

TAIEX expert mission
on the Resource Efficiency of Construction and Concrete Materials

***European research of aggregates for concrete: current
status and developments in progress***

MARTA SÁNCHEZ DE JUAN

Dr. Civil Engineer
Head of the Technical Regulation Area

MINISTRY OF PUBLIC WORKS AND TRANSPORT
SPAIN

msdejuan@fomento.es

HARMONISED STANDARDS

- European standard related to products
- Developed by CEN
- Created following a request from the European Commission
- Manufacturers, other economic operators, or conformity assessment bodies can use harmonized standards to demonstrate that products, services, or processes comply with relevant EU legislation



CE Marking

- ☐ Products made according to harmonised European Standards carry the CE marking
- ☐ Such products have access to the European Union market
- ☐ The CE marking affixing falls under the responsibility of the relevant manufacturers



Harmonised European Standards of aggregates

- ✓ EN 12620: Aggregates for concrete
- ✓ EN 13043: Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
- ✓ EN 13055-1: Lightweight aggregates – Part 1: Lightweight aggregates for concrete, mortar and grout
- ✓ EN 13055-2: Lightweight aggregates – Part 2: Lightweight aggregates for bituminous mixtures and surface treatments and for unbound and bound applications
- ✓ EN 13139: Aggregates for mortar
- ✓ EN 13450: Aggregates for railway ballast
- ✓ EN 13242: Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
- ✓ EN 13383-1: Armourstone – Part 1: Specification

Harmonised European Standards of aggregates

- ✓ **EN 12620: Aggregates for concrete**
- ✓ EN 13043: Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
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- ✓ EN 13383-1: Armourstone – Part 1: Specification

EN 12620: Aggregates for concrete

SCOPE

- ☐ Aggregates and filler aggregates
- ☐ Obtained by processing natural, manufactured or recycled materials and mixtures of these aggregates
- ☐ Use in concrete, in buildings, roads and civil engineering works
- ☐ Aggregates having an oven dried particle density greater than 2000 kg/m^3
- ☐ Recycled aggregates (coarse and fine) having an oven dried particle density greater than 1500 kg/m^3

EN 12620: Aggregates for concrete

SCOPE

- ☐ Unfamiliar materials from secondary sources, must comply fully with this standard and national regulations for dangerous substances

EN 12620: Aggregates for concrete

Classification

Geometrical characteristics

Physical characteristics

Chemical characteristics

Durability

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Classification

- ☐ Fines: under 0,063 mm
- ☐ Coarse aggregate: $D > 4$ mm and $d > 1$ mm
- ☐ Fine aggregate: $D \leq 4$ mm and $d = 0$ mm
- ☐ Natural graded 0/8 mm aggregate
- ☐ All-in aggregate
- ☐ Filler aggregate
- ☐ Added filler
- ☐ Mixed filler

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Geometrical characteristics

- ☐ Aggregate size
- ☐ Grading (coarse and fine aggregate)
- ☐ Fines content
- ☐ Fines quality (fine and all-in aggregate)
- ☐ Harmful fines of fillers
- ☐ Particle shape
- ☐ Percentage of crushed particles
- ☐ Shell content

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Geometrical characteristics: AGGREGATE SIZE

Sieve sizes for specifying aggregates sizes

Basic set mm	Basic set plus set 1 mm	Basic set plus set 2 mm
0	0	0
1	1	1
2	2	2
4	4	4
—	5,6 (5)	—
—	—	6,3 (6)
8	8	8
—	—	10
—	11,2 (11)	—
—	—	12,5 (12)
—	—	14
16	16	16
—	—	20
—	22,4 (22)	—
31,5 (32)	31,5 (32)	31,5 (32)
—	—	40
—	45	—
63	63	63

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Geometrical characteristics: GRADING (EN 933-1)

Aggregate	Size	Percentage passing by mass					Category
		2D	1,4D	D	d	d/2	
Coarse	D/d ≤ 2 or D ≤ 11,2 mm	100	98 to 100	85 to 99	0 to 20	0 to 5	G _C 85/20
		100	98 to 100	80 to 99	0 to 20	0 to 5	G _C 80/20
	D/d > 2 and D > 11,2 mm	100	98 to 100	90 to 99	0 to 15	0 to 5	G _C 90/20
Fine	D ≤ 4 mm and d = 0	100	95 to 100	85 to 99	-	-	G _F 85
Natural graded 0/8	D = 8 mm and d = 0	100	98 to 100	90 to 99	-	-	G _{NG} 85
All-in	D ≤ 45 mm and d = 0	100	98 to 100	90 to 99	-	-	G _A 90
		100	98 to 100	85 to 99	-	-	G _A 85

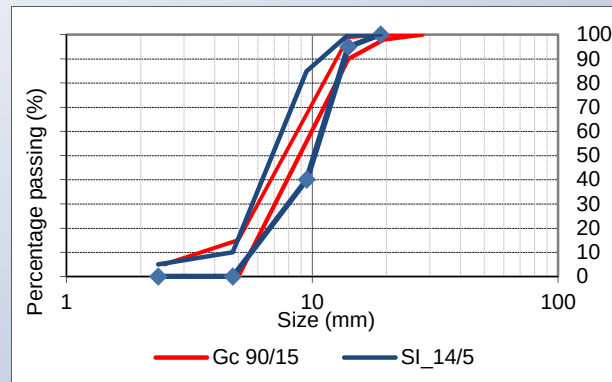
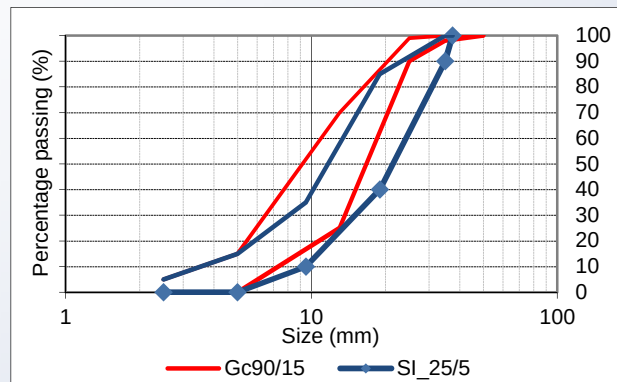
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Geometrical characteristics: GRADING FOR FILLER
(EN 933-10)

Aggregate	Size (mm)	Percentage passing by mass
Filler	2	100
	0,125	85 to 100
	0,063	70 to 100

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Geometrical characteristics: GRADING



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Geometrical characteristics: SHAPE

Categories for maximum values of flakiness index (EN 933-3)

Flakiness Index	Category FI
≤ 15	FI_{15}
≤ 20	FI_{20}
≤ 35	FI_{35}
≤ 50	FI_{50}
> 50	$FI_{Declared}$
No requirement	FI_{NR}



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Geometrical characteristics: SHAPE

Categories for maximum values of shape index (EN 933-4)

Shape Index	Category <i>SI</i>
≤ 15	SI_{15}
≤ 20	SI_{20}
≤ 40	SI_{40}
≤ 55	SI_{55}
> 55	SI_{Declared}
No requirement	SI_{NR}



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Geometrical characteristics: SHELL CONTENT

Category for maximum values of shell content of coarse and all-in aggregate (EN 933-7)

Shell content %	Category <i>SC</i>
≤ 10	SC_{10}
> 10	SC_{Declared}
No requirement	SC_{NR}

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Geometrical characteristics: FINES CONTENT

Categories for maximum values of fines content (EN 933-1)

Aggregate	0,063 mm sieve Percentage passing by mass	Category f
Coarse aggregate	$\leq 1,5$	$f_{1,5}$
	≤ 4	f_4
	> 4	f_{Declared}
	No requirement	f_{NR}
Natural graded 0/8 mm aggregate	≤ 3	f_3
	≤ 10	f_{10}
	≤ 16	f_{16}
	> 16	f_{Declared}
All-in aggregate	No requirement	f_{NR}
	≤ 3	f_3
	≤ 11	f_{11}
	> 11	f_{Declared}
Fine aggregate	No requirement	f_{NR}
	≤ 3	f_3
	≤ 10	f_{10}
	≤ 16	f_{16}
	≤ 22	f_{22}
	> 22	f_{Declared}
	No requirement	f_{NR}

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Geometrical characteristics: FINES QUALITY

Fines of the fine aggregate or all-in aggregate shall be considered non-harmful when any of the four following conditions apply:

- a) The fines content of the fine aggregate or all-in aggregate $< 3 \%$ or other value according to the provisions valid in the place of use of the aggregate;
- b) The sand equivalent value (SE) when tested in accordance with EN 933-8 satisfies the national regulation;
- c) The methylene blue value (MB) on 0/2 mm fraction and on 0/0,125 mm fraction when tested in accordance with EN 933-9 satisfies the national regulation;
- d) There is evidence of satisfactory use with no experience of problems.

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Physical characteristics

- ☐ Resistance to fragmentation
- ☐ Resistance to wear
- ☐ Particle density and water absorption
- ☐ Constituents of coarse recycled aggregates
- ☐ Related to durability:
 - Freeze-thaw resistance of coarse aggregate
 - Volume stability-drying shrinkage
 - Alkali-silica reactivity

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Physical characteristics: RESISTANCE TO FRAGMENTATION

Categories for maximum values of Los Angeles coefficient (EN 1097-2)

Los Angeles coefficient	Category <i>LA</i>
≤ 15	LA_{15}
≤ 20	LA_{20}
≤ 25	LA_{25}
≤ 30	LA_{30}
≤ 35	LA_{35}
≤ 40	LA_{40}
≤ 50	LA_{50}
> 50	LA_{Declared}
No requirement	LA_{NR}



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Physical characteristics: RESISTANCE TO FRAGMENTATION

Los Angeles coefficient test method (EN 1097-2)

- ☐ Test on fraction 10/14 mm
- ☐ In addition, following requirements:
 - a) between 60% and 70% passing a 12,5 mm test sieve; or
 - b) between 30% and 40% passing a 11,2 mm test sieve.
- ☐ Additional grading created from product sizes other than 10/14 mm

Range classification mm	Intermediate sieve size mm	Percentage passing intermediate sieve %	Number of balls	Mass of ball load G
4 to 6,3	5	30 to 40	7	2930 to 3100
4 to 8	6,3	60 to 70	8	3410 to 3540
6,3 to 10	8	30 to 40	9	3840 to 3980
8 to 11,2	10	60 to 70	10	4250 to 4420
11,2 to 16	14	60 to 70	12	5120 to 5300

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Physical characteristics: RESISTANCE TO FRAGMENTATION

Categories for maximum values of resistance to impact (EN 1097-2)

Impact value %	Category <i>SZ</i>
≤ 18	SZ_{18}
≤ 22	SZ_{22}
≤ 26	SZ_{26}
≤ 32	SZ_{32}
> 32	SZ_{Declared}
No requirement	SZ_{NR}



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Physical characteristics: RESISTANCE TO FRAGMENTATION

Resistance to impact test method (EN 1097-2)

- ❑ Sample shall contain:
 - at least 5 kg of the size fraction 8/10 mm and
 - 2,5 kg of each of the size fractions 10/11,2 mm and 11,2/ 12,5 mm.

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Physical characteristics: RESISTANCE TO WEAR

Categories for maximum micro deval coefficient (EN 1097-1)

micro-Deval coefficient	Category M_{DE}
≤ 10	M_{DE10}
≤ 15	M_{DE15}
≤ 20	M_{DE20}
≤ 25	M_{DE25}
≤ 35	M_{DE35}
> 35	M_{DE} Declared
No requirement	M_{DENR}



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Physical characteristics: RESISTANCE TO WARE

Micro deval coefficient test method (EN 1097-1)

- ☐ Test on fraction 10/14 mm
- ☐ In addition, following requirements:
 - a) between 60% and 70% passing a 12,5 mm test sieve; or
 - b) between 30% and 40% passing a 11,2 mm test sieve.
- ☐ Additional grading created from product sizes other than 10/14 mm

Fracciones granulométricas mm	Tamaño del tamiz intermedio mm	Porcentaje que pasa por el tamiz intermedio %	Masa de la carga abrasiva g
4 a 6,3	5	30 a 40	2 000 ± 5
4 a 8	6,3	60 a 70	2 800 ± 5
6,3 a 10	8	30 a 40	4 000 ± 5
8 a 11,2	10	60 a 70	4 400 ± 5
11,2 a 16	14	60 a 70	5 400 ± 5

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Physical characteristics: DENSITY AND WATER ABSORTION

- ☐ No classification or categories
- ☐ Test method EN 1097-6
 - a wire basket method for aggregate particles retained on the 31,5 mm sieve
 - a pyknometer method for aggregate particles passing the 31,5 mm test sieve and retained on the 4 mm test sieve (clause 8);
 - a pyknometer method for aggregate particles passing the 4 mm test sieve and retained on the 0,063 mm test sieve (clause 9).

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Physical characteristics: CONSTITUENTS OF COARSE RECYCLED AGGREGATES

Categories for constituents of coarse recycled aggregates (EN 933-11)

Constituent	Description
Rc	Concrete, concrete products, mortar Concrete masonry units
Ru	Unbound aggregate, natural stone Hydraulically bound aggregate
Rb	Clay masonry units (i.e. bricks and tiles) Calcium silicate masonry units Aerated non-floating concrete
Ra	Bituminous materials
FL	Floating material in volume
X	Other: Cohesive (i.e. clay and soil) Miscellaneous: metals (ferrous and non-ferrous), non-floating wood, plastic and rubber Gypsum plaster
Rg	Glass

Constituent	Content Percentage by mass	Category
Rc	≥ 90	Rc_{90}
	≥ 80	Rc_{80}
	≥ 70	Rc_{70}
	≥ 50	Rc_{50}
	< 50	$Rc_{Declared}$
	No requirement	Rc_{NR}
Rc + Ru	≥ 95	Rcu_{95}
	≥ 90	Rcu_{90}
	≥ 70	Rcu_{70}
	≥ 50	Rcu_{50}
	< 50	$Rcu_{Declared}$
	No requirement	Rcu_{NR}
Rb	≤ 10	Rb_{10-}
	≤ 30	Rb_{30-}
	≤ 50	Rb_{50-}
	> 50	$Rb_{Declared}$
	No requirement	Rb_{NR}

Constituent	Content Percentage by mass	Category
Ra	≤ 1	Ra_{1-}
	≤ 5	Ra_{5-}
	≤ 10	Ra_{10-}
X + Rg	$\leq 0,5$	$XRg_{0,5-}$
	≤ 1	XRg_{1-}
	≤ 2	XRg_{2-}
	Content cm ³ /Kg	
FL	$\leq 0,2^a$	$FL_{0,2-}$
	≤ 2	FL_{2-}
	≤ 5	FL_{5-}

^a The $\leq 0,2$ category is intended only for special applications requiring high quality surface finish.

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Physical characteristics: DURABILITY

- ❑ Freeze-thaw resistance of coarse aggregate

Categories for maximum magnesium sulphate soundness (EN 1367-2)

Magnesium sulfate value Percentage loss of mass	Category <i>MS</i>
≤ 18	<i>MS18</i>
≤ 25	<i>MS25</i>
≤ 35	<i>MS35</i>
> 35	<i>MS_{Declared}</i>
No requirement	<i>MSNR</i>

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Physical characteristics: DURABILITY

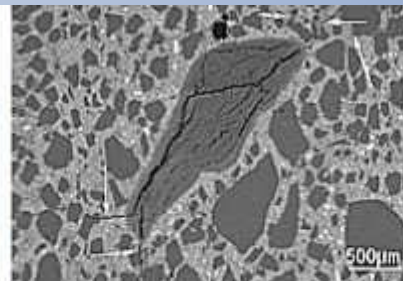
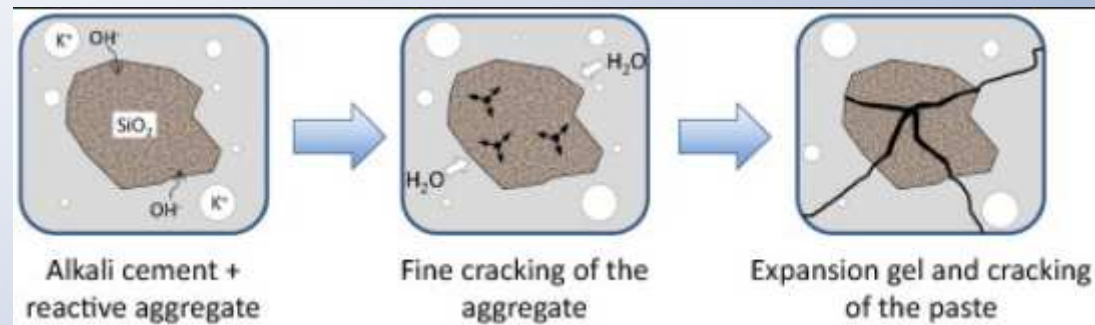
☐ Volume stability-drying shrinkage

Where disruptive shrinkage cracking of concrete might occur due to the properties of the aggregates, the drying shrinkage associated with aggregates to be used in structural concrete shall, when required, not exceed 0,075 % when tested in accordance with EN 1367-4 and the results declared as a pass or fail.

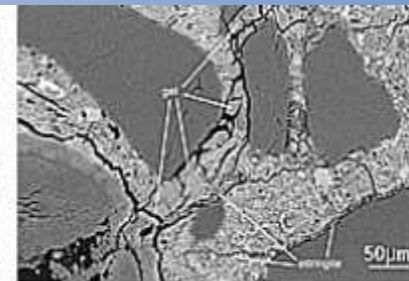
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Physical characteristics: DURABILITY

❑ Alkali-silica reactivity



Scanning electron microscope image of chert aggregate particle with numerous internal cracks due to ASR; cracks extend into the adjacent concrete



Detail of aggregate showing alkali-silica gel extruded into cracks within the concrete. Ettringite is also present within some cracks

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Chemical characteristics

- ☐ Chloride ion content
- ☐ Sulfur compounds
- ☐ Other constituents:
 - ✓ That alter the rate of setting and hardening of concrete
 - ✓ That affect the volume stability
- ☐ Petrographic description
- ☐ Classification of constituents of recycled aggregate
- ☐ Carbonate content

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Chemical characteristics: CHLORIDE ION CONTENT

- Different test methods for natural and recycled aggregates
 - o Natural aggregates: water-soluble chloride ion content (EN 1744-1)
 - o Recycled aggregates: acid-soluble chloride ion content (EN 1744-5)

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Chemical characteristics: ACID-SOLUBLE SULFATE

Categories for maximum values of acid-soluble sulfate content (EN 1744-1)

Aggregate	Acid soluble sulfate content Percentage by mass	Category AS
Aggregates other than air-cooled blastfurnace slag	$\leq 0,2$ $\leq 0,8$ $> 0,8$	$AS_{0,2}$ $AS_{0,8}$ $AS_{Declared}$
	No requirement	AS_{NR}
Air-cooled blastfurnace slag	$\leq 1,0$ $> 1,0$	$AS_{1,0}$ $AS_{Declared}$
	No requirement	AS_{NR}

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Chemical characteristics: TOTAL SULFUR

- ❑ It is determined in accordance with EN 1744-1, shall not exceed:
 - o 2% S by mass for air-cooled blastfurnace slag
 - o 1% S by mass for aggregates other than air cooled blastfurnace
- ❑ Special precautions are necessary if pyrrhotite, (an unstable form of iron sulfide FeS), is present in the aggregate. If this mineral is known to be present, a maximum total sulfur content of 0,1 % as S shall apply.

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Chemical characteristics: WATER SOLUBLE SULFATE CONTENT OF RECYCLED AGGREGATES

Categories for maximum values of water soluble sulfate content of recycled aggregates (EN 1744-1)

Water-soluble sulfate content Percentage by mass	Category SS
$\leq 0,2$	$SS_{0,2}$
No requirement	SS_{NR}

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Chemical characteristics: CONSTITUENTS THAT ALTER THE RATE OF SETTING AND HARDEINING OF CONCRETE

- Organic material (EN 1744-1): The proportions of such materials shall be such that they do not:
 - o Increase the setting time of mortar test specimens by more than 120 min;
 - o Decrease the compressive strength of mortar test specimens by more than 20% at 28 days.

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Chemical characteristics: CONSTITUENTS THAT ALTER THE RATE OF SETTING AND HARDEINING OF CONCRETE

- Lightweight organic material (EN 1744-1)

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Chemical characteristics: CONSTITUENTS THAT ALTER THE RATE OF SETTING AND HARDEINING OF CONCRETE

Categories for influence of water-soluble materials from recycled aggregates on the initial setting time of cement paste (EN 1744-6)

Change in initial setting time, t_e (min)	Category (A)
≤ 10	A ₁₀
≤ 40	A ₄₀
> 40	A _{Declared}
No requirement	A _{NR}

CONCLUSIONS

- ☐ A very extensive standard
- ☐ Classification of most of the properties
- ☐ Declared value for:
 - Water absorption and density
 - chloride ion content
- ☐ Limited value for:
 - Total sulfurs
 - Constituents that alter the rate of setting and hardening of concrete
 - Volume stability-drying shrinkage
 - Grading of filler
- ☐ Under revision (future publication in 2018-2019)

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Chemical characteristics: CONSTITUENTS THAT AFFECT THE VOLUME STABILITY OF AIR-COOLED BLASTFURNACE SLAG

- o Air-cooled blastfurnace slag aggregate shall be free from dicalcium silicate disintegration (EN 1744-1, 19.1.)
- o Air-cooled blastfurnace slag aggregate shall be free from iron disintegration (EN 1744-1, 19.2.)

THANK YOU FOR YOUR ATTENTION

MARTA SÁNCHEZ DE JUAN
Dr. Civil Engineer
Head of the Technical Regulation Area

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