



PILING SYSTEMS
FAST. SIMPLE. SAFE.

CONTRIBUTION TOWARDS
THE *MM* ROLE OF MICROPILES *MM* IN A SUSTAINABLE
DEEP FOUNDATIONS INDUSTRY

MSC.-ING. FREDDY LOPEZ (TIROLER ROHRE GMBH, AUSTRIA)

ING. DIPL.-BW. ERICH STEINLECHNER MBA (TIROLER ROHRE GMBH, AUSTRIA)

What are we gonna do tonight, Brain?



Same thing we do every night, Pinky:
make the world a better place using micropiles!

3RD MICROPILE WORLD CUP – EXECUTIVE REPORT



SOURCE: THE METROPOLITAN CABLE CAR INTEGRATION NETWORK IN LA PAZ, BOLIVIA (2019)



ANTÓNIO GUTERRES (UN SECRETARY-GENERAL / Nov. 7, 2022)
SOURCE: UN WEB TV ([HTTPS://MEDIA.UN.ORG/EN/ASSET/K1M/K1MIBY0FLU](https://media.un.org/en/asset/k1m/k1miby0flu))

THE WORLD EMITS AROUND **48 BILLION METRIC TONS OF GHG**
(CO₂e) EACH YEAR (WORLD BANK, 2023)

“...THE ANSWER [TO THE CLIMATE CHANGE] IS IN OUR HANDS AND THE CLOCK IS TICKING. WE ARE IN THE FIGHT OF OUR LIVES, AND WE ARE LOSING...”

“...GREENHOUSE GAS EMISSIONS KEEP GROWING. GLOBAL TEMPERATURES KEEP RISING. AND OUR PLANET IS FAST APPROACHING TIPPING POINTS THAT WILL MAKE CLIMATE CHAOS IRREVERSIBLE. WE ARE ON A HIGHWAY TO CLIMATE HELL WITH OUR FOOT STILL ON THE ACCELERATOR...”

“...[CLIMATE CHANGE] IS THE DEFINING ISSUE OF OUR AGE. IT IS THE CENTRAL CHALLENGE OF OUR CENTURY. IT IS UNACCEPTABLE, OUTRAGEOUS AND SELF-DEFEATING TO PUT IT ON THE BACK BURNER...”

“...THE SCIENCE IS CLEAR: ANY HOPE OF LIMITING TEMPERATURE RISE TO 1.5 °C MEANS ACHIEVING GLOBAL NET-ZERO EMISSIONS BY 2050. BUT THAT 1.5 °C GOAL IS ON LIFE SUPPORT – AND THE MACHINES ARE RATTLING...”

“...WE NEED ALL HANDS ON DECK FOR FASTER, BOLDER CLIMATE ACTION.... THE GLOBAL CLIMATE FIGHT WILL BE WON OR LOST IN THIS CRUCIAL DECADE – ON OUR WATCH...”



SOURCE: STRABAG ([HTTPS://WORK-ON-PROGRESS.STRABAG.COM/EN](https://work-on-progress.strabag.com/en))



GUTERRES`S SPEECH (COP 27)



STRABAG`S VIDEO UNTIL 00:00:34



STRABAG`S VIDEO FROM 00:00:34



AHHH....STUPID CONSTRUCTION INDUSTRY!

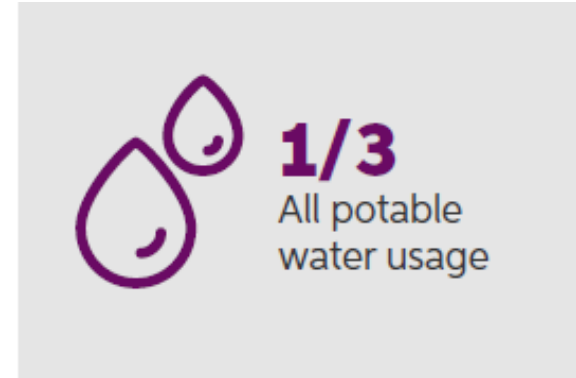
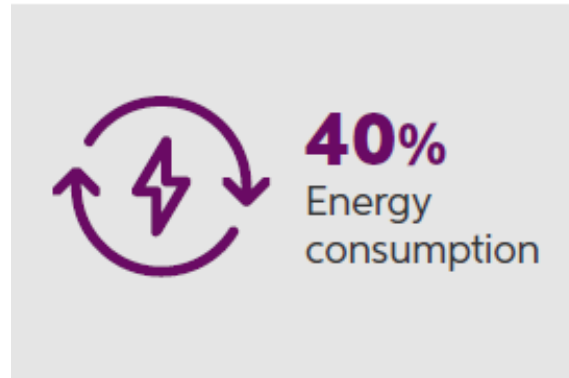
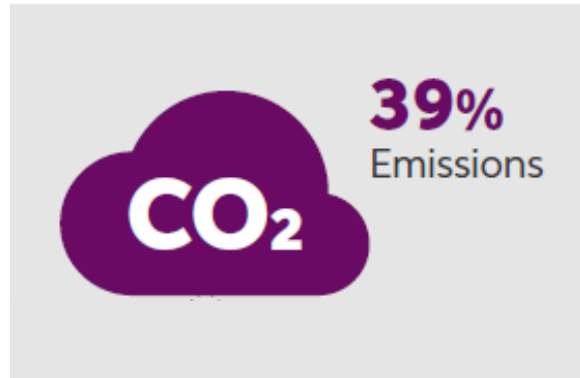


YEAH.....WE CAN DO IT!

EMOTIONAL TIME LINE

THE BUILT ENVIRONMENT CONSISTS OF **BUILDINGS** AND **INFRASTRUCTURE**

IS RESPONSIBLE FOR A LARGE SHARE OF THE HUMAN-MADE ENVIRONMENTAL IMPACT



Resource depletion

Air, water and land pollution

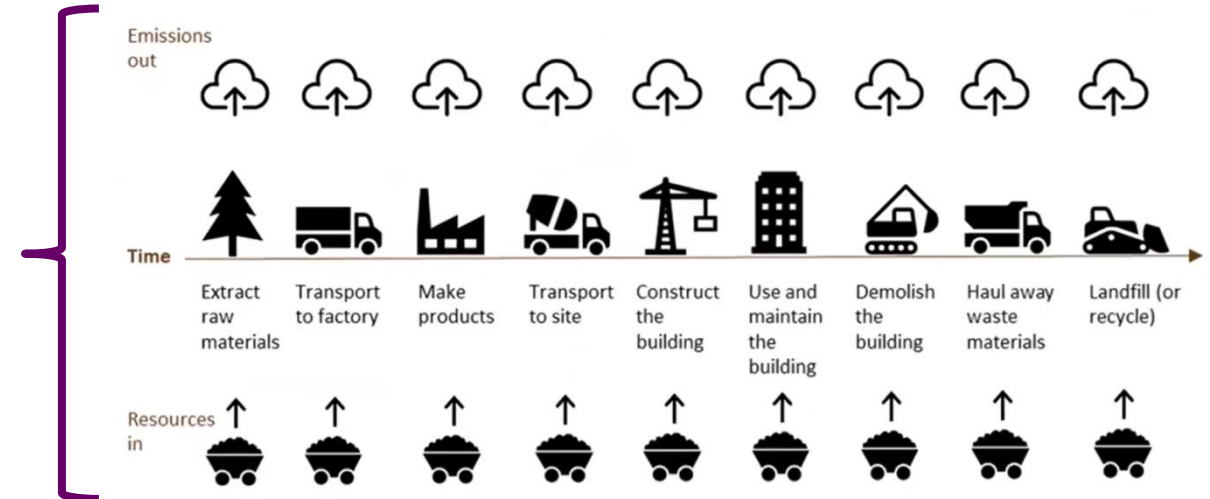
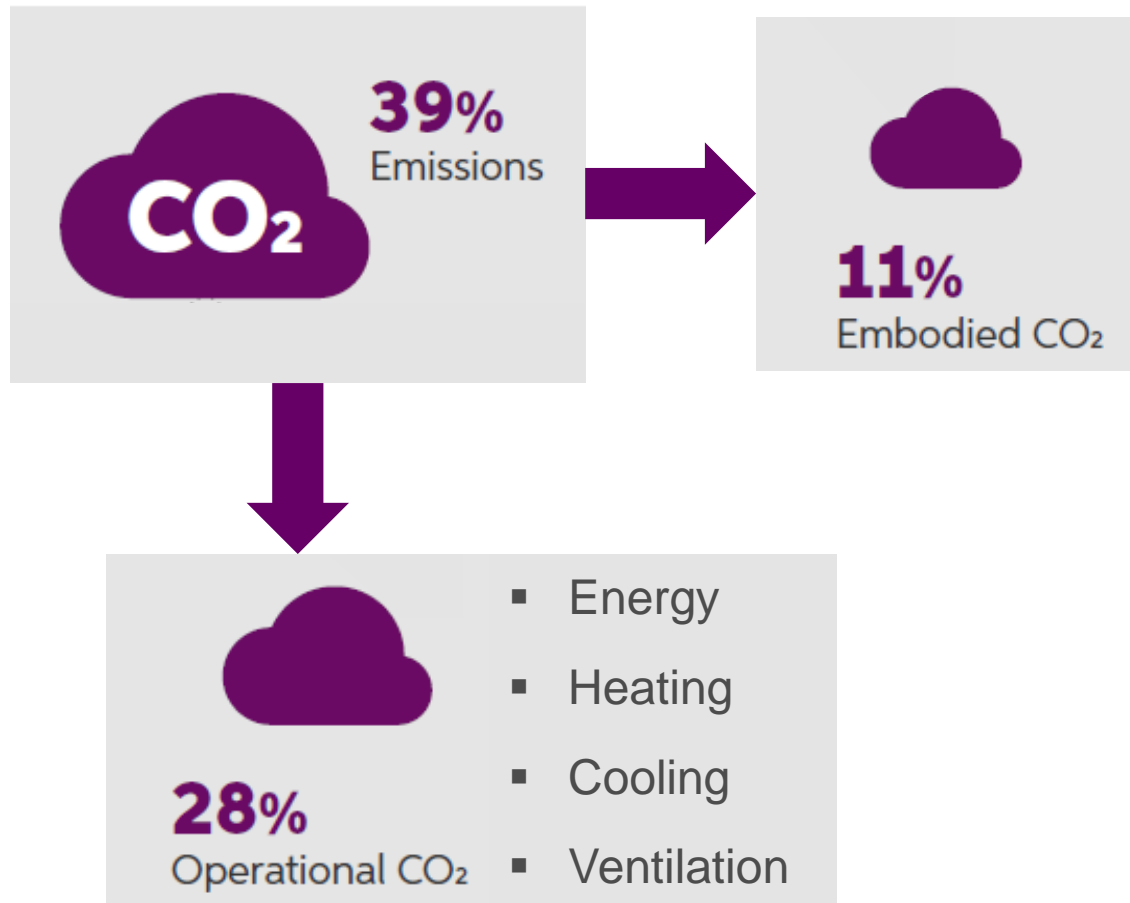
Biodiversity loss

SOURCE: AIB AND IGBC (2022) / WGBC (2023)

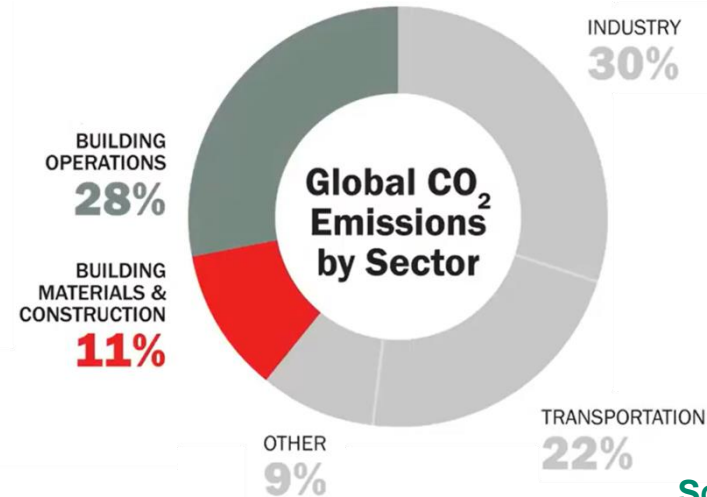
THE EMISSIONS OF THE BUILT ENVIRONMENT



THE BUILT ENVIRONMENT IS RESPONSIBLE FOR THE LARGEST GLOBAL EMISSIONS OF GREENHOUSE GASES:



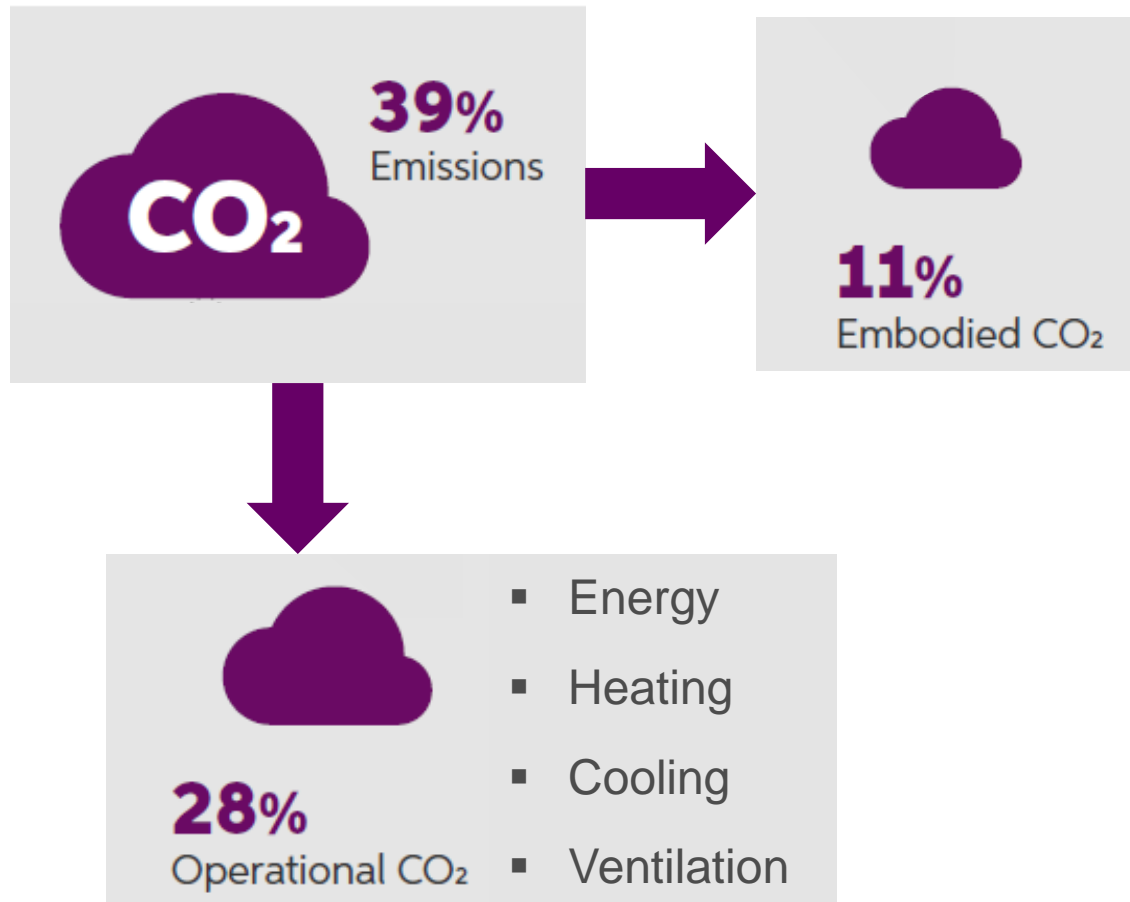
SOURCE: ATHENA INSTITUTE



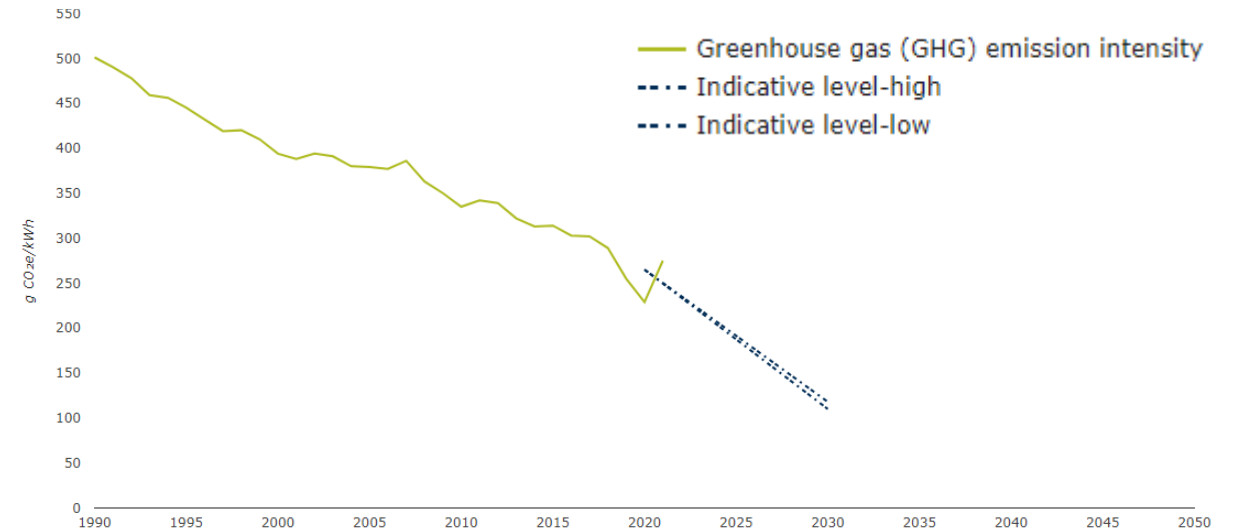
SOURCE: ARCHITECTURE 2030

GLOBAL EMISSIONS: THE CONSTRUCTION INDUSTRY IS THE BIGGEST OFFENDER

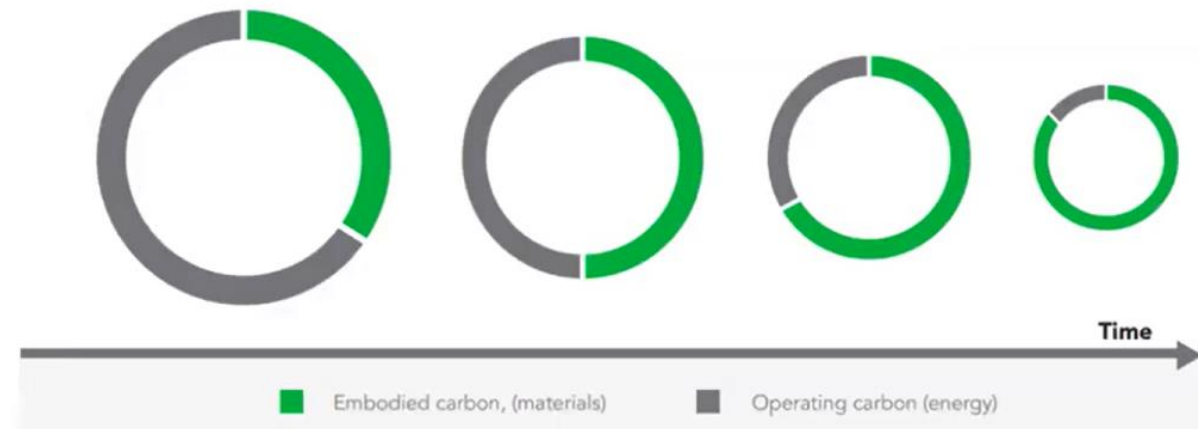
AS OPERATIONAL ENERGY DECARBONIZES, THE IMPORTANCE OF EMBODIED CARBON GROWS CONSTANTLY



EU level – Greenhouse gas emission intensity of electricity generation



SOURCE: EUROPEAN ENVIRONMENT AGENCY (2022)



- 75 % OF WORLD'S POPULATION LIVING IN CITIES BY 2060
- TWICE THE GLOBAL BUILDING FLOOR AREA BY 2060

THERE ARE DIFFERENT GLOBAL INITIATIVES TO DECARBONIZE THE CONSTRUCTION INDUSTRY BY 2050:



WORLD GREEN BUILDING COUNCIL (2018): ROADMAP TO:

- NET ZERO CARBON OPERATION OF EXISTING BUILDINGS
- NET ZERO WHOLE LIFE CARBON FOR NEW BUILDINGS

INSTITUTE FOR SUSTAINABLE INFRASTRUCTURE (2018):

ENVISION® IS A FRAMEWORK FOR A SYSTEMIC CHANGE TO A SUSTAINABLE & RESILIENT INFRASTRUCTURE

THERE ARE DIFFERENT GLOBAL INITIATIVES TO DECARBONIZE THE CONSTRUCTION INDUSTRY BY 2050:



LEVEL(S) (2020):

EUROPEAN FRAMEWORK FOR SUSTAINABLE BUILDINGS



CONSTRUCTING THE FUTURE (2020):

A FRAMEWORK FOR A SUSTAINABLE CONSTRUCTION INDUSTRY
(AUSTRALIAN CONSTRUCTORS ASSOCIATION)

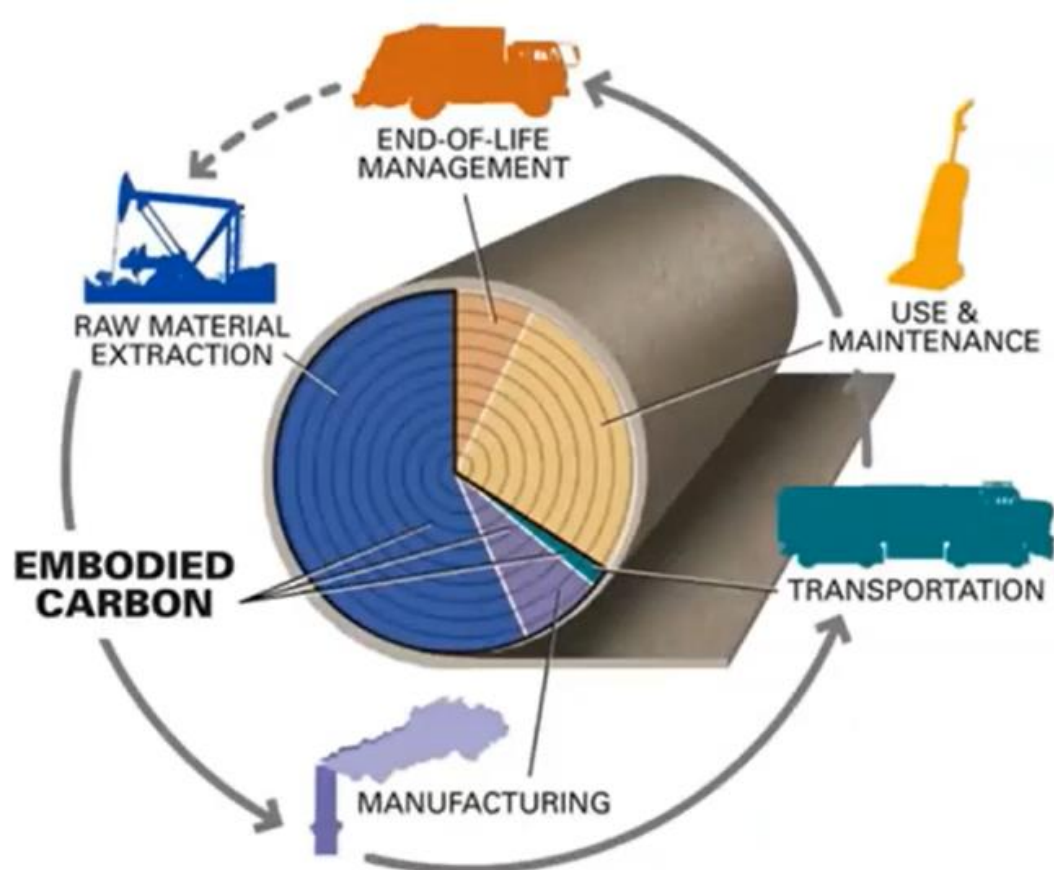
BRINGING EMBODIED CARBON UPFRONT



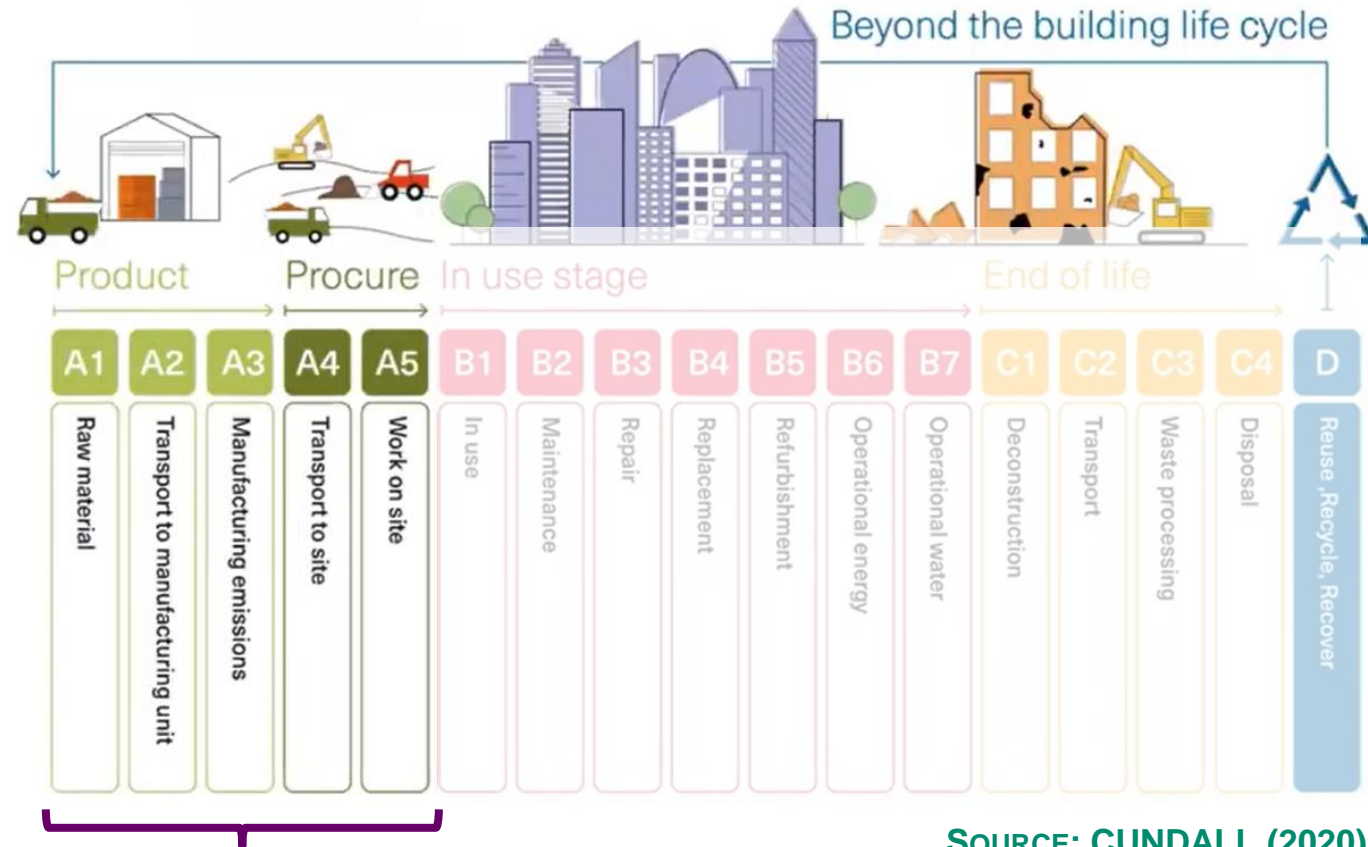
“WE CANNOT MANAGE WHAT WE CANNOT MEASURE”

THE REQUIRED DATA COMES FROM **LIFE CYCLE ANALYSIS (LCA)** OR **LIFE CYCLE INVENTORIES (LCI)**

HELPFUL MEANS TO **ADDRESS (NOT PREDICT)** THE **POTENTIAL ENVIRONMENTAL IMPACT OF MATERIALS**



SOURCE: BURO HAPPOLD (2021)



UPFRONT EMBODIED CARBON (> 50%)

SOURCE: CUNDALL (2020)

Building LCA Tools



Athena
Impact Estimator
for Buildings

One
Click



WoodWorks



Databases



Industrial data



International Aluminium Institute

& more

SOURCE: SPHERA (2020)

REQUIREMENTS FOR DATA QUALITY: **ACCURACY, REPRESENTATIVENESS AND COMPLETENESS**

ONE PARTICULARLY RELIABLE AND ACCURATE SOURCE IS THE ENVIRONMENTAL PRODUCT DECLARATION (EPD)



EPD – ENVIRONMENTAL PRODUCT DECLARATION
as per ISO 14025 and EN 15804+A2



PUBLISHER	Bau EPD GmbH, A-1070 Vienna, Seidengasse 13/3, www.bau-epd.at
PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Vienna, Seidengasse 13/3, www.bau-epd.at
DECLARATION OWNER	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2022-1-ECOINVENT-Pfahlsysteme
ISSUE DATE	31.08.2022
VALID TO	31.08.2027
NUMBER OF DATA SETS	9
ENERGY MIX APPROACH	MARKET-BASED APPROACH

SOURCE: TIROLER ROHRE GMBH (2022)

MANUFACTURERS SHOW THE **SPECIFIC LCA** OF THEIR PRODUCTS

CONDUCTED ACC. TO INTERNATIONAL STANDARDS (**ISO 14025 / EN 15804+A2**)

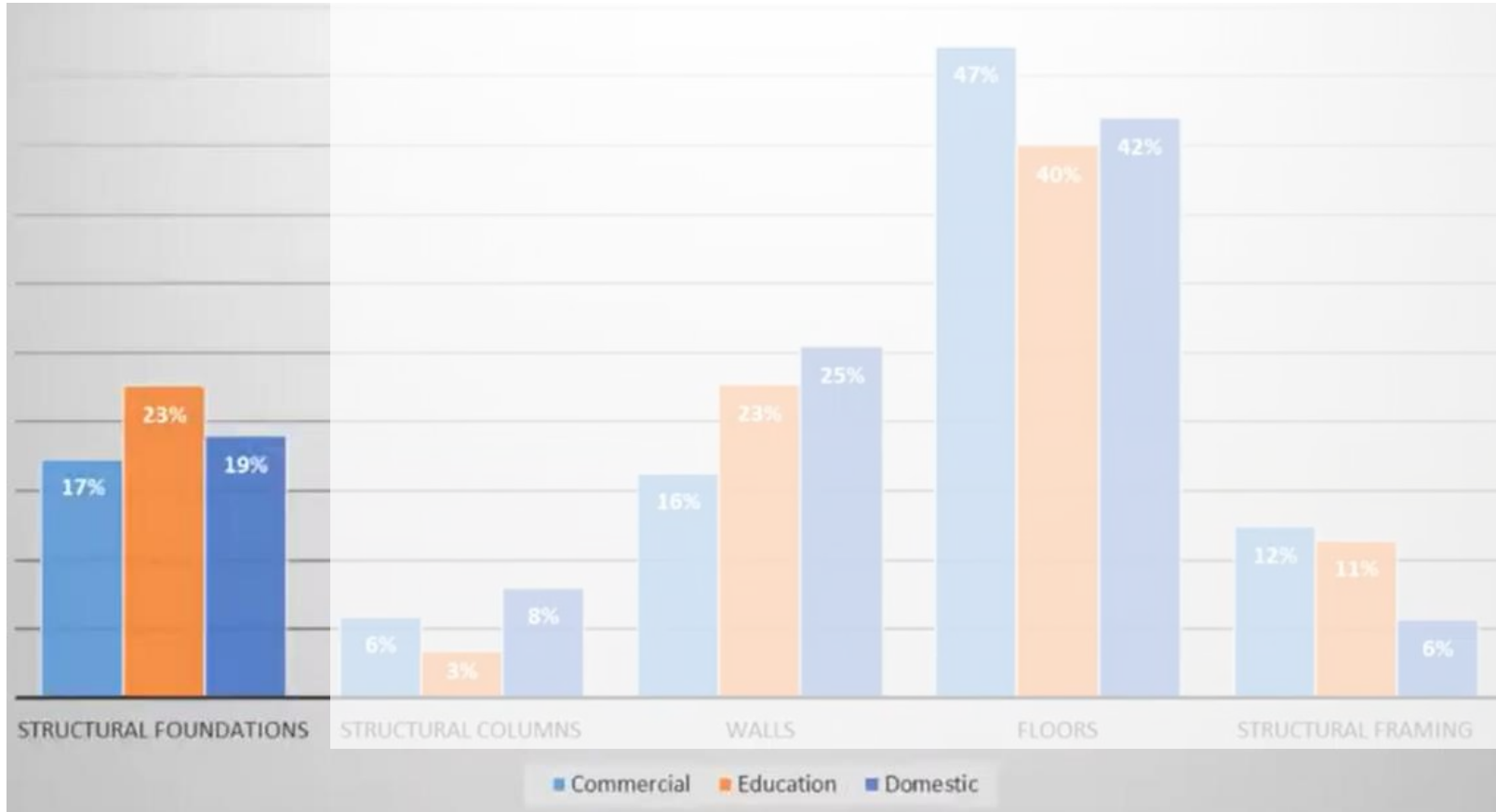
CARRIED OUT BY AN **INDEPENDENT 3RD PARTY** TO VERIFY THE INFORMATION → **TRANSPARENCY**

THE EMBODIED CARBON IN DEEP FOUNDATIONS

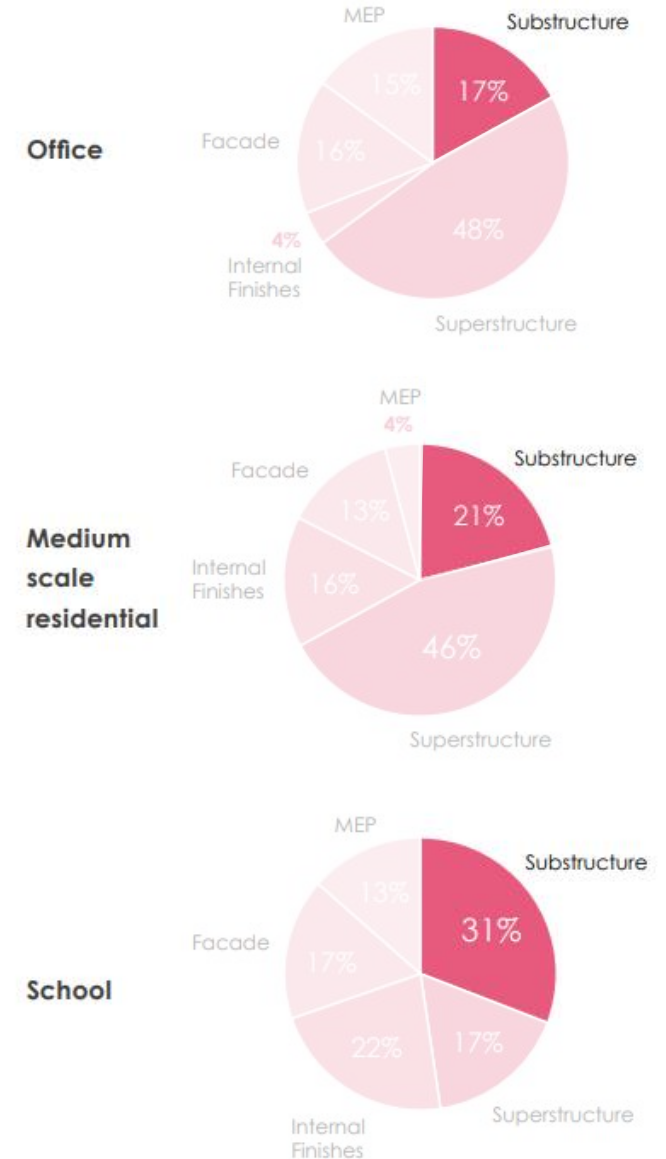


WHERE IS THE EMBODIED CARBON?

IN BUILDINGS:



SOURCE: BOSTON SOCIETY FOR ARCHITECTURE (2020)



SOURCE: LONDON ENERGY TRANSFORMATION INITIATIVE (2020)

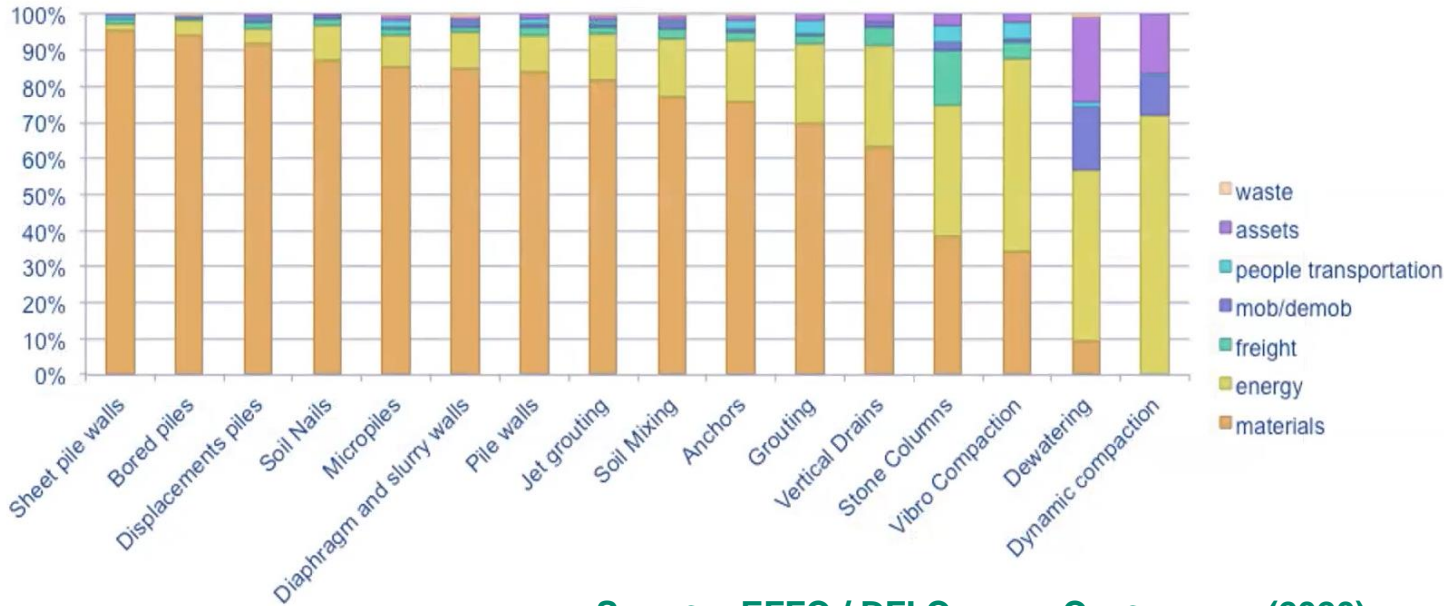
HOW TO ESTIMATE THE EMBODIED CARBON (CARBON FOOTPRINT OR GLOBAL WARMING POTENTIAL IN CO₂e)?



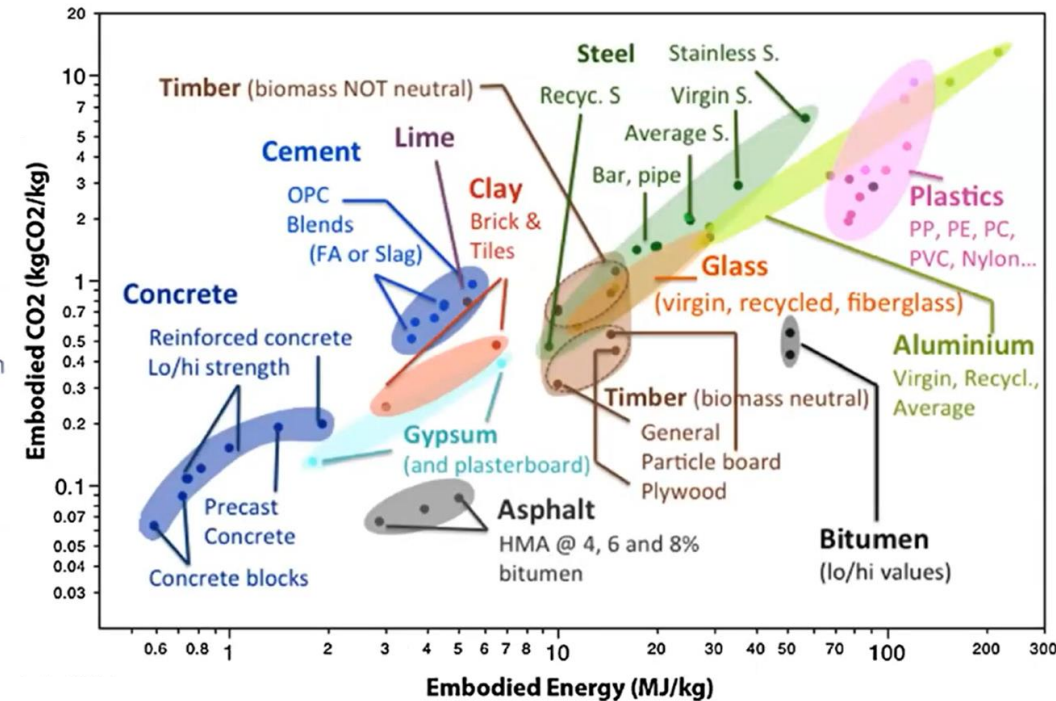
Carbon Calculator



• CO₂ Emission Distribution



SOURCE: EFFC / DFI CARBON CALCULATOR (2020)



SOURCE: BARCELO ET AL (2014)

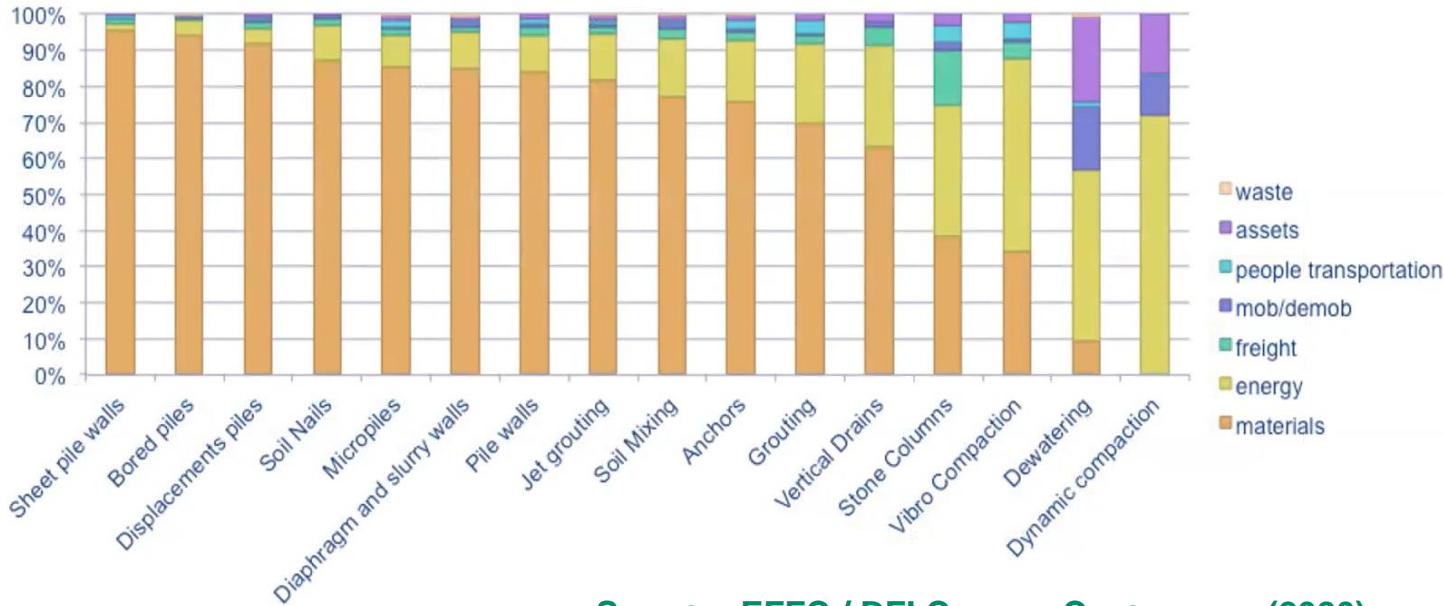
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Carbon Calculator

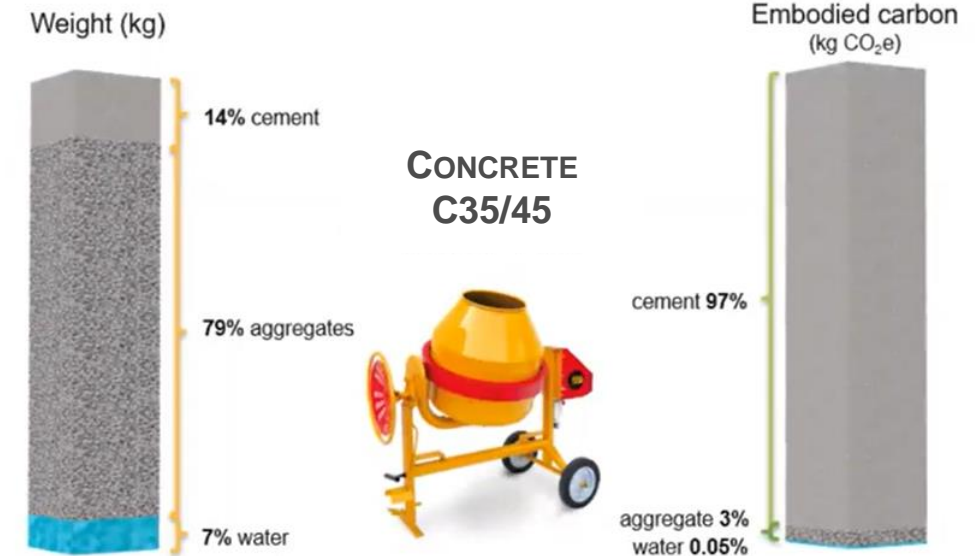


• CO2 Emission Distribution



SOURCE: EFFC / DFI CARBON CALCULATOR (2020)

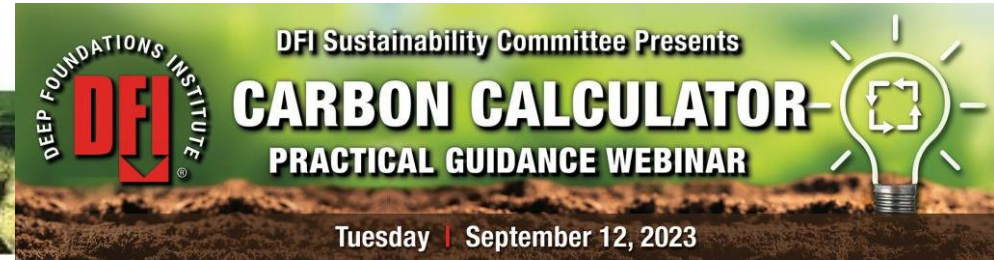
Embodied Carbon in Concrete (Product stage A1-A3)



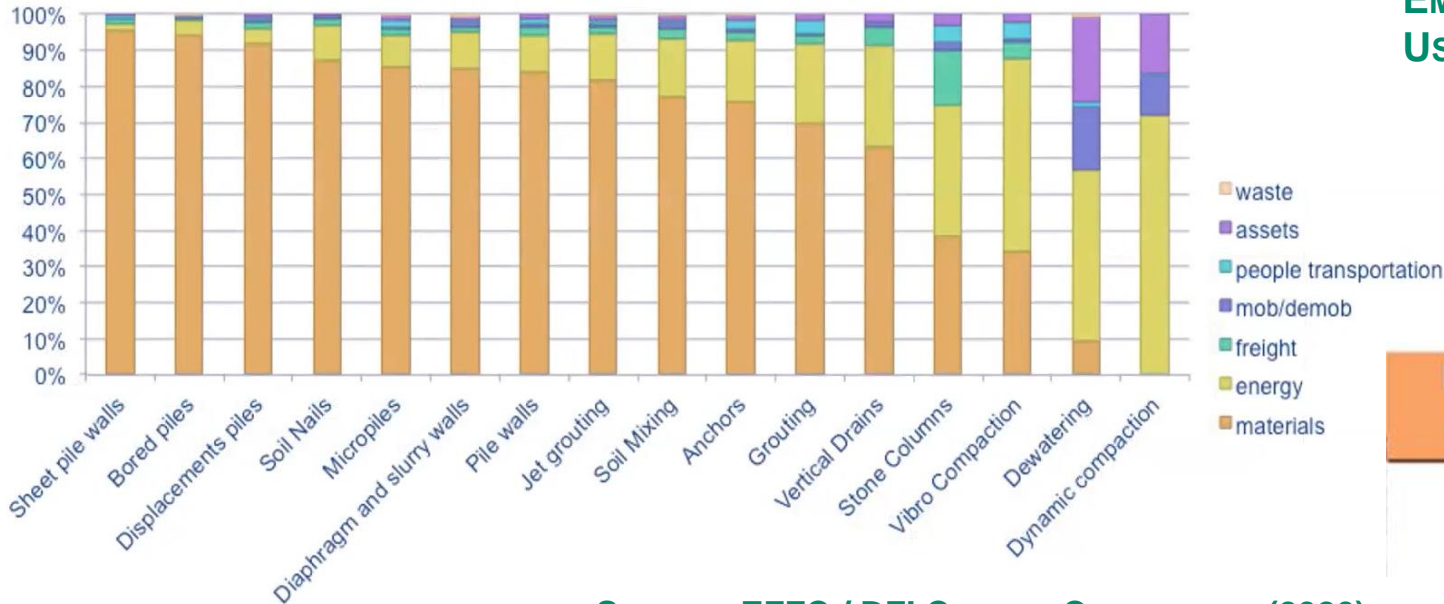
HOW TO ESTIMATE THE EMBODIED CARBON (CARBON FOOTPRINT OR GLOBAL WARMING POTENTIAL IN CO₂e)?



Carbon Calculator



• CO2 Emission Distribution



SOURCE: EFFC / DFI CARBON CALCULATOR (2020)

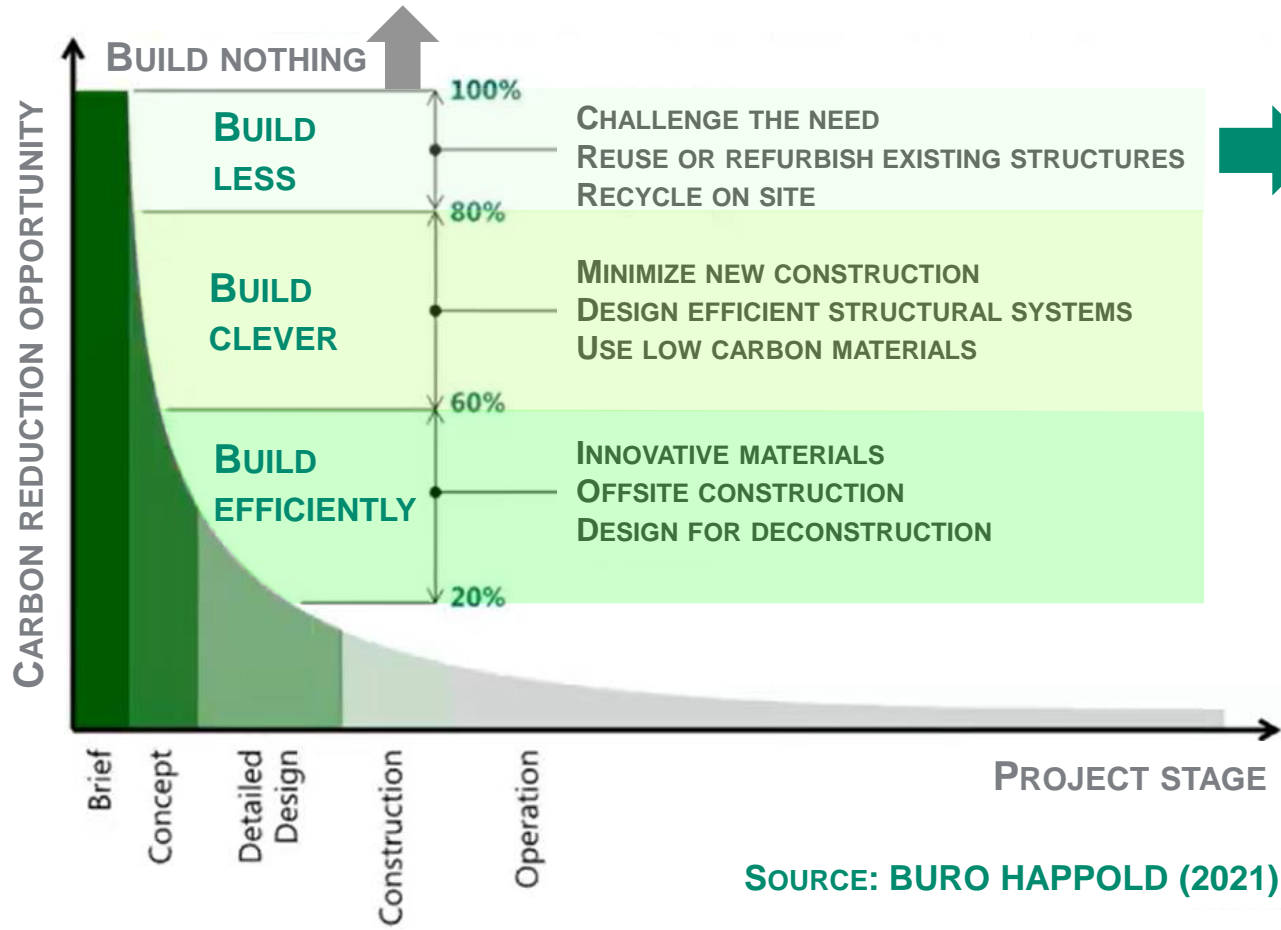
EMBODIED CARBON IN STEEL USE NOT ONLY LESS STEEL, BUT BETTER STEEL



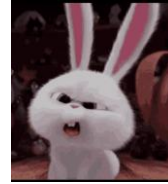
Structural Element	Ton CO ₂ e / Ton
Fabricated Hot-Rolled Structural Sections	1.16
Fabricated Steel Plate	1.47
Fabricated Hollow Structural Sections (HSS)	2.39

Recycled Content	Embodied Carbon (UK) (Product stage A1-A3)	Embodied Carbon (HK) (Product stage A1-A3)
20%	2.51 kg CO ₂ /kg	2.3 kg CO ₂ /kg
80%	0.97 kg CO ₂ /kg	1.3 kg CO ₂ /kg

EMBODIED CARBON REDUCTION POTENTIAL (OPPORTUNITY)

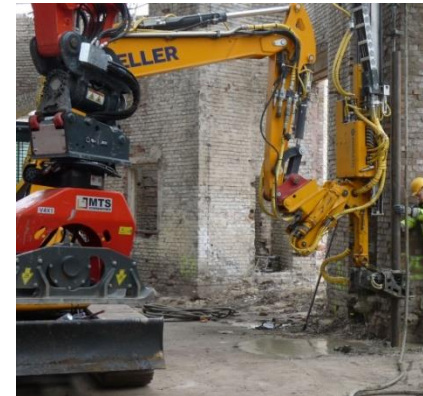


SOURCE: BURO HAPPOLD (2021)



ISN'T IT WHAT WE DO WITH MICROPILES?

RETROFITTING OF EXISTING FOUNDATIONS



SOURCE: ISCHEBECK (GER)



SOURCE: PCA GROUND ENGINEERING (AU)

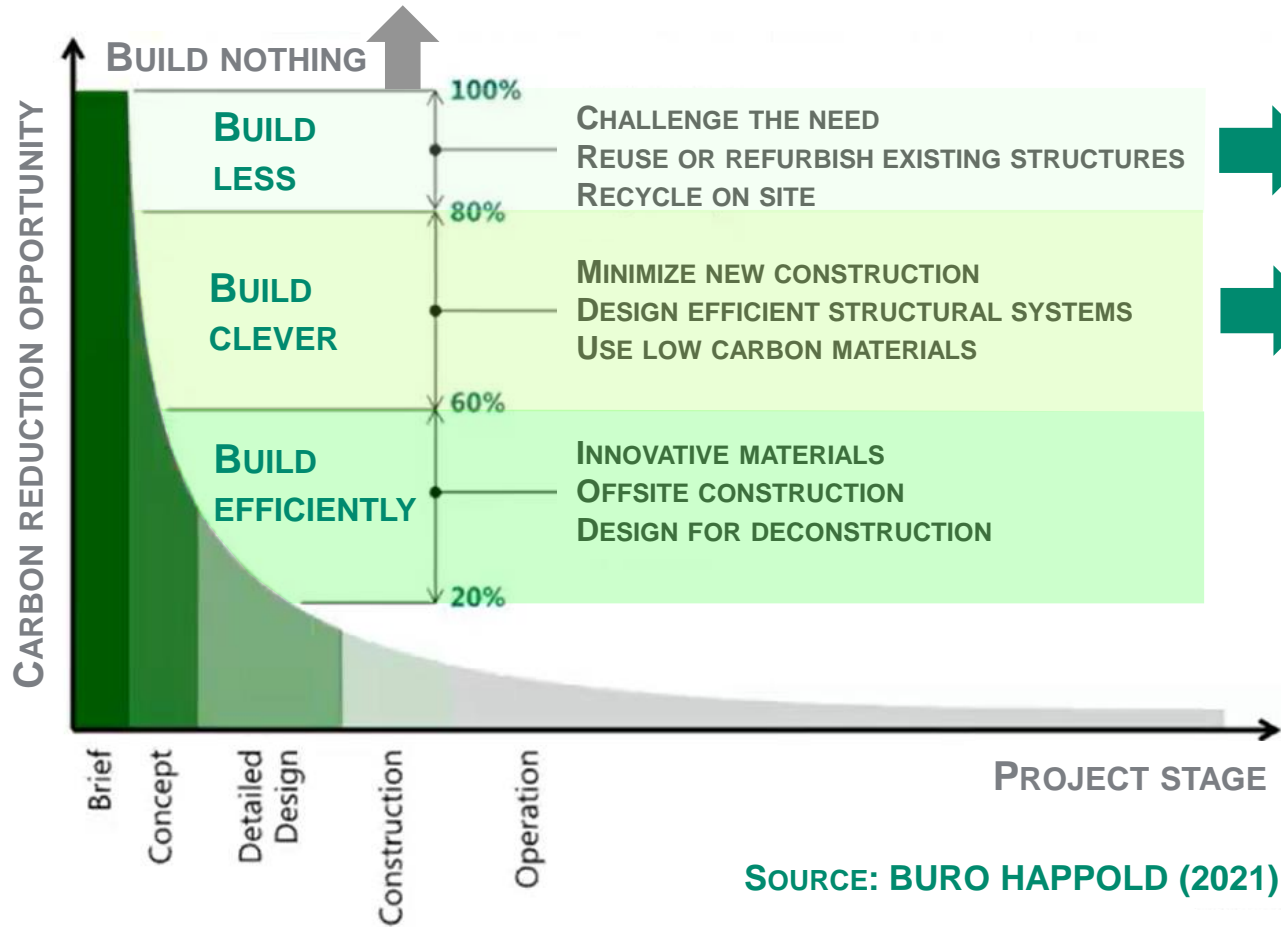


SOURCE: KELLER CIM. (ES)

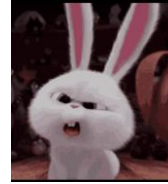


SOURCE: DUROTERRA (USA)

EMBODIED CARBON REDUCTION POTENTIAL (OPPORTUNITY)



SOURCE: BURO HAPPOLD (2021)



ISN'T IT WHAT WE DO WITH MICROPILES?

RETROFITTING OF EXISTING FOUNDATIONS

OPTIMIZATION OF FOUNDATIONS:
REDUCTION OF FOUNDATION'S SIZE: LESS CONCRETE / REINFORCEMENT
REPLACEMENT OF LARGER PILING ELEMENTS (I.E. BORED PILES)
USE RECYCLED MATERIALS (DUCTILE IRON, STEEL)



SOURCE: EBS GEO-STRUCTURAL (CA)

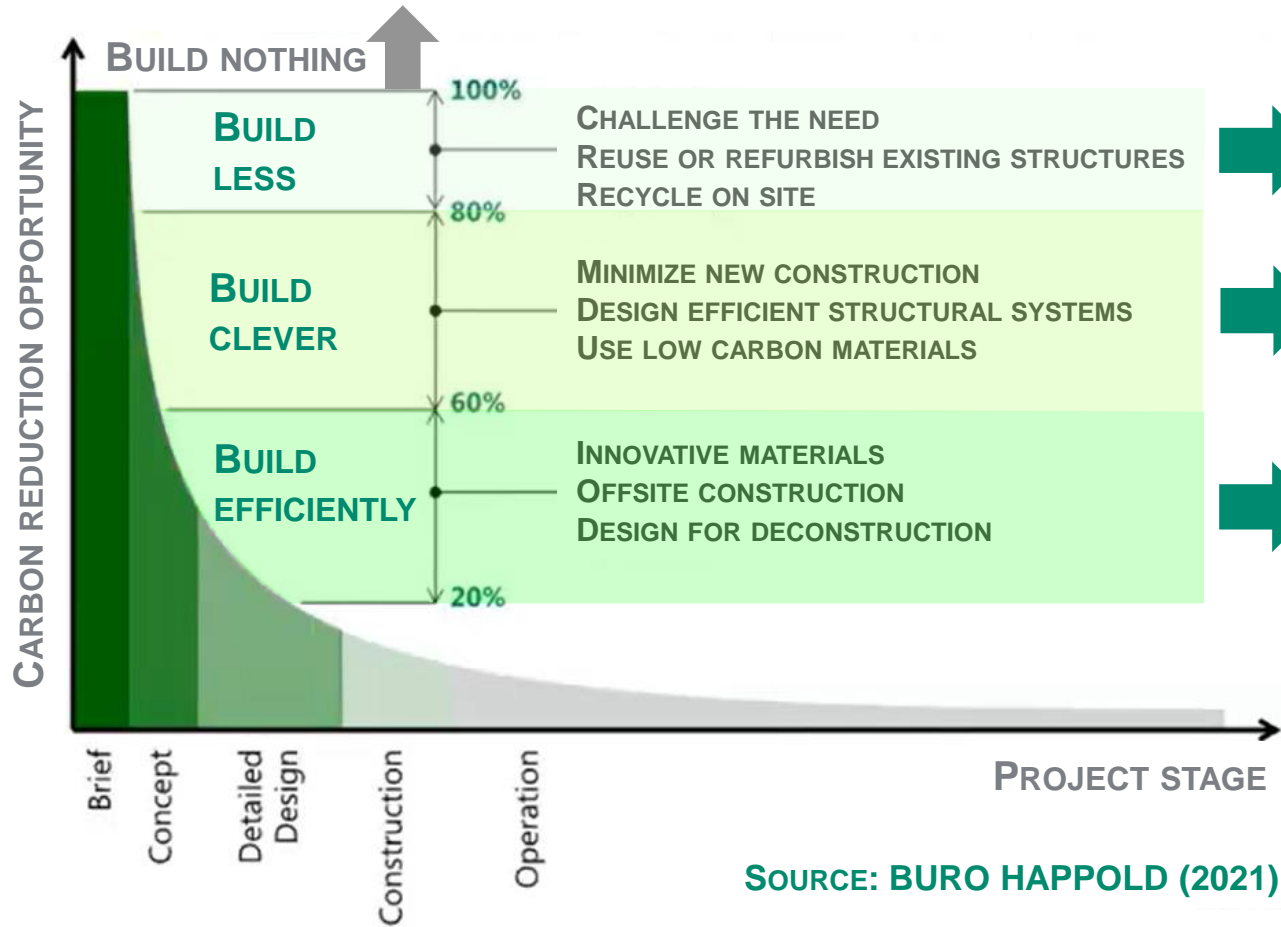


SOURCE: ISCHEBECK (GER)

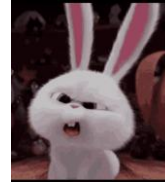


SOURCE: TRM PILING SYSTEMS (AT)

EMBODIED CARBON REDUCTION POTENTIAL (OPPORTUNITY)



SOURCE: BURO HAPPOLD (2021)



ISN'T IT WHAT WE DO WITH MICROPILES?

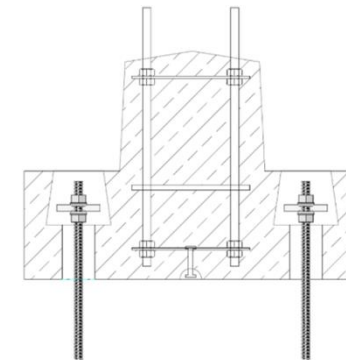
RETROFITTING OF EXISTING FOUNDATIONS

OPTIMIZATION OF FOUNDATIONS:
 REDUCTION OF FOUNDATION'S SIZE: LESS CONCRETE / REINFORCEMENT
 REPLACEMENT OF LARGER PILING ELEMENTS (I.E. BORED PILES)
 USE RECYCLED MATERIALS (DUCTILE IRON, STEEL)

USE OF PRE-CAST (PRE-FABRICATED) FOUNDATION ELEMENTS (I.E. PILE CAPS)



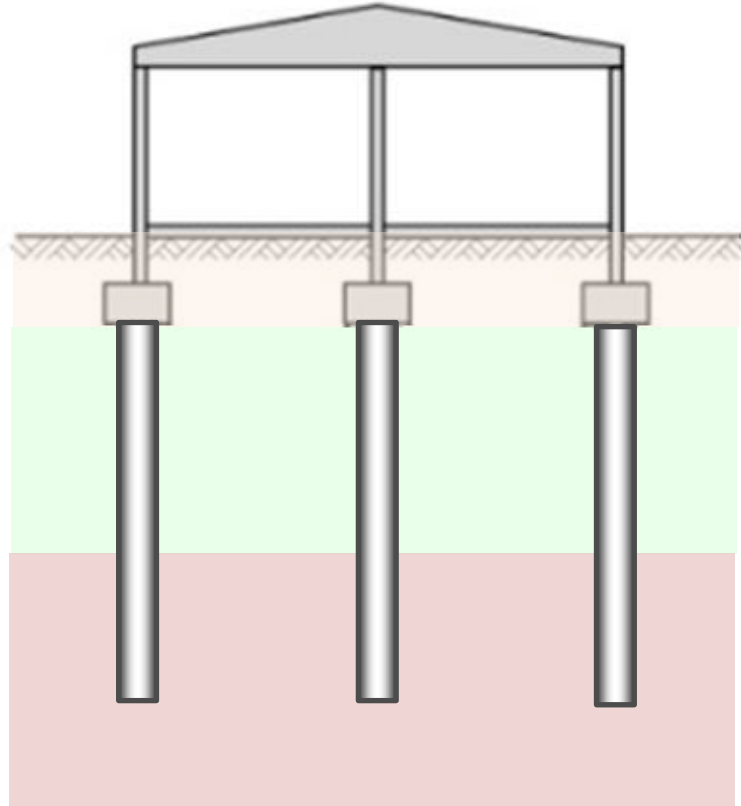
SOURCE: ISCHEBECK (GER)



SOURCE: BAATZ AND EFCO-FARODIA (LU)

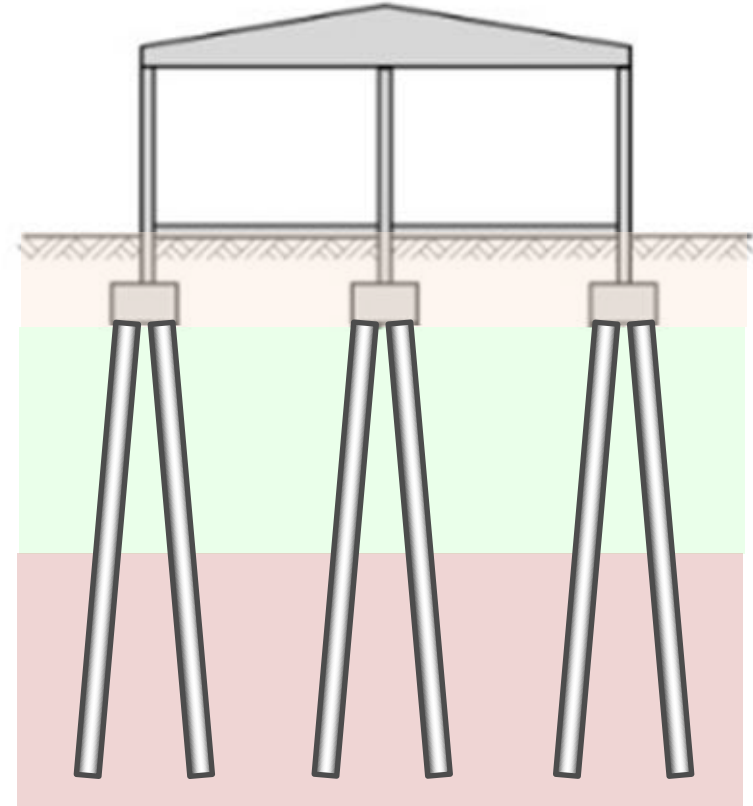


EXAMPLE 1: CONSTRUCTION OF A NEW INDUSTRIAL BUILDING IN GERMANY (2017)



TECHNICAL PROPOSAL (ORIGINAL)

NUMBER OF PILES: 24
TYPE: BORED PILES
DIAMETER: 620 MM
LENGTH: 8 M



TECHNICAL PROPOSAL (ALTERNATIVE)

NUMBER OF PILES: 43
TYPE: MICROPILES TRM 118 | 7.5MM
DIAMETER: 270 MM
LENGTH: 10 M

EXAMPLE 1: CONSTRUCTION OF A NEW INDUSTRIAL BUILDING IN GERMANY (2017)

EMBODIED CARBON (KG CO₂e)
24 NR. BORED PILES (Ø 620MM, L = 8 M)

Dimension: 620mm / 8m x 24				diameter
Transport concrete: 30 km				620
Transport reinforcement: 100 km				
A1-A3	Material production	Concrete		15.967,41
		Reinforcement	kg CO ₂ equiv	3.195,53
		Total		19.162,94
A4	Transport to construction site	Concrete		688,68
		Reinforcement	kg CO ₂ equiv	38,31
		Total		726,99
A5	Building process	Total per m of piles	kg CO ₂ equiv	2.091,47
		Once per pile		2.358,39
Total			kg CO ₂ equiv	24.339,79

EMBODIED CARBON (KG CO₂e)
43 NR. TRM PILES 118 | 7.5MM (Ø 270MM, L = 10 M)

Dimension: 118/7.5/10m x 43		Type of pipe - 118/7,5	
Transport of ductile pipes by road 300 km		kg CO ₂ equiv	
Transport concrete: 30 km		V270	
A1 - A3	Material production	Infill concrete	1.063,42
		Ductile pipe	9.589,00
		Grouting	5.136,33
		Total	15.788,75
A4	Transport to construction site	Ductile pipe - road	291,14
		Ductile pipe - ship	x
		Infill concrete	46,92
		Grouting	226,79
		Total	564,85
A5	Building process	Total	926,29
Total			17.279,89

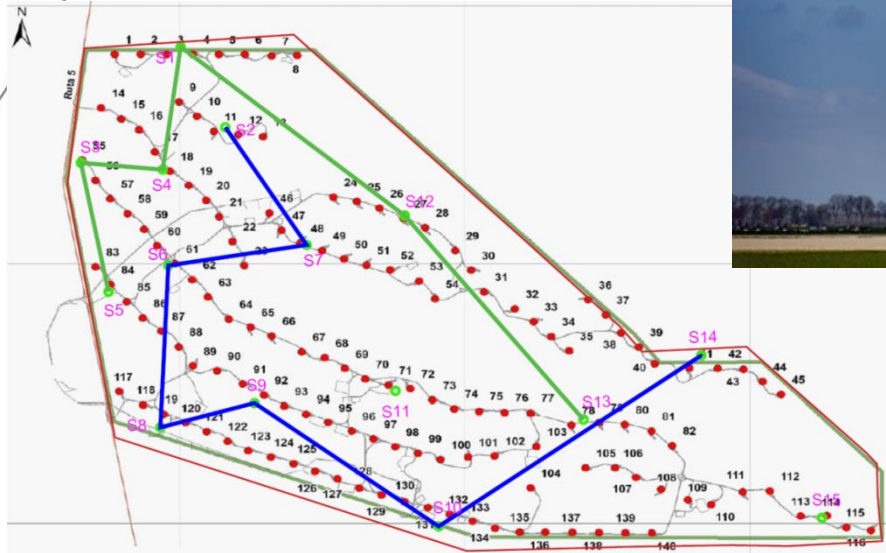
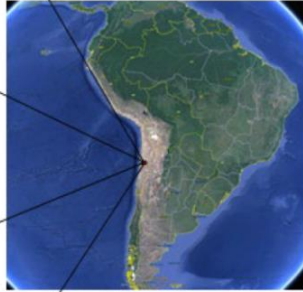
EMBODIED CARBON: MICROPILED FOUNDATION / PILED FOUNDATION → 0.71

COSTS ANALYSIS: MICROPILED FOUNDATION / PILED FOUNDATION → 0.74

SCHEDULE ANALYSIS: MICROPILED FOUNDATION / PILED FOUNDATION → 0.43



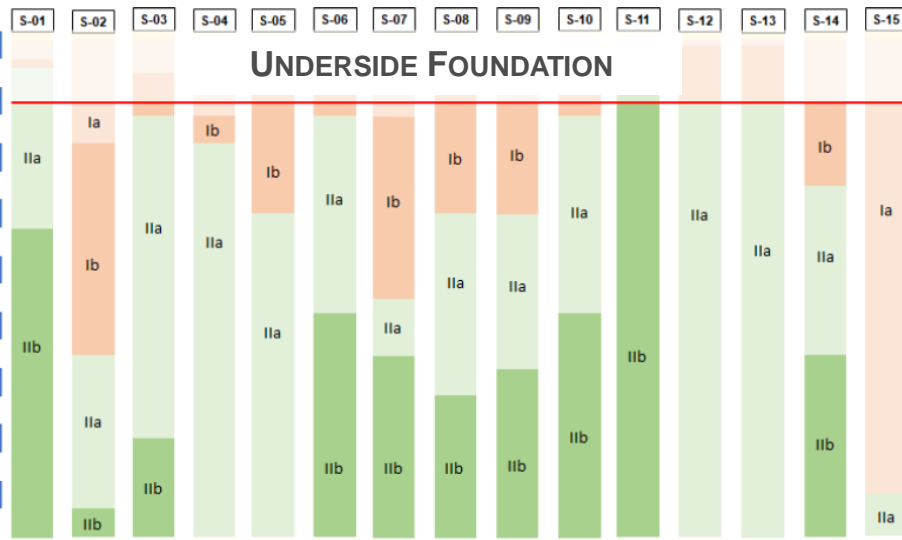
EXAMPLE 2: FOUNDATIONS OF ONSHORE WIND ENERGY GENERATORS IN CHILE (2020)



SOURCE: ISCHEBECK CHILE (CL)



EXAMPLE 2: FOUNDATIONS OF ONSHORE WIND ENERGY GENERATORS IN CHILE (2020)



Unidad geotécnica	Descripción	Propiedades elásticas			γ (kN/m ³)	Resistencia al corte		Cap. por-tante σ_{adm} (kPa)	Módulo de balasto ks (MN/m ³)	Fricción unitaria q_s (kPa)
		G_0 (MPa)	E_0 (MPa)	μ (-)		ϕ' (°)	c' (kPa)			
Ia	Su/Us	75 - 200	250 - 350	0.3	1.3 - 1.4	25-28	25-50	>200	6-60	150
Ib	Sg (cemented)	200 - 300	350 - 600	0.3	1.5 - 1.7	32-35	5-10	>250	20-90	250
IIa	Sg / Gs	450 - 650	900 - 1200	0.3	1.7 - 1.9	25-32	50-100	>350	90-120	300
IIb	Rock	>650	>1200	0.3	>1.9	>32	>150	>500	>120	400

5 Minimum foundation stiffness's

The get a correct dynamic behaviour of the complete wind turbine system including the foundation the following **dynamic** foundation stiffness range against the turn over moment (MxyF) is required;

- Lower (or minimum) bound: $\geq 1.6E11$ Nm/rad

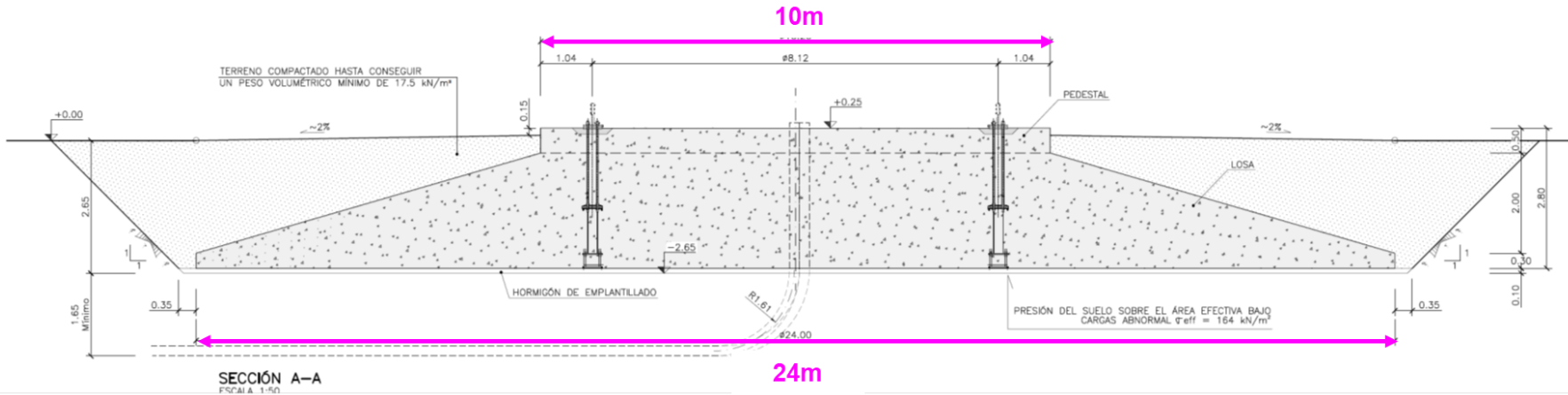
The **static** foundation stiffness range against the turn over moment (MxyF) must be;

- Lower (or minimum) bound: $\geq 2.7E10$ Nm/rad

A minimum horizontal foundation stiffness of **4.0E8 [N/m]** is required.

Requirements for the foundation stiffness are based on a minimum foundation weight of **500E3 kg**.

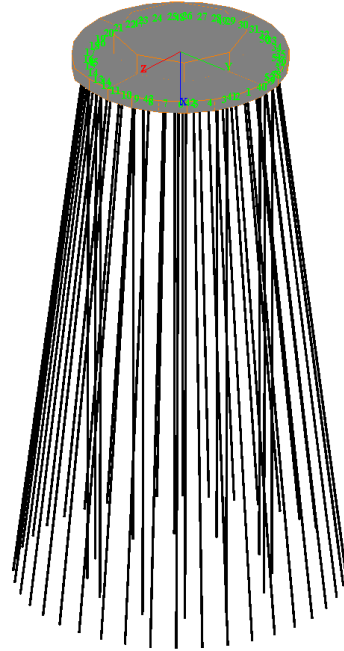
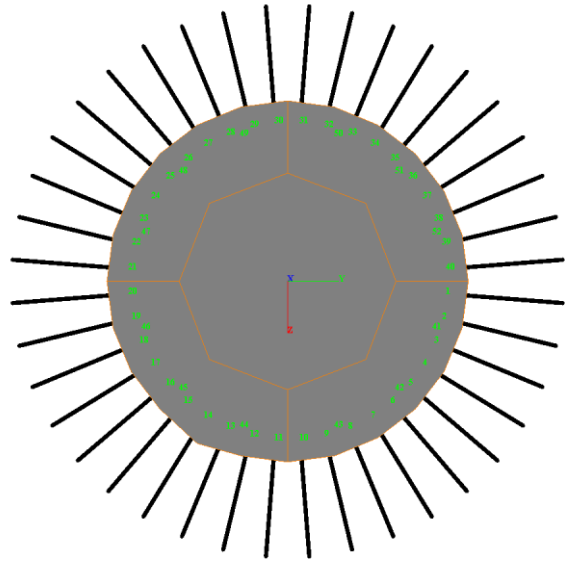
TECHNICAL PROPOSAL (ORIGINAL)



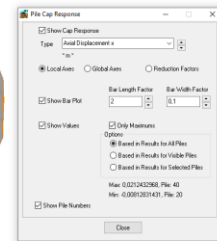
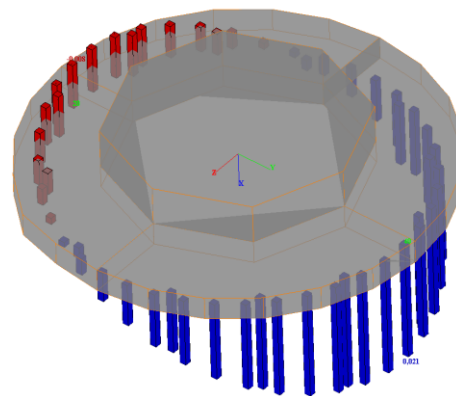
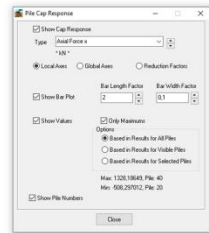
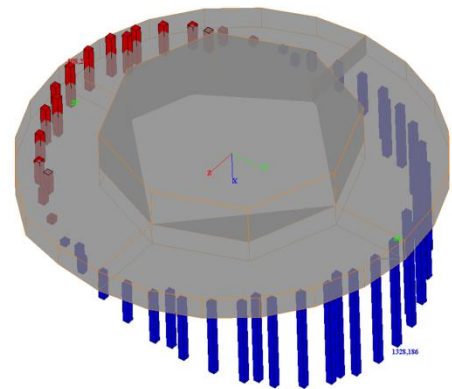
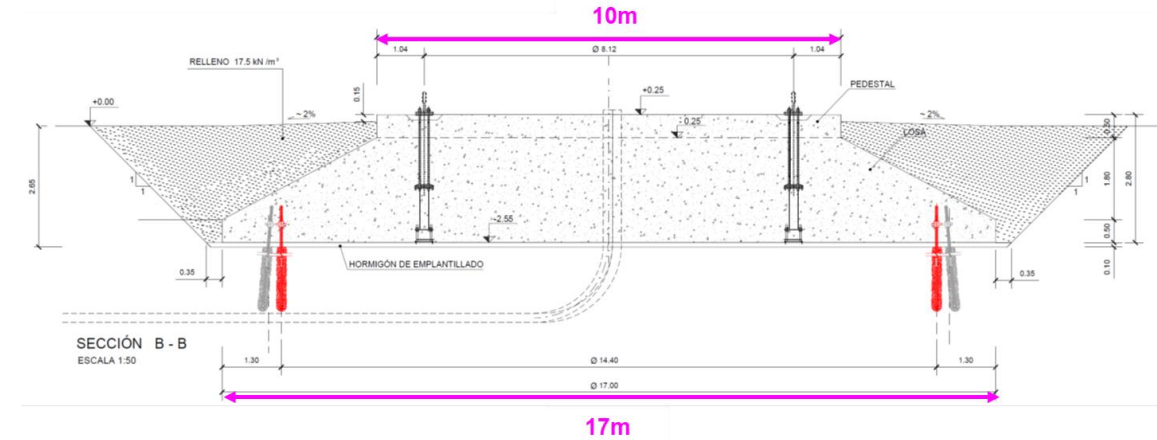
Quantities		
Concrete for pedestal (m ³)	G45	38
Concrete for slab (m ³)	G35	620
Blinding concrete (m ³)	G10	48
Mortar (m ³)	C90/105 O SIMILAR	1.94
Excavation (m ³)		1 539
Backfill (m ³)		868

SOURCE: ISCHEBECK CHILE (CL)

EXAMPLE 2: FOUNDATIONS OF ONSHORE WIND ENERGY GENERATORS IN CHILE (2020)



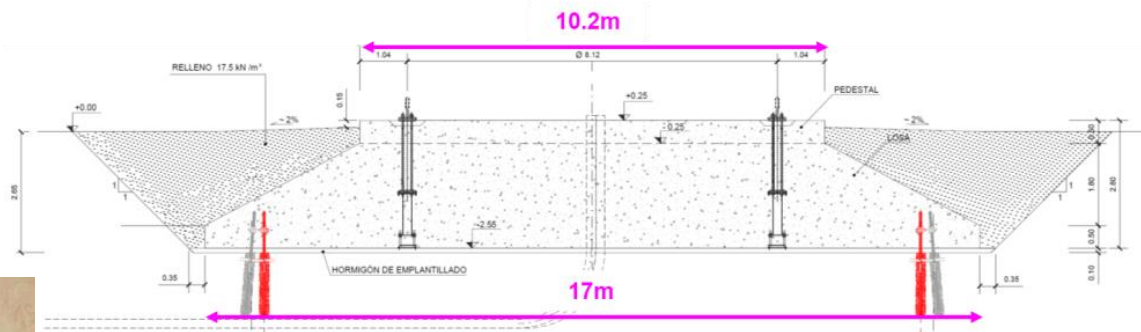
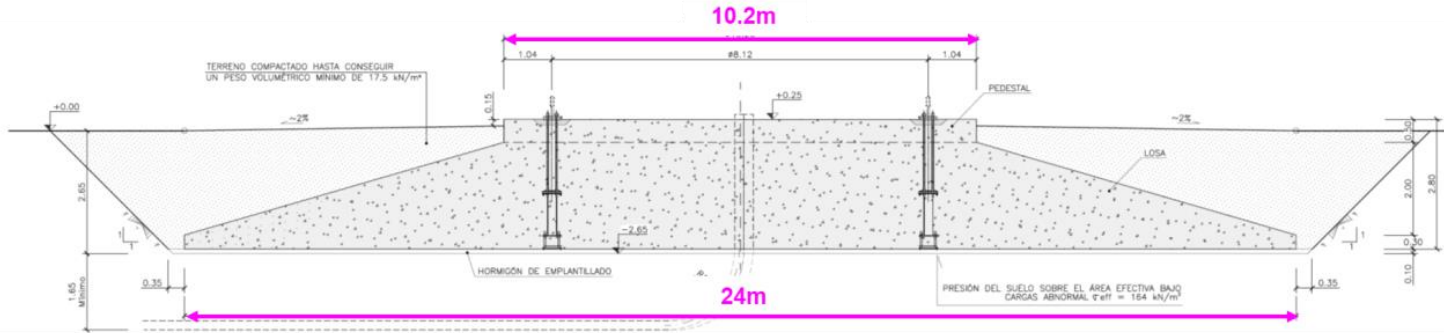
**TECHNICAL PROPOSAL (ALTERNATIVE):
52 NR. TITAN ISCHEBECK 103/78 (L = 13.5M)**



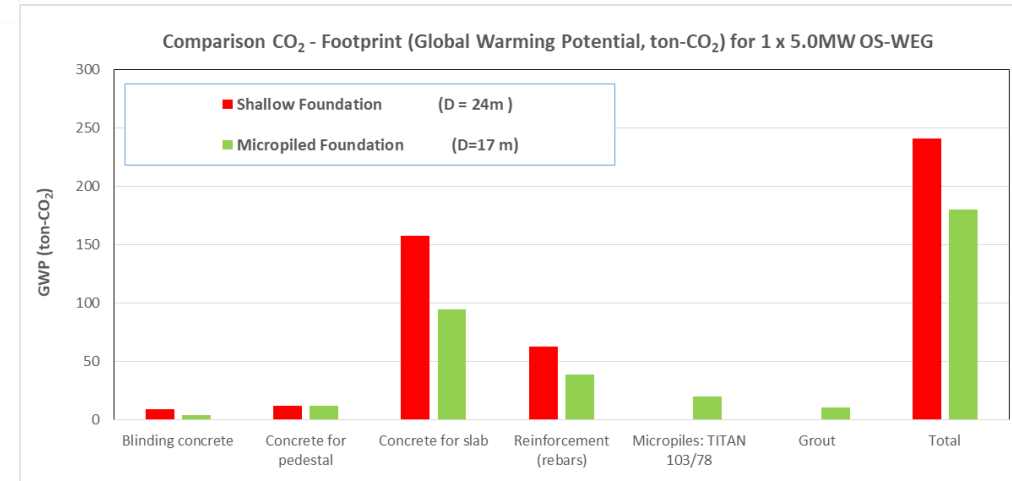
Quantities		
Concrete for pedestal (m ³)	G45	38
Concrete for slab (m ³)	G35	372
Blinding concrete (m ³)	G10	23
Mortar (m ³)	C90/105 O SIMILAR	1.94
Excavation (m ³)		867
Backfill (m ³)		433

SOURCE: ISCHEBECK CHILE (CL)

EXAMPLE 2: FOUNDATIONS OF ONSHORE WIND ENERGY GENERATORS IN CHILE (2020)



	Shallow Foundation (D = 24m)	Micropiled Foundation (D=17m)
Position	GWP (ton-CO₂) für 1x 5.0MW WEA	
Blinding concrete	8,8	4,2
Concrete for pedestal	12,0	12,0
Concrete for slab	157,6	94,6
Reinforcement (rebars)	62,4	38,7
Micropiles: TITAN 103/78	0,0	20,2
Grout	0,0	10,5
Total	240,8	180,1



EMBODIED CARBON: MICROPILED FOUNDATION / SHALLOW FOUNDATION → 0.75

SOURCE: ISCHEBECK (GER)

COSTS ANALYSIS: MICROPILED FOUNDATION / SHALLOW FOUNDATION → 1.05



PRE-CAST CONCRETE FOUNDATIONS: SMART & GREEN ANKER FOUNDATIONS (GERMANY)



SOURCE: SMART & GREEN ANKER FOUNDATIONS (2023)

PRE-CAST CONCRETE FOUNDATIONS: SMART & GREEN ANKER FOUNDATIONS (GERMANY)

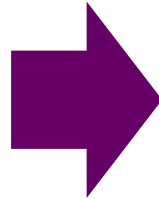
	ANKER precast foundations	Cast-in-place concrete foundations
CO ₂ emissions*	≈ 105 000 kg CO ₂	≈ 350 000 kg CO ₂
<small>*Comparative calculation based on an Enercon E-115 with 149m HH at a location in Germany</small>		
Dependency on cast-in-place concrete	0%	100 %
Construction time	≈ 5 days	≈ 42 days
Weather dependency	low	high
Logistics	≈ 40 standard trucks	≈ 100 concrete mixers within 48 hours
Quality	industrial prefabrication under controlled conditions	inconstant
Blinding layer	no blinding layer required	blinding layer necessary
Dismantling	simple low cost	complex high cost



SOURCE: SMART & GREEN ANKER FOUNDATIONS (2023)



SOURCE: CBS NEWS (2023)

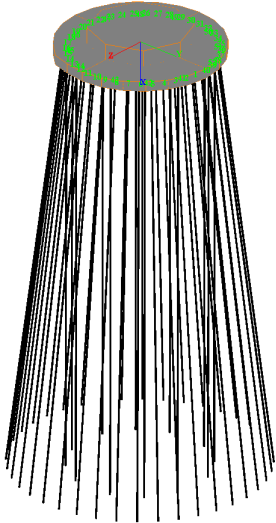
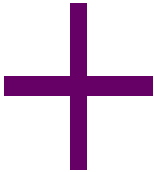
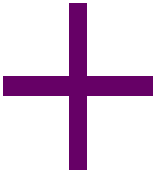


BRIMSTONE (OAKLAND, CALIFORNIA)
WORLD'S 1ST CARBON-NEGATIVE CEMENT,
MADE OUT CALCIUM SILICATE ROCKS (I.E. BASALT),
INSTEAD OF LIMESTONE



SOURCE: WWW.BRIMSTONE.COM

EMBRACE INNOVATION (GOING THE EXTRA MILE)



- AS PART OF THE CONSTRUCTION INDUSTRY, WE HAVE A GREAT RESPONSIBILITY FOR THE IMPACT OF OUR DAILY WORK.
- **MICROPILES** GIVE US THE TOOLS TO WALK TOWARDS A MORE SUSTAINABLE DEEP FOUNDATIONS INDUSTRY, BY ALLOWING US TO BUILD CLEVER AND EFFICIENTLY
- THE LARGEST EMBODIED CARBON REDUCTION POTENTIAL LAYS IN THE DESIGN
- WITH INFORMED DECISIONS ABOUT THE EMBODIED CARBON IMPACT OF THE MATERIALS WE USE, WE CAN HAVE A HUGE IMPACT IN THE FINAL EMISSIONS OF OUR PROJECTS
- USE LOW CARBON MATERIALS → PREFER THE USE OF RECYCLED MATERIALS
- DEMAND ENVIRONMENTAL PRODUCT DECLARATIONS FROM YOUR LOCAL SUPPLIERS
- NO MATTER HOW LITTLE OUR CONTRIBUTION MIGHT SEEM, IT IS IN OUR HANDS TO MAKE SOME REAL CHANGE, FOR A BETTER FUTURE (AT ANY SIZE AND IN ANY SCALE)
- WE NEED TO EMBRACE CHANGE AS AN OPPORTUNITY FOR INNOVATION



“...ONE THING IS CERTAIN: THOSE THAT GIVE UP ARE SURE TO LOSE. SO LET’S FIGHT TOGETHER – AND LET’S WIN. FOR THE 8 BILLION MEMBERS OF OUR HUMAN FAMILY – AND FOR GENERATIONS TO COME...”

ANTÓNIO GUTERRES (COP 27)

ACKNOWLEDGMENTS:

TO MY LOVELY FRIENDS AT FRIEDR. ISCHEBECK GMBH

TO MY FAMILY AT TRM PILING SYSTEMS FOR ALLOWING ME TO LIVE
A COMMON VISION, EVERY SINGLE DAY

TO THE ISM FOR GRANTING US THE OPPORTUNITY TO SHARE OUR
PASSION FOR MICROPILES

TO YOU, MICROPILE ENTHUSIASTS, FOR TRYING TO MAKE A BETTER
WORLD WITH MICROPILES



TRM TIROLER ROHRE GMBH
DUROTERRA



TRM TIROLER ROHRE GMBH
DUROTERRA