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HERAKLION 2019

OPTIMIZATION OF WASTE MATERIAL REUSE IN CONCRETE USING INNOVATIVE COMBINATION METHOD BASED ON MATHEMATICAL MODEL AND AI

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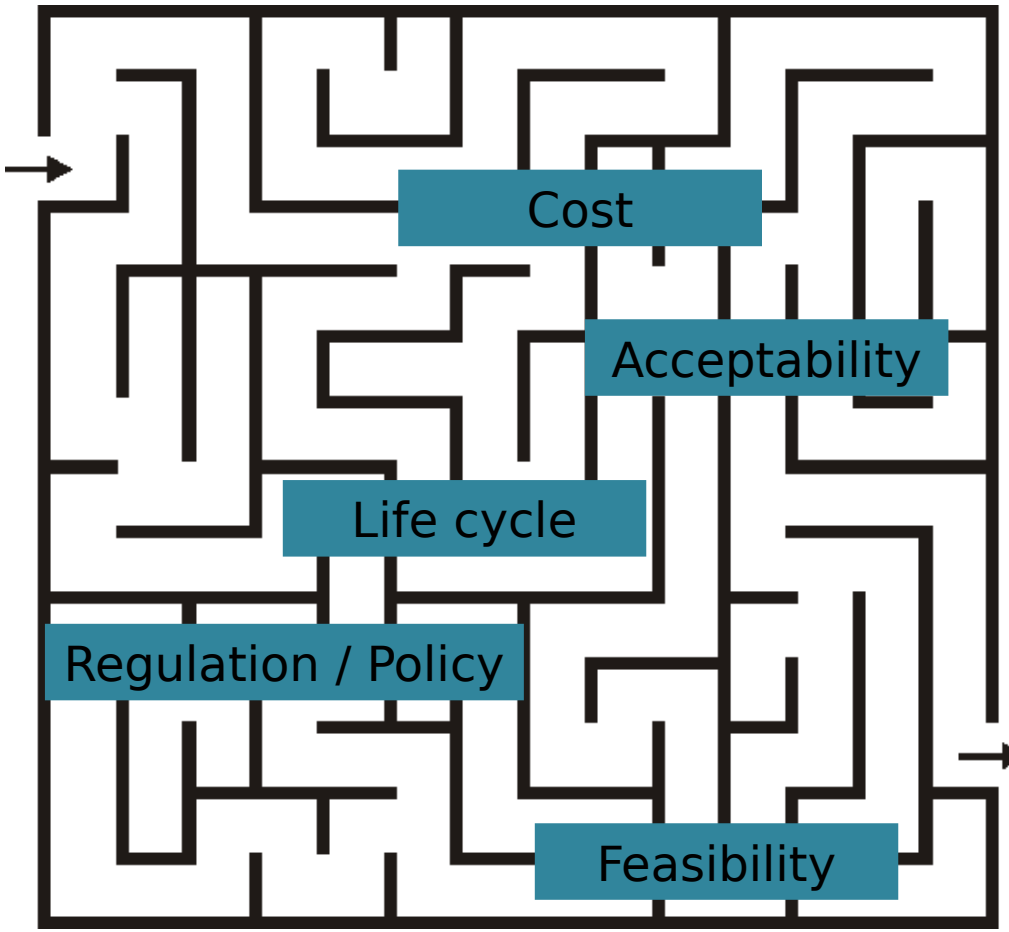
26 – 29 June

Context

“WASTE”

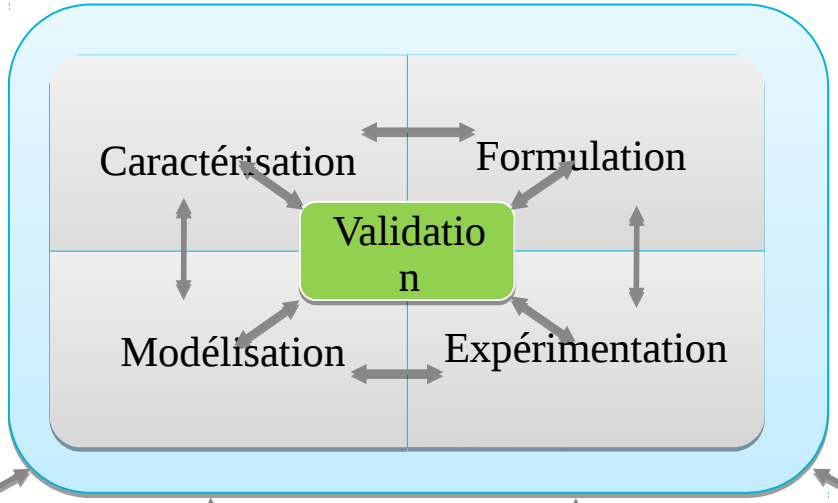


Materials, structure

Context

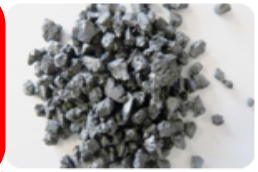
Valorisation des SPI

Complex decision
Multi parameters



Traitement | Durability | Environment | Cost


Sediments


Tires


Fibres VP


Slag


Bauxaline


Mâchefers


Gravael

Context

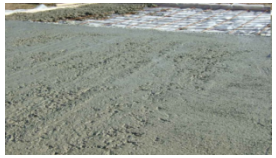
Dredged sediments
+ 500 million m³ / year

Immersion

Temporary solution
Environmental pollution

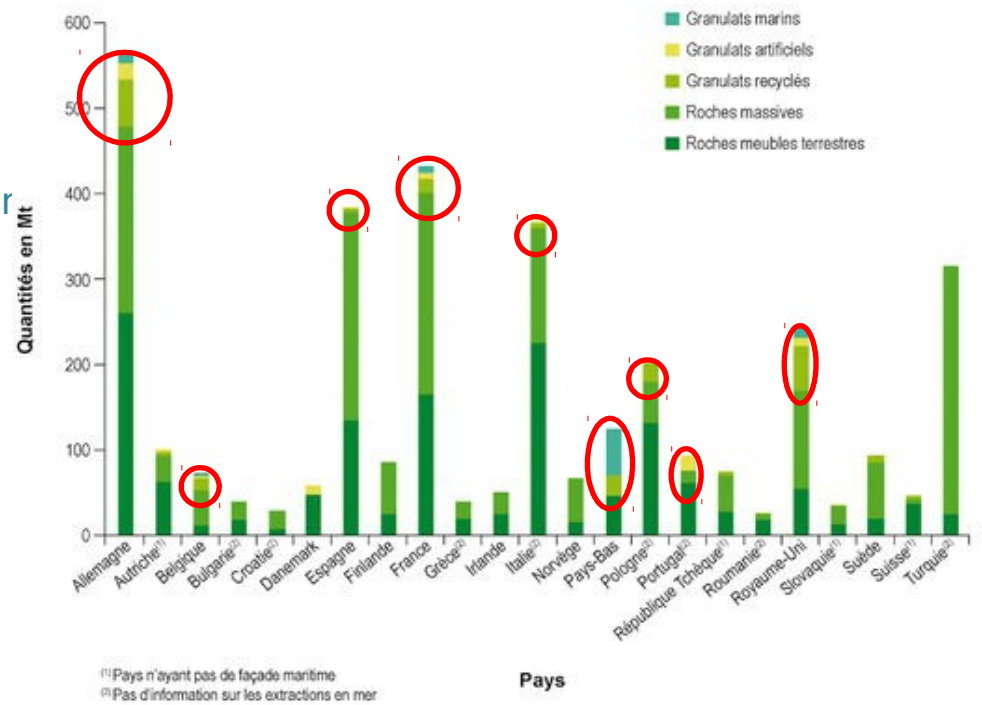
stocking

Too important tonnage
Environmental pollution

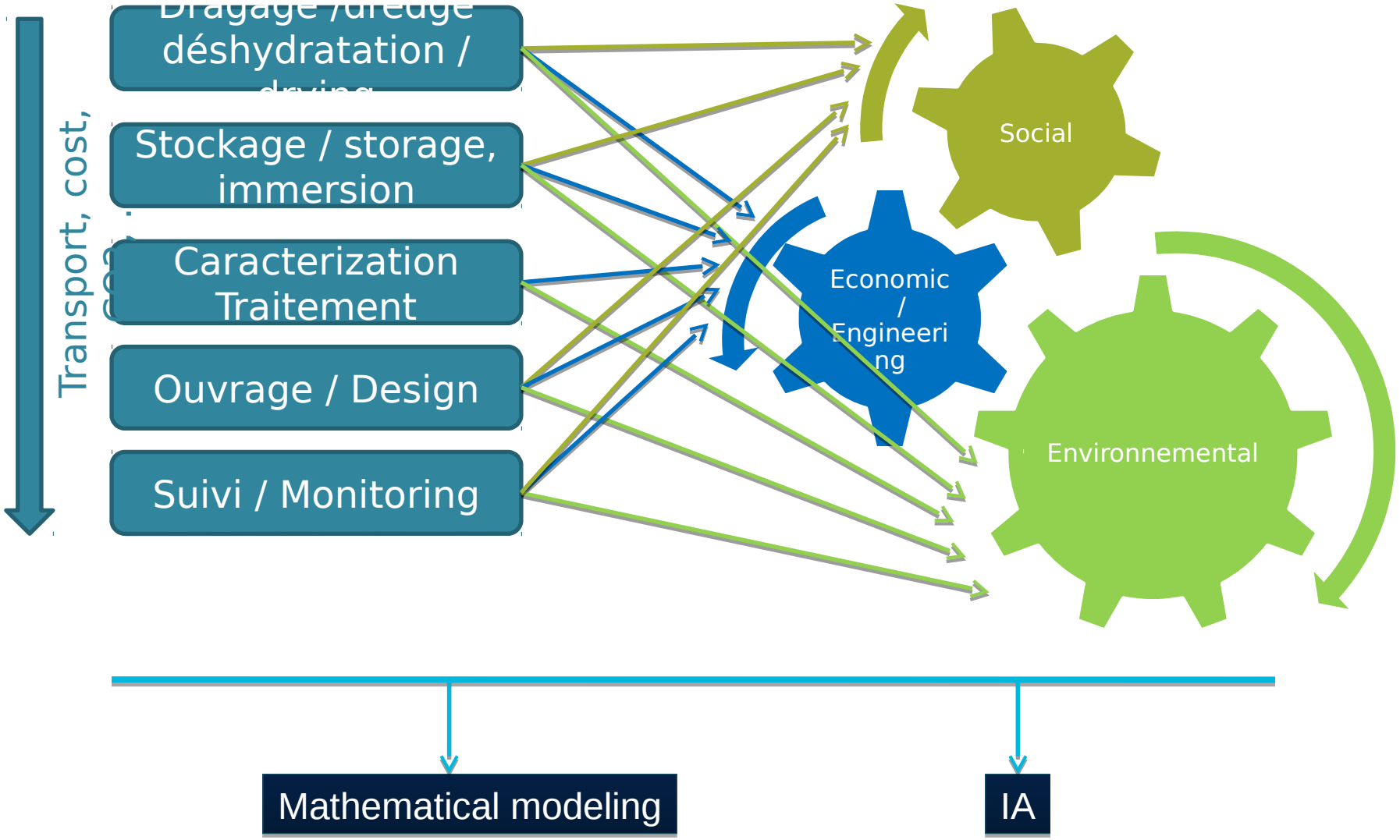


Sources of aggregates in Europe

Les différentes sources de granulats en Europe (source UEPG-2009)



Operational & IA approach : sediment reused



hematical operational approach

oftware : Input data

Sediment

- Name
- Type of sample
- *Characteristics*
. Chemical (as, zn, ...)
. Mechanical (GTR)
- Centre of studies
- dredging date
- dredging location
- *GPS coordinates*
- *Transport costs* T / km
- Operating costs
- Notes

Treatment center

- Unit name
-Type of treatment
- **For each type:**
. Name of treatment
. Cost € / T
. Impact on polluting element%
- Address of the center
- GPS coordinates
- Notes

Storage areas

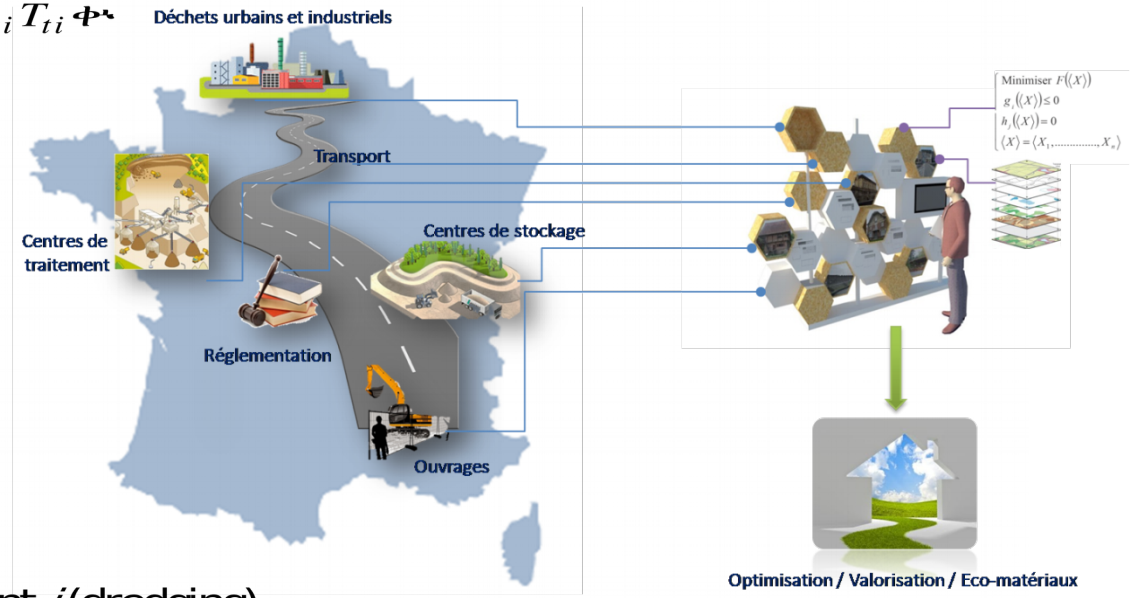
- Zone Name
- *Type (Inert, Not dangerous, Dangerous)*
- *GPS coordinates*
- *Storage costs € / T*
-Notes

Materials

- Name
- *GPS coordinates*
- *Transportation cost*
- *Operating cost (or purchase)*
- *Characteristics*
. chemical
. mechanics
-Notes

hematical model : Objective function

$$Min \sum_{i=1}^{n} C_i x_i + \sum_{j=1}^{m} C_j S_j + \sum_{i=1}^{n} \sum_{t=1}^{|T|} C_{ti} T_{ti}$$



With:

C_i : Operating cost of sediment i (dredging)

C_j : Purchase cost of the material j and transport cost (T/Km)

C_{ti} : Cost of treatment t applied to sediment i and sediment transport cost (T/Km)

hematical model : Constraints

ronmental constraints : Heavy metals

$$e_{si} \left(1 - \sum_{t=1}^{|T|} e_{sit} T_{ti}\right) \leq e_s + (1 - x_i) M$$

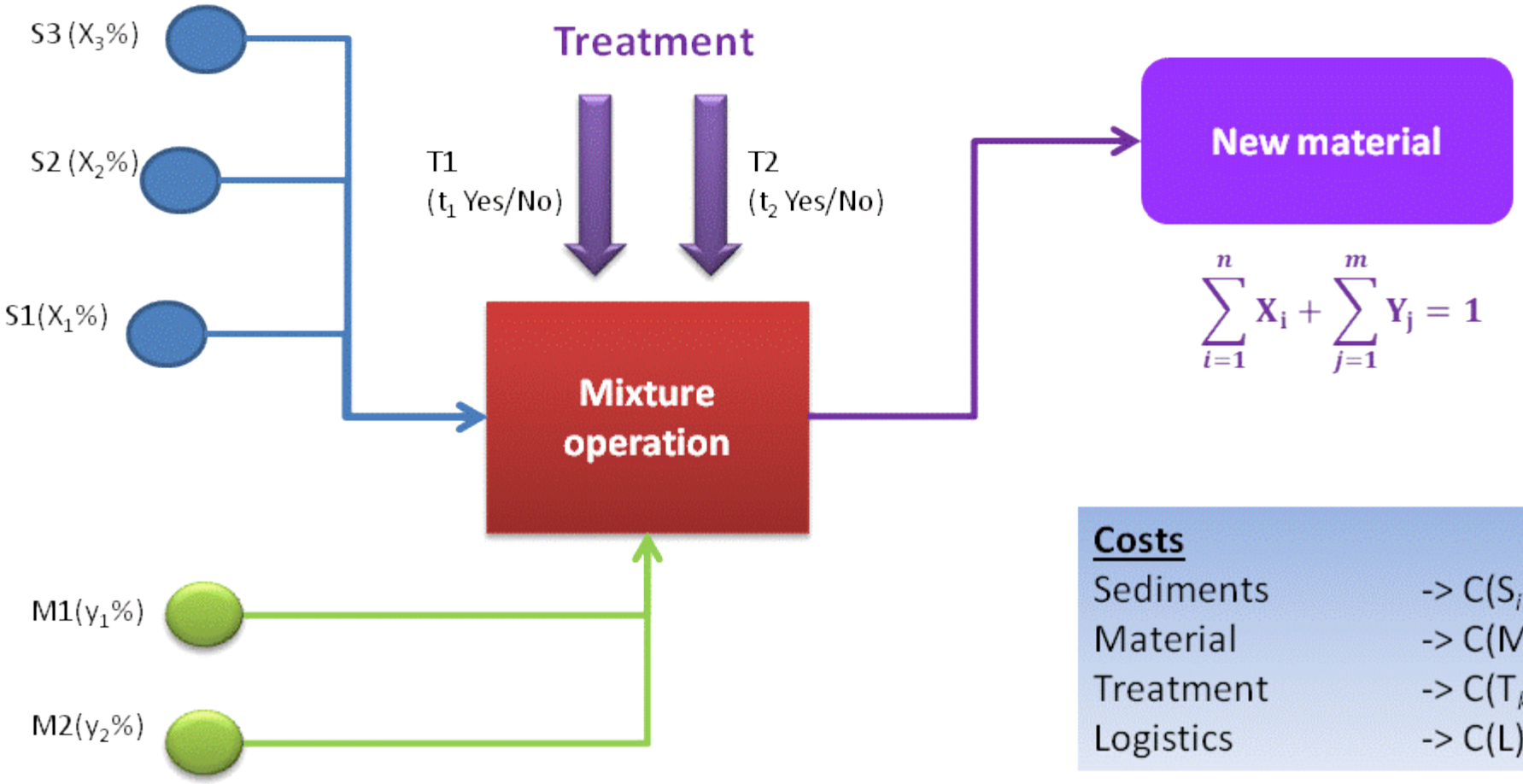
ronmental constraints : Organic matter

$$e_{Mi} \left(1 - \sum_{t=1}^{|T|} e_{Mit} T_{ti}\right) \leq e_M \left(1 + \sum_{j=1}^{m} S_j\right) + (1 - x_i) M$$

Mechanical constraints

$$P_d^{0.4} \left(\sum_{i=1}^{n} x_i + \sum_{j=1}^{m} S_j\right) \leq \sum_{i=1}^{n} (P_{id} \times x_i) + \sum_{j=1}^{m} (P_{jd} \times S_j) \leq P_d^{0.25} \left(\sum_{i=1}^{n} x_i + \sum_{j=1}^{m} S_j\right)$$

P_{id} P_{jd} associated percentage to the diameter d in sediment i (material j)

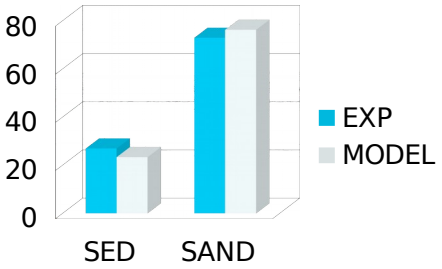


$$\sum_{i=1}^{n} X_i\, C(S_i) + \sum_{j=1}^{m} Y_j C(M_i) + \sum_{k=1}^{K} T_k C(T_k) + C(L) \rightarrow \text{Min}$$

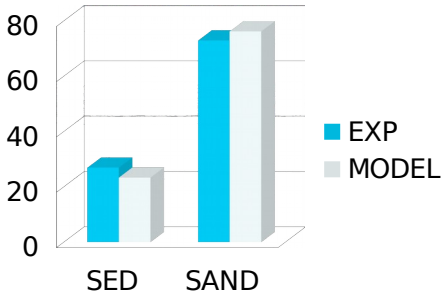
Results

Mathematical model : Validation

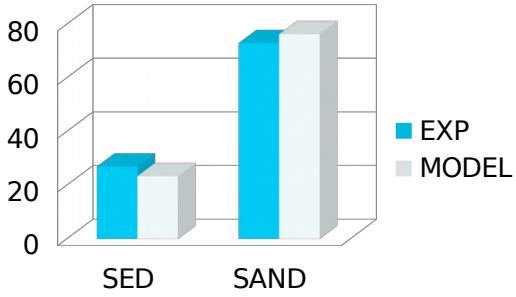
(PhD GPMD 2012)
Experimental results : Optimal mixtures : SED 30%, SAND 70%,
Modelisation results : Optimal mixtures : SED 31,9%, SAND 68%,



(PhD LMCU 2013)
Experimental results : Optimal mixtures : SED 40%, SAND 60%,
Modelisation results : Optimal mixtures : SED 41,4%, SAND 58,56%,



(PhD PRISMA 2015) PRISMA
Experimental results : Optimal mixtures : SED 27%, SAND 73%,
Modelisation results : Optimal mixtures : SED 23,4%, DAND 76,3%,



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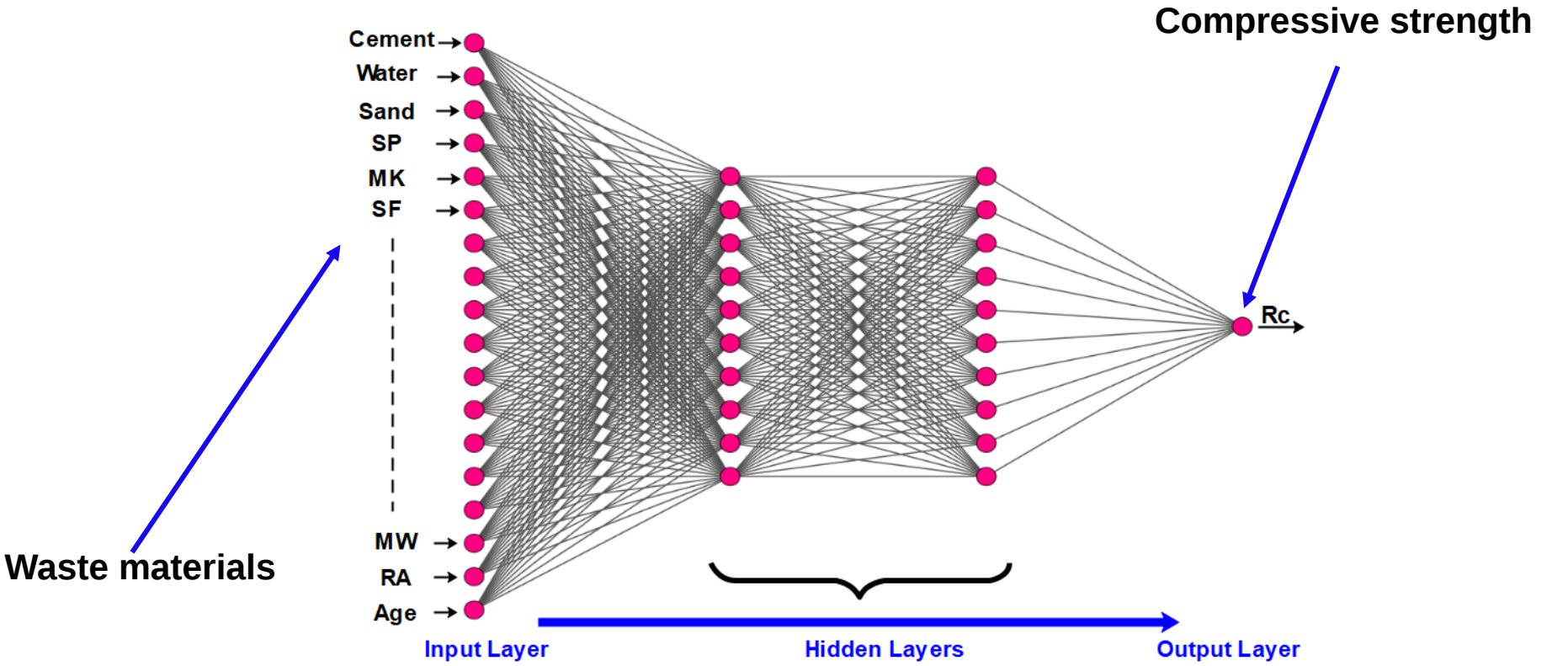
Architecture



❶ Building up a **neural network**

❷ Integrating **18 inputs, 2 hidden layers, 1 Output** based on **1310 experimental data values.**

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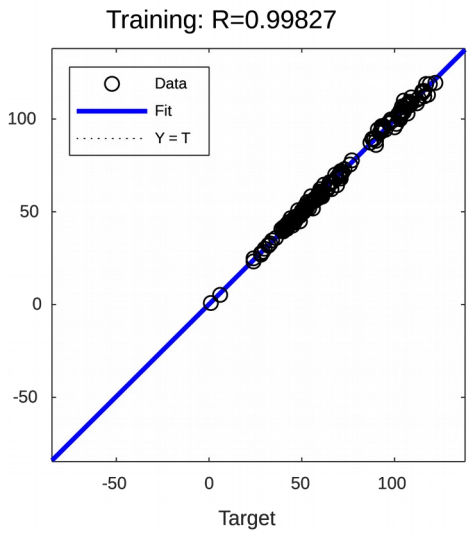
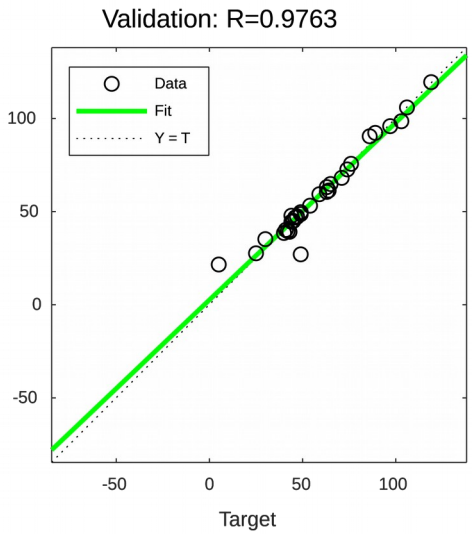
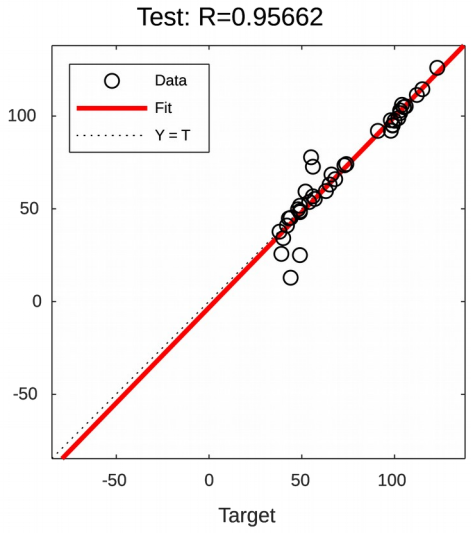
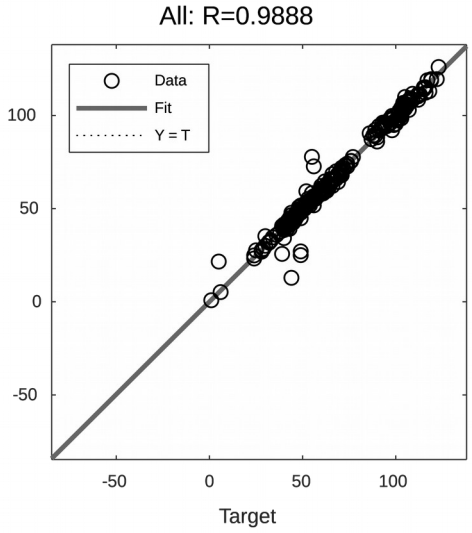
Results









- The fit is **highly good** for all data sets
- **R^2** values is **0.95** or above in each case.
- There is **Good correlation** between predicted and actual values

Operational & IA approach : sediment reused

Reusd possibility : Projects SETARMS, PRISMA, ECOSED, GPMD, SEDIMATERIAUX

Road

Dyke

self-compacting concrete

Urban furniture

Reservoir concrete pavement

Aggregates

FOUNDING MEMBERS OF THE CHAIR: CIRCULAR ECONOMY OF SEDIMENTS ECOSED DIGITAL 4.0

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