

ERMCO

**IMPORTANCE OF ENSURING
THE STRENGTH OF CONCRETE
IN CONCRETE STRUCTURES**

Aslı Özbora
ERMCO Technical Manager

Dia do Betão 2023

5 June 2023

ERMCO

- founded: October **1967** in **Munich**, Germany
- members: EU and International **Associations** of **ready mixed concrete producers**
 - Full Members
 - Associate Members
 - Corresponding Members
- first based in **Germany**, then **United Kingdom** and since 2002 in **Brussels**

From standards to Quality Management systems

The 1st *European* standard for concrete **EN 206-2004** opened the way to:

- durability requirements,
- higher strength classes,
- improved consideration of additions,
- factory production control systems,
- improved conformity criteria

circulated and
widespread to
the industry

Implementation of **quality systems** fostered by **EN 206** has:

- improved competitiveness of the industry by monitoring production,
- reduced delays and waste,
- contributed to a motivating and successful working environment.



Why Concrete Compressive Strength is important?

Factors Affecting Concrete Strength

- Quality of the materials such as cement, coarse aggregate, fine aggregate, mixing water, and admixtures,
- w/b ratio,
- Aggregate proportion (coarse: fine),
- Ratio of aggregate to cement,
- Age of concrete,
- Air entrainment,
- Temperature of concrete,
- Compaction conditions,
- Curing conditions,



information about concrete quality as well as the suitability of concrete for the relevant project.



ERMCO

**New Identity Testing System
with RFID Tracking in Turkey**

Dia do Betão 2023

5 June 2023



Electronic Concrete Monitoring System

Latest Directive came into force in 2019, to ensure:

- **Full control of concrete in compliance with the new Earthquake Code.**
- **Traceability of concrete quality to the end user.**

With this latest Directive;

- **Identity testing obligation is extended.**
- **Concrete samples will be digitally tracked.**



Conformity Assessment for Compressive Strength

Samples should be taken and tested in accordance with the relevant regulations (EN 206 and TS 13515)

Samples should be prepared in accordance with EN 12390-2

Sampling Plan					
1. Criteria	2. Criteria	Minimum concrete load or number of truck mixers to be sampled	Number of samples		
Amount of poured concrete per day (m ³)	Surface area of a slab or shear wall per day (m ²)		7	28	Σ
0-24	-	2	2	6	8
25-100	<450	3	3	9	12
101-150	451-650	4	4	12	16
151-200	651-850	5	5	15	20
201-250	851-1050	6	6	18	24
251-300	1051-1250	7	7	21	28
301-400	1251-1450	8	8	24	32
401-500	1451-1650	9	9	27	36
501-600	1651-1850	10	10	30	40
>600	>1850	The increase to be made for each additional 200 m ³ or 900 m ²			
		1	1	3	4

Determination of compressive strength of samples according to EN 12390-3
The suitability of concrete compressive strength, tested at 28 days of age determined on the samples.

How This System Works?

- Authorized 3rd party laboratories take samples from construction sites.
- Test frequencies, identity criteria;
 - Defined in new Annex B1 in TS 13515 (comp. to EN 206),
 - Applied to same class concrete delivered to one construction site within one day:

Average amount of same class concrete to one site in Turkey: 50-60 m³/day

Total amount of same class concrete (m ³ /day)	Surface area of a slab or shear wall (m ² /day)	# of truckmixers to be sampled
0 - 24	-	2
25 - 100	< 450	3
101 - 150	451 - 650	4
151 - 200	651 - 850	5
201 - 250	851 - 1050	6

Tracking with RFID-1

RFID tags are only used for tracking samples for compressive strength.

Method:

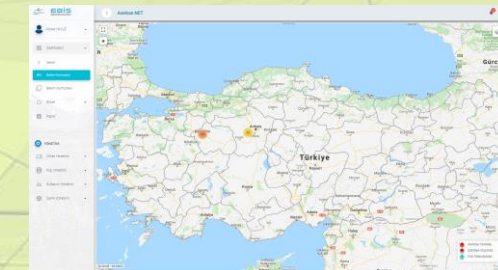
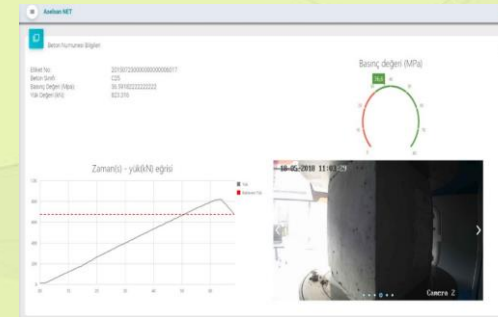
- RFID tags are put in the middle of the specimens.
- Location, time etc. are read by a mobile reader.
- Info of concrete & site are introduced to EBIS mobile app.



Tracking with RFID-2



- Specimens are taken into lab. after 16-72 hrs.
- Test is done after 7&28 (or specified) days using a a special testing machine.
- Report is automatically generated and saved in the system.



BETON DENEY RAPORU	
RAPOR TARİHİ	25.02.2018 10:42:32
RAPOR NO	1613001
LAB. NO	1613001
TEST ESNASINDA KAPAĞIN KAPALI OLDUĞUNDAN EMİN OLUNUZ!	
3000 kN	
aselsan NET EBIS	

BETON DENEY RAPORU	
RAPOR TARİHİ	25.02.2018 10:42:32
RAPOR NO	1613001
LAB. NO	1613001
TEST ESNASINDA KAPAĞIN KAPALI OLDUĞUNDAN EMİN OLUNUZ!	
3000 kN	
aselsan NET EBIS	

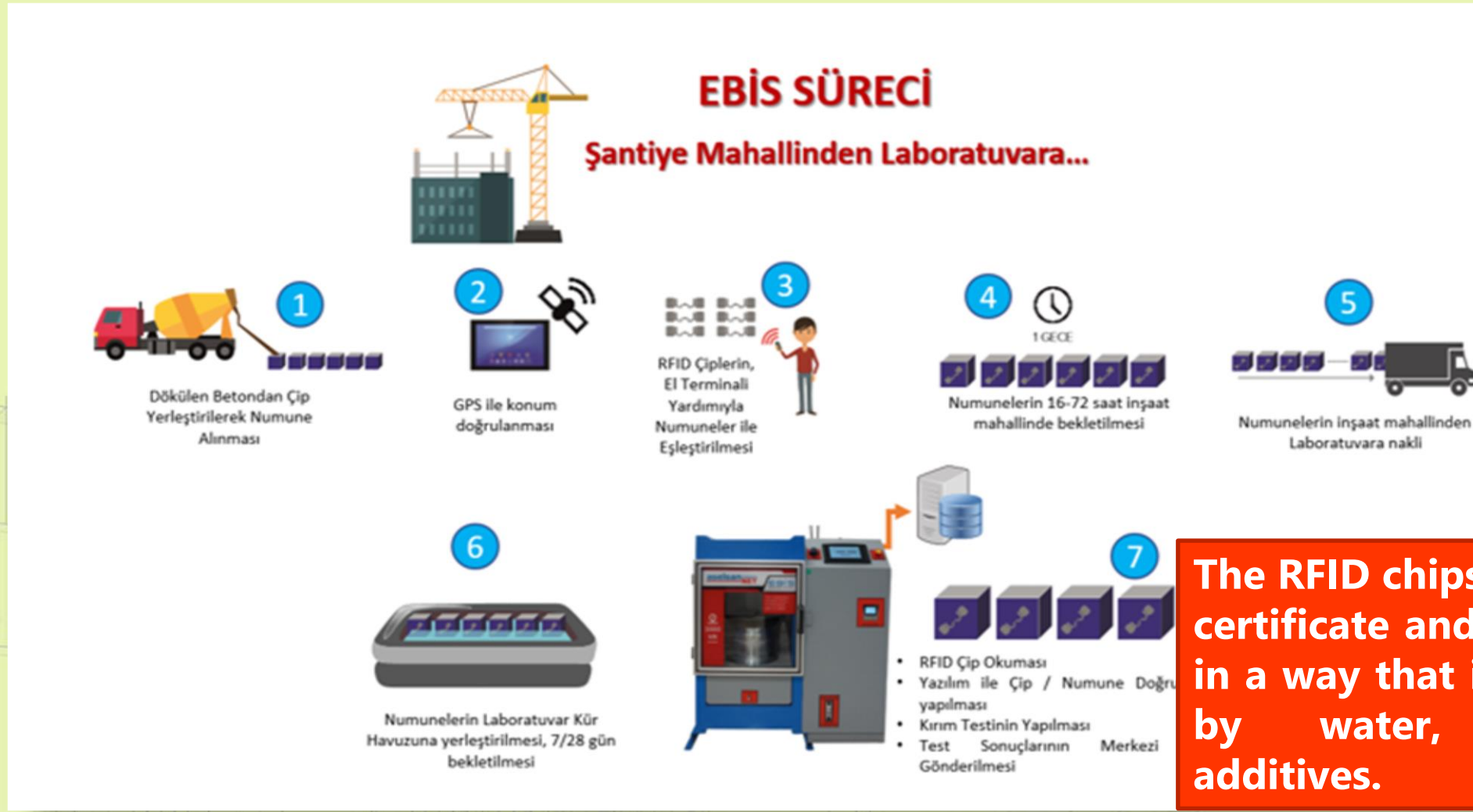
BETON DENEY RAPORU	
RAPOR TARİHİ	25.02.2018 10:42:32
RAPOR NO	1613001
LAB. NO	1613001
TEST ESNASINDA KAPAĞIN KAPALI OLDUĞUNDAN EMİN OLUNUZ!	
3000 kN	
aselsan NET EBIS	

BETON DENEY RAPORU	
RAPOR TARİHİ	25.02.2018 10:42:32
RAPOR NO	1613001
LAB. NO	1613001
TEST ESNASINDA KAPAĞIN KAPALI OLDUĞUNDAN EMİN OLUNUZ!	
3000 kN	
aselsan NET EBIS	

EBIS (Electronic Concrete Monitoring System) software

Status	Casting Date	Curing Date	Test Date	Sample Type	Concrete Class	Compressive Strength		
İşlemler	Durumu	Yıf No	Alınma Tarihi	Kür Tarihi ↑	Kırılma Tarihi	Numune Tipi	Beton Sınıfı	Basınc Dayanımı (MPa)
(Tümü) 🔍						(Tümü) ▼	(Tümü) ▼	
⋮	Test Edildi	1472898	27.06.2018 00:00		04.07.2018 16:32	Küp Numunesi (15x15)	C25	26,55 ✎ 🗑️ ⋮
⋮	Numune Alındı	1501917	20.07.2018 14:02			Küp Numunesi (15x15)	C25	✎ 🗑️ ⋮
⋮	Test Edildi	1472898	27.06.2018 00:00		04.07.2018 16:32	Küp Numunesi (15x15)	C25	27,73 ✎ 🗑️ ⋮
⋮	Numune Alındı	1501917	20.07.2018 14:02			Küp Numunesi (15x15)	C25	✎ 🗑️ ⋮
⋮	Kür Havuzunda	1509608	20.07.2018 11:36	21.07.2018 13:42		Küp Numunesi (15x15)	C25	✎ 🗑️ ⋮
⋮	Kür Havuzunda	1509608	20.07.2018 11:36	21.07.2018 13:42		Küp Numunesi (15x15)	C25	✎ 🗑️ ⋮
⋮	Kür Havuzunda	1329969	19.07.2018 12:19	20.07.2018 17:53		Küp Numunesi (15x15)	C35	✎ 🗑️ ⋮

EBIS (Electronic Concrete Monitoring System) PROCESS



The RFID chips have an IP 68 certificate and are produced in a way that is not affected by water, heat and additives.

Delivery Note with QR Code & Truckmixer Tag

Tagged concrete truckmixers & delivery notes with QR code to have access to details on the concrete on the construction site, to save time and labor, and to prevent possible interventions.

Information included in the delivery notes with QR code:

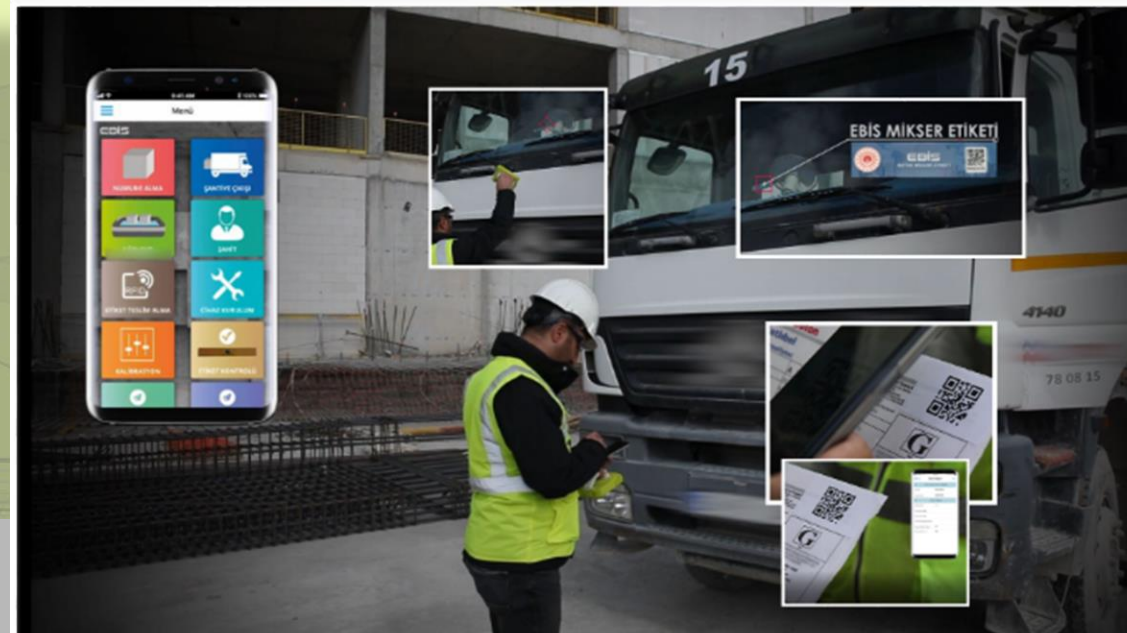
- ✓ Delivery Note Serial Number
- ✓ Manufacturer Tax Number
- ✓ Dispatch Date and Time
- ✓ Concrete Amount
- ✓ Concrete Strength Class
- ✓ 7/28 Days Strength Development Rate
- ✓ Consistency Class
- ✓ Density Class
- ✓ Chloride Content Class
- ✓ D_{max}
- ✓ Water / Cement Ratio
- ✓ Vehicle Plate Number
- ✓ Cement Type
- ✓ Chemical Admixture
- ✓ Mineral Additive
- ✓ Fibers



Delivery Note with QR Code & Truckmixer Tag

- The **delivery notes with QR code** and **tags on the concrete truckmixers** reaching the construction site are **scanned by RFID reader**.
- The **vehicle registration plate** of the truckmixer is **verified**.
- If the relevant tag does not correspond to a valid value or if more than one tag is scanned «Incorrect Barcode» warning is displayed.

Contributing to the secure operation of the system



EBIS (Electronic Concrete Monitoring System)



- Interest of many countries worldwide, and requests received from other countries.
- Implementations: Memorandum of Understanding in the Field of Construction Works signed with **Albania, Azerbaijan, Turkish Republic of Northern Cyprus, Uzbekistan** and **Qatar**, and procedures initiated for the establishment of laboratory and EBIS system.
- Requests received from countries such as **Romania, Turkmenistan, Kazakhstan, Kyrgyzstan**, and **Mongolia**, and negotiations are ongoing.
- Approximately 26 million fresh concrete samples taken since the first use of the system in Turkey up to present.

Identity criteria for compressive strength

Table B1.2 of TS 13515

# of test results	Mean of test results	Any individual test result
1	Not applicable	$\geq f_{ck}$
2 - 4	$\geq f_{ck} + 1 \text{ Mpa}$	$\geq f_{ck} - 4 \text{ MPa}$
≥ 5	$\geq f_{ck} + 2 \text{ MPa}$	$\geq f_{ck} - 4 \text{ MPa}$



In case of non-conformity:
assessment of in-situ
strength by taking cores
from the structure.

Effect of System to Construction & RMC Sectors:

- Avoidance of external intervention in the system
- Significant improvement of quality control of concrete
- Reduction of unfair competition
- Transfer of quantity & quality info of concrete to e-government information system.





ERMCO

Control System in France

Dia do Betão 2023

5 June 2023

Control System in France

- Concrete conformity as material: ***NF EN 206/CN*** ;
- Conformity of concrete in structure and conformity of structure:
 - ✓ ***NF EN 13670/CN (Execution of concrete structures)***,
 - ✓ ***NF DTU 21P1-1 (Building works — Execution of concrete structures — Part 1-1: Model technical specification)***,
 - ✓ ***specific contract documents.***



Control System in France

Specifications and Minimum Characteristics of Concrete

- **Specifications** and **minimum characteristics** of concrete on construction site must comply with the provisions:
 - Defined in «**Specification of Concrete**» of **NF EN 206/CN**;
 - Specified in **relevant tables** (NA.F.1 and NA.F.3) of the «**specified limit values applicable in France for the composition and properties of concrete**» in the **National Annex to NF EN 206/CN**.
- **Contractor** to provide, at the beginning of the work, **supporting documents** of the concrete (NF DTU 21 P1-1), specifying according to **NF EN 206/CN** if it is designed concrete, prescribed concrete, etc.
- The minimum characteristics of the concrete depend on:
 - **Exposure resistance class**,
 - **Specific requirements for the structures** (NF DTU 21 P1-1 – site categories).



Control System in France

Production Process Control and Concrete Properties - NF DTU 21P1-1

- **Controls** carried out by the company to verify in a timely manner that the concrete intended for the **project** can be **presumed to meet the requirements of the works contract**.
- Controls do not replace the identity tests defined in NF DTU 21 P1-2.



Control System in France

Nature of Controls - NF DTU 21P1-1

- Execution specifications must define **batches** in the sense of the **national annex to NF EN 13670/CN**, based on the specificities of the construction site.
- For these batches, production periods may be subject to **sampling based on weighbridge tickets**.
- For special cases (ex: post-tensioned prestressing, category C, PA or PB), the contractor verifies the **weighbridge tickets** and the **Technical Product Sheets (TPS)** of the constituents made available to them by the supplier.



Control System in France

Controls (NF EN 206/CN) - NF DTU 21P1-1:

Type 1- Results are known before the placement

- Visual inspections
- Consistency measurements
- Air content measurements (air entrainment)



Type 2- Results are known only after the placement of concrete

- Strength measurements

Control System in France

Control Procedure - NF DTU 21P1-1

- In case of doubt in Type 1  to increase frequency of controls Type 2

(Strength measurements on cylinders or cubes - NF EN 12390-3; Sampling - NF EN 12350-1)

- A batch can only provide one sample. The sample should contain a volume of concrete at least 1.5 times the volume required for the tests.
- Results of all these measurements recorded.
- Interpretation of strength measurements done in accordance with Annex A.
- For any construction site, the contracting parties can agree in the DPM (Detailed Project Manual) to enhance the means of concrete control.

Volume of each batch does not exceed:

- *1,000 m³ for concretes that hold an NF certification or are recognized as equivalent under the conditions indicated in the foreword;*
- *500 m³ for other concretes, or a volume not exceeding the amount used in one month of continuous work.*

Control System in France / Concrete Controls for the intended structure

NF DTU 21P1-1

Site Category	Concrete with specified properties		Concrete with prescribed composition	
	Consistency	Strength	Consistency	Strength
All categories	Visual inspection for each load	According to the construction category	Visual inspection for each load	According to the construction category
Category A	Measurement if doubts arise from visual inspection	Measurement at the beginning of the construction, then: <ul style="list-style-type: none"> • Every 500 m³ or every month • Or every 1,000 m³ if certified concrete 	None	None ¹⁾
Category B			Measurement at the beginning of the construction, then every 250 m ³ or every month ²⁾	
Category C			Measurement at the beginning of the construction, then every 150 m ³ or every month ²⁾	
Special Structures PA, PB, PC	At least the requirements of Category C	Measurements according to specific documents of the project	At least the requirements of Category C	Measurements according to specific documents of the project

¹⁾ Refer to 6.4.

²⁾ In the case of using an air-entraining agent, the consistency measurement is supplemented by a standardized test to verify the air content (NF EN 12350-7), which **25** should also be conducted in case of doubts arising from visual inspection.

³⁾ The above-defined controls are user controls, distinct from producer controls.

Categories to ensure increasing levels of control based on:

- **Scale of the works.**
- **Presence of any special structures.**

Category A / Projects of minor importance:

at most *two floors above the ground floor and one basement*. This category particularly applies to individual or semi-detached houses built in small numbers. Unless otherwise specified in the Detailed Project Manual (DPM), Category A projects fall under **Execution Class 1** (NF EN 13670/CN).

Category B/ Projects of moderate importance:

only *elements of standard dimensions and typical loads*. This category includes buildings with a *maximum of 16 levels, significant housing complexes, or common industrial constructions*. The amount of concrete used does not exceed 5,000 cubic meters. Unless otherwise specified in the DPM, Category B projects fall under **Execution Class 2** (NF EN 13670/CN).

Category C / Projects of major importance:

only *elements of standard dimensions and typical loads*. This category includes buildings with *more than 16 levels, industrial or commercial warehouses with heavy loads or high traffic, as well as large-scale sports complexes*. Unless otherwise specified in the DPM, Category C projects fall under **Execution Class 3** (NF EN 13670/CN).

Control System in France / Concrete Controls for the intended structure

NF DTU 21P1-1

Site Category	Concrete with specified properties		Concrete with prescribed composition	
	Consistency	Strength	Consistency	Strength
All categories	Visual inspection for each load	According to the construction category	Visual inspection for each load	According to the construction category
Category A	Measurement if doubts arise from visual inspection	Measurement at the beginning of the construction, then: <ul style="list-style-type: none"> • Every 500 m³ or every month • Or every 1,000 m³ if certified concrete 	None	None ¹⁾
Category B			Measurement at the beginning of the construction, then every 250 m ³ or every month ²⁾	
Category C			Measurement at the beginning of the construction, then every 150 m ³ or every month ²⁾	
Special Structures PA, PB, PC	At least the requirements of Category C	Measurements according to specific documents of the project	At least the requirements of Category C	Measurements according to specific documents of the project

¹⁾ Refer to 6.4.

²⁾ In the case of using an air-entraining agent, the consistency measurement is supplemented by a standardized test to verify the air content (NF EN 12350-7), which should also be conducted in case of doubts arising from visual inspection.

26

³⁾ The above-defined controls are user controls, distinct from producer controls.

Special structural elements PA, PB, and PC of Category A, B, and C projects

- Significant cantilevers
 - Transfer floors or highly stressed elements
 - Slender columns
 - Long-span floors
 - Structures requiring delicate execution techniques
 - Structures for which the characteristic design strength required for cast-in-place concrete is at least 35 MPa at 28 days.
- These elements to be indicated on the structural drawings.
 - Execution controls for special structural elements PB and PC cannot be less stringent than the corresponding categories B and C to which they belong.
 - For Category PA projects, the execution to be at least level 2.

Control System in France

Analysis- NF DTU 21P1-1

- ✓ If presumption of compliance with the requirements of the works contract is not obtained:
 - reasons to be analysed,
 - process to resolve the uncertainty to be implemented.

This process may consist of:

- Additional tests.
- Tests on hardened concrete and/or on the structure *(NF EN 13791/CN)*.
- Physico-chemical analysis of the concrete and its constituents.
- A comprehensive analysis of the durability and strength of the relevant structure (or part of the structure).





ERMCO

Thank You for Your Attention