Construction, deconstruction, reuse of the structural elements:

the circular economy to reach zero carbon

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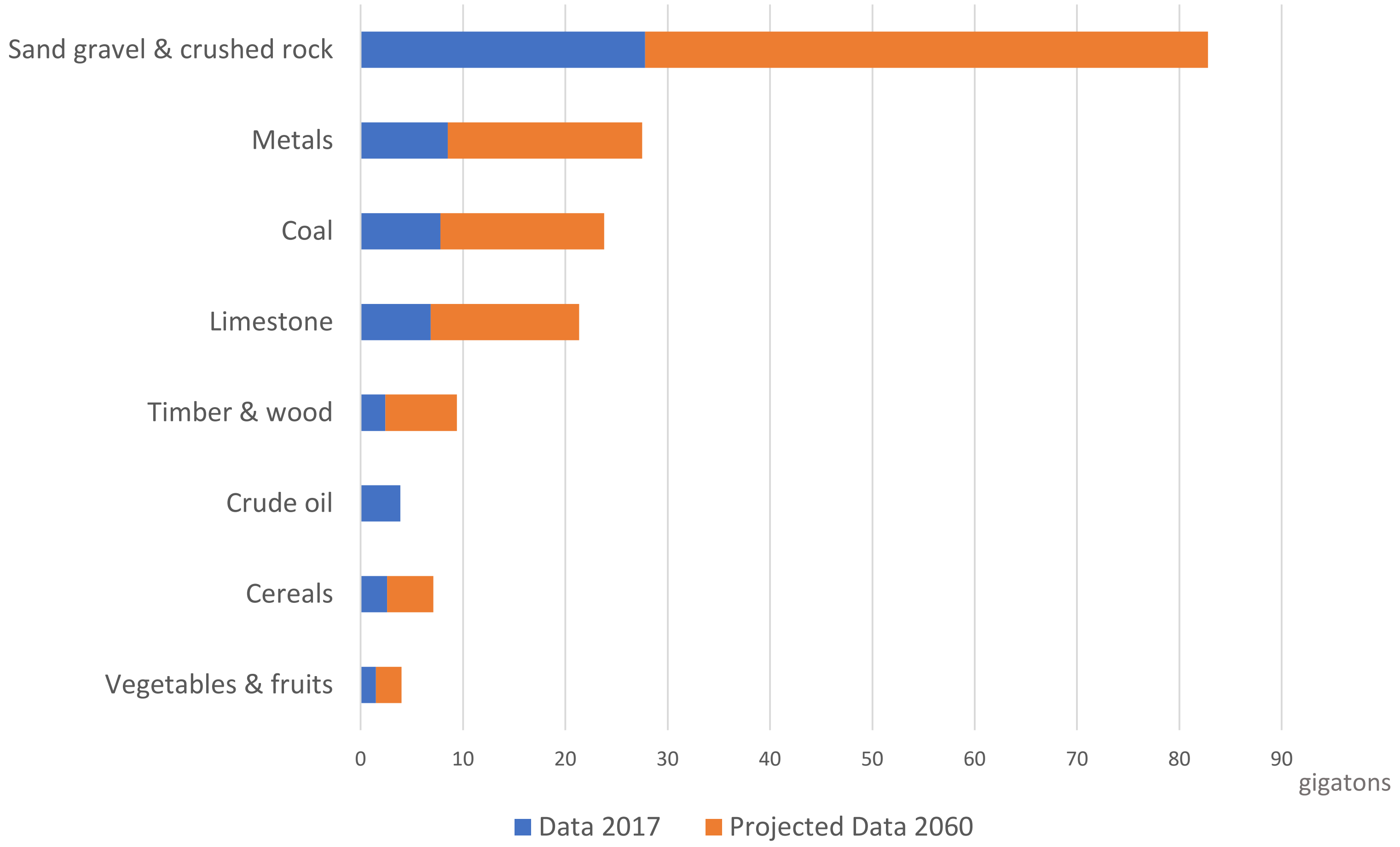
- RESOURCES CONTEXT
- ECO DESIGN FOR SUSTAINABLE CITIES
- BIM 6D ENVIRONMENTAL DATA
- TRACEABILITY TO PRESERVE MATERIALS
- CONCLUSION

RESOURCES CONTEXT

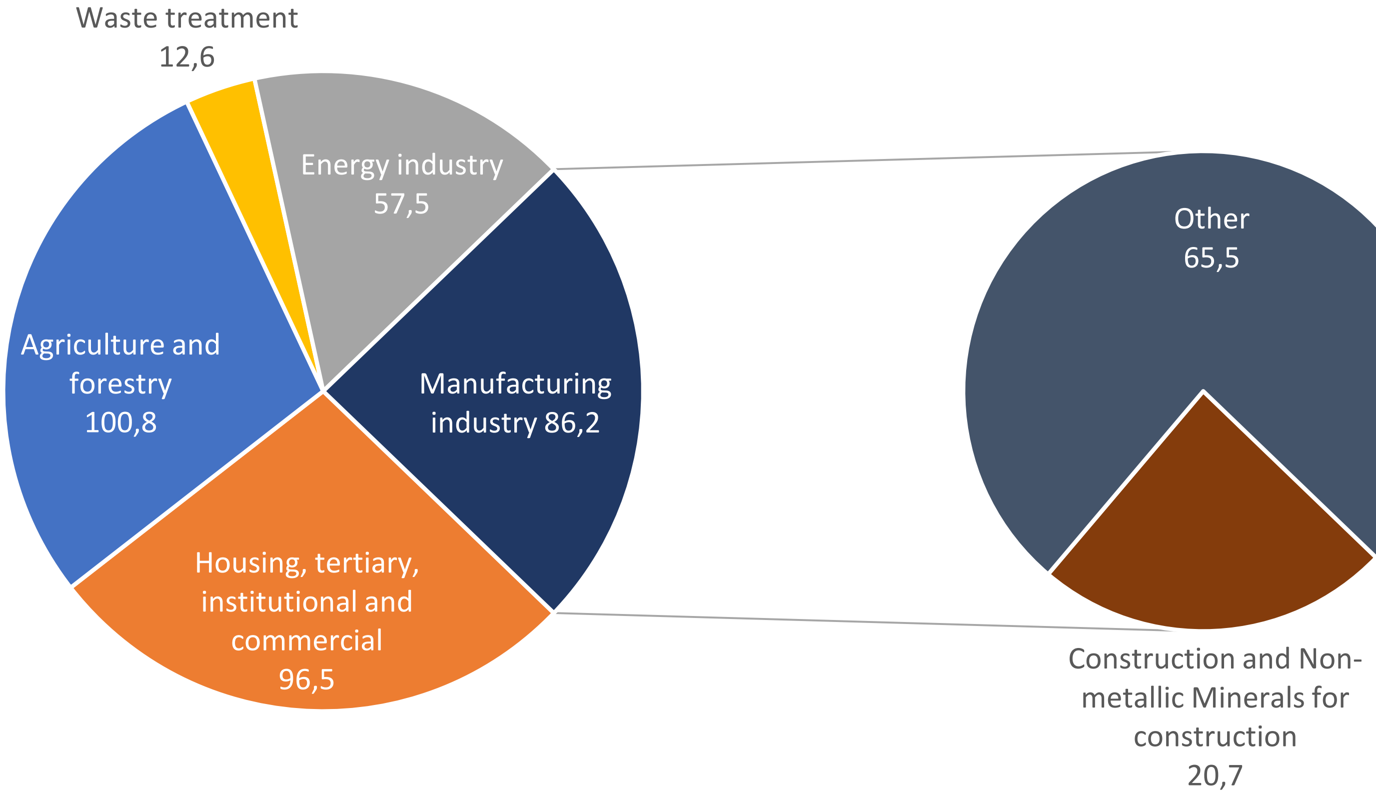
01.

Construction materials dominate total materials use in the world in 2017 and 2060



Reference : OECD Global Materiel Resources Outlook to 2060

Greenhouse gas emissions in France in million tons eq CO_2



Reference : CITEPA, 2014

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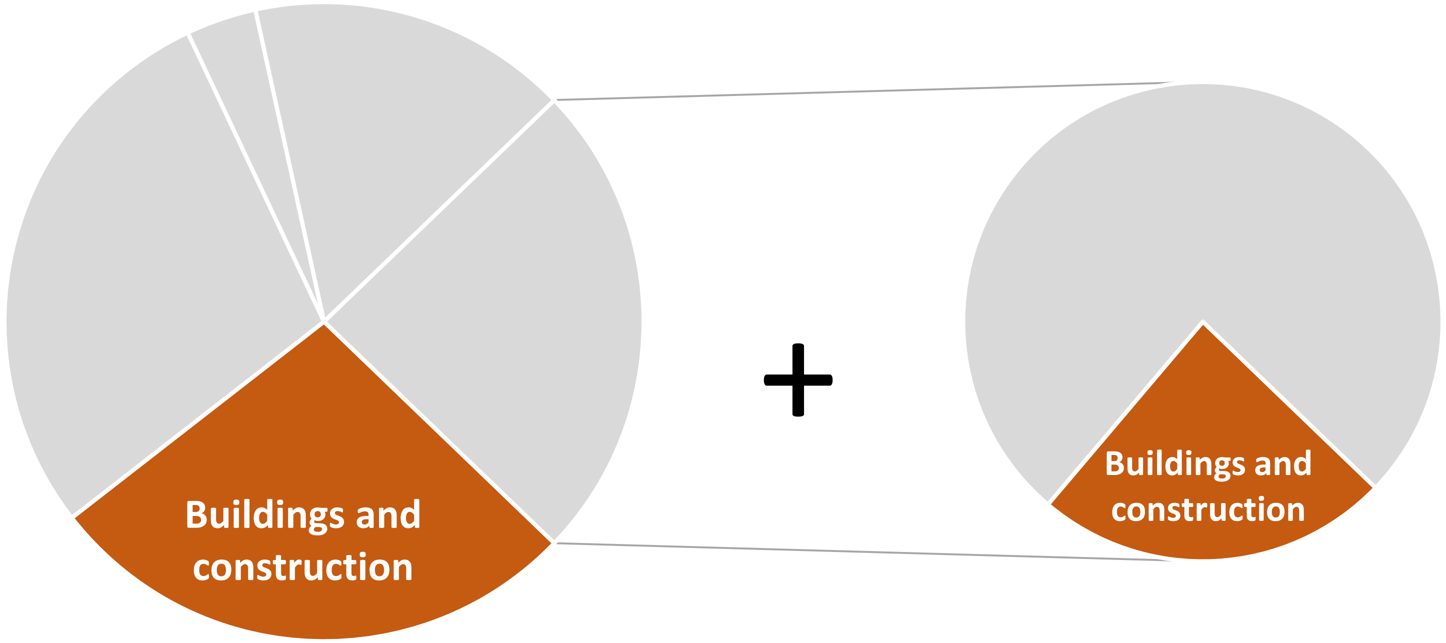
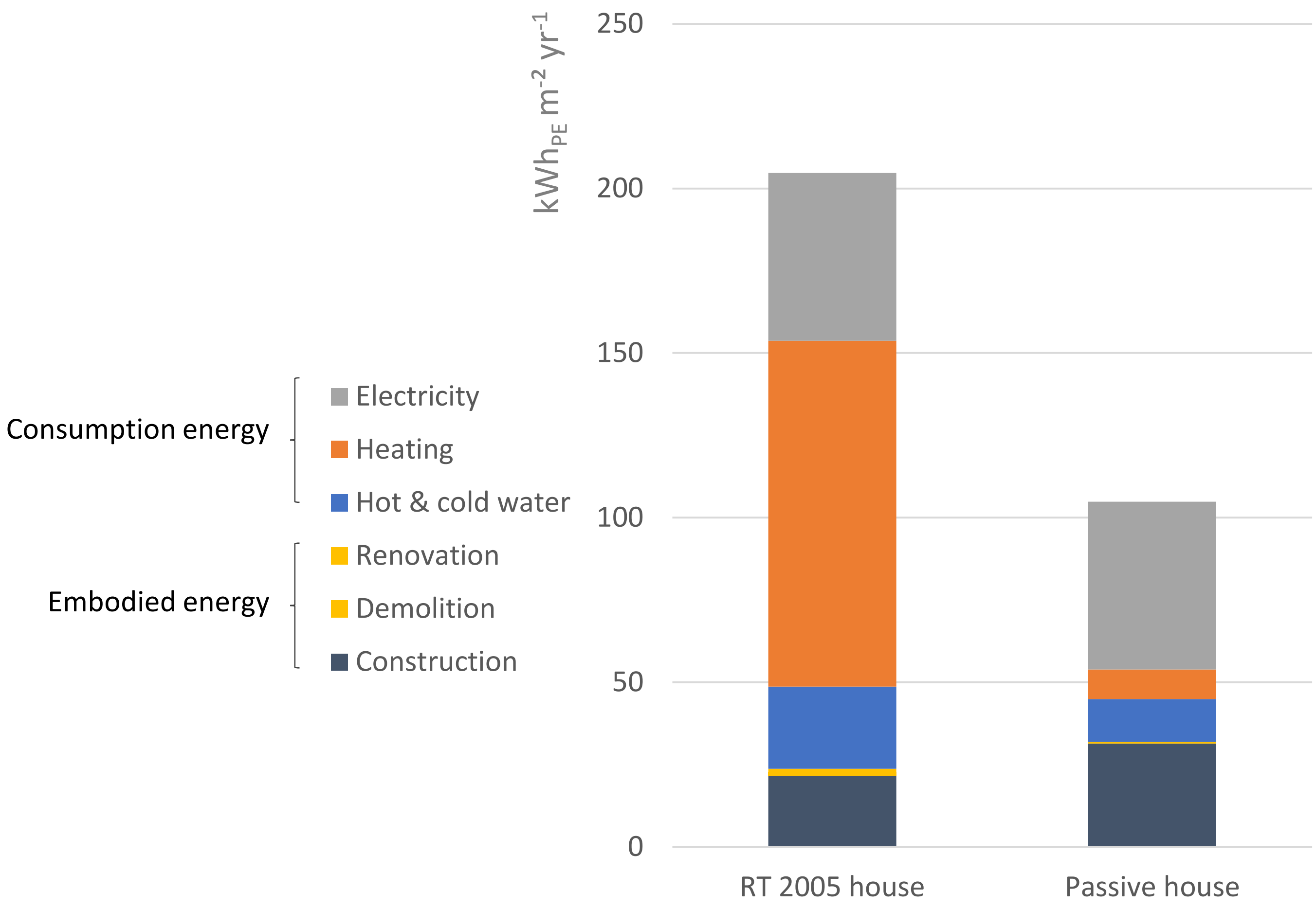


Being 33% of tons eq CO_2
for the construction and operation of buildings

Reference : CITEPA, 2014

Embodied energy contribution to the global balance



Reference : Peuportier Bruno, EIVP Summer University of September 6, 2018 (with logiciel EQUER, Mines ParisTech)

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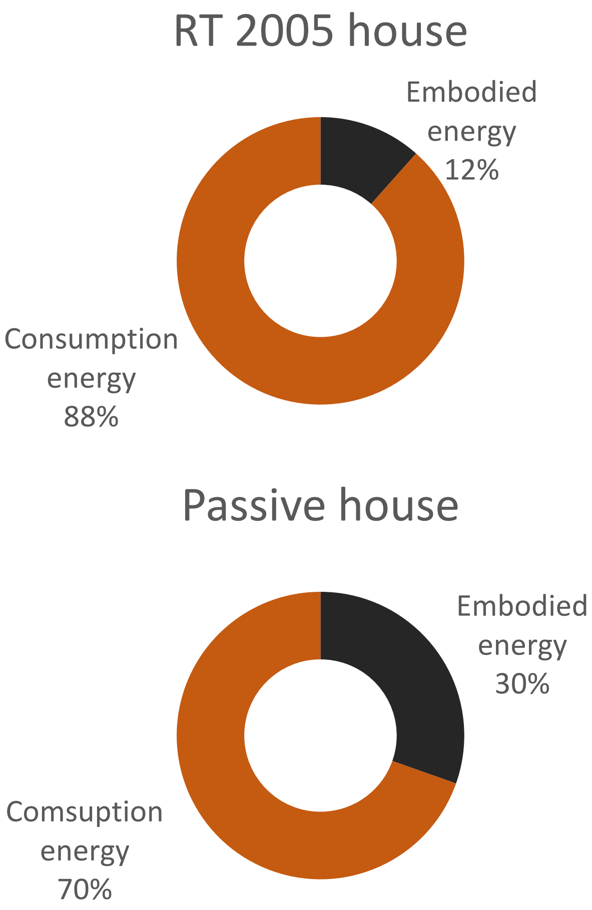
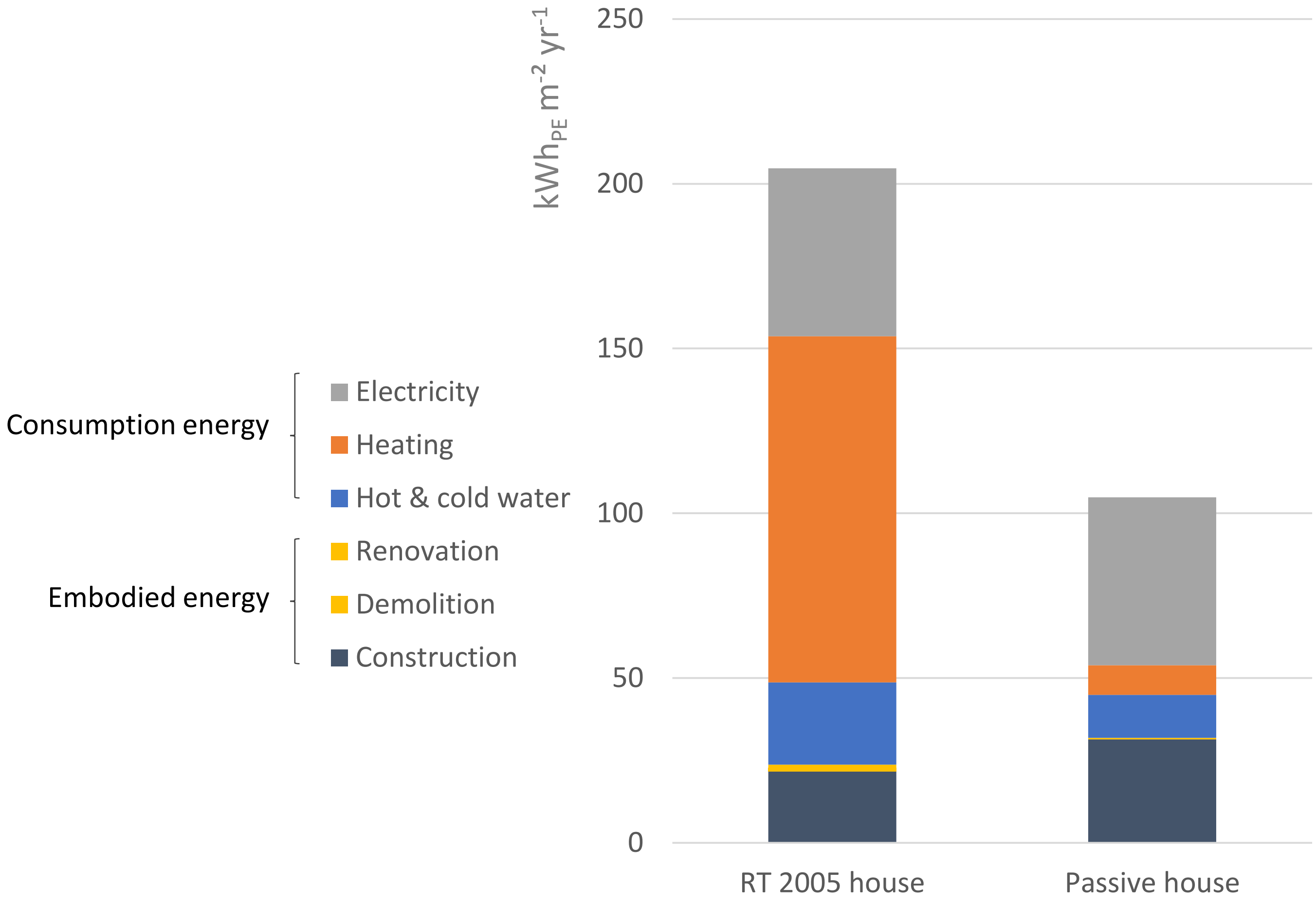
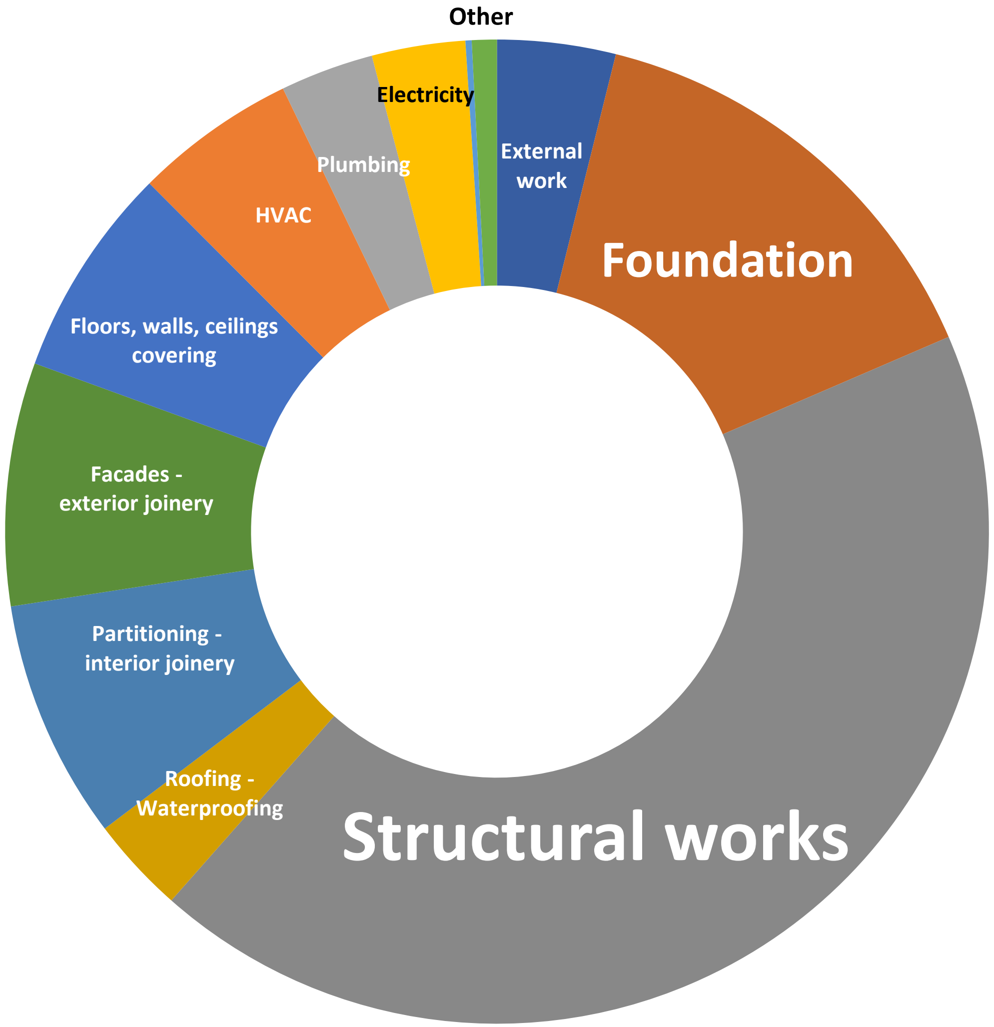




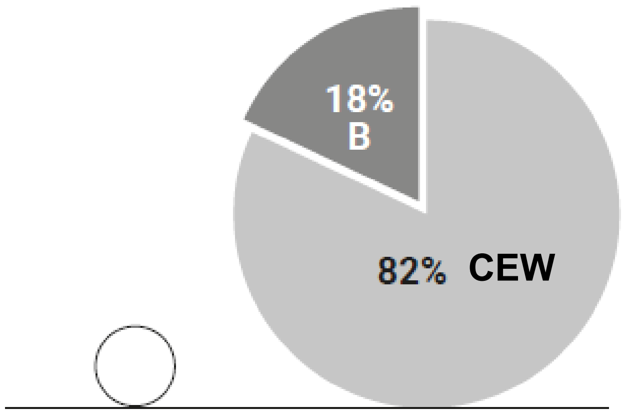
Reference : Peuportier Bruno, EIVP Summer University of September 6, 2018 (with logiciel EQUER, Mines ParisTech)

Greenhouse gas emissions in buildings



Reference : CTB n°349, March 2016

Waste reduction

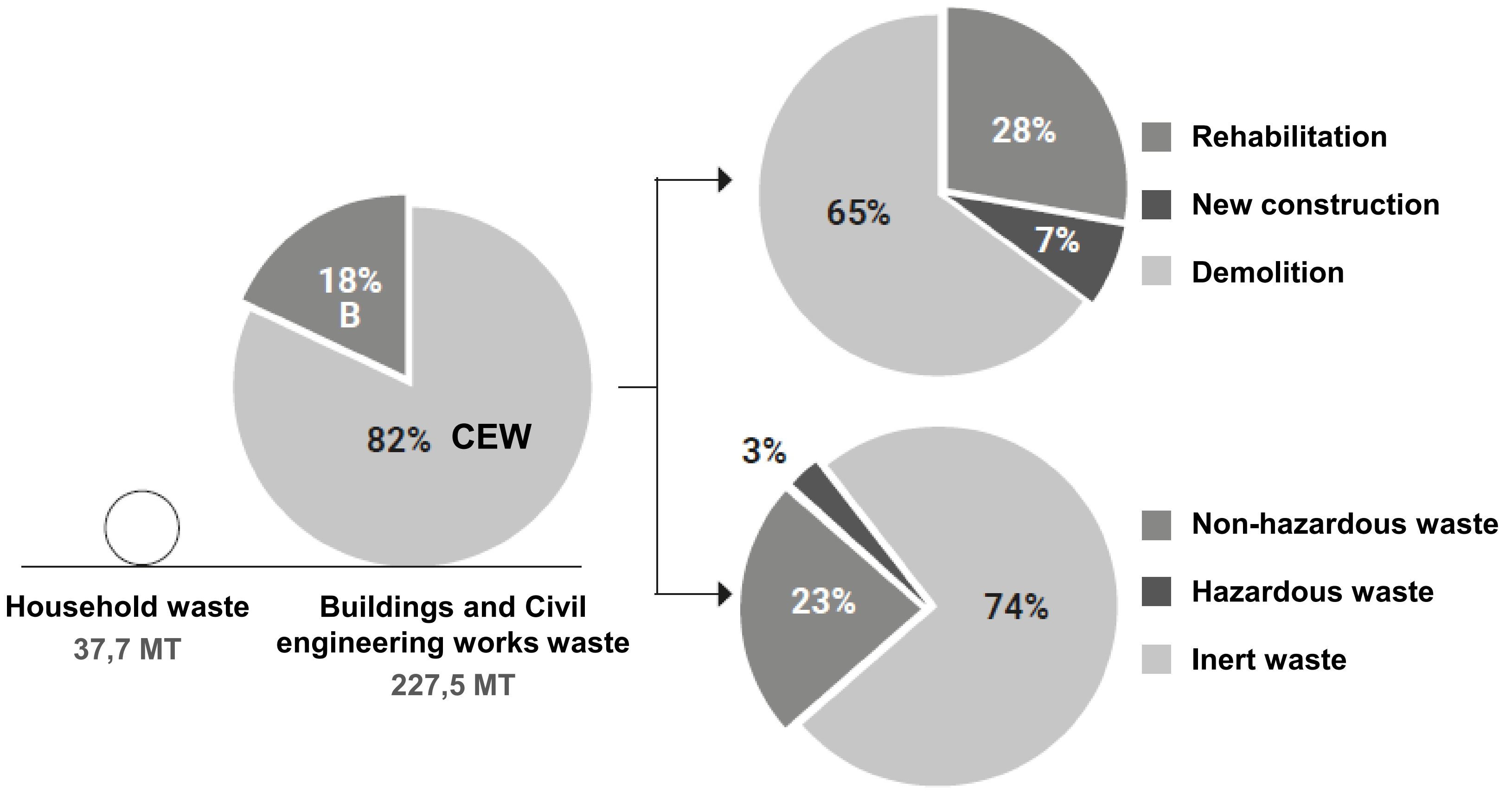


Household waste
37,7 MT

Buildings and Civil engineering works waste
227,5 MT

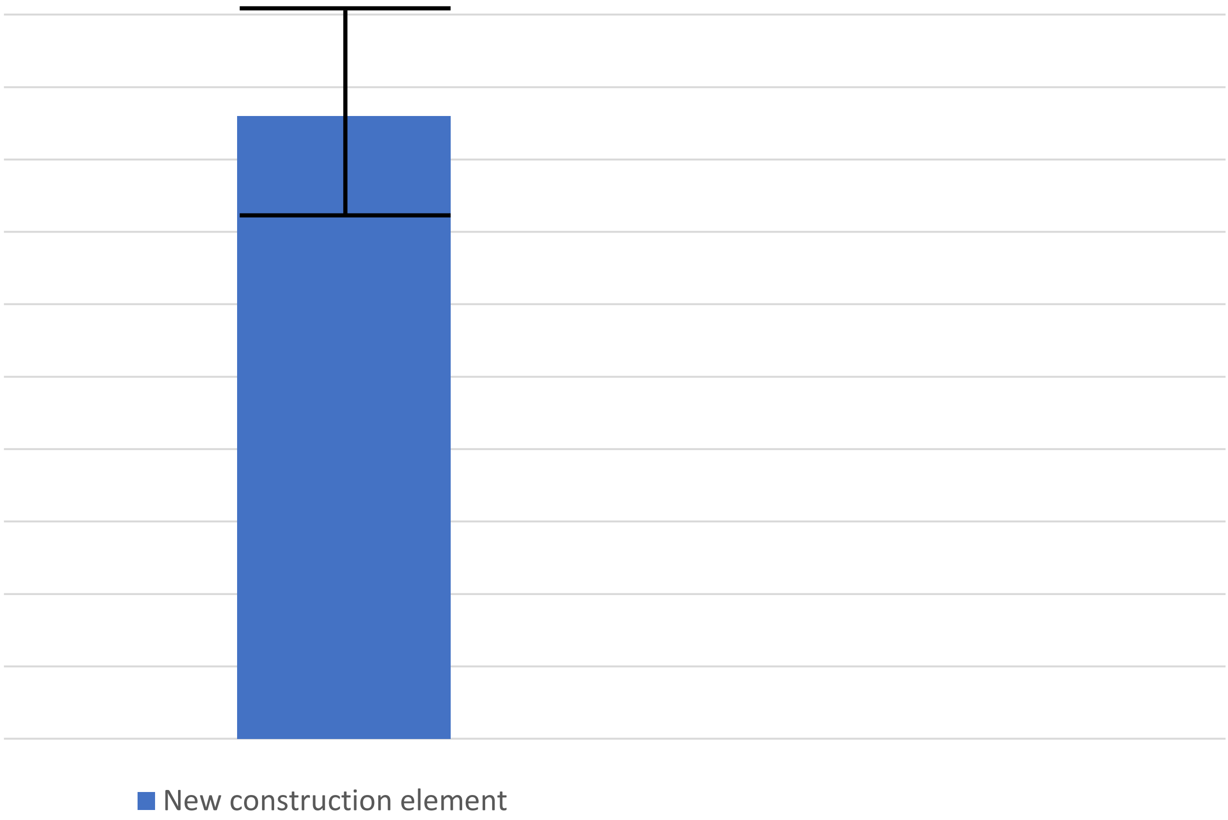
Reference : Repar 2, from SOeS 2014

Waste reduction

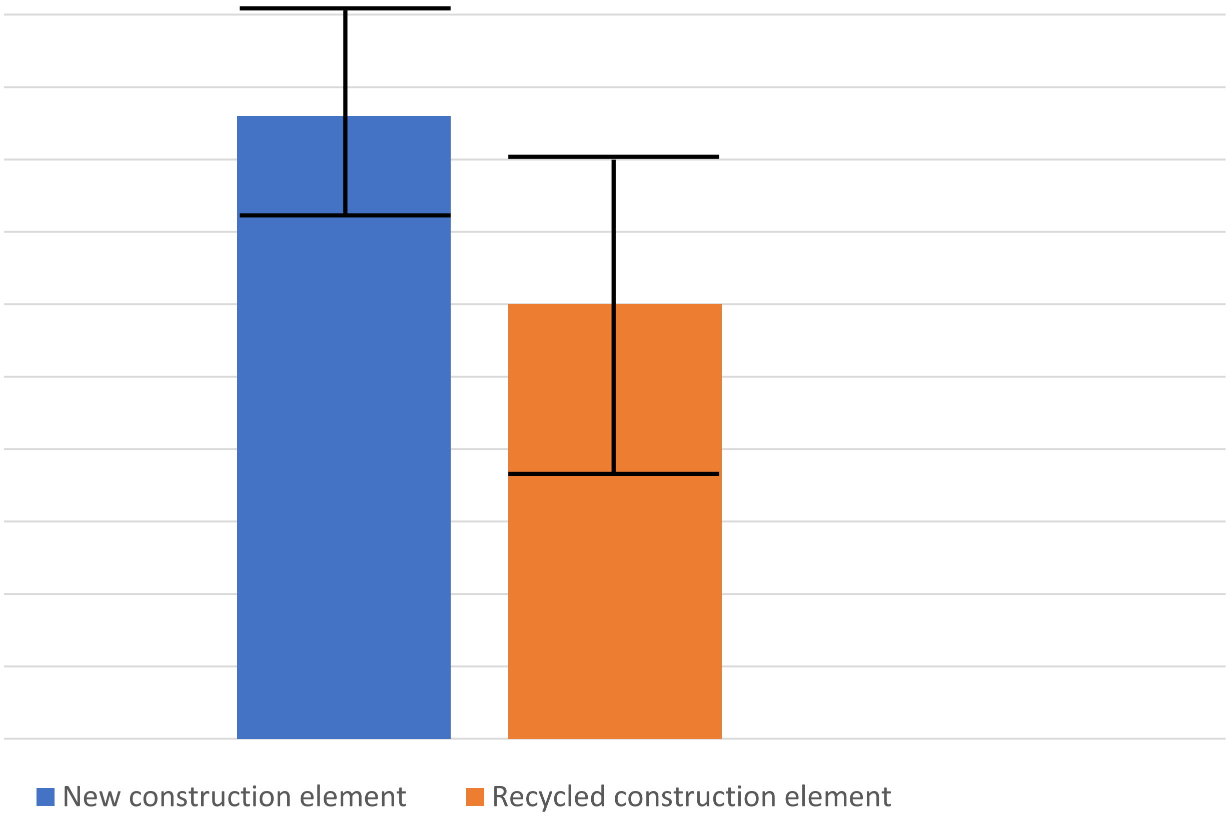


Reference : Repar 2, from SOeS 2014

Impacts of reclamation



Impacts of reclamations



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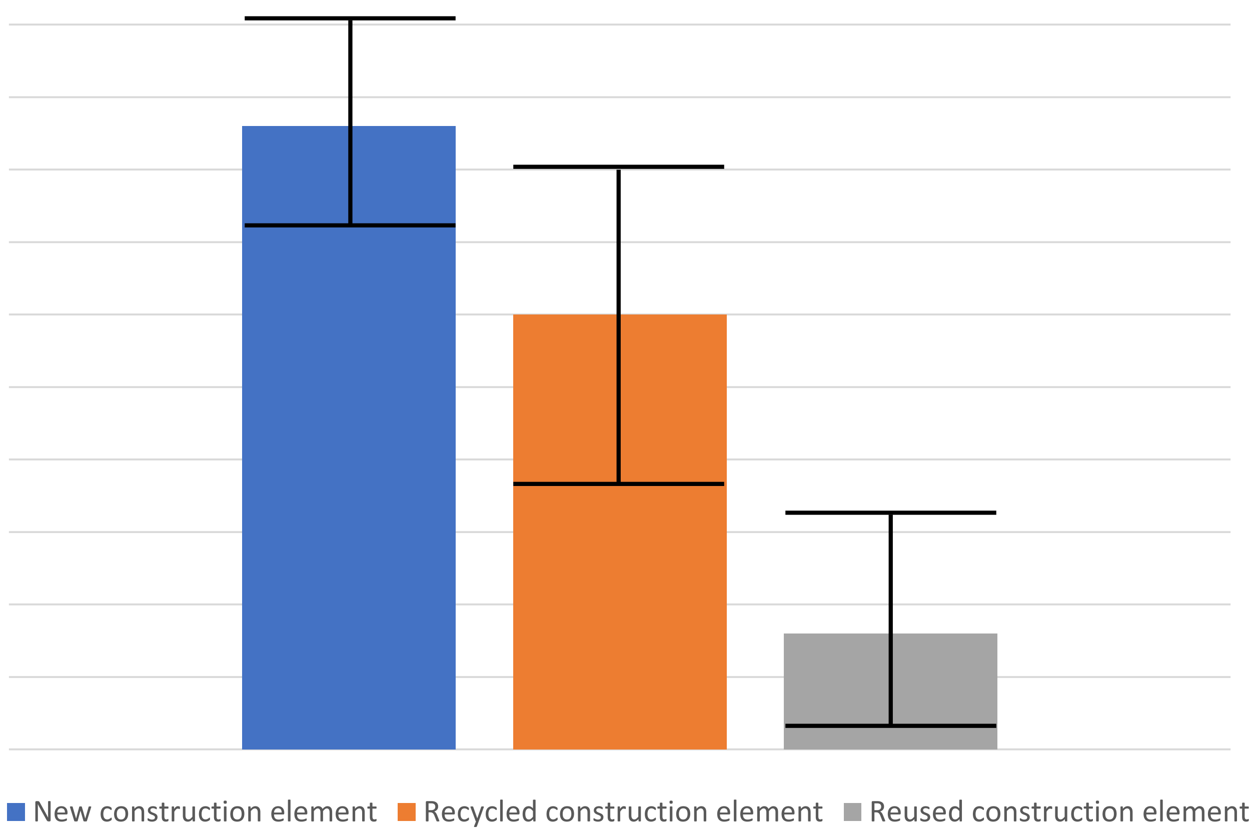

ECO DESIGN FOR SUSTAINABLE CITIES

02.

RESEARCH: STRUCTURAL SYSTEM

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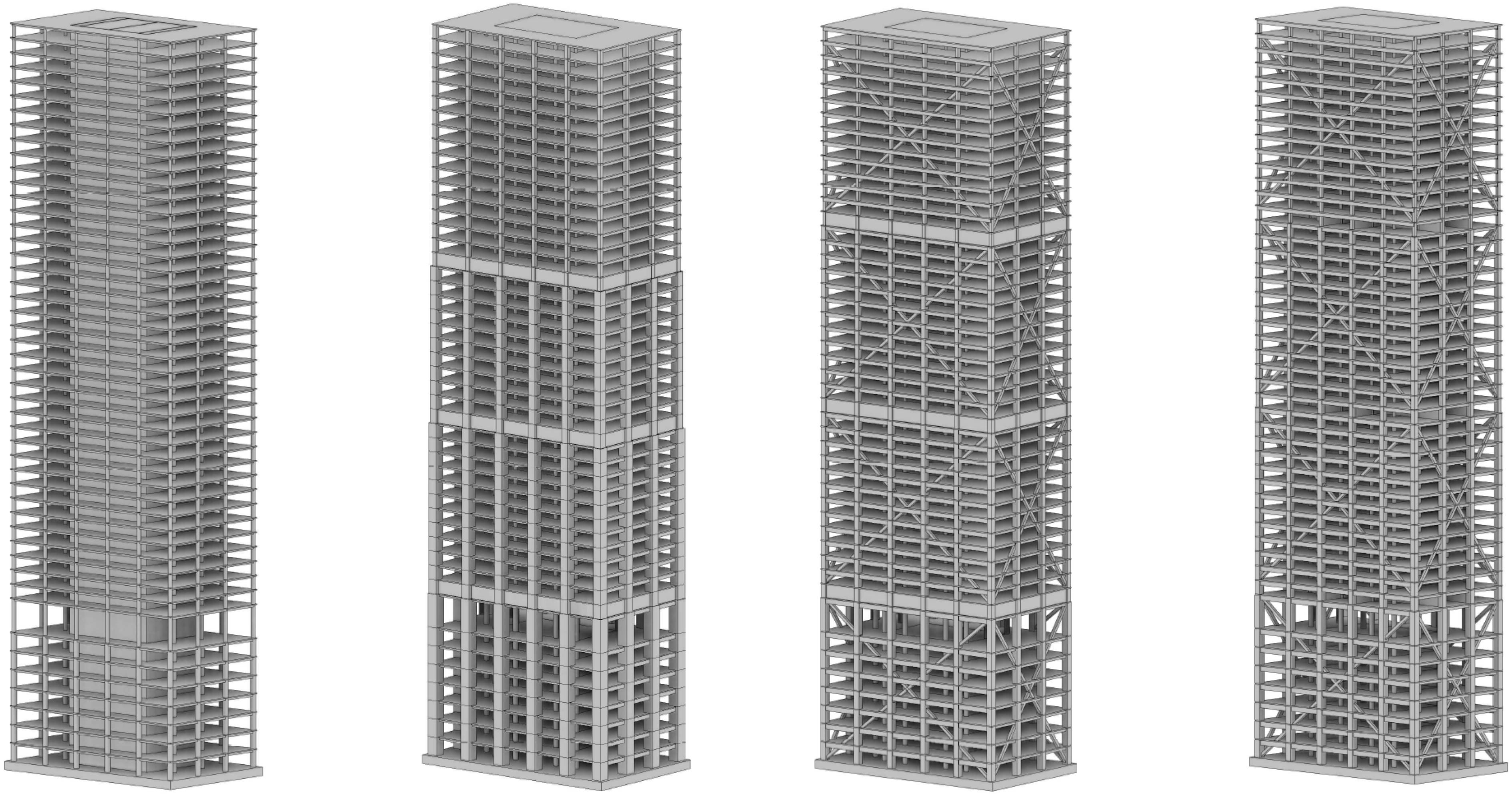


T1 **Concrete tube**

T2 **Tubed mega frame + outriggers**

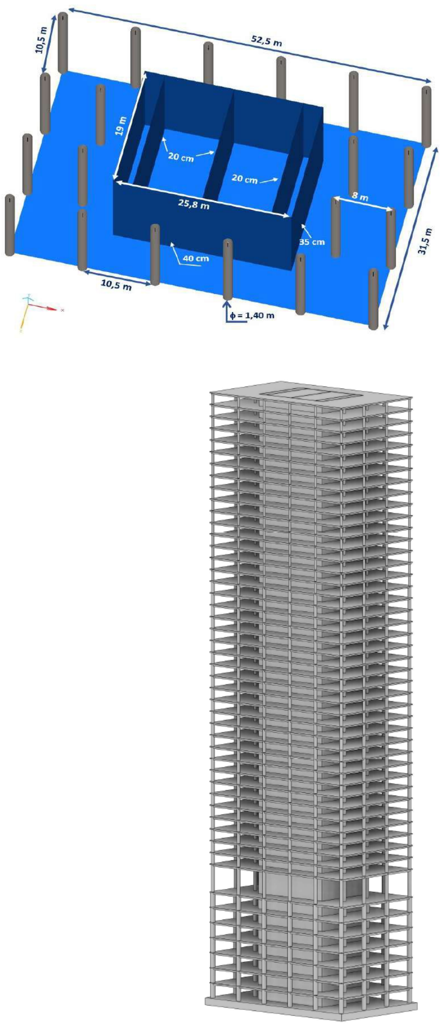
T3 **Outriggers + cross bracing**

T4 **Crosswall + cross bracing**

RESEARCH: STRUCTURAL SYSTEM

École des Ponts ParisTech

setec tpi



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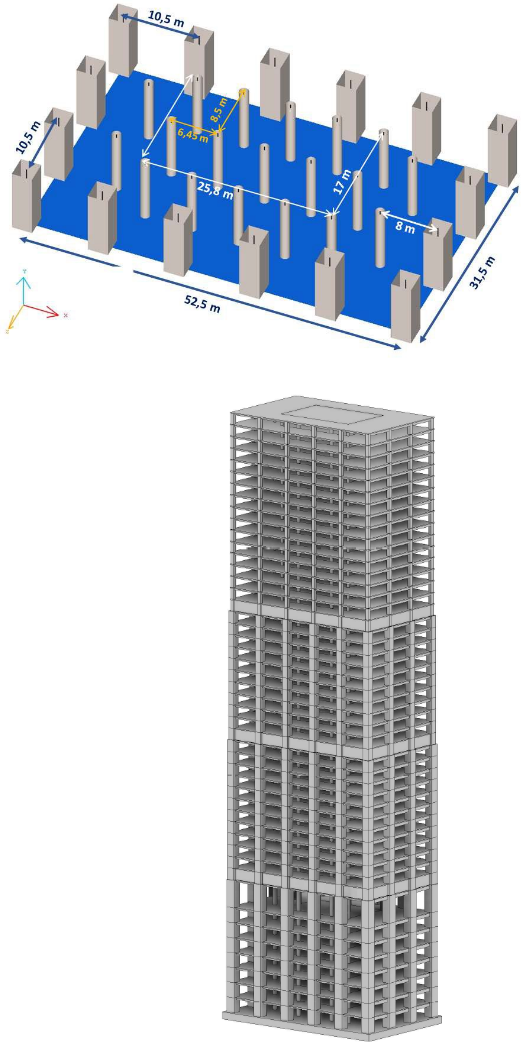
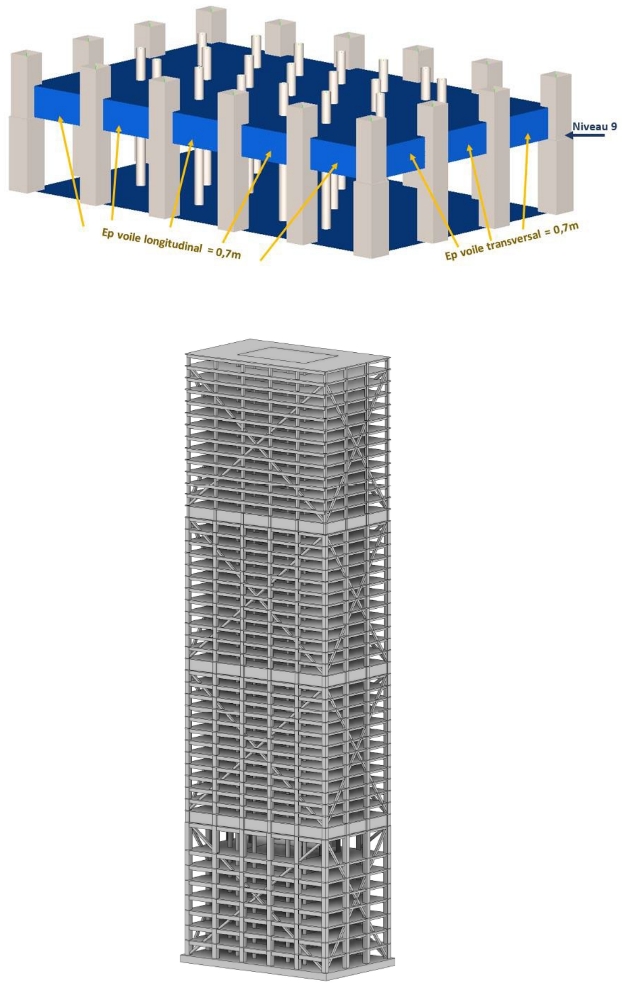
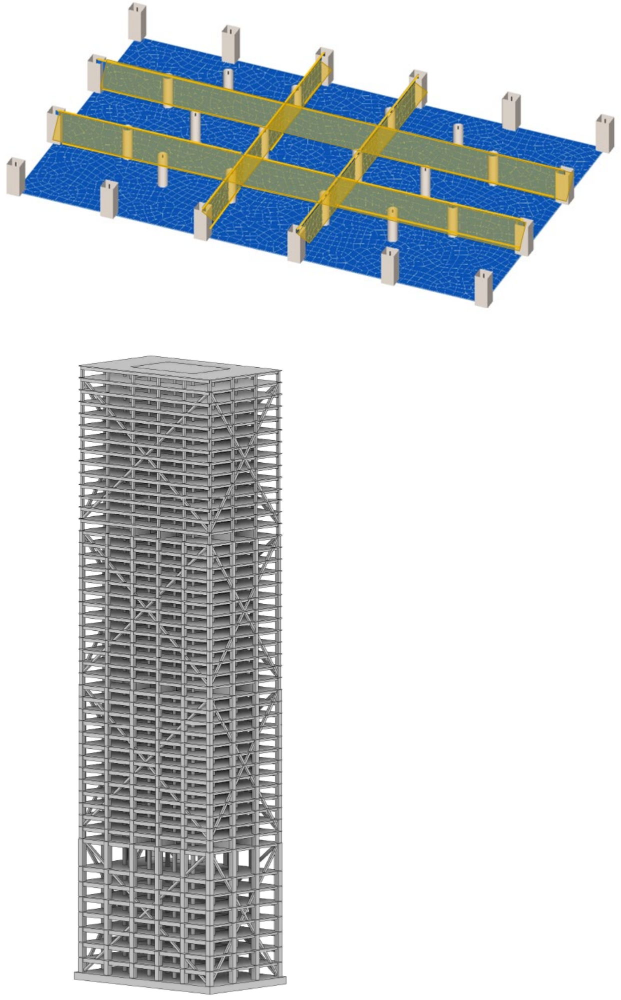


T2 **Tubed mega frame + outriggers**



T3 **Outriggers + cross bracing**



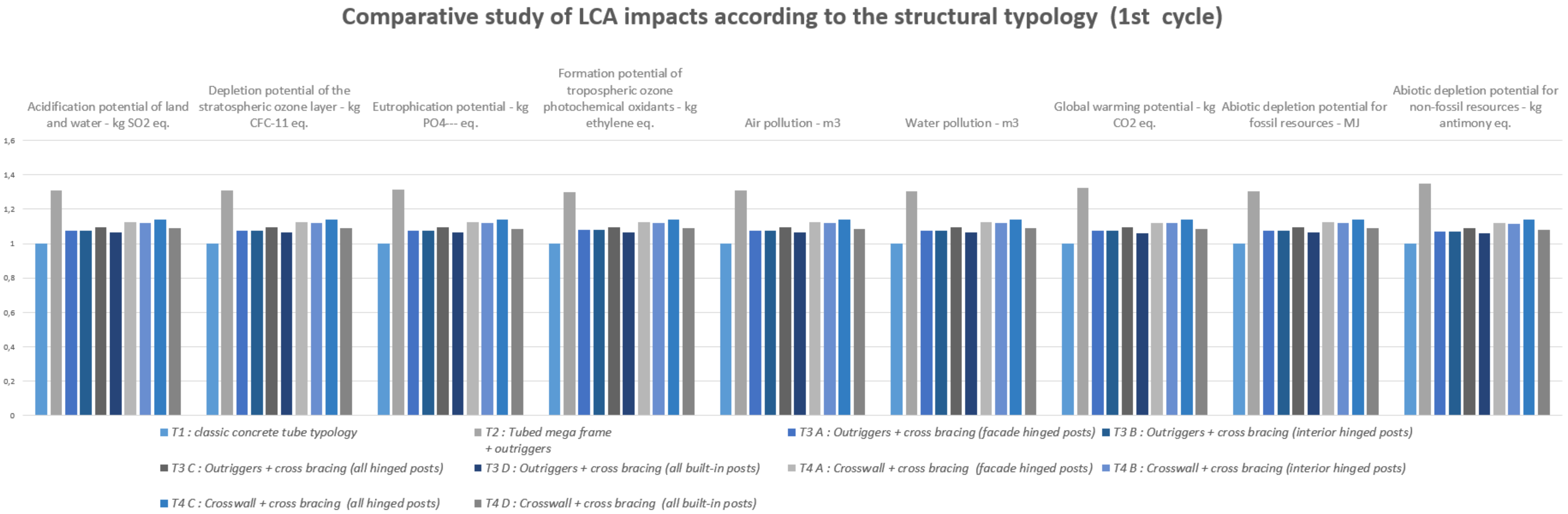
T4 **Crosswall + cross bracing**

RESEARCH: STRUCTURAL SYSTEM

Comparative study of LCA impacts (NF EN 15804) scenario for the 1st cycle:

- Focused on incoming materials
- Until delivery on site (before construction)
- Variations of structural typologies in order to determine the most virtuous for the same load
- For a model, 4 variations of the number of hinged columns : none / only interior columns / only façade columns / all columns

RESEARCH: STRUCTURAL SYSTEM



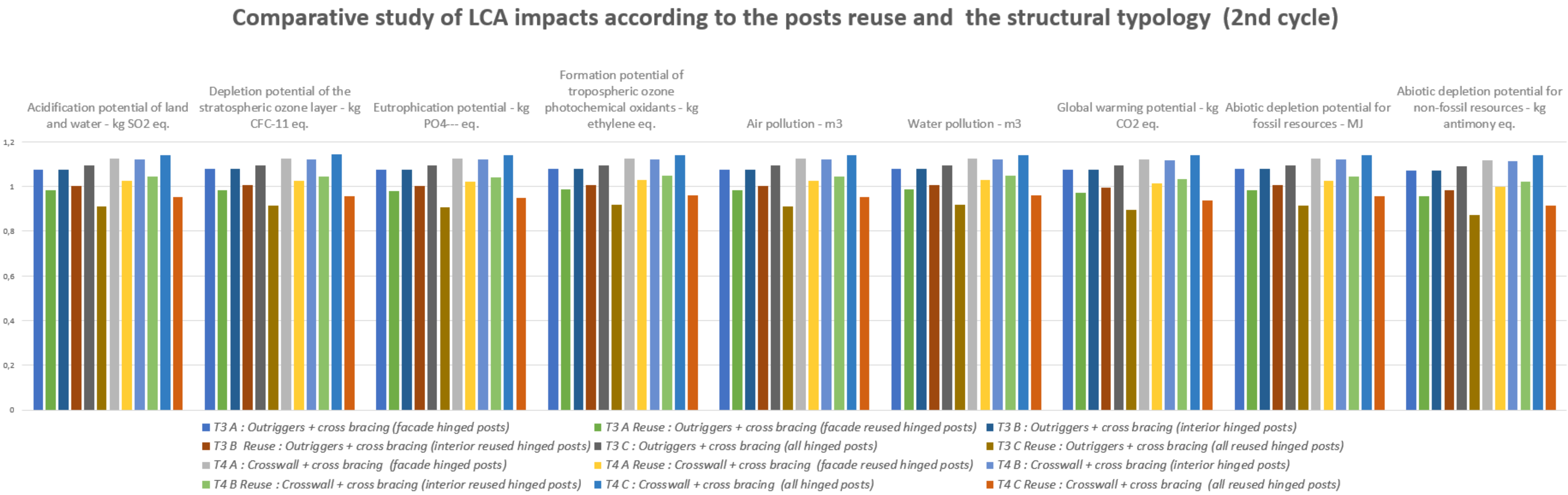
NF EN 15804

RESEARCH: STRUCTURAL SYSTEM

Comparative study of LCA impacts (NF EN 15804) scenario for the 2nd cycle with reused columns :

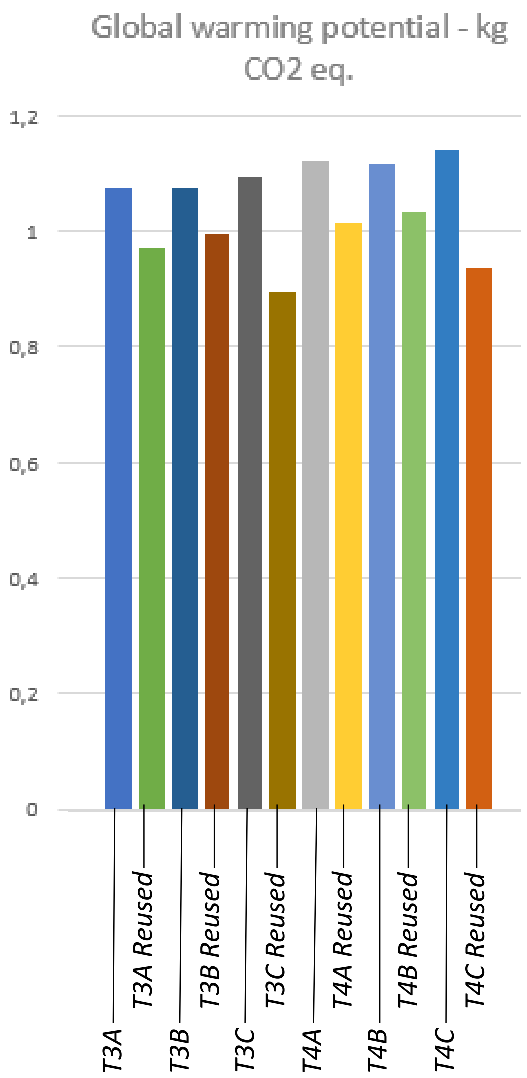
- Focused on incoming materials
- Until delivery on site (before construction)
- Models and their variations with hinged columns (that will be considered as reused) > *T3 & T4 variations*

RESEARCH: STRUCTURAL SYSTEM



NF EN 15804

RESEARCH: GWP ZOOM

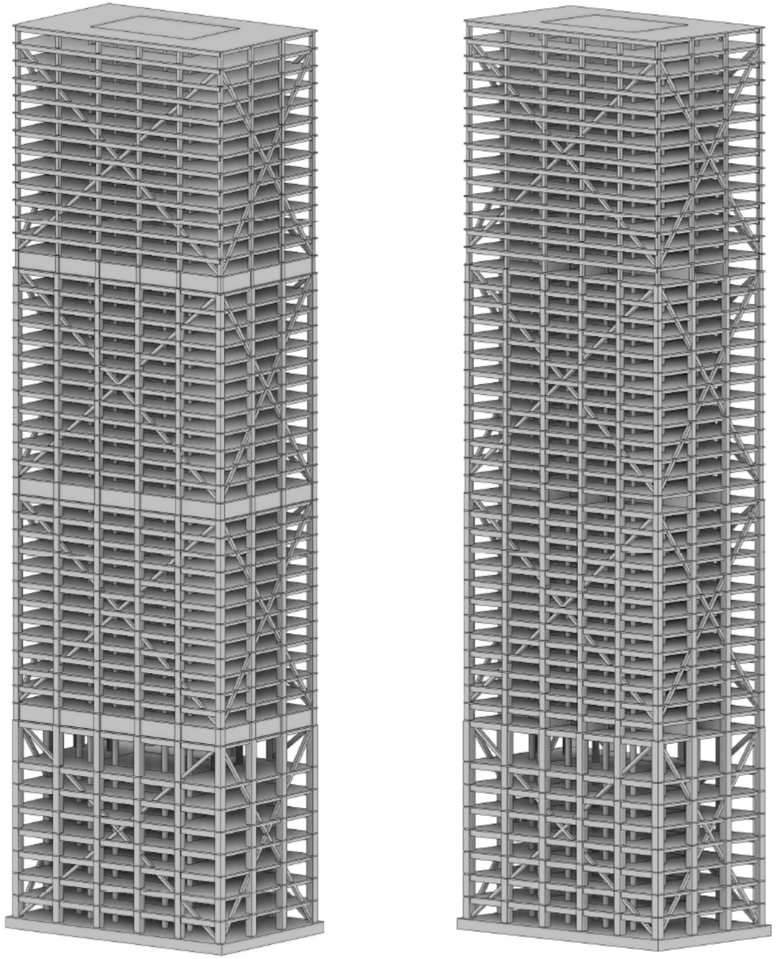


1st cycle of construction :

- T3 A : Outriggers + cross bracing (facade hinged posts)
- T3 B : Outriggers + cross bracing (interior hinged posts)
- T3 C : Outriggers + cross bracing (all hinged posts)
- T4 A : Crosswall + cross bracing (facade hinged posts)
- T4 B : Crosswall + cross bracing (interior hinged posts)
- T4 C : Crosswall + cross bracing (all hinged posts)

2nd cycle with reused columns :

- T3 A Reuse : Outriggers + cross bracing (facade reused hinged posts)
- T3 B Reuse : Outriggers + cross bracing (interior reused hinged posts)
- T3 C Reuse : Outriggers + cross bracing (all reused hinged posts)
- T4 A Reuse : Crosswall + cross bracing (facade reused hinged posts)
- T4 B Reuse : Crosswall + cross bracing (interior reused hinged posts)
- T4 C Reuse : Crosswall + cross bracing (all reused hinged posts)



T3 Outriggers + cross bracing

T4 Crosswall + cross bracing

BIM 6D
ENVIRONMENTAL DATA

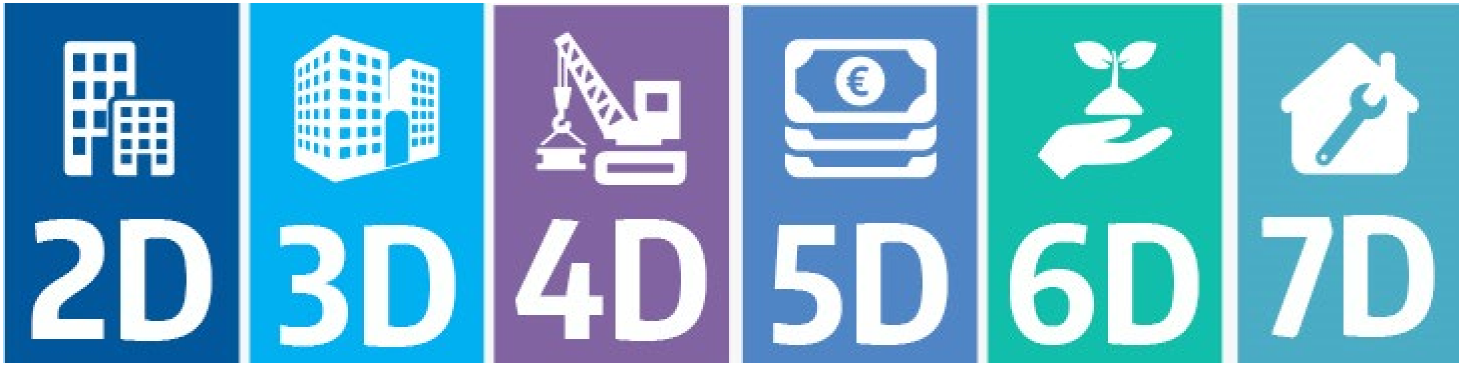
03.

DATA RELATING TO RESPONSIBILITIES

The principal structural data for high-rise buildings can be divided into four categories:

- **the properties of the element (static):** geometry, composition, resistance class, relevant standard, etc.;
- **the behaviour of the element (mechanical):** position, type of loads, stress applied, connection conditions, creep, ageing characteristics, etc.;
- **the overall behaviour of the structure (mechanical):** exposure class, differential shortening, soil compaction, top displacement, top acceleration, differential displacements between floors, scaling criterion, useful life of structure, etc.;
- **information for the reuse process:** checks required, residual performance tests, deconstruction phasing, etc.

DATA RELATING TO SUSTAINABLE DEVELOPMENT



6D covers everything related to the sustainable development of a building, for example energy analysis and carbon footprint estimation for each phase. It will be possible to find the data for the calculation of BREEAM or LEED.

TRACEABILITY TO PRESERVE MATERIALS

04.

TYPES OF TRACEABILITY

Ensuring traceability involves keeping the information both digitally but also physically in the material, using various tools:

- Digital traceability: BIM model
- Passive physical traceability: RFID chips
- Active physical traceability: sensors, IoT

PASSIVE PHYSICAL TRACEABILITY: RFID CHIPS

Reference : RFID NFC 360SmartConnect ©

ACTIVE PHYSICAL TRACEABILITY: SENSORS, IOT

Reference : Captae LERM setec

CONCLUSION

05.

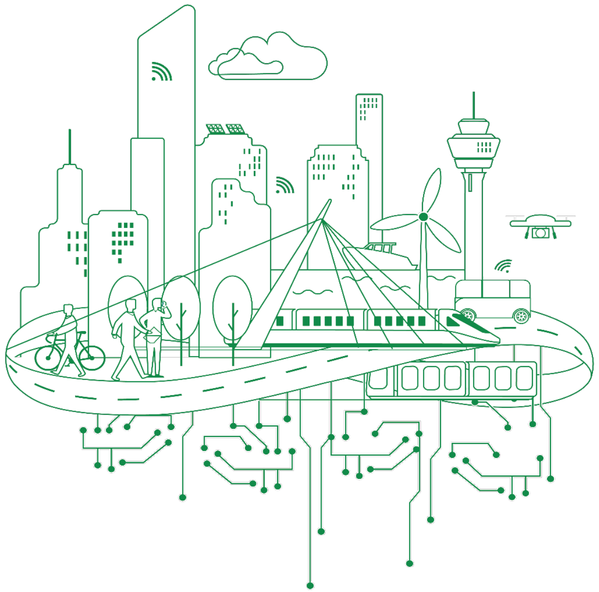
CONCLUSION

The first results show that re-use allows a significant reduction of the embodied energy of a building element. Since the re-used element avoids the fabrication of an identical new element, it reduces GHGs and waste generation. All LCA impacts show an advantage in reuse.

- Embodied energy ↘
- GWP – kg CO2 eq. ↘
- LCA impacts ↘
- Waste ↘

Data on the implementation and analysis of a deconstruction process is needed to continue the research. Issues of removal, storage and re-use process must also be taken into account.

THANK YOU FOR YOUR ATTENTION



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