Chapter 03

Alternative binders and substitute products

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WHAT IS :

ALTERNATIVE BINDERS AND SUBSTITUTE PRODUCTS?

Alternative binders and substitute products refer to options that can be used as replacements for traditional binding agents or materials in various industries..

WHAT IS THE GOAL?

These alternatives may be sought for economic, environmental, or performance reasons.

(Ces alternatives peuvent être recherchées pour des raisons économiques, environnementales ou de performance.)

SOME EXAMPLES IN DIFFERENT CONTEXTS !!

1. Manufacturing and Adhesives:

- Traditional Binder: Petroleum-based adhesives.
- Alternative Binder: Bio-based adhesives derived from renewable sources, reducing environmental impact.

- Liant traditionnel : Adhésifs à base de pétrole.
- Liant alternatif : Adhésifs biosourcés dérivés de sources renouvelables, réduisant l'impact sur l'environnement.

2. Food Industry:

- Traditional Binder: Egg as a binder in baking.
- Alternative Binder: Vegan substitutes like applesauce, flaxseeds, or

- - Liant traditionnel : Œuf comme liant dans la pâtisserie.
- Liant alternatif : Substituts végétaliens comme la compote de pommes, les graines de lin ou l'agar-agar.

3. Agriculture:

- Traditional Binder: Chemical fertilizers.
- Alternative Binder: Organic or bio-based fertilizers that promote sustainable and eco-friendly farming practices.

- Liant traditionnel : Engrais chimiques.
- Liant alternatif : Engrais organiques ou biosourcés qui favorisent des pratiques agricoles durables et respectueuses de l'environnement.

5. Energy:

- Traditional Binder: Lithium-ion batteries often use cobalt.
- Alternative Binder: Research into cobalt-free batteries or batteries with alternative materials for sustainability (durabilité) and cost reduction.

- Liant traditionnel : Les batteries lithium-ion utilisent souvent du cobalt.
- Liant alternatif : Recherche sur les batteries sans cobalt ou les batteries utilisant des matériaux

6. Plastics and Packaging:

7. Textiles:

8. Paper Industry:

9. Pharmaceuticals:

1. Towards higher-performance concretes

(Vers des bétons plus performants)

i. Définition of concretes performance

- The performance of concrete refers to its ability to meet the desired engineering and structural requirements (exigences) in various applications.

ii. Properties to perform

- Strength (solidité)
- Durability (durabilité)
- and versatility (polyvalence).

iii. Factors contributing into the performance of concrete

There are Several factors contribute to the performance of concrete:

- Compressive Strength

  Tensile Strength
- Durability (Durabilité):
- Workability (Facilité de mise en œuvre): The ease with
- Setting and Hardening:

- Shrinkage and Creep:
- Density:
- Sustainability:

- Examples

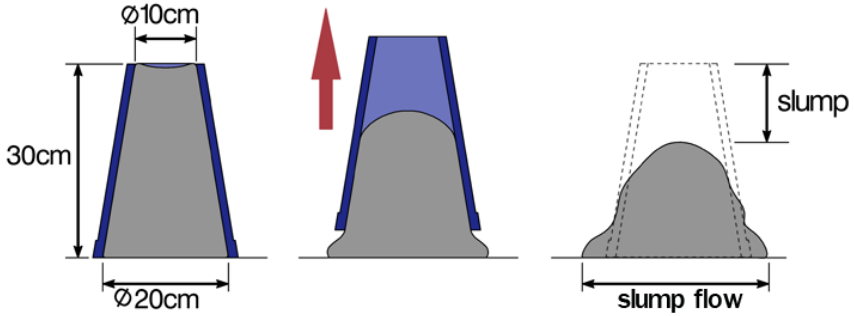
  These examples demonstrate the diverse range of higher-performance concrete types and their applications across various construction projects, each tailored to meet specific performance requirements and project goals.

1. High-Strength Concrete (HSC):
2. Fiber-Reinforced Concrete (FRC):
3. Ultra-High Performance Concrete (UHPC):
4. High-Performance Lightweight Concrete (HPLC):
5. High-Performance Concrete for Sustainability

High-Strength Concrete (HSC): High-strength concrete typically has compressive strengths exceeding 6,000 psi (41 MPa). It's used in high-rise buildings, bridges, and other structures where superior strength is essential to support heavy loads and reduce the size of structural elements.

Béton à haute résistance (HSC) : Le béton à haute résistance a généralement une résistance à la compression supérieure à 41 MPa (6 000 psi). Il est utilisé dans les immeubles de grande hauteur, les ponts et d'autres structures où une résistance supérieure est essentielle pour supporter de lourdes charges et réduire la taille des éléments structurels.

No	% sand	Slump value of concrete	
		Normal strength concrete (NSC) (mm)	High strength concrete (HSC) (mm)
1	100	70	48
2	80	80	52
3	60	68	47
4	40	60	45
5	30	55	40
6	20	40	35
7	0	30	28



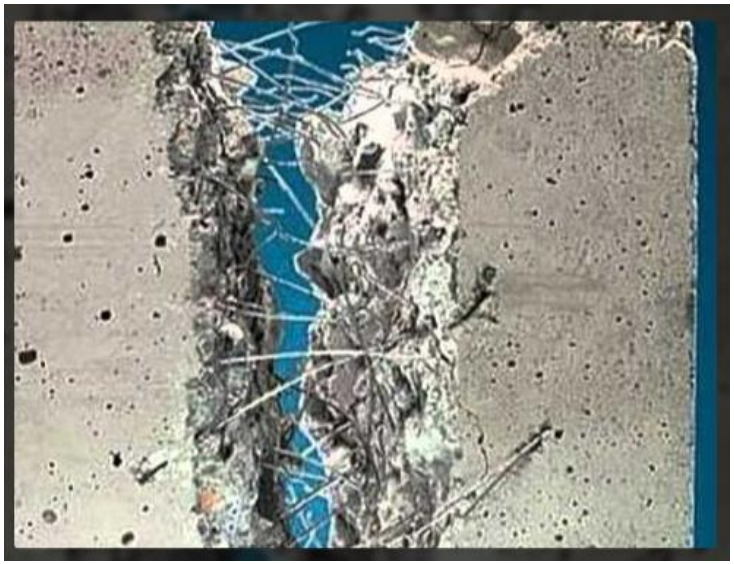
The Slump value of normal and high strength concrete

Valeur d'affaissement (الركود)du béton normal et du béton à haute résistance

Self-Consolidating Concrete (SCC): Béton autoplaçant (BAP) SCC is highly flowable and can fill intricate formwork without the need for vibration, making it ideal for complex shapes and congested reinforcement areas. It's commonly used in architectural concrete elements, precast concrete products, and high-performance structures.

Béton autoplaçant (BAP) : Le béton autoplaçant est très fluide et peut remplir des coffrages complexes sans nécessiter de vibration, ce qui le rend idéal pour les formes complexes et les zones d'armature encombrées. Il est couramment utilisé dans les éléments architecturaux en béton, les produits préfabriqués en béton et les structures à haute performance.

Fiber-Reinforced Concrete (FRC): Béton renforcé par des fibres (FRC) FRC contains fibers such as steel, glass, or synthetic materials, which enhance its toughness, crack resistance, and ductility. It's utilized in tunnel linings, industrial floors, and earthquake-resistant structures to improve resilience and durability.



Béton renforcé par des fibres (FRC) : Le béton renforcé de fibres contient des fibres telles que l'acier, le verre ou des matériaux synthétiques, qui améliorent sa ténacité, sa résistance aux fissures et sa ductilité. Il est utilisé dans les revêtements de tunnels, les sols industriels et les structures résistantes aux tremblements de terre pour améliorer la résilience et la durabilité.

TABLE I

CHEMICAL AND PHYSICAL PROPERTIES OF THE HPP45 SYNTHETIC FIBRES

Characteristics	Material properties
Fibre length and diameter	45mm and 1mm
Type/ shape	Macro/ monofilament
Aspect ratio	45
Specific gravity	0.91
Electrical conductivity	Low
Acid and salt resistance	High
Melting point	1640C
Ignition point	> 5500C
Thermal conductivity	Low
Alkaline resistance	Alkaline proof

(a) (b) (c) (d) (e)

Examples of steel fibers

Mechanical Properties and Anti-Spalling Behavior of Ultra-High Performance Concrete with Recycled and Industrial Steel Fibers

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Ultra-High Performance Concrete (UHPC): Béton à ultra-hautes performances (BUHP) : UHPC is characterized by exceptional strength, durability, and ductility, with compressive strengths often exceeding 21,000 psi (145 MPa). It's used in bridge decks, prefabricated elements, and infrastructure repairs due to its outstanding mechanical properties and resistance to environmental degradation.

Béton à ultra-hautes performances (BUHP) : Le BFUP se caractérise par une résistance, une durabilité et une ductilité exceptionnelles, avec des résistances à la compression dépassant souvent 21 000 psi (145 MPa). Il est utilisé pour les tabliers de ponts, les éléments préfabriqués et les réparations d'infrastructures en raison de ses propriétés mécaniques exceptionnelles et de sa résistance à la dégradation de l'environnement.

High-Performance Lightweight Concrete (HPLC): Béton léger à haute performance (BHLP) HPLC combines high strength with reduced density, offering advantages such as improved seismic performance, reduced dead loads, and enhanced thermal insulation. It's applied in lightweight structural elements, floor and roof systems, and building envelopes.

Béton léger à haute performance (BHLP) : Le HPLC associe une résistance élevée à une densité réduite, offrant ainsi des avantages tels que l'amélioration des performances sismiques, la réduction des charges permanentes et l'amélioration de l'isolation thermique. Il est utilisé dans les éléments structurels légers, les systèmes de planchers et de toits et les enveloppes de bâtiments.

High-Performance Concrete for Sustainability: Béton haute performance pour le développement durable : Concrete mixes incorporating supplementary cementitious materials like fly ash, slag cement, or silica fume exhibit improved sustainability by reducing CO2 emissions, conserving natural resources, and enhancing long-term durability. These sustainable concrete mixes are used in green building projects, sustainable infrastructure, and environmentally sensitive areas.

Béton haute performance pour le développement durable : Les mélanges de béton incorporant des matériaux cimentaires supplémentaires tels que les cendres volantes, le ciment de laitier ou la fumée de silice présentent une durabilité accrue en réduisant les émissions de CO2, en préservant les ressources naturelles et en améliorant la durabilité à long terme. Ces mélanges de béton durables sont utilisés dans les projets de construction écologique, les infrastructures durables et les zones écologiquement sensibles.

2. Towards binders with mineral additions as substitutes for clinker

i. Definition of additions:

- A mineral additive for concrete is a finely divided material, generally with a grain size of less than 100µm,

- It is incorporated into concrete during manufacture to improve certain properties (workability(la facilité de mise en œuvre), consistency) or to give it special properties: compactness, durability, resistance to aggressive environments, etc.

Mineral additions are defined in standard NF EN 206/CN

(Les additions minérales sont définies dans la norme NF EN 206/CN)

ii. benefits

By incorporating mineral additions as substitutes for clinker, several benefits can be achieved:

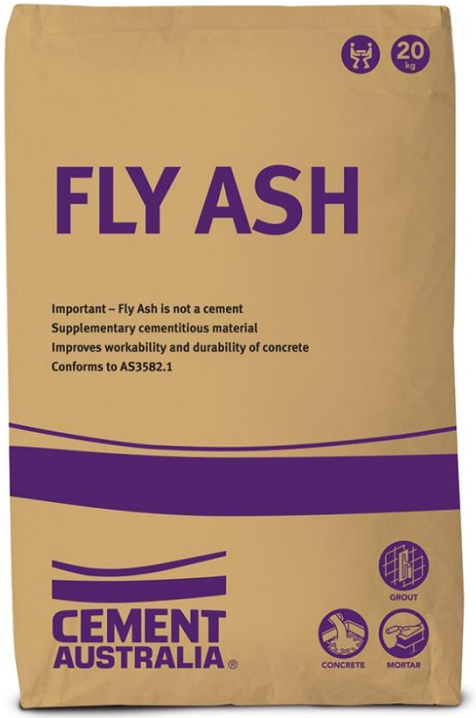
1. Reduced Carbon Emissions:
2. Utilization of Industrial Byproducts:
3. Improved Performance:
4. Mitigation (Atténuation) of Alkali-Silica Reaction (ASR):
5. Reduced Heat of Hydration: Cost Savings

iii. Common mineral additions for clinker and their roles

1. Fly Ash (Cendres volantes):
2. Ground Granulated Blast Furnace Slag (GGBFS):
3. Silica Fume (Fumée de silice):
4. Natural Pozzolans (Pouzzolanes naturelles):
5. Limestone Powder (Poudre de calcaire):

Fly Ash


Adda247
UPSC
Fly Ash

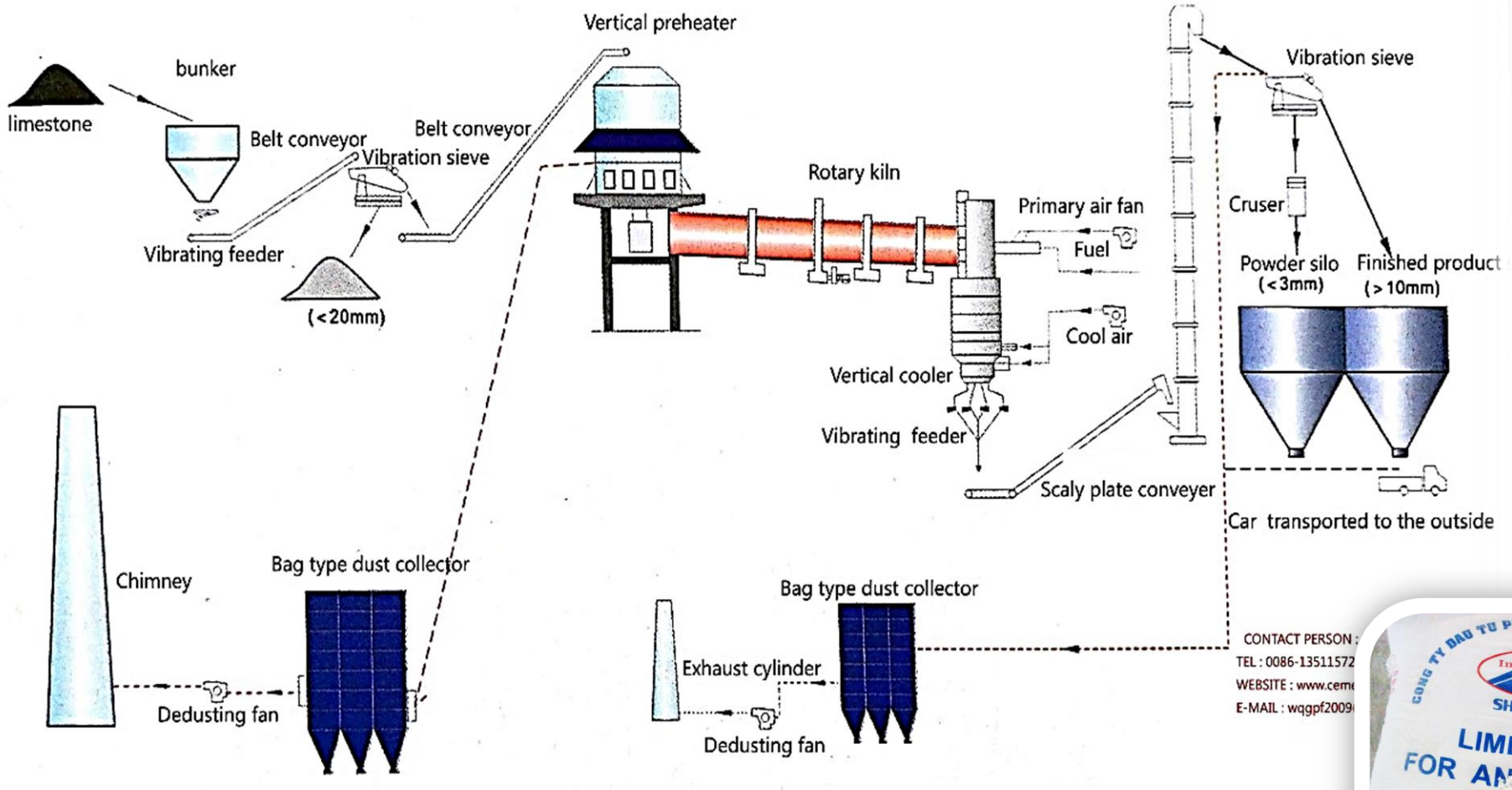

20
kg
FLY ASH
Important – Fly Ash is not a cement
Supplementary cementitious material
Improves workability and durability of concrete
Conforms to AS3582.1
CEMENT AUSTRALIA
GROUT
CONCRETE
MORTAR

Pozzolan deposits (Gisement)

Natural Pozzolans

Limestone Powder production

Process flow chart of active lime production line



3. New alternative binders

i. Definition :

New alternative binders refer to a class of construction materials that are used either as replacements or supplements to traditional binders like Portland cement.

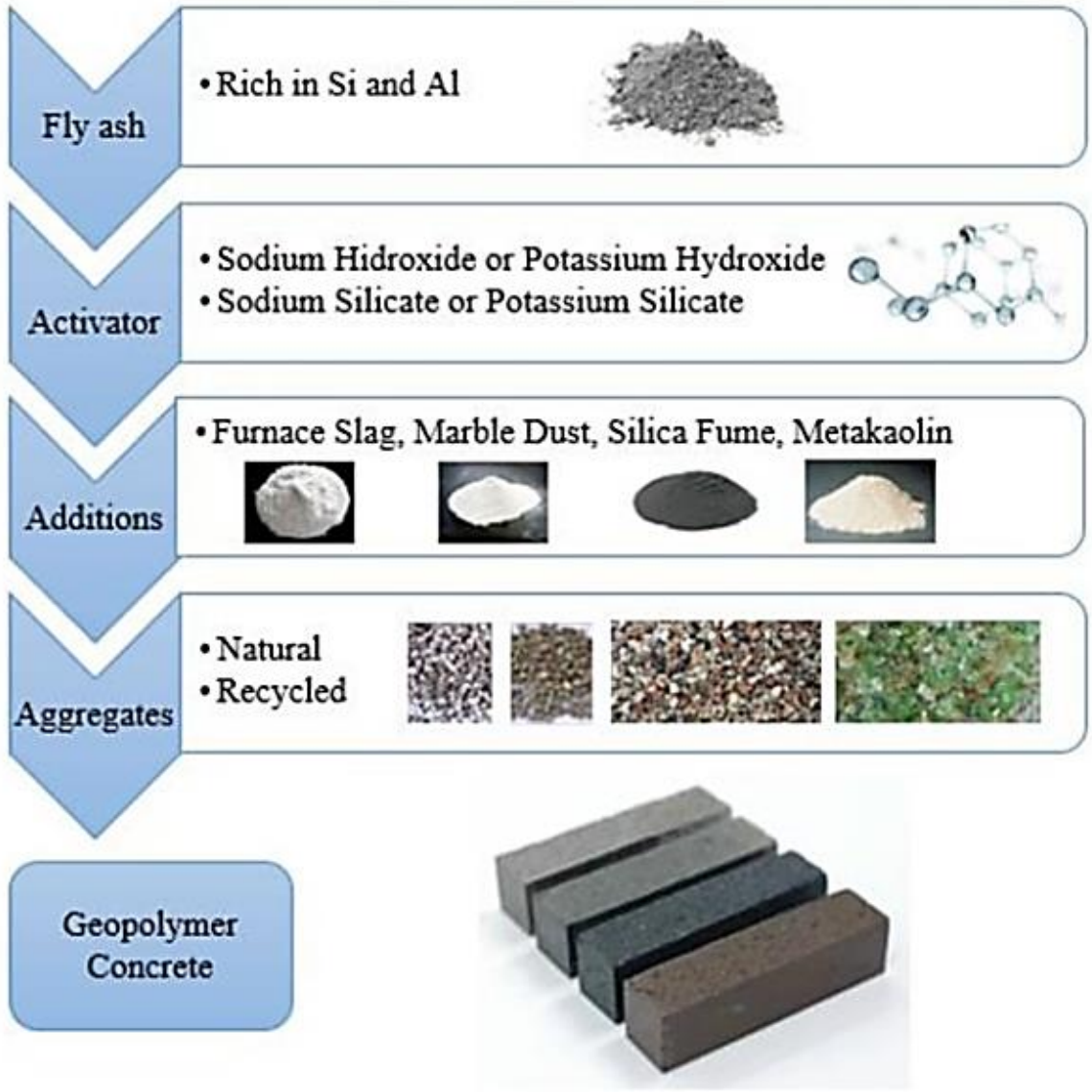
These alternative binders often offer advantages in terms of sustainability, performance, and environmental durability.

ii. Exemple of new alternative binders

Here are some of the most promising new alternative binders:

Geopolymers (Géopolymères) :

- Geopolymers are inorganic binders formed by the reaction of aluminosilicate materials (has the general formula : $(MAlO_2)(SiO_2)_x(H_2O)_y$ where M^+ is usually H^+ and Na^+) with an alkaline activator.
- They offer high strength, low porosity, and excellent chemical resistance. Geopolymers are often made from industrial waste materials such as fly ash or blast furnace slag.



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Alumina Cement:

- Alumina cement is manufactured from clinker containing a high proportion of calcium aluminate.
- It is used in specialized applications requiring high chemical resistance, such as refractory linings and sulfate-resistant mortars.