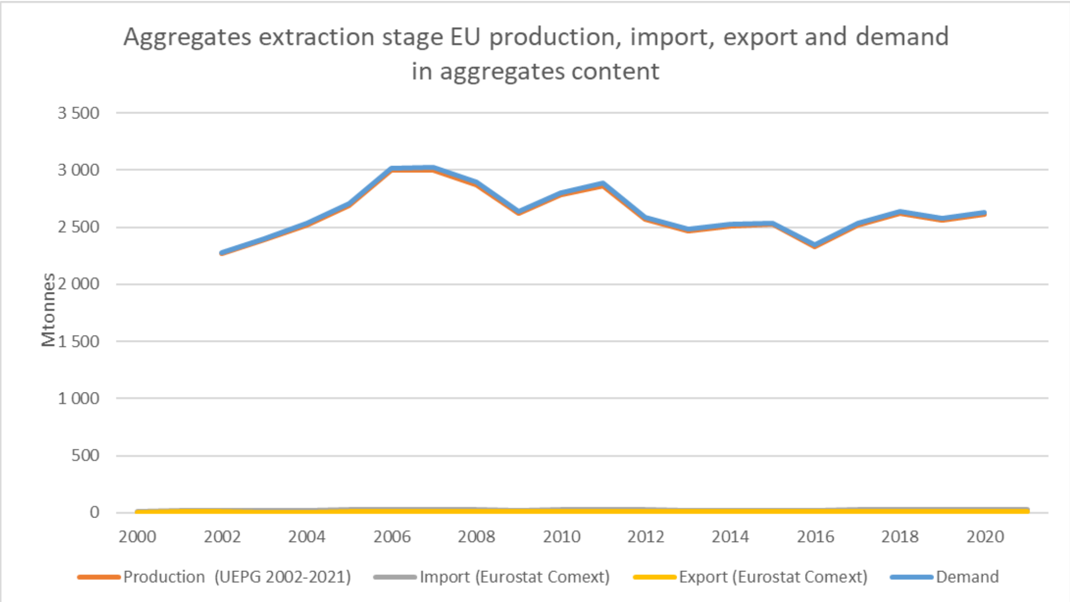

Figure 14. Aggregates (CN 25171010, CN 25171020, CN 25171080, CN 25174900, CN 25174100) extraction stage apparent EU consumption. Production data is available from UEPG (2002-2021). Consumption is calculated in aggregates content (EU production+import-export).

Average import reliance of aggregates at extraction stage is 0.6 % for 2016-2020.

GLOBAL AND EU USES AND END-USES

The use of aggregates takes place entirely in construction related activities (UEPG, 2021).

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According to data provided by (BIO Intelligence Service, 2015) and (UEPG, 2018), in the EU 40% of the aggregates are directly used in construction works as structural (unbound) materials, 45% are used in concrete manufacture, 10% in asphalt products, and 5% in other products (railway ballast and armour stone).

With respect to the end-use construction sub-sector, aggregates and construction products containing aggregates are used in residential and social buildings (45%); commercial and public buildings (20%); commercial buildings (20%); construction and infrastructure (15%); roads, runaways and railways (10%); coastal protection and landscape design (5%); and 'others' (sport, leisure, etc): 5% (UEPG, 2021).

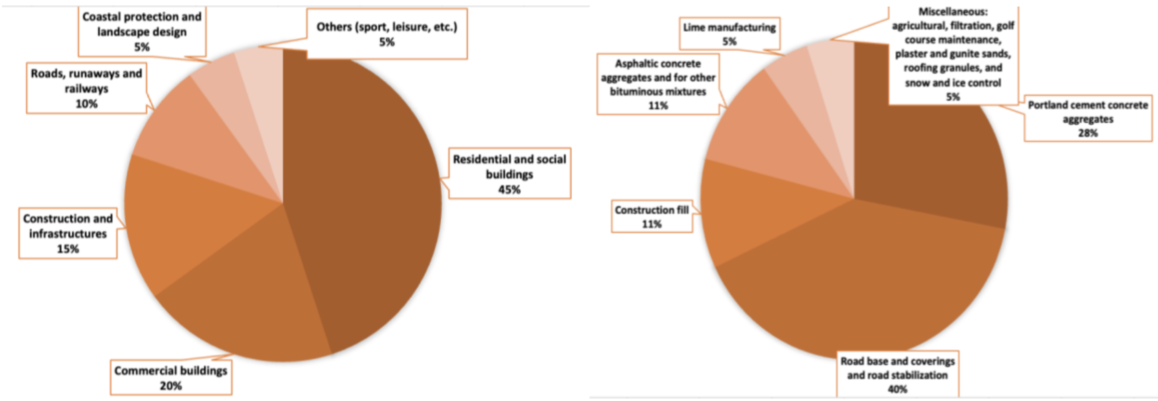

Figure 15: Left: EU27 applications of aggregates (UEPG. 2021) Right: Illustrative US applications of aggregates (USGS, 2022).

Relevant industry sectors are described using the NACE sector codes as listed in Table 1

Table 5: Aggregates applications, 2-digit and examples of associated 4-digit NACE sectors, and value-added per sector for 2019) (Eurostat, 2021).

Applications	2-digit NACE sector	Value added of NACE 2 sector (M€) - 2019	4-digit CPA
Construction	C23 - Manufacture of other non-metallic mineral products	72,396	C2363 - Manufacture of ready-mixed concrete

APPLICATIONS OF AGGREGATES

Aggregates are essential raw materials used in the built environment, including a wide range of applications including residential and commercial buildings, public infrastructure projects, and other types of construction.

They can be used directly (without binders) in road construction and civil engineering for numerous applications, including roadbed layers, macadam construction, constructional fill in engineering structures, armour stone, railway ballast, filter stone etc.

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Aggregates are also used in bound condition after mixing with a binding material such as cement, lime, gypsum or bituminous pitch for the manufacture of ready-mixed and precast concrete, asphalt, mortar, and other products for a variety of applications in buildings and infrastructure works. For example, aggregates are mixed with cement and water in standardised volumetric proportions to produce various concrete grades; aggregates may comprise up to 80% in mass of the concrete mix (PCA 2019) (UEPG 2019a).

The type of aggregate used in construction involves specific properties, and different types of aggregates may be fit for one end-use but not for another.

The suitability of a specific aggregate for one construction application depends principally on its physical and mechanical properties, although in some applications mineralogical or chemical properties are also important.

Demanding applications such as concrete manufacture and road construction require the most stringent technical specifications. For general-purpose applications, an aggregate of high strength and durability with low porosity is generally suitable. Lower quality aggregates may be acceptable for applications of low intensity of use, e.g., constructional fill (BGS 2013).

The European Standards developed by the Technical Committee CEN/TC 154 specify aggregate performance requirements, sampling and methods of test. e.g., the European standard EN 12620:2002+A1:2008 'Aggregates for concrete' (CEN, 2008). Specifications for products cover aggregates obtained by processing natural, manufactured, or recycled materials and mixtures of these aggregates for different end-use products, in respect of particle shape and size distribution, particle density and water absorption, resistance to fragmentation, wear, impact, abrasion and polishing and other factors.

SUBSTITUTION

The substitutability of aggregates is summarised in Table 6. There is no substitute for aggregates

Table 6: Substitution options for aggregates by application.

Use	Percentage*	Substitutes	Sub share	Cost	Performance
Residential and social buildings	45%	No substitutes			
Commercial buildings	20%	No substitutes			
Construction and infrastructures	15%	No substitutes			
Roads, runaways and railways	10%	No substitutes			
Coastal protection and landscape design	5%	No substitutes			

*Estimated end use shares of aggregates based on agreed outputs of SCRREEN Experts Validation Workshop (2022). Substitute ratings based on agreed outputs of SCRREEN Experts Validation Workshop (Dondi,M 2022).

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SUPPLY

EU SUPPLY CHAIN

The flows of aggregates through the EU economy in 2012 are shown in Figure 16.

Aggregates are materials that are used directly in the construction sectors. The average annual EU aggregates' consumption in period 2016-2020 was 5075 Mt. Most of the internal demand is covered by domestic production (5048 Mt). The aggregates industry is characterised by thousands of operations serving local or regional markets. A network of local quarries allows achieving relatively short distribution distances. Main EU producers of aggregates are Austria, France, Germany, Italy, Poland, Spain and Sweden. It is estimated, that 9.3 % of aggregates were recycled in 2019.

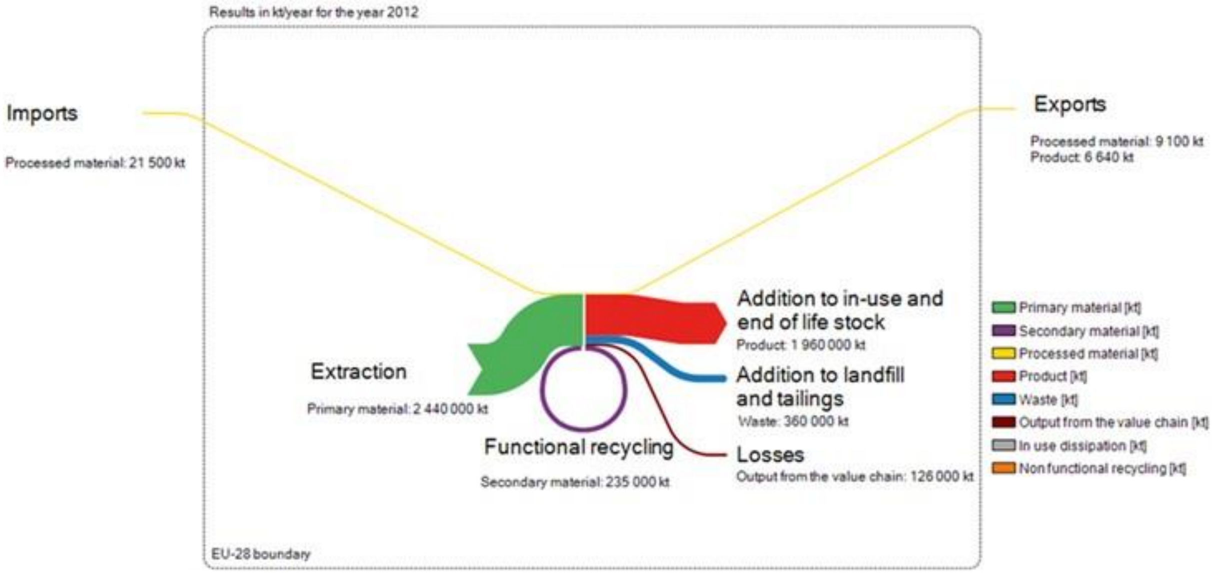

Figure 16: Simplified MSA of aggregates' flows in the EU (BIO Intelligence Service 2015).

Import and export of aggregates are almost negligible and reaches only 0.8 % (40 Mt) and 0.2 % (13 Mt) share respectively. Main importers of aggregates are, due to the transport costs, neighbouring countries of EU such as Belarus, Norway, Serbia, Switzerland, Turkey and the United Kingdom. Similar situation is with export where the main trade partners are Gibraltar, Moldova, Russia, Switzerland, Ukraine, and the United Kingdom.

According to data reported by the European Aggregates Association (2022), in 2019 the aggregates industry in EU comprised 13,505 companies (mostly SMEs) which operated 23,284 extraction sites across the EU (Figure 17). The aggregates sector is by far the largest amongst the non-energy extractive industries in the EU (UEPG 2018) and the total volume of aggregates extraction exceeds the total volume of all other minerals produced in the EU (BGS 2019a).

Aggregates are not traded in processed form.

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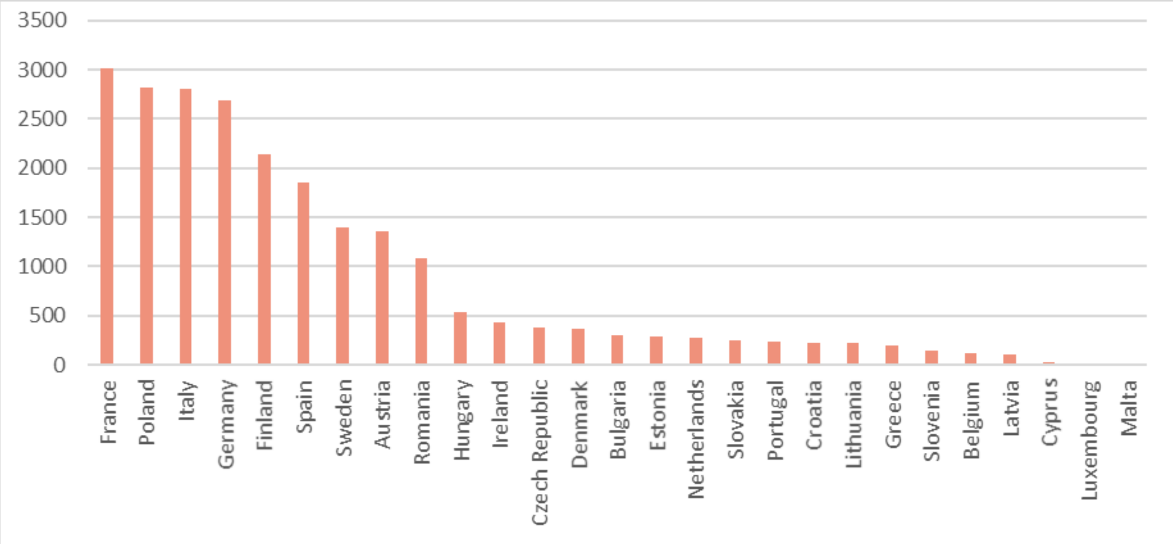

Figure 17: Number of extraction sites in the EU in 2019 (UEPG 2022)

Table 7. Relevant Eurostat PRODCOM production codes for aggregates

Mining		Processing/refining	
Prodcom code	**title**	**Prodcom code**	**title**
08.11.30.30	Dolomite, crude, roughly trimmed or merely cut into rectangular or square blocks or slabs (excluding calcined or sintered dolomite, agglomerated dolomite and broken or crushed dolomite for concrete aggregates, road metalling or railway or other ballast).	**23.99.13.20**	Pre-coated aggregates
08.12.12.10	Gravel and pebbles of a kind used for concrete aggregates, for road metalling or for railway or other ballast; shingle and flint.		
08.12.12.40	Other broken or crushed stone, of a kind commonly used for concrete aggregates, for road metalling or for railway or other ballast (excluding pebbles, gravel, shingle, flint, limestone, dolomite and other calcareous stone)		

SUPPLY FROM PRIMARY MATERIALS

GEOLOGY, RESOURCES AND RESERVES OF AGGREGATES

GEOLOGY

Natural aggregates are extracted from hard rock formations and deposits of sand and gravel (LafargeHolcim, 2019), and in some countries by sea-dredging as marine aggregates (UEPG, 2019b). The resources of natural aggregates are among the most abundant and widely distributed in the earth's crust, occurring in a variety of geologic environments.

Most hard rocks are potentially suitable for crushed rock aggregates. The typical rock types quarried are the hard, dense and cemented sedimentary rocks (limestone, dolomite and certain sandstones), as well as the tougher, crystalline igneous rocks (e.g. granite, diorite, basalt, diabase, andesite) (BGS, 2013).

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Sand & gravel deposits are accumulations of unconsolidated granular materials resulting from rock erosion and weathering. Sand & gravel are sourced from fluvial, glaciofluvial, glacial, marine, eolian and lake sediments (Pfleiderer, 2017). The main onshore deposit types are the near-surface fluvial (river) and the glaciofluvial sediments. Sand to gravel ratios are variable, but river deposits typically have lower fines content (silt and clay) than glacial deposits. Glaciofluvial deposits are generally thicker, but the overburden thickness can also be high (BGS 2013). Marine deposits of sand & gravel occur as small patches separated or covered by extensive areas of uneconomic deposits of gravel-bearing sediments. They vary in their thickness, composition and particle size, and their proximity to the shore. Their formation is substantially similar to those on land, but became submerged due to sea-level rise after the most recent glacial period and subsequently re-worked by tidal currents (BGS, 2013)

GLOBAL RESOURCES AND RESERVES:

Natural aggregates resources are abundant all over the world. Reserves of crushed rock and sand & gravel are assessed as adequate, except in cases in which extraction and extraction economics are controlled by factors such as environmental regulations, land use, geographic distribution and quality requirements for specific uses (USGS, 2019). The economic viability of a deposit is also determined by the thickness of the geologic overburden, and the thickness of the deposit of a particular quality, e.g. fines content (BGS, 2013). As a general rule, resources and reserves data are not reported internationally (Cao et al., 2018), neither at a company level (SCRREEN workshops, 2019).

EU RESOURCES AND RESERVES[4]

Deposits of suitable quality for natural aggregates production are plentiful in most parts of Europe. Available data on aggregates reserves and resources in EU are listed in Tables 2-5. However, access restrictions at the local level are considered as the major issue that may constrain aggregates supply (UEPG, 2017- 2018).

Despite the information gaps and classification discrepancies, (Velegrakis et al. 2010) provides an overview of the proven recoverable marine aggregate reserves in some EU Member states. Marine sand reserves in Denmark have been estimated to be significant (in the order of several billion m^3), but coarse sand/gravel resources are somewhat limited in the North Sea. The German recoverable marine aggregate reserves of the Baltic Sea are limited (of the order of 40-50 million m^3), whereas the Polish reserves have been estimated to be close to a 100 million m^3.

[4] For Europe, there is no complete and harmonised dataset that presents total EU resource and reserve estimates for aggregates. The EGDI and Minerals4EU project are the only EU-level repositories of some mineral resource and reserve data for aggregates, but this information does not provide a complete picture for Europe. It includes estimates based on a variety of reporting codes used by different countries, and different types of non-comparable datasets (e.g. historical estimates, inferred reserves figures only, etc.). In addition, translations of Minerals4EU data by application of the CRIRSCO template is not always possible, meaning that not all resource and reserve data for aggregates the national/regional level is consistent with the United Nations Framework Classification (UNFC) system (Minerals4EU, 2019). Many documented resources in Europe are based on historic estimates and are of little current economic interest. Data for these may not always be presentable in accordance with the UNFC system. However, a very solid estimation can be done by experts

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Table 8: Aggregates reserves in EU according to the EGDI portal – data collected in the frame of Mintell4EU project (EGDI, 2022)

Country	Year	Commodity	Quantity	Reporting code	Reserve/ Resource Type
Czech Republic	2019	Crushed rock	747 Mm^3	National reporting code	
Spain	2019	Crushed rock	6.1 Gt	National reporting code	Historic reserve estimate

Table 9: Aggregates resources in EU according to the EGDI portal – data collected in the frame of Mintell4EU project (EGDI, 2022)

Country	Year	Commodity	Quantity	Reporting code	Reserve/ Resource Type
Czech Republic	2019	Crushed rock	> 228 Mm^3	National reporting code	Historic resource estimate
Hungary	2019	Crushed rocks Andesite Granite, syenite Sandstone Gravel	874 Mm^3 609 Mm^3 32 Mm^3 34 Mm^3 > 451 Mm^3	Russian (NAEN) Code	A+B+C1+C2

Table 10: Resources of aggregates (crushed rock) in the EU in 2013. (Minerals4EU, 2019)

Country	Sub-commodity	Classification	Quantity	Unit	Reporting Code
Finland	Crushed rock	not specified	18,314	Mm^3	None
Estonia	Dolomite	Measured+Indicated	368	Mm^3	National reporting code
	Limestone	Measured+Indicated	964	Mm^3	
Latvia	Dolomite	Explored deposits	188	Mm^3	National reporting code
		Evaluated deposits	485	Mm^3	
Lithuania	Dolomite	Measured (explored in detail)- code 111, 121, 211, 221, 334	115	Mm^3	National reporting code
		Indicated (preliminary explored)- code 122, 335	120	Mm^3	
		Inferred (prognostic) - code 333, 337	300	Mm^3	
	Limestone	Measured (explored in detail)- code 111, 121, 211, 221, 335	211	Mm^3	
		Indicated (preliminary explored)- code 122, 336	343	Mm^3	
		Inferred (prognostic) - code 333, 338	915	Mm^3	
Poland	Dolomite	Poland (A+B+C1)	259	Mt	National reporting code
		Poland (C2 + D)	75	Mt	
		Poland - total	335	Mt	
Czechia	Crushed stone	Potentially economic	227,685	km^3	National reporting code
		P1	61,357	km^3	
		P2	408,807	km^3	
		P3	ZERO	km^3	
	Dolomite	Potentially economic	12,212	kt	
		P1	23,946	kt	
		P2	ZERO	kt	
		P3	ZERO	kt	
	Limestone	Potentially economic	744,752	kt	
		P1	82,489	kt	
		P2	350,957	kt	
		P3	ZERO	kt	
Slovakia	Crushed rock (economic)	verified (Z1)	128	Mm^3	National Reporting code
		probable (Z2)	401	Mm^3	
		anticipated (Z3)	249	Mm^3	

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Country	Sub-commodity	Classification	Quantity	Unit	Reporting Code
	Crushed rock (non- reserved)	not specified	753	Mm³	
	Crushed rock (subeconomic)	not specified	7	Mm³	
	Dolomite (economic)	verified (Z1)	75	Mt	
		probable (Z2)	167	Mt	
		anticipated (Z3)	442	Mt	
	Dolomite (subeconomic)	not specified	9	Mt	
	Limestone (economic)	verified (Z1)	198	Mt	
		probable (Z2)	605	Mt	
		anticipated (Z3)	1313	Mt	
	Limestone (subeconomic)	not specified	41	Mt	
Hungary	Crushed stone	(RUS) A+B	99	Mm³	Russian Classification
		(RUS) C1	438	Mm³	
		(RUS) C2	565	Mm³	
Slovenia	Dolomite	National	38	Mt	National reporting code
	Limestone	National	79	Mt	
Greece	Aggregates		unlimited		None
Cyprus	Rocks for aggregates	known	136	Mt	None
	Rocks for armourstone	estimated	27	Mt	
Spain	Crushed rock		unlimited		None

Table 11: Resources of aggregates (sand & gravel) in the EU data in 2013. (Minerals4EU, 2019)

Country	Sub-commodity	Classification	Quantity	Units	Reporting Code
Finland	Sand & gravel	not specified	46,861	Mm³	None
Estonia	Gravel	Measured+Indicated	150	Mm³	National reporting code
	Sand	Measured+Indicated	945	Mm³	
Latvia	Sand	Explored deposits	365	t	National reporting code
		Evaluated deposits	797	t	
	Sand & gravel	Explored deposits	381	Mm³	
		Evaluated deposits	708	Mm³	
Lithuania	Gravel	Measured (explored in detail)- code 111, 121, 211, 221, 331	650	Mm³	National Reporting code
		Indicated (preliminary explored)- code 122, 332	679	Mm³	
		Inferred (prognostic) - code 333, 334	2,146	Mm³	
	Sand	Measured (explored in detail)- code 111, 121, 211, 221, 332	293	Mm³	
		Indicated (preliminary explored)- code 122, 333	286	Mm³	
		Inferred (prognostic) - code 333, 335	919	Mm³	
Denmark	Marine Sand, gravel, rubble and stone	Not specified	14,000	Mm³	None
Poland	Sand & gravel	Poland (A+B+C1)	10,005	Mt	National reporting code
		Poland (C2 + D)	7,967	Mt	
		Poland - total	17,973	Mt	
Czechia	Sand & gravel	Potentially economic	461,808	km³	National reporting code
		P1	149,027	km³	
		P2	946,239	km³	
		P3	ZERO	km³	
Slovakia	Sand & gravel (economic)	verified (Z1)	83	Mm³	None
	Sand & gravel (economic)	probable (Z2)	67	Mm³	
	Sand & gravel (economic)	anticipated (Z3)	5	Mm³	
	Sand & gravel (non-reserved)	not specified	352	Mm³	

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Country	Sub-commodity	Classification	Quantity	Units	Reporting Code
	Sand & gravel (sub-economic)	not specified	5	Mm^3	
Austria	Sand & gravel	None	19,677	Mm^3	None
Hungary	Gravel	(RUS) A+B	925	Mm^3	Russian Classification
		(RUS) C1	4,071	Mm^3	
		(RUS) C2	2,203	Mm^3	
Slovenia	Sand & gravel	National	23	Mt	National
Romania	Sand & gravel	(UNFC) 333	1,250	Mt	UNFC
Spain	Sand & gravel		Unlimited		None

GLOBAL AND EU MINE PRODUCTION

Sand and gravel are mined worldwide and account for the most significant volume of solid material extracted globally. However, there is no global monitoring or reporting for aggregates production. A recent report by UN Environment estimates total extraction from quarries, pits, rivers, coastlines and the marine environment at 40,000 to 50,000 Mt per year (UNEP, 2019). The construction industry consumes over half for concrete, i.e. 25,009 to 29,600 Mt in 2012, estimated indirectly through the global production of cement for concrete (UNEP, 2014). In total, China, India and Asia represent 67% of global aggregates production (UNEP, 2019).

According to the UEPG (2022) the annual production of natural aggregates in the EU in 2019 was 2,554 Mt (compared to 4.2 billion tonnes at the world level), of which 1,082 Mt consisted of crushed rock, 1,164 Mt of sand and gravel and 43,6 Mt of marine aggregates. Germany is the leading EU producer by volume, followed by France, Poland and Italy. Production of aggregates in EU is relatively stable over the past 10 years as it seen on Figure 3 (UEPG 2012-2022). However there was a notable decrease of their production between 2012 and 2016 as a consequence of crisis in mining and construction sector.

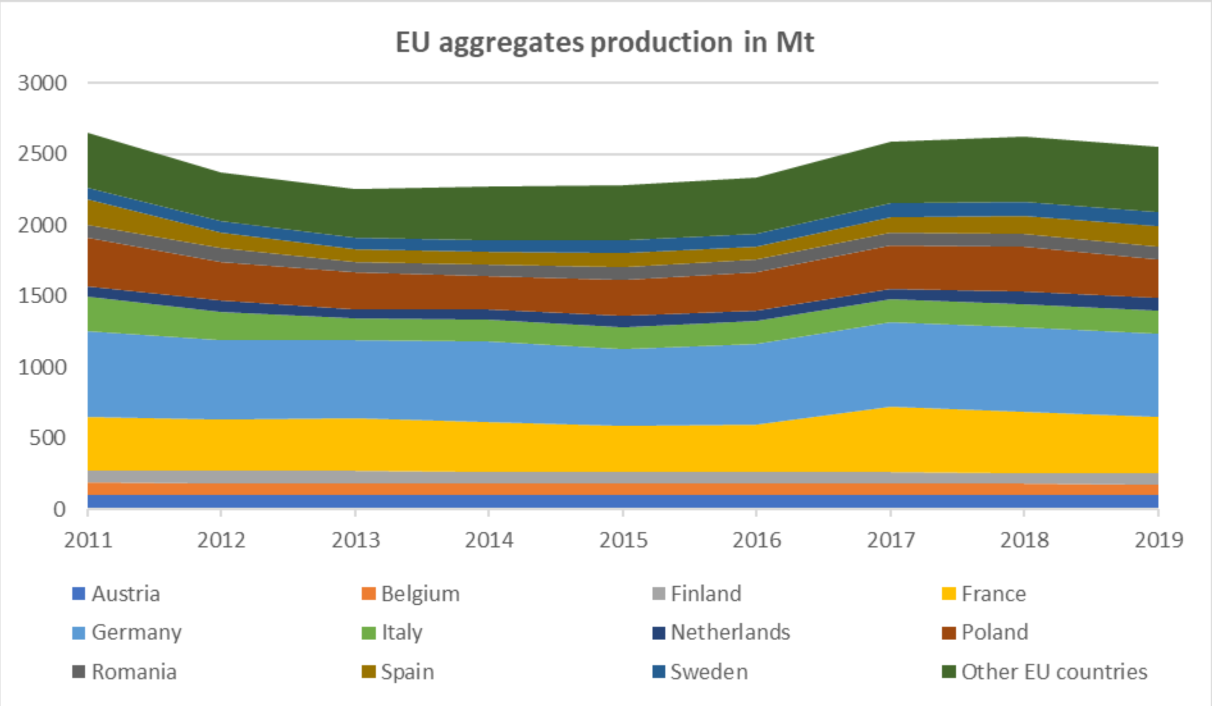

Figure 18: EU aggregates production in Mt in period 2011-2019 (UEPG 2012-2022)

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OUTLOOK FOR SUPPLY

It is expected that urbanization processes in EU and worldwide will increase demand for aggregates (Fortune Business Insights, 2021). However, no shortcomings in supply for those needs are expected since aggregates have almost unlimited resources also within the EU. The constraining factors that can limit their availability or extraction are environmental restrictions (dust emissions, wastewater generation, vulnerability of underground water bodies etc. or conflicts with other land and subsurface uses.

PROCESSING

Crushed rock is extracted in surface quarries. Overburden is removed by a combination of hydraulic excavators, ripping and blasting to be used for restoration and landscaping. Blasting is the commonly applied technique to release the required rock from the operating quarry face, which is normally developed in distinct benches. After any subsequent breaking of larger rock blocks by mobile machinery like hydraulic breakers, the extracted rock is transported by haul trucks to the crushing plant or a mobile crusher on the quarry floor (BGS, 2013).

Sand & gravel are extracted from fluvial deposits by open-pit mechanical excavation, from lakes and rivers by dredging or pumping, from coastal beaches, or from the sea bed by dredging (marine aggregates) (BGS, 2013; UNEP, 2019).

The extracted materials are then processed into final products by a multi-stage operation that may involve successive stages of crushing and screening to reduce the raw material to the required size and shape and segregate particle sizes. Washing is included in the process when required to remove harmful materials such as clay and silt (Garbarino et al. 2018; LafargeHolcim 2019).

SUPPLY FROM SECONDARY MATERIALS/RECYCLING

Recycled aggregates from construction and demolition waste (C&DW) are an important source of aggregate supply. Concrete, bricks, tiles and asphalt are the most commonly recycled C&D waste materials. Recycling reduces natural aggregates resource depletion and landfilling of waste.

Concrete, the most used material in buildings, is often recycled at its end of life at demolition or construction sites close to urban areas. Unless transported in large volumes by rail or waterway, transportation in long distances (usually maximum 35 km) is not economically attractive. Environmental benefits of recycling diminish over longer distances as well (CSI, 2009; Ecorys, 2016). Concrete from C&D waste can be reprocessed into coarse or fine aggregates after impurities removal (e.g. insulation, steel reinforcement, wood, joint sealants and plastics) before crushing and grading. An effective sorting out at the construction site or the treatment facility is essential to enlarge the recycling potential. Processing by mobile sorters and crushers often takes place at the demolition or construction sites. Coarse aggregates are used in various civil engineering applications and as backfilling material in quarries, but mostly in road construction for the sub-base and base layers. Recycled aggregates from C&D concrete often have better compaction properties and require less cement for sub-base uses. Fine aggregates obtained from crushed concrete waste can be used in

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place of natural sand in mortars and, in case of appropriate quality, may substitute a portion (up to 20 %) of natural aggregates in new concrete (CSI, 2009; Bio Intelligence Service, 2011; SCRREEN workshop, 2019).

Economic and quality limitations of recycling are recognised for mixed C&D waste consisting of bricks, concrete, ceramics, etc., contaminated with wood, plastic, metals and other materials (SCRREEN workshops, 2019). Crushed bricks, tiles and ceramics from C&D waste are recycled as a substitute of natural aggregates in certain less demanding end uses, such as constructional fill and in road sub-base (Bio Intelligence Service, 2011).

Reclaimed asphalt is recycled by adding to new asphalt mixes, with the aggregates and the old bitumen performing the same function as in their original application. The recycling processes involve hot or cold mix techniques that may take place offsite or in-situ by direct incorporation into the new asphalt pavement. Screening and crushing of the reclaimed asphalt may be necessary.

Due to the massive amounts of waste generated, C&DW has been identified as a priority waste stream for reuse and recycling (European Commission 2015). The EU Waste Framework Directive (Directive 2008/98/EC) stimulates recycling by requiring the Member States to take the necessary measures to achieve a minimum recovery target of 70% by weight (re-use, recycling and other material recovery, including backfilling) of non-hazardous construction and demolition waste by 2020.

According to production data published by the European Aggregates Association, the average annual production of recycled aggregates from C&DW (including those reused on-site) is 208 Mt for 2019 period (UEPG, 2022); from these data the end-of-life recycling input rate (EOL-RIR) is estimated at 9 %. Even with full recycling of all generated quantities of C&DW as they are officially reported by Eurostat waste management statistics (Eurostat, 2019d), up to 12% of the current total demand of aggregates could be covered by recycled aggregates. In practice, this means that the extraction of natural aggregates will continue to supply the most substantial part of market needs.

Also, industrial by-products such as iron and steel slags, coal-fired power station ash, china clay residues, fly ash leftover from waste incineration, and spent foundry sand are other sources of secondary aggregates supply. Aggregates derived from industrial by-products are classified as ‘manufactured’ aggregates, which are mainly valorised in road construction (BGS, 2013; USGS, 2019; UEPG, 2019a). According to the statistics published by the European Aggregates Association, approximately 66 million tonnes of manufactured aggregates are produced in the EU annually (UEPG, 2022).

The natural rocks removed as an overburden during surface mining of ores, industrial minerals, and coal is another potential source of secondary raw materials, when complying with Regulation (EU) No 305/2011 for the marketing of construction products. This option includes, for example, aggregates used in earthworks and infrastructure construction, hydraulic engineering, landfill construction (Garbarino et al. 2018).

In the assessment, 9 % was used as the EOL-RIR (background data from UEPG (2022).

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OTHER CONSIDERATIONS

HEALTH AND SAFETY ISSUES

Aggregates are not classified as hazardous according to EU Regulation No.1272/2008 classification, labelling and packaging of substances and mixtures (CLP). The main health hazard from aggregates is airborne dust generated during production, handling and use. Occupational exposure to respirable dust, particularly if it contains respirable crystalline silica, should be monitored and controlled. Repeated inhalation of excessive amounts of respirable silica may cause silicosis (Aggregate Industries 2021a, 2021b).

ENVIRONMENTAL ISSUES

In Europe, land-use conflicts and absence or complexity of aggregates policies are among the challenges for long-term and sustainable aggregates supply. The integration of mineral resources policies into land-use planning at different levels is a key factor for achieving responsibly sourced minerals. (SnapSEE, 2014; UEPG, 2022).

Given that aggregates represent by far the largest number of extraction sites in the EU (Garbarino et al., 2018), it is important to note that the European Aggregates industry is involved in initiatives for extraction site rehabilitations and biodiversity preservation. More than 200 environmental case studies demonstrate the compatibility of aggregates extraction and environmental protection (UEPG, 2023).

A report published by the UN acknowledges the need for improved governance of global sand resources and adequate assessment of environmental impacts of over-exploitation. In some parts of the world among emerging and developing countries, illegal extraction of sand from riverine and marine ecosystems results in environmental damages on rivers, deltas and coastal and marine ecosystems such as land loss through river and coastal erosion, impacts to biodiversity, lowering of the water table and pollution, impacts on landscape and hydrological function etc. (UNEP 2019).

NORMATIVE REQUIREMENTS

European Standards, established from 1st January 2004 on, address the use of aggregates in concrete, mortar, asphalt, railway ballast, armourstones, etc. (MPA 2021).

The US Mine Safety and Health Administration (MSHA, 2020), in cooperation with the Maine Aggregate Association, developed the Aggregates Safety Series on Small Mines: a tool developed to assist mines in developing effective plans on how to train / ensure safety measures for mining activities related to aggregates.

Another aspect highlighted in (Mc Guire et al. n.a.) is that aggregate mining is becoming increasingly more regulated under county and municipal land use and zoning regulations in the US. The document provides guidelines for review and approval of operating permits in the aggregate mining industry.

HEALTH AND SAFETY ISSUES RELATED TO AGGREGATES OR

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SOCIO-ECONOMIC AND ETHICAL ISSUES

ECONOMIC IMPORTANCE OF AGGREGATES FOR EXPORTING COUNTRIES

Table 12 lists the countries for which the economic value of exports of aggregate products represent more than 0.1 % in the total value of their exports.

Table 12: Countries with highest economic shares of aggregates exports in their total exports

Country	Export value (USD)	Share in total exports (%)
State of Palestine	41143040.58	3.03%
Gambia	424855.1	1.61%
Mozambique	63488972.51	1.24%
Suriname	6368787.054	0.42%
Oman	183665674.6	0.41%
Croatia	85369946	0.39%
Montenegro	1395219.189	0.27%
Iceland	14265902.99	0.24%
Jamaica	3193909.6	0.22%
Honduras	8435911.3	0.17%
Norway	265441082.8	0.16%
Belarus	63348500	0.16%
Bosnia Herzegovina	9715709.78	0.11%
Slovenia	50634687.21	0.11%

Source: COMTRADE (2022), based on data for 2021

The State of Palestine has a very significant (3 %) share of aggregates compared to total exports. Gambia and Mozambique also have significant shares above 1 %, whereas Suriname, Oman, Croatia, Montenegro, Iceland, Jamaica, Honduras, Norway, Belarus, Bosnia Herzegovina and Slovenia have a share of aggregates compared to total exports ranging from 0.4 % to 0.1 %. For all other exporting countries, this share is below 0.1 %.

SOCIAL AND ETHICAL ASPECTS

The EU is self-sufficient for aggregate materials, and no particular threats exist for what concerns social sustainability and security of supply.

Local conflicts are characterized by discrepancies regarding localized environmental costs to communities versus the dispersed economic benefit for the whole society (Baker 1992). However, it is often argued that if mining operations are prevented, regional costs will increase, shifting the problems to more truck traffic, noise, accidents, and more hydrocarbons being released into the atmosphere (Robinson 2002). Some researchers argue that this discussion is highly influenced by public perceptions or "socio-cultural constraints" and the NIMBY (Not in My Back Yard) syndrome, often exceeding reality as the industry has incorporated technology to reduce and eliminate hazards associated with extraction (Müller 2019).

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Consequently, considerable obstacles created by local communities in the development and smooth operation of aggregates extraction sites are not infrequent. As a conclusion, social acceptance of the extractive activities by the local communities is necessary to ensure the undisturbed flow of aggregates that society needs for infrastructure development and building purposes (Chalkiopoulou and Hatzilazaridou 2011).

RESEARCH AND DEVELOPMENT TRENDS

RESEARCH AND DEVELOPMENT TRENDS FOR LOW-CARBON AND GREEN TECHNOLOGIES

- TRAC[5] project: Tailor-made Recycled Aggregate Concretes (2018 – 2024, EU)

Concrete is the main construction material used on earth. The increasing population and urbanization has led to construction of new high-rise buildings and demolishing existing old low-rise ones. This has become not only the cause of natural resources depletion at an alarming rate but also gradually becoming a challenge for environmental preservation. Concrete industry consumes many natural resources and produces a large amount of construction waste. To ensure sustainable, cost-effective but still profitable concrete production, the research aspires to develop tailor-made concretes by using more recycled concrete aggregate (RCA) for structural applications.

- SUPERCONCRETE [6] project: - SUstainability-driven international/intersectoral Partnership for Education and Research on modelling next generation CONCRETE (EU, 2015 – 2019)

SUPERCONCRETE addresses theoretical models for next-generation concretes, characterised by a significant sustainability enhancement for the construction industry. Three advanced concrete classes (CCs) are selected which represent the projects' key research lines:

- Low-Carbon Concrete (LCC), characterised by non-conventional constituents, often derived from recycling industrial waste or by-products;

- High-Class Concrete (HCC), encompassing materials with enhanced performance in strength, durability;

- Fibre-reinforced Cementitious Composites (FCC), with special features on fibre/textile reinforcement and matrix improvement.

- Fully utilizing carbonated recycled aggregates in concrete: Strength, drying shrinkage and carbon emissions analysis (Xiao et al. 2022)

  In this study, natural aggregates, recycled aggregates (RAs), and carbonated RAs were combined to prepare concrete. Strength, drying shrinkage, microstructures, and the carbon emissions of concrete prepared with different aggregate combinations were explored and compared. The results show that the compressive strengths of carbonated fully recycled aggregate concrete (CFRAC) increased by 20.9 % and the drying shrinkage at 180 days decreased by 23.3 % compared with that of concrete with RAs due to the

[5] https://cordis.europa.eu/project/id/777823
[6] https://cordis.europa.eu/project/id/645704

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reduction of water absorption of RAs and the additional water. The pore structure of CFRAC was densified and improved by carbonation treatment on RAs. Furthermore, the carbon emission analysis showed that CFRAC had 7.1%~13.3% lower carbon emission and 13.4 %~18.4 % lower CO_2 intensity than natural/recycled aggregate concrete due to the shorter transportation distance and the carbon absorption. Generally, CFRAC had improved properties and environmental benefits, which shows carbonation treatment is a valuable way to promote waste concrete recycling.

- IOSOBIO[7] project: - Development and Demonstration of Highly Insulating, Construction Materials from Bio-derived Aggregates (EU, 2015 – 2019)

The ISOBIO project developed a new approach to insulating materials through the novel combination of existing bio-derived aggregates with low embodied carbon with innovative binders to produce durable composite construction materials. These novel composites aimed at targeting 50 % lower embodied energy and carbon than traditional oil based insulation panels, and increasing thermal insulation compared with traditional systems by at least 20 %. By using bio-based materials, using vertical integration from raw material production through to finished systems, the ISOBIO project aims to reduce costs by at least 15% over traditional systems. The use of bio-based materials ensures that whole life energy use is reduced through taking advantage of the photosynthesis of atmospheric carbon which is sequestered in the fabric of the building for its lifetime. The ISOBIO materials take advantage of the natural moisture sorption/desorption characteristics of bio-based materials, which is known to passively manage the indoor environment resulting in greatly improved indoor air and environmental quality, whilst at the same time reducing the demand for air conditioning.

- Impact of recycled aggregates on mechanical properties of concrete (Mathur et al. 2022)

The voluminous disposal of demolition waste into landfills is proving to be an owing cause of environmental pollution. An essential outlook for economic construction is the processing of the waste procured from construction works to preserve an ecological balance. To contribute towards research to generate sustainable reusable construction products, an attempt was made to analyse the feasibility of recycled coarse aggregates (RCA) as a substitute for coarse aggregate. An experiment has been conducted to develop sustainable concrete grade M30 conforming to Indian Standards. The partial replacement was carried out using construction and demolition (C&D) waste extracted from the nearby dump yard in the vicinity of Ahmedabad city and processed at a nearby recycling plant. This C & D waste was from recent collapse of one of the girder of bridge. In this present investigation an attempt was carried out to check the feasibility of the 40 days old recycled concrete aggregate (RCA) on the properties of M 30 grade of concrete. A total of 5 batches were produced with a 10 % increment of RCA. The physical properties of natural and RCA were compared. A comparative analysis between the hardened properties of the control mix and recycled aggregate concrete (RAC) was performed. Test parameters determined to study the impact of recycled aggregate were compressive strength, flexural strength, and split tensile strength. It was observed that the specific gravity and water absorption of recycled aggregates (R.A.) were lower and higher, respectively, in contrast to natural coarse aggregate. The results prove that the performance of concrete containing recycled constituents was largely affected by the

[7] https://cordis.europa.eu/project/id/636835

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properties and quality of aggregate and deviates slightly towards the lower end of the desired level but reduces the environmental impact of disposal.

- InnoWEE[8] project: Innovative pre-fabricated components including different waste construction materials reducing building energy and minimising environmental impacts (2016 – 2020, EU)

The basic project idea was to embed the waste from building demolition (fragmented bricks, fragmented plaster or concrete, fragmented glasses, machined wood from windows frame or from wood beams after demolition etc.) in a geopolymer matrix to produce prefabricated panels for different use. More specifically the main objective was in fact the development of an optimized reuse of construction and demolition Waste materials producing high added value prefabricated insulating and radiating panels to be used in energy efficient buildings.

OTHER RESEARCH AND DEVELOPMENT TRENDS

- Particulate and mineral-associated organic carbon fractions reveal the roles of soil aggregates under different land-use types in a karst faulted basin of China (Peng et al. 2022)

Soil aggregation has been recognized as the main mechanism of organic carbon (C; OC) stabilization, and OC dynamics within aggregates are closely linked to soil OC (SOC) sequestration. To unravel the roles of different-sized aggregates and the associated OC fractions in SOC accumulation, SOC stocks (SOCS), aggregate distributions, and OC fractions within aggregates were measured under five typical land-use types (cropland, grassland, shrubland, plantation forest, and natural forest) in a karst faulted basin, China.

- Characterization of road surfacing aggregates based on their mineralogical fingerprint (Wang et al. 2022)

To ensure the safety of infrastructure users, the long-term skid resistance is a crucial factor and is determined in large by the mineralogical and morphological characteristics of surfacing aggregate. Most studies have investigated these aggregate properties separately without considering the interrelation between one another. The objective of this study is to consider the morphological characteristics as well as the mineralogical fingerprint of aggregate to develop an innovative approach to optimize the aggregate selection process.

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