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Ultra High Durability Concrete

Rethinking coastal defence and Green-energy Service infrastructures through enHancEd-durAbiLity high-performance cement-based materials

WP4. Concept and development of UHDC

10 - UPV (Leader)
Pedro Serna
Partners participating: **UPV, POLIMI, ANF, RDC, API, PENETRON, TUD, BGU, UOM**

January 10th, 2018

WP objectives

- Formulation of innovative types of UHDC (SO 1)

based on: **nano- to microscale functionalization**

- matrix and interface **densification**,
- reduce early age durability-critical phenomena (autogenous **shrinkage**)
- improve **self-healing**.

Feasibility of **recycling UHDC** elements,

- <u>UHDC mix design - technologically **robust** for Pilots</u>
- Quantification of the **<u>material properties</u>**

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WP objectives
Strategy

Close collaboration:

SMEs - **research institutions**

develop products evaluating long-term durability in service.

feedback with WP5

jointly focus development

improvement of UHDC mix design – Durability evaluation methodologies

Quantification of the **material properties** (mechanical and durability)
to be used in **DAD (WP3)** (durability oriented design)

A technologically **robust material** for
feedback with **WP8 pilot applications**.
Overlapping time (M 12-27)

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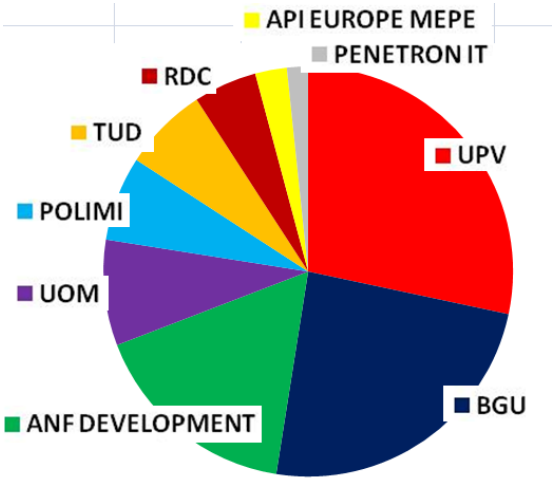
WP 4 timeline: M1-M27

TASK			Year 1				Year 2				Year 3			
N	Leader		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
4.1	ANF Development	Improvement in concrete constituents to enhance its durability	1-9											
4.2	UPV	UHDC mix-design concept and formulation	1-16											
4.3	Polimi	Introduction of new functionalities to UHDC			7-18									
4.4	BGU	Adaptation of UHDC to different application technologies			7-18									
4.5	UOM	Recycling UHDC elements							19-27					

	Beneficiary	PM
1	POLIMI	8,0
5	ANF DEVELOPMENT	20,0
6	RDC	6,0
8	API EUROPE MEPE	3,0
9	PENETRON IT	2,0
10	UPV	34,0
11	TUD	8,0
13	BGU	29,0
14	UOM	10,0
	Total	120,0

WP4 effort: 120 PM

9 beneficiary



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Expected interactions within WPs

Input:

- Definition of scenarios and of durability demands and performance parameter, such as preliminary criteria for DAD from **WP3**.
- Prototypes definition / Structural demands from **WP8**
- Raw materials availability / Construction Technological Aspects from **WP8**

Output:

- Results mix design of UHDC feed **WP8**.
- Results mechanical behaviour of UHDC and of self healing capability evaluation feed **WP3**
- Technological support to produce UHDC for each prototype to feed **WP8**

"Close-loop" to WP5. (results validation - analysis / providing test specimens)

Task 4.1. Improvement in concrete constituents to enhance its durability

Partners: **ANF Development**, API Europe, Penetron IT **Timing M1- M9**

- Functionalization effectiveness and improvement of production of:
  alumina nano-fibres (ANF Development),
  crystalline admixtures (Penetron IT)
  nanocellulose (API Europe):
- Improving geometry (particle size / nano-fibre diameters) - “grading” form
- Acting on surface: defect structure / active groups (nature, number) improve the reactivity
- Improving the dispersion process:
  ultra-sonication in factory and supply in liquid form
  self-dispersing powder
- Verification of the compatibility with other constituents
- **Scalability to production in pilot demonstration** (WP7, WP8)

Supply other WP Parters ON TIME

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Task 4.2. UHDC mix-design concept and formulation

Partners **UPV,** PoliMi, TUD, BGU **Timing M1-M16**

- Development of UHDC mix designs to be used in WP8 pilots,

starting from existing UHPC/UHPFRC and incorporating:

selected mix constituents, tailored to the intended scenarios; using locally available materials (reduce cost) maintaining the required mechanical and durability performance

micro/macro-fibres, to improve resistance to aggressive exposures (e.g. amorphous alloy (Saint Gobain) - petro-chemical polymeric, alkali-resistant glass).

- **Testing mechanical and durability performance**, in un-cracked / micro-cracked states (also in situations as erosion induced by airborne particles - equipment available at BGU), environmental conditions (XS and XA) in collaboration with WP5 (durability and aging) to TRL5 with the technology validated in the relevant environment.

UPV – Reference mix-design and testing framework

PoliMi (locally available constituents),

TUD and BGU (alternative fibre reinforcement), testing the mixes, in each partner lab facilities.

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Task 4.3. Introduction of new functionalities to UHDC

Partners: **PoliMi**, TUD, BGU, API Europe, ANF Development, Penetron IT, UPV **Timing M7-M18**

Adaptation of UHDC including products from Task 4.1 enhancing durability.

- nano-cellulose crystals (API - UPV) and alumina nanofibers (ANF - UPV, PoliMi) compared to carbon nanotubes and graphene (BGU);
- crystalline admixtures (Penetron - PoliMi) – vs - superabsorbent polymers (TUD),

also investigating: synergy effects with fibres (chemical prestressing)
crack sealing capacity in chloride env.

Tests for self-healing effectiveness:

- permeability tests of cracked specimens
- mechanical recovery tests,
- quantifying the densification and microstructural changes

Techniques: (neutron radiography, computer scan tomography, nano-indentation).

Synergy WP5

ANF / API /Penetron will provide improved products
and advise their use / mixing design guidelines.

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Task 4.4. Adaptation of UHDC to different application technologies

Partners: **BGU,** UPV, PoliMi, UOM, RDC **Timing M7-M18**

Adapt the UHDC mix-design formulations for **three different technologies**:

- Direct pouring of self-compacting mixes (PoliMi),
- Spraying or shotcrete (UPV, UOM)
- Impregnation of textile (BGU).

Scalability of the RDC production to precast and cast-in-place real scale applications **(RDC).**
Produce the **concrete technology needed in pilots** of WP8, to TRL5 and 6.
Including rules for: concrete plant or precast factory
transportation and application in real conditions.
Direct **collaboration with WP8** - to pilot site information: facilities, tailored requirements.

Mixture design modifications (Admixt. Dosage or other) - kept to minimum
orientated to technological robustness and scalability
maintaining the durability properties.

Side-tests will be performed to ensure the durability, and monitoring efficiency.
Possibility of tailoring UHDC for **digital fabrication** - through clustering with **RILEM TC DFC,.**

Task 4.5. Recycling UHDC elements

Partners: **UOM**, UPV **Timing: M19-M27**

feasibility of using aged UHDC rubbles as aggregates for new structures.

- artificially ageing of UHDC elements by carbonation and cracking (UM, UPV);

- characterisation of the aged UHDC rubbles and size optimization: physical and chemical properties / contents and resistance (for XS and XA conditions) (UOM);

- use of recycled UHDC for new concrete elements: effect on mechanical and durability properties (UPV).

Jointly: UOM and UPV

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Deliverables and Milestones

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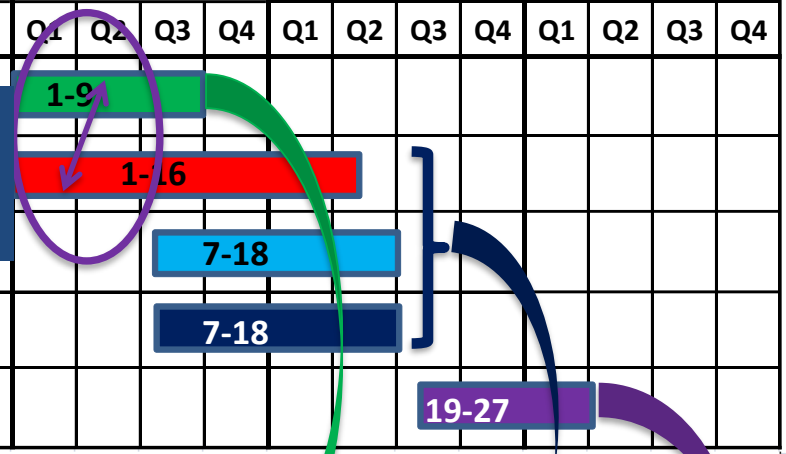
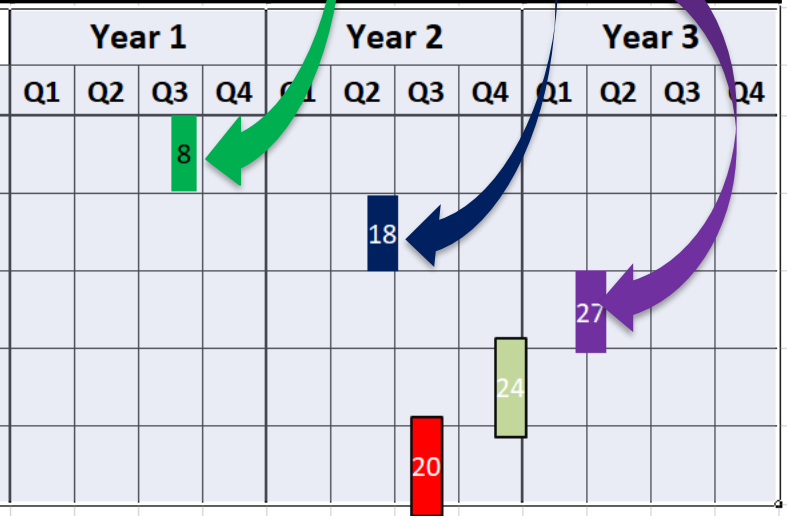


Deliverables and Millestones			Year 1				Year 2				Year 3			
N	Leader		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
D 4.1	ANF Development	Recommendation on the use of CA, NF and NC for production of UHDC												
D 4.2	BGU	Guidelines for mix design of functionalised UHDC and adaption to different application												
D 4.3	UOM	Recommendations for the use of recycled UHDC elements as aggregate for new concrete												
MS 4	CMW	Holistic approach to material and structure concept and design for UHDC applications via DAD												
MS 5	UPV	Recommended UHDC formulations to be used for the pilot applications in WP8												



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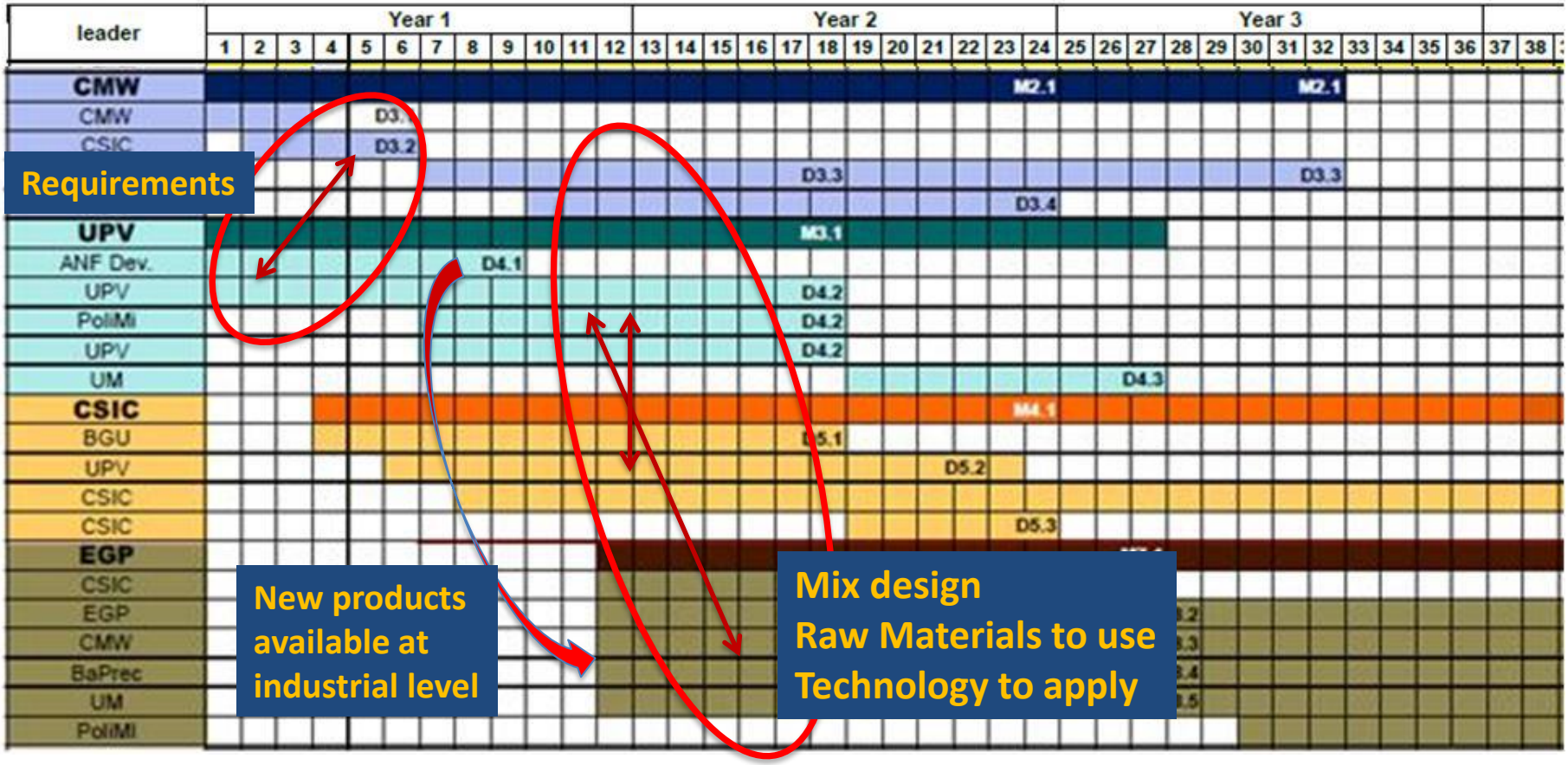
Risks


leader
Year 1
Year 2
Year 3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38
CMW
CMW
CSIC
UPV
ANF Dev.
UPV
PoliMi
UPV
UM
CSIC
BGU
UPV
CSIC
CSIC
EGP
CSIC
EGP
CMW
BaPrec
UM
PoliMi
M2.1
M2.1
D3.
D3.2
D3.3
D3.3
D3.4
M3.1
D4.1
D4.2
D4.2
D4.2
D4.3
D5.1
D5.2
D5.3
Requirements
New products available at industrial level
Mix design
Raw Materials to use
Technology to apply

Coordination in WP4

- Mailing list with all task leaders and partners
- **start activities at M1** – First meeting ¿need?
- ***Task Leaders***: T4.1 (ANF DEVELOPMENT), T4.2 (UPV), T4.3 (POLIMI), T4.4(BGU), T4.5(UOM)
- **Skype meetings every 1 Month**: progress work review and contingencies respect WP

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