

Leveraging openBIM for Low- Carbon Design

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SYSP

The climate emergency imposes taking action in reducing carbon emissions

THE PARIS AGREEMENT

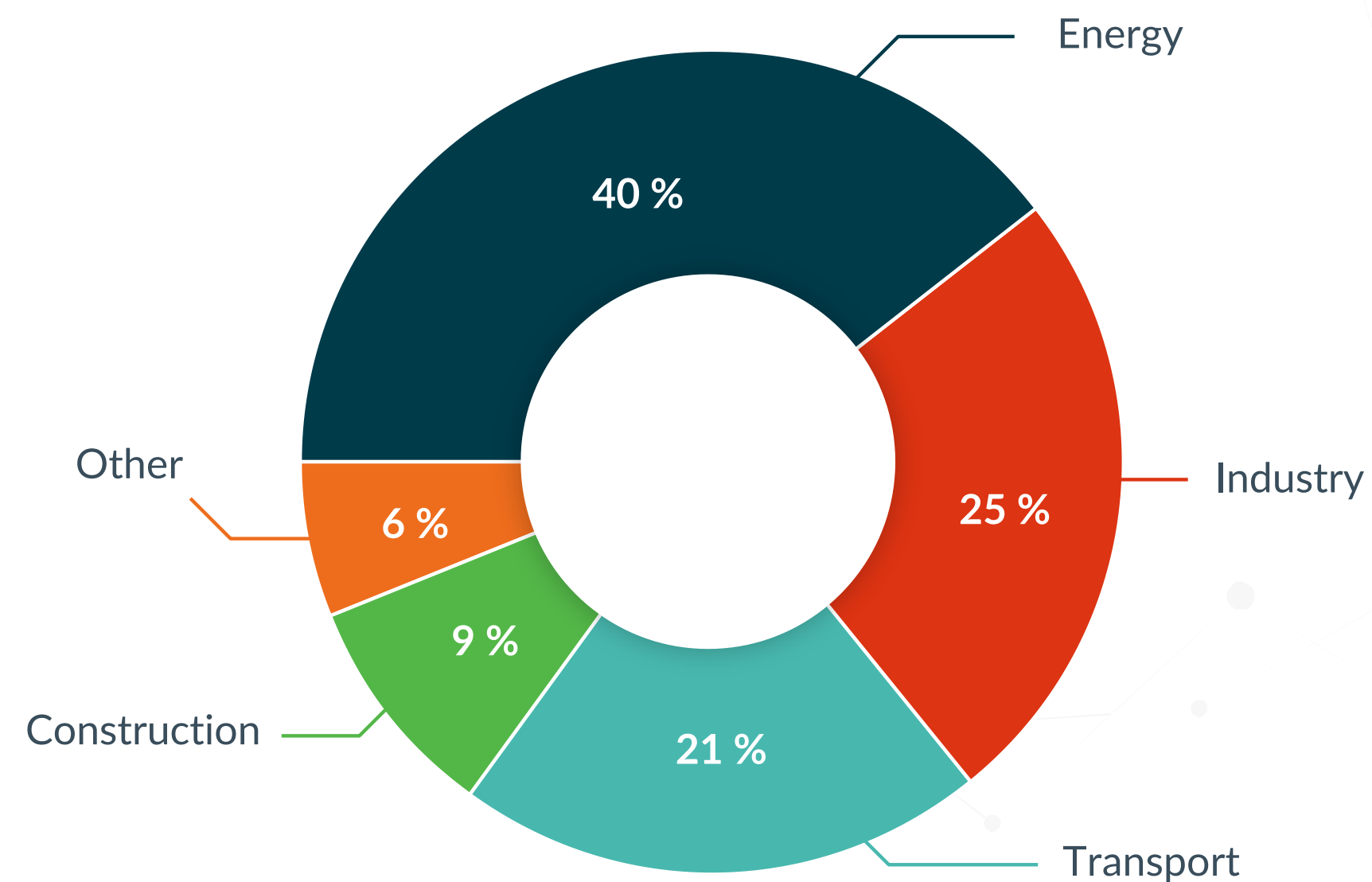
2050: Carbon neutrality

WITHIN THE EU

2030: 50% reduction in carbon emissions



As a mobility and transport expert, SYSTRA has a key role to play



CO2 emissions by sector in 2020

Source: International Energy Agency

Infrastructures have a significant carbon footprint



A COMMERCIAL BUILDING OF 6 500m²

6 000 tCO₂e

Equivalent to **1 200 x** per capita per year carbon emissions*



A 1 000m TUNNEL

20 000 tCO₂e

Equivalent to **4 000 x** per capita per year carbon emissions*



A 1 000m RAILWAY VIADUCT

22 850 tCO₂e

Equivalent to **4 570 x** per capita per year carbon emissions*



ASSESSING THE CARBON FOOTPRINT OF TRANSPORT INFRASTRUCTURES
IS LESS COMMON AND MORE COMPLEX THAN THAT OF BUILDINGS.
TO HELP MANAGE IT EFFICIENTLY, SYSTRA HAS DEVELOPED **CARBONTRACKER**

Source: Construction21 and SYSTRA projects, figures applied to construction, carbon emissions in France

Why CARBONTRACKER ?

A carbon tool **developed specifically for infrastructure projects**



A database of carbon data derived from our 20 years of global expertise



We go further than a mere technological approach by addressing the carbon footprint, you **give meaning to your projects within the context of the climate emergency**



A web solution created with professionals from multiple areas of technical expertise (BIM, climate and carbon, civil engineering, architecture, systems etc.)



A decision-making tool to view and determine **the most appropriate optimisation solutions depending on your criteria**



Ability to visualise the emissions avoided via optimisations and to obtain reliable information in order to **communicate the positive effects of the project to your stakeholders**



CARBONTRACKER

Implementation Success Factors

Using the CarbonTracker web application, which is BIM-compatible, to

MEASURE

MANAGE

CONTROL

carbon emissions at **every stage of a transport infrastructure project**

Quantify in real time the carbon footprint and the avoided emissions

Measure carbon emissions for various assets and design scenarios



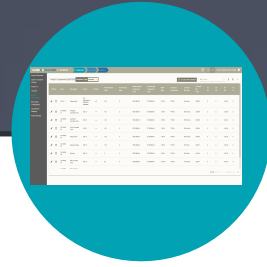
Run sensitivity tests to compare carbon emissions when varying parameters

Assess progress towards project carbon reduction targets

Identify carbon emissions hotspots across the lifecycle of the infrastructure

SUPPORT DECISION-MAKING AROUND SUSTAINABLE DESIGN SOLUTIONS

Harnessing a Multi-Platform Web App and Open Data



CONFIGURATION DATA

All configuration Data including the CO2 database can be exported in JSON files



INPUT DATA

The use of OpenBIM supports the life cycle process through open and transparent standardized digital description



OUTPUT DATA

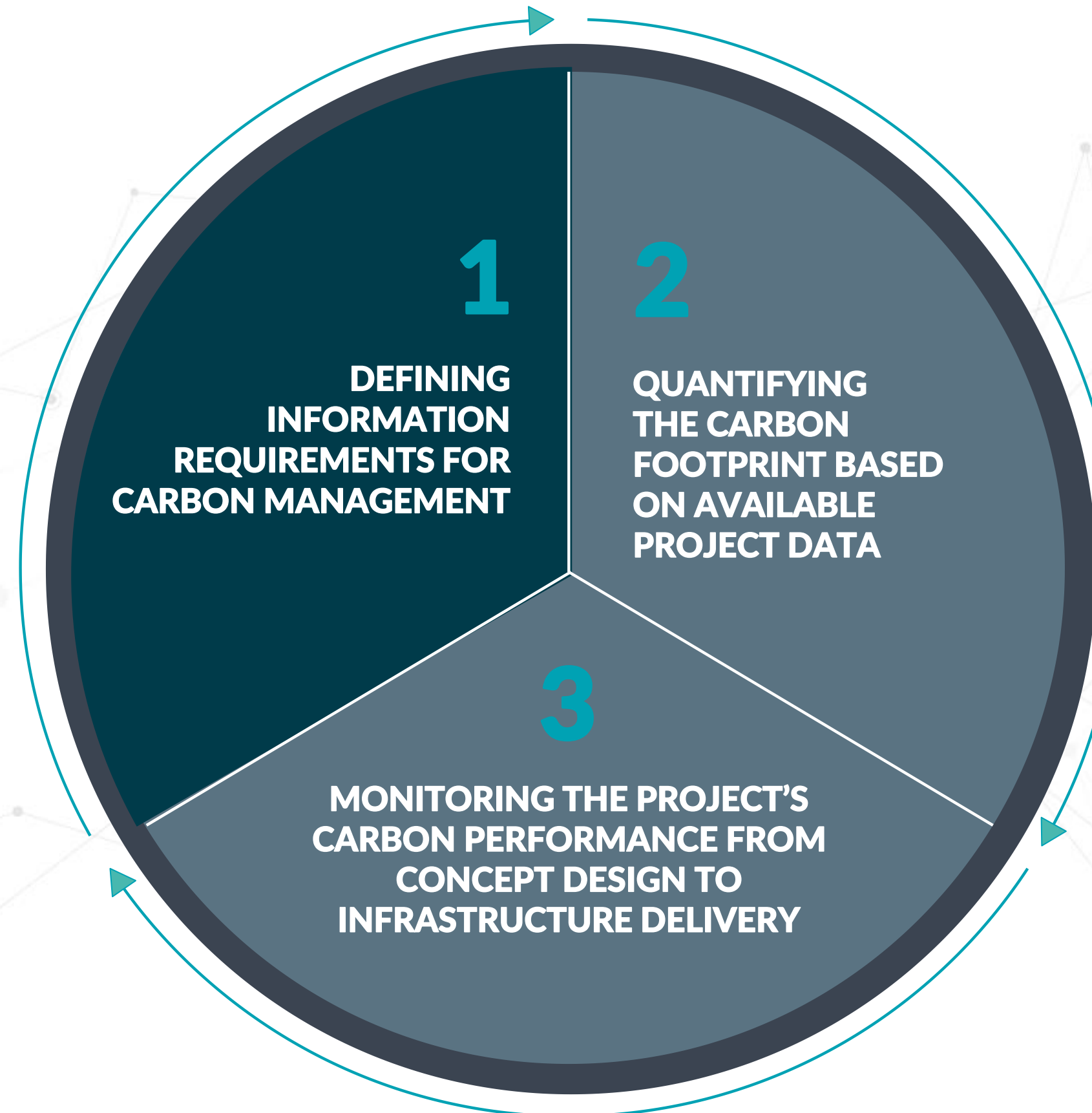
All Results DATA can be exported in JSON files.



CARBONTRACKER is a web application with data stored in an open-source database.

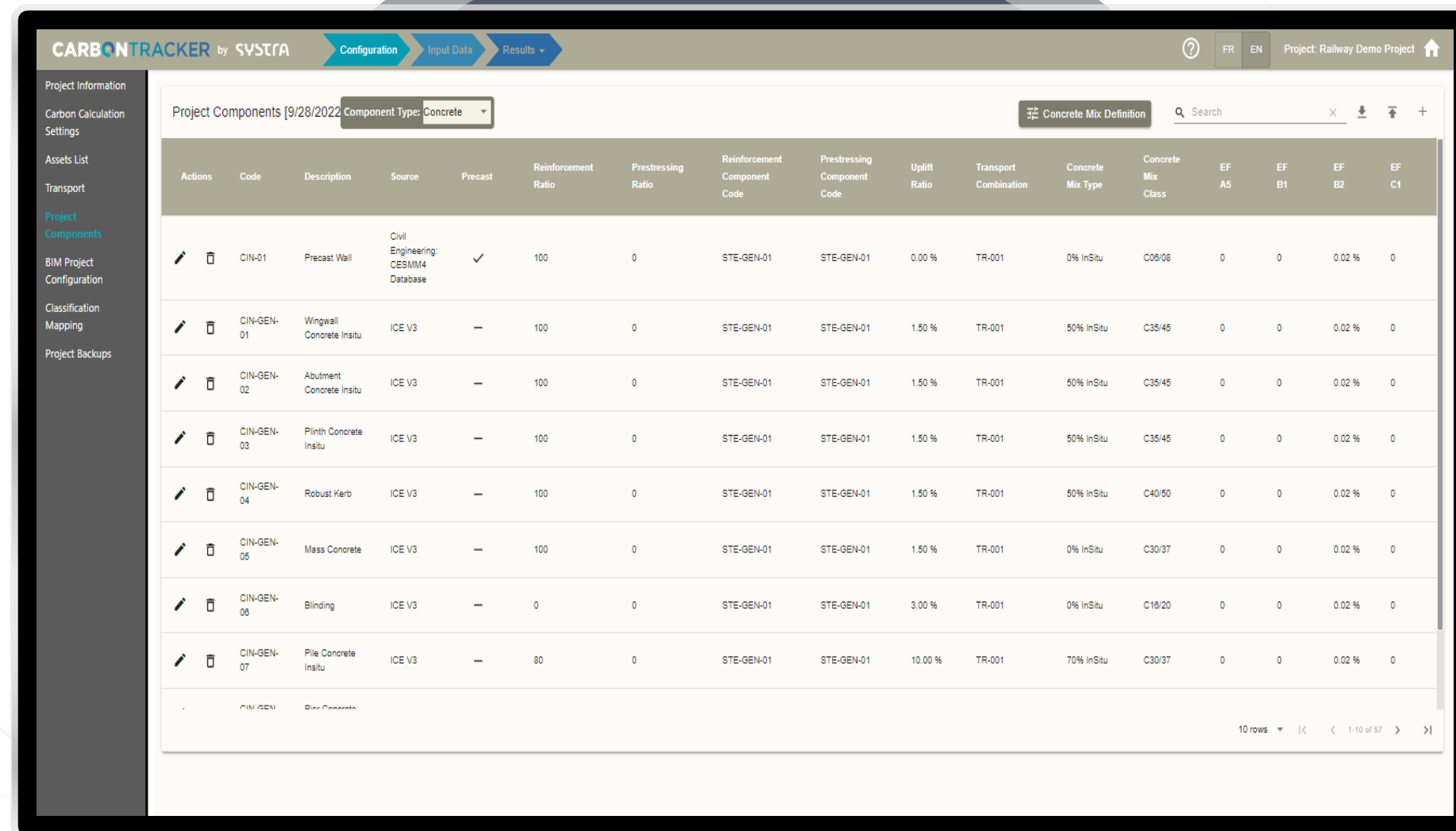
All historicized Configuration and Output Data can be exported in JSON files including links with Design files used for the calculations.

Tracking the carbon footprint in 3 steps



A robust Database and a Methodology compliant with International Standards

1



The screenshot displays the CARBONTRACKER software interface. The top navigation bar includes 'Configuration', 'Input Data', and 'Results'. The main area shows a table titled 'Project Components [9/28/2022 Component Type: Concrete]'. The table has columns for Actions, Code, Description, Source, Precast, Reinforcement Ratio, Prestressing Ratio, Reinforcement Component Code, Prestressing Component Code, Uplift Ratio, Transport Combination, Concrete Mix Type, Concrete Mix Class, and four columns for Emission Factors (EF A5, EF B1, EF B2, EF C1). The table lists various concrete components like Precast Wall, Wingwall Concrete In Situ, Abutment Concrete In Situ, etc., with their respective properties and emission factors.

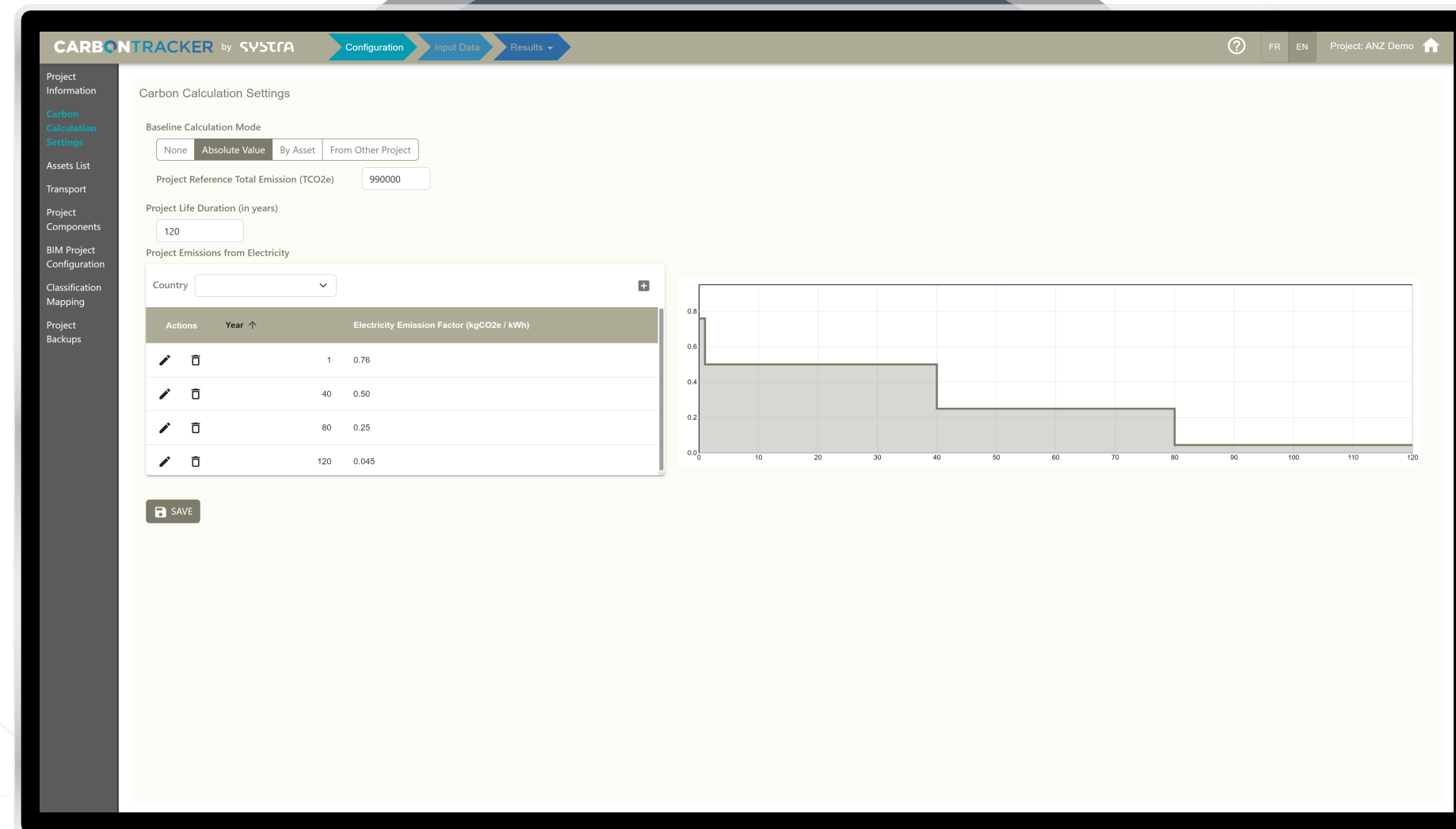
Actions	Code	Description	Source	Precast	Reinforcement Ratio	Prestressing Ratio	Reinforcement Component Code	Prestressing Component Code	Uplift Ratio	Transport Combination	Concrete Mix Type	Concrete Mix Class	EF A5	EF B1	EF B2	EF C1
✎	CIN-01	Precast Wall	Civil Engineering CESMM4 Database	✓	100	0	STE-GEN-01	STE-GEN-01	0.00 %	TR-001	0% In Situ	C06/08	0	0	0.02 %	0
✎	CIN-GEN-01	Wingwall Concrete In Situ	ICE V3	—	100	0	STE-GEN-01	STE-GEN-01	1.50 %	TR-001	50% In Situ	C35/45	0	0	0.02 %	0
✎	CIN-GEN-02	Abutment Concrete In Situ	ICE V3	—	100	0	STE-GEN-01	STE-GEN-01	1.50 %	TR-001	50% In Situ	C35/45	0	0	0.02 %	0
✎	CIN-GEN-03	Plinth Concrete In Situ	ICE V3	—	100	0	STE-GEN-01	STE-GEN-01	1.50 %	TR-001	50% In Situ	C35/45	0	0	0.02 %	0
✎	CIN-GEN-04	Robust Kerb	ICE V3	—	100	0	STE-GEN-01	STE-GEN-01	1.50 %	TR-001	50% In Situ	C40/50	0	0	0.02 %	0
✎	CIN-GEN-05	Mass Concrete	ICE V3	—	100	0	STE-GEN-01	STE-GEN-01	1.50 %	TR-001	0% In Situ	C30/37	0	0	0.02 %	0
✎	CIN-GEN-06	Blinding	ICE V3	—	0	0	STE-GEN-01	STE-GEN-01	3.00 %	TR-001	0% In Situ	C16/20	0	0	0.02 %	0
✎	CIN-GEN-07	Pile Concrete In Situ	ICE V3	—	80	0	STE-GEN-01	STE-GEN-01	10.00 %	TR-001	70% In Situ	C30/37	0	0	0.02 %	0

CARBONTRACKER is backed-up by a central database most relevant to infrastructures and relies on robust quantification methods. It includes emission factors for hundreds of components and for electricity depending on the local energy mix of each country.

- A database developed based on SYSTRA's technical expertise and using multiple recognized national and international data sources
- Carbon calculation methodology in compliance with lifecycle assessment standards, ISO 14040, ISO 14044 and EN 15978 and a powerful tool that can support the PAS 2080 certification
- Emissions assessed for the whole project lifecycle and per lifecycle stage; from material extraction (A1) to operation (B6) and deconstruction at the end of life (C1).
- Emission factors for different transport modes and for current and future electricity mix depending on the decarbonisation strategy of each country

Defining Information Requirements for CARBON Management

1



Configuring the tool to suit project characteristics and local context

- Baseline and Carbon calculation
- Granularity of Carbon Assessments (Asset Breakdown)
- Project Transport Combinations
- Design input data requirements
- Frequency of Assessments

- Project Information
- Carbon Calculation Settings**
- Assets List
- Transport
- Project Components
- BIM Project Configuration
- Classification Mapping
- Project Backups

Carbon Calculation Settings

Baseline Calculation Mode

None Absolute Value By Asset From Other Project

Project Reference Total Emission (TCO2e) 990000

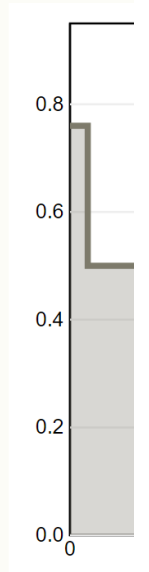
Project Life Duration (in years)

120

Project Emissions from Electricity

Country

Actions	Year ↑	Electricity Emission Factor (kgCO2e / kWh)
	1	0.76
	40	0.50
	80	0.25
	120	0.045



SAVE



Baseline and Carbon Calculation Settings

- Baseline Calculation Mode
- Project Life Duration
- Project Emissions from Electricity



- Project Information
- Carbon Calculation Settings
- Assets List**
- Transport
- Project Components
- BIM Project Configuration
- Classification Mapping
- Project Backups

Project Asset Types +

- ACC - Accomodation x
- BAC - Accomodation Bridge x
- BBS - Box Structure x
- BCU - Major Culvert x
- BDU - Divuender x
- BFB - Pedestrian Bridge x
- PFM - O&M Platform x
- SCC - Cut and Cover x
- SRC - Retained Cutting x
- SRW - Retaining Wall x
- TPO - Tunnel Portal x
- VIA - Viaduct x

Assets List

Actions	Code	Type	Name	Description
	FRP-000000019	PFM	Lake 0019 O&M Platform	Lake 0019 O&M Platform
	FRP-000000162	SCC	River 0162 Cut and Cover	River 0162 Cut and Cover
	FRP-000000164	TPO	Lane 0164 Tunnel Portal	Lane 0164 Tunnel Portal
	FRP-000000165	SCC	Hill 0165 Cut and Cover	Hill 0165 Cut and Cover
	FRP-000000166	TPO	River 0166 Tunnel Portal	River 0166 Tunnel Portal
	FRP-000000169	TPO	Lane 0169 Tunnel Portal	Lane 0169 Tunnel Portal
	FRP-000000196	PFM	Hill 0196 O&M Platform	Hill 0196 O&M Platform
	FRP-000000197	PFM	Field 0197 O&M Platform	Field 0197 O&M Platform
	FRP-000000198	PFM	House 0198 O&M Platform	House 0198 O&M Platform
	FRP-000000199	PFM	Lane 0199 O&M Platform	Lane 0199 O&M Platform
	FRP-000000200	PFM	House 0200 O&M Platform	House 0200 O&M Platform
	FRP-000000201	PFM	River 0201 O&M Platform	River 0201 O&M Platform
	FRP-000000202	PFM	Lake 0202 O&M Platform	Lake 0202 O&M Platform
	FRP-000000203	PFM	Field 0203 O&M Platform	Field 0203 O&M Platform
	FRP-000000204	PFM	House 0204 O&M Platform	House 0204 O&M Platform
	FRP-000000205	PFM	Hill 0205 O&M Platform	Hill 0205 O&M Platform
	FRP-000000209	PFM	Hill 0209 O&M Platform	Hill 0209 O&M Platform

Granularity of Carbon Assessments

- Asset Breakdown Structure
- Asset Life Duration
- Codification and Naming

- Project Information
- Carbon Calculation Settings
- Assets List
- Transport**
- Project Components
- BIM Project Configuration
- Classification Mapping
- Project Backups

Transport Combination			
Actions	Code	Description	Combination
	TR-001	Local Transport Combination	ROA-03 - 50km
	TR-002	Australia Continental Combination	ROA-01 - 50km
	TR-003	Continental Truck	ROA-01 - 500km
	TR-004	Aggregate Transport Combination	ROA-01 - 175km
	TR-005	Steel and rebar Project Specific	ROA-03 - 500km

Last modified : 3/5/2023



Project Transport Combinations

- Different Transport Scenarios (Naval, Road, Rail, Air)
- Transport scenarios can be combined and individually assigned to elements in the database

- Project Information
- Carbon Calculation Settings
- Assets List
- Transport
- Project Components
- BIM Project Configuration**
- Classification Mapping
- Project Backups

BIM Project Configuration

Asset Tag Parameter Name:

BIM Classification Parameter Name:

BIM Platform:

BIM Checking Configuration

Type:

Actions	Parameter	Project Parameter Name	Required	Rule 1
	Volume	<input type="text" value="Volume"/>	✓	/^([0-9]*[.])?[0-9]+/g
	Reinforcement Ratio	<input type="text" value="Ratio_Armature"/>	—	
	Prestressing Ratio	<input type="text" value="Ratio_Precontrainte"/>	—	
	Concrete Mix Type	<input type="text" value="Grade_Mix"/>	✓	
	Concrete Mix Class	<input type="text" value="Classe_Beton"/>	—	

Classification Mapping

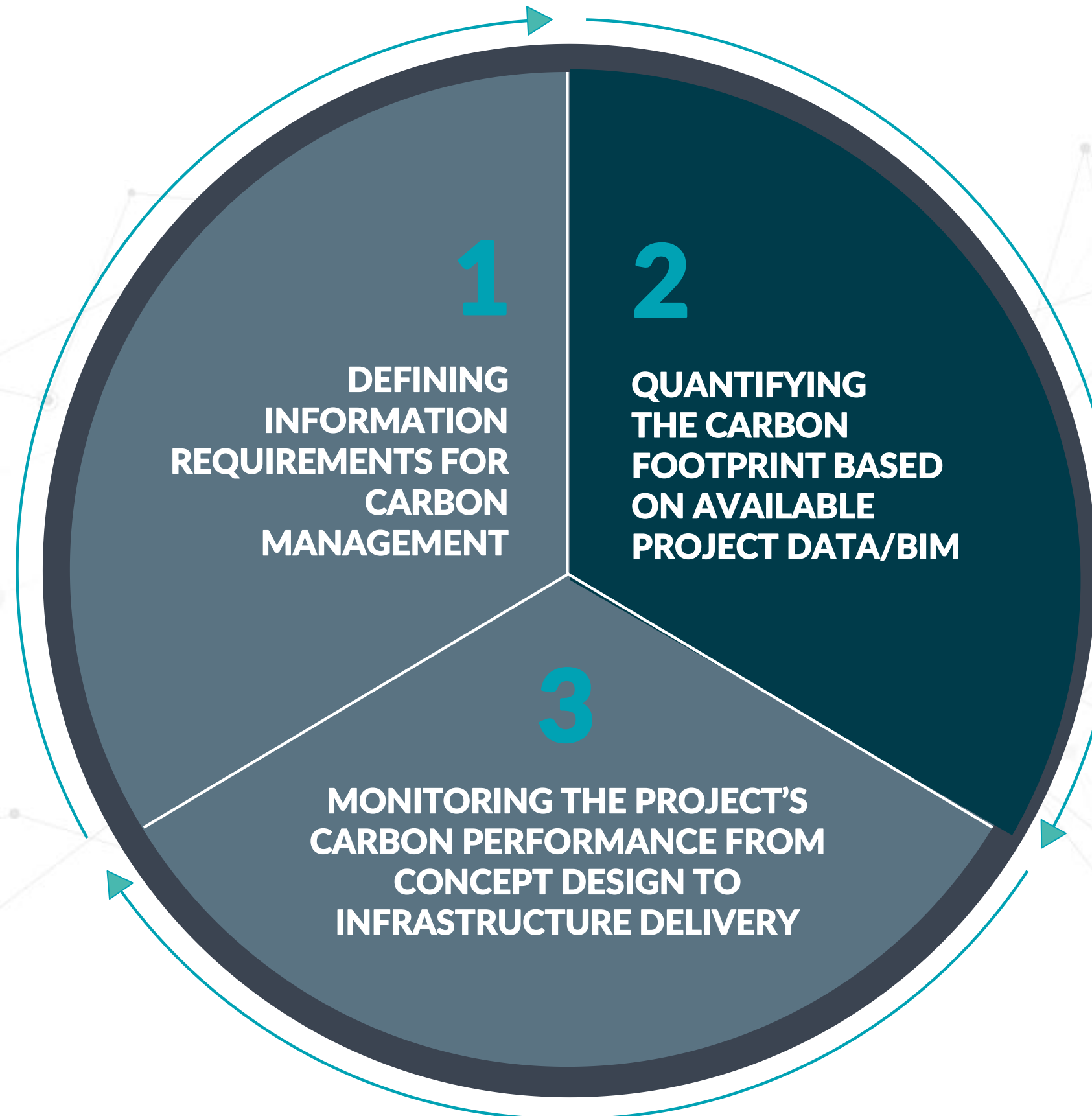
Actions	Project Classification Value	Project Classification Description	Pr
	BR-Ss_20_50_10_95-M-WingwallConcreteInsitu	Wingwall Concrete Insitu	Cc
	CB-Ss_20_50_10_95-M_WingwallConcreteInsitu	Wingwall Concrete Insitu	Cc
	CS-Ss_20_50_10_95-M_WingwallConcreteInsitu	Wingwall Concrete Insitu	Cc



Design Input Data Requirements

- BIM Project Configuration
 - Asset Tag Parameter
 - Classification Parameter
- BIM Checking Configuration
- Classification Mapping

Tracking the carbon footprint in 3 steps

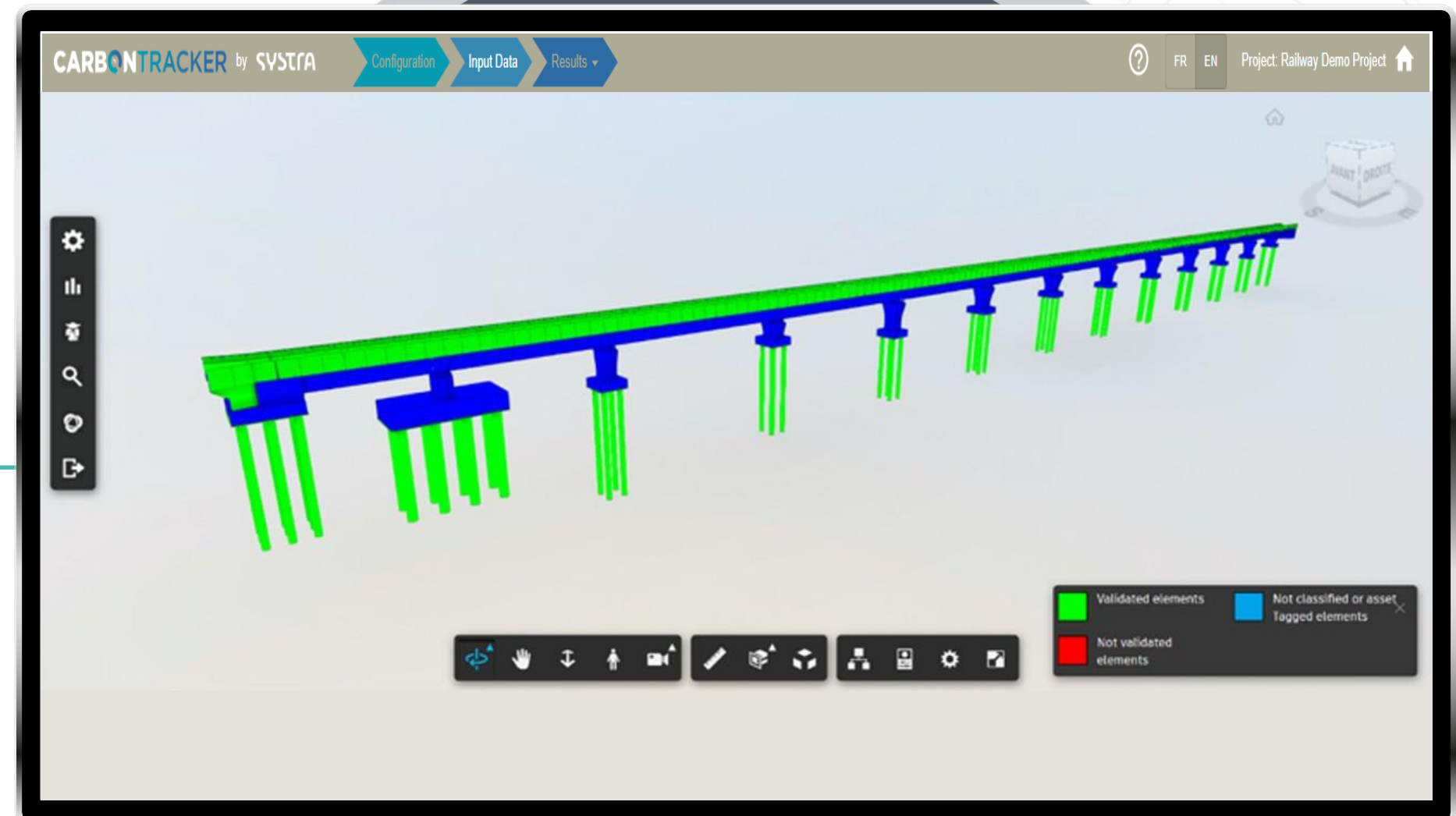


Quantifying the carbon footprint based on available project data / BIM

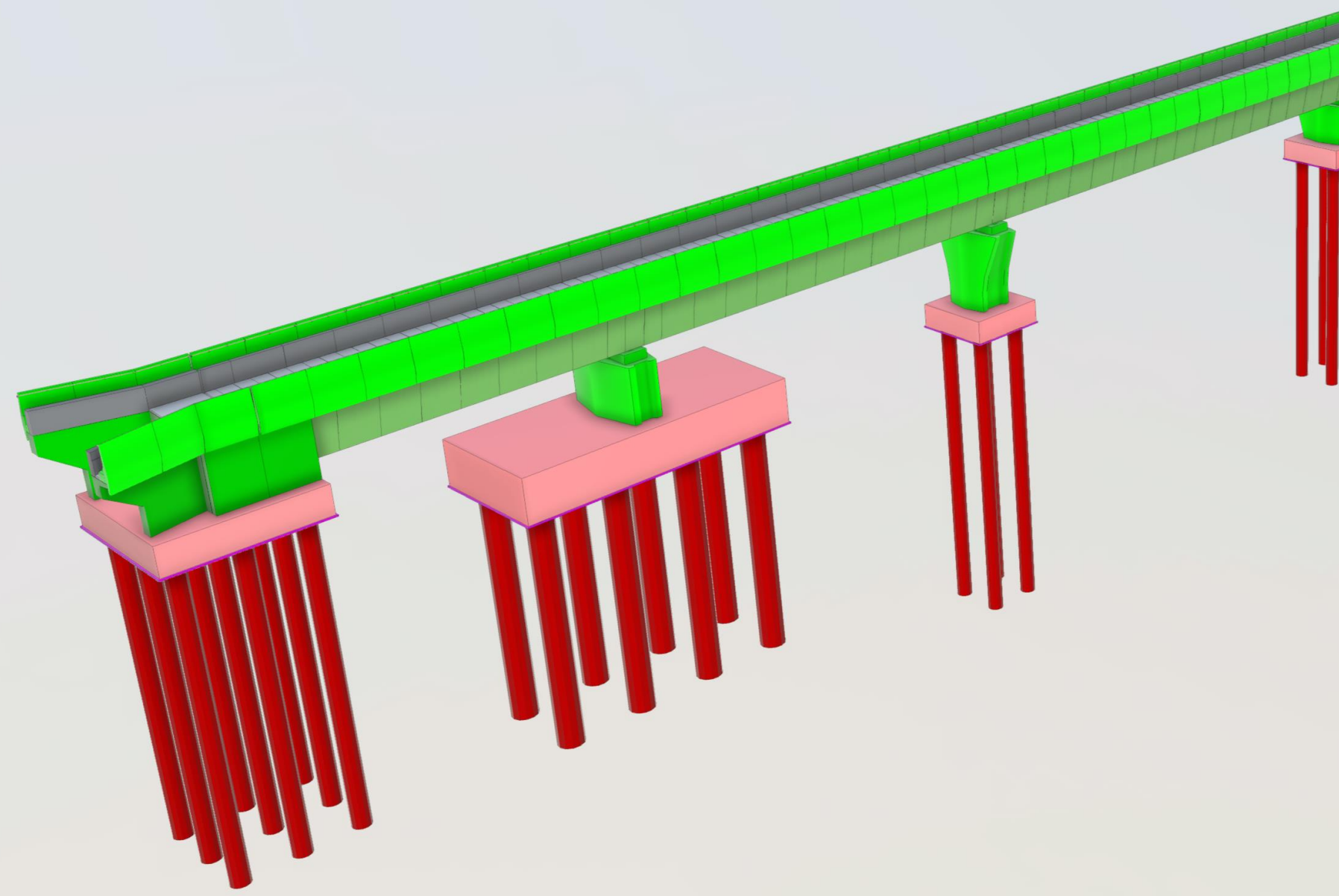
2

CARBONTRACKER is compatible with BIM technology but can also integrate non-BIM data from multiple sources (Excel, JSON, ..) allowing to adapt to a project's design maturity.

- **Captures** non-BIM and BIM data based on project models.
- **Checks BIM and non-BIM data** for missing properties and errors in configuration, providing relevant alerts
- **After initial configuration, automatically maps** project components and assets and calculate their carbon emissions



ASSESS THE CARBON FOOTPRINT FROM THE EARLY PHASES OF THE PROJECT TO SET OR COMPARE WITH A REFERENCE SCENARIO PER ASSET OR FOR THE ENTIRE PROJECT



BIM Project Configuration

Asset Tag Parameter Name: UAID

BIM Classification Parameter Name: category

BIM Platform: Forge

SAVE

BIM Checking Configuration

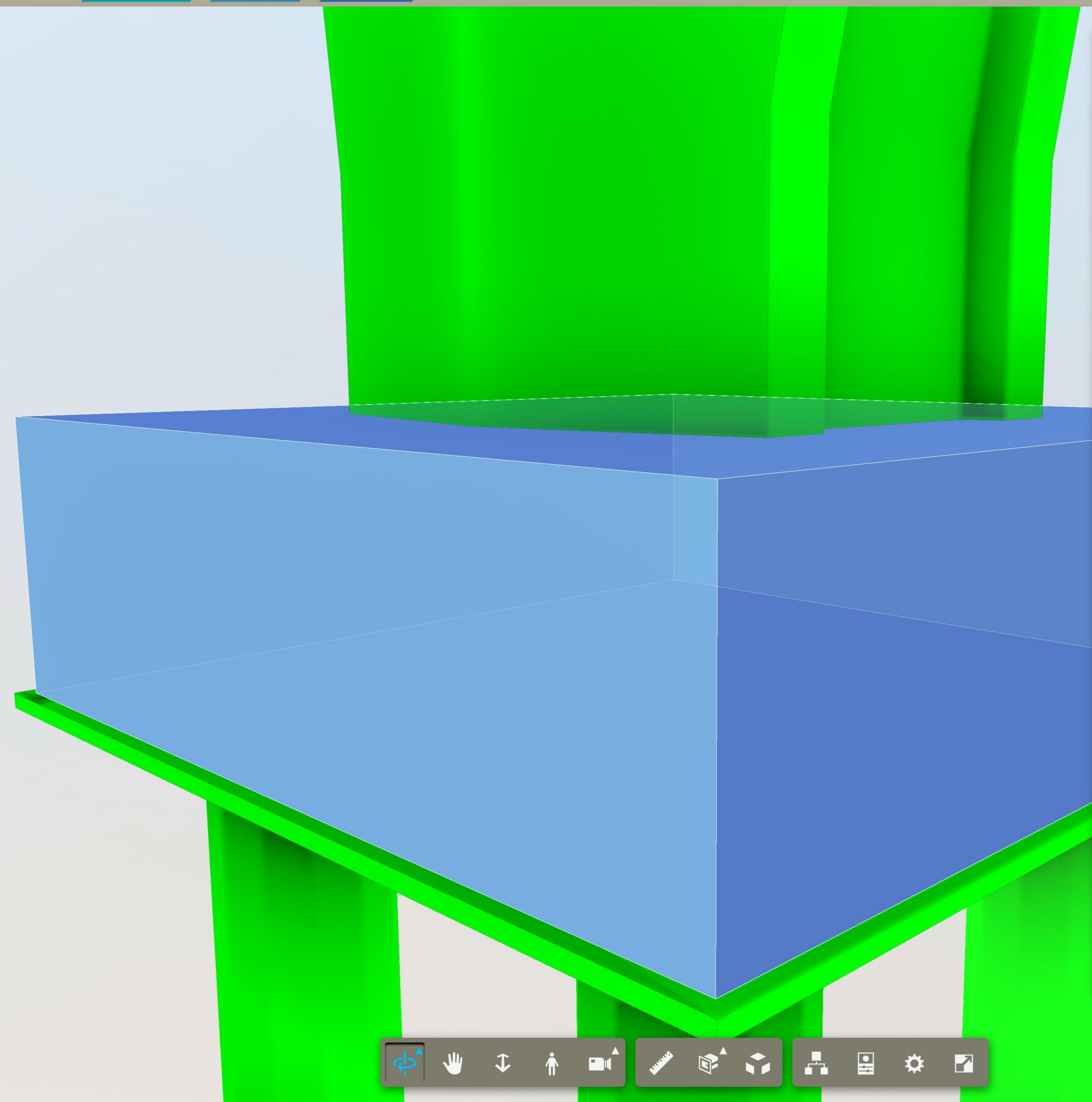
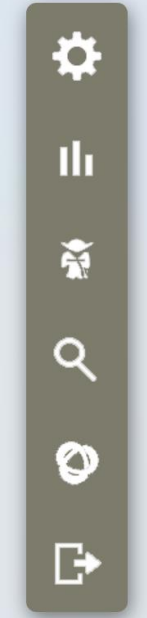
Type: Concrete

Actions	Parameter	Project Parameter Name
	Volume	Volume
	Reinforcement Ratio	Ratio_Armature
	Prestressing Ratio	Ratio_Precontrainte
	Concrete Mix Type	Grade_Mix
	Concrete Mix Class	Classe_Beton

Classification Mapping

Actions	Project Classification Value	Project Classification Description
	BR-Ss_20_50_10_95-M-WingwallConcreteInsitu	Wingwall Concrete Insitu
	CB-Ss_20_50_10_95-M_WingwallConcreteInsitu	Wingwall Concrete Insitu
	CS-Ss_20_50_10_95-M_WingwallConcreteInsitu	Wingwall Concrete Insitu





Model Analytics

Control Points Objects Figures Asset Figures Classification

2

<div style="font-size: 2em; color: blue;">82.44%</div> <p>Classified Objects 2544 objects</p>	<div style="font-size: 3em;">162</div> <p>Classification Values in the Configuration</p>
<div style="font-size: 2em; color: blue;">6.17%</div> <p>Used Classifications 10/162 classifications used from configuration</p>	<div style="font-size: 3em;">12</div> <p>Classification Values in the Model 10 correct & 2 unexpected</p>
<div style="font-size: 2em; color: red;">17.56%</div> <p>Not Classified Objects 542 objects</p>	

Unexpected values for classification: CB-Ss_20_50-M_Bearings, ?

■ Validated Elements
 ■ Not classified or asset Tagged Elements
 ■ Not validated elements



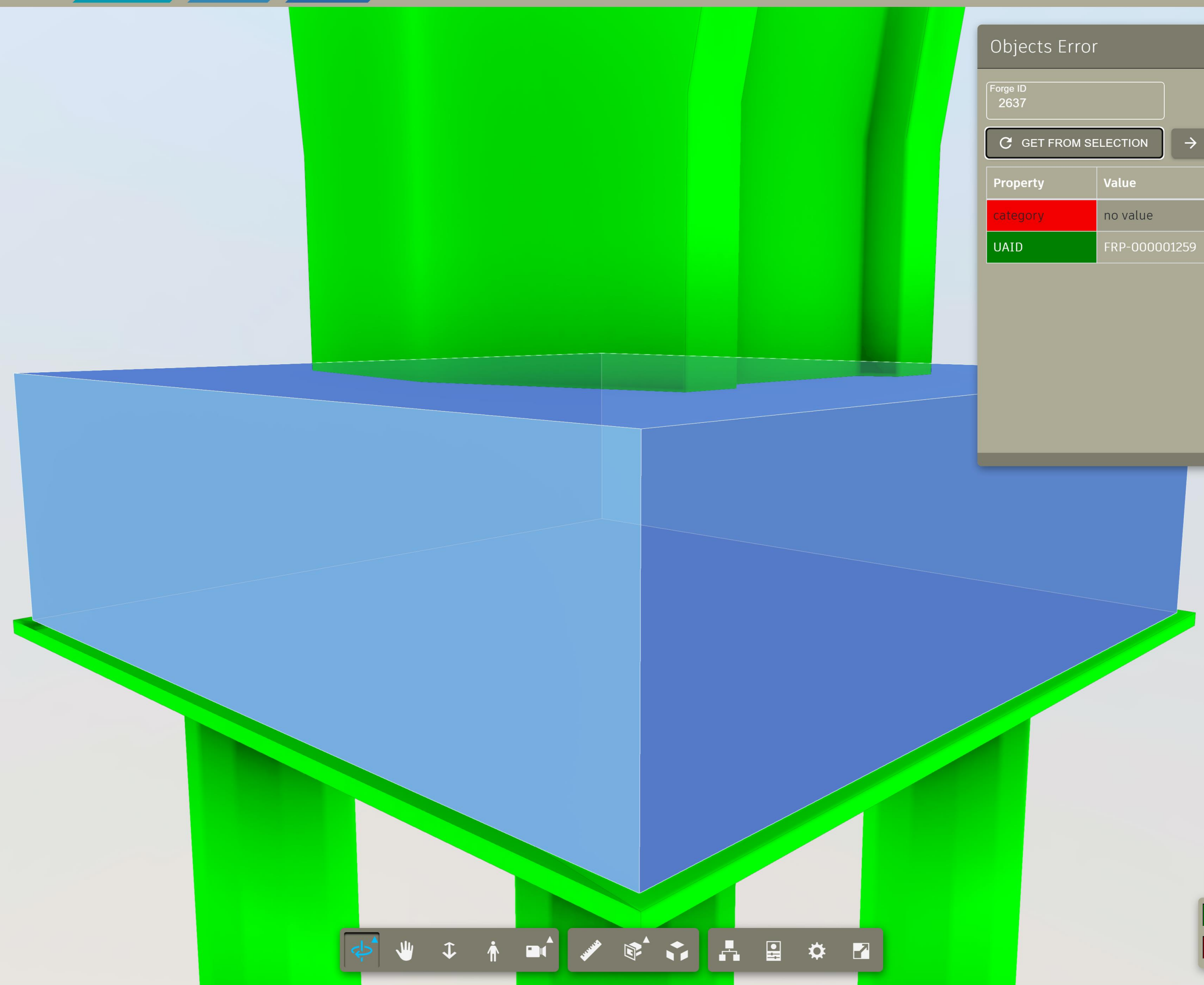
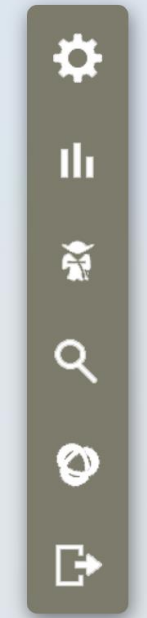
2

Objects Error

Forge ID: 2637

GET FROM SELECTION APPLY

Property	Value	Rule
category	no value	Classification Code
UAID	FRP-000001259	AssetCode



Validated Elements Not classified or asset Tagged Elements

Not validated elements

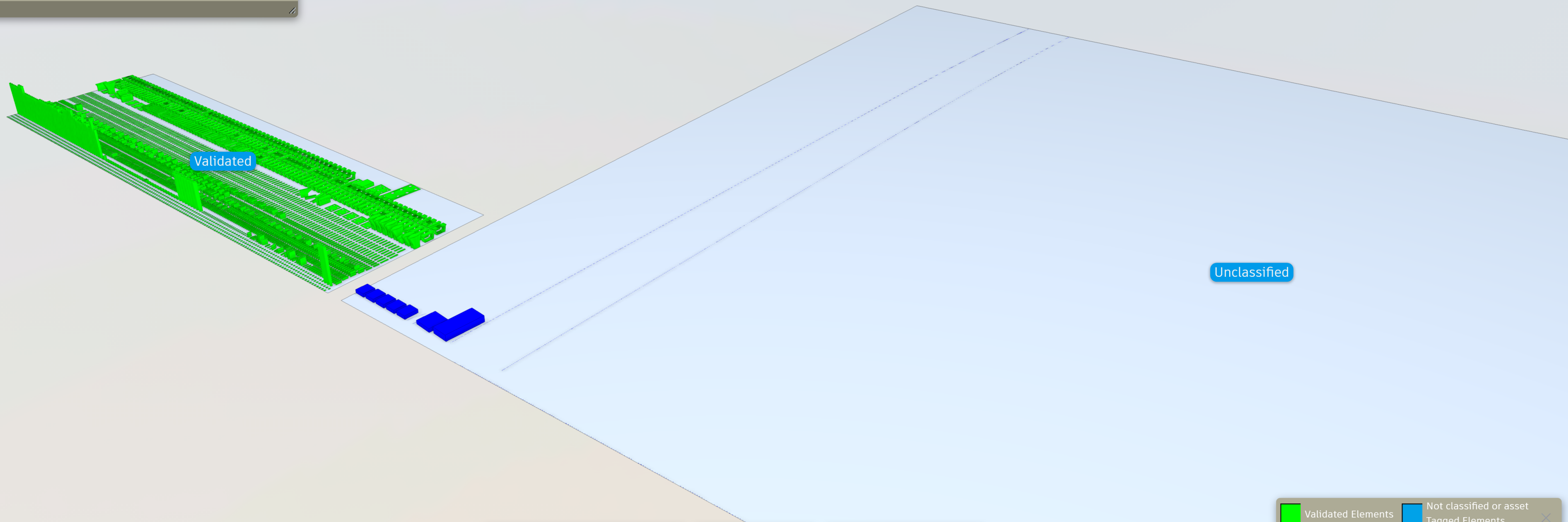


Visual Cluster

- Checking Classification (Object Status)
- Project Classification (category)
- CarbonTracker Components
- Other Classification

Property Name

→ APPLY



Validated Elements

Not validated elements

Not classified or asset Tagged Elements

2

Export Control Reports

Export Format

Excel BCF

Error Status

Validated Elements
 Not Validated Elements

Export other parameters in report

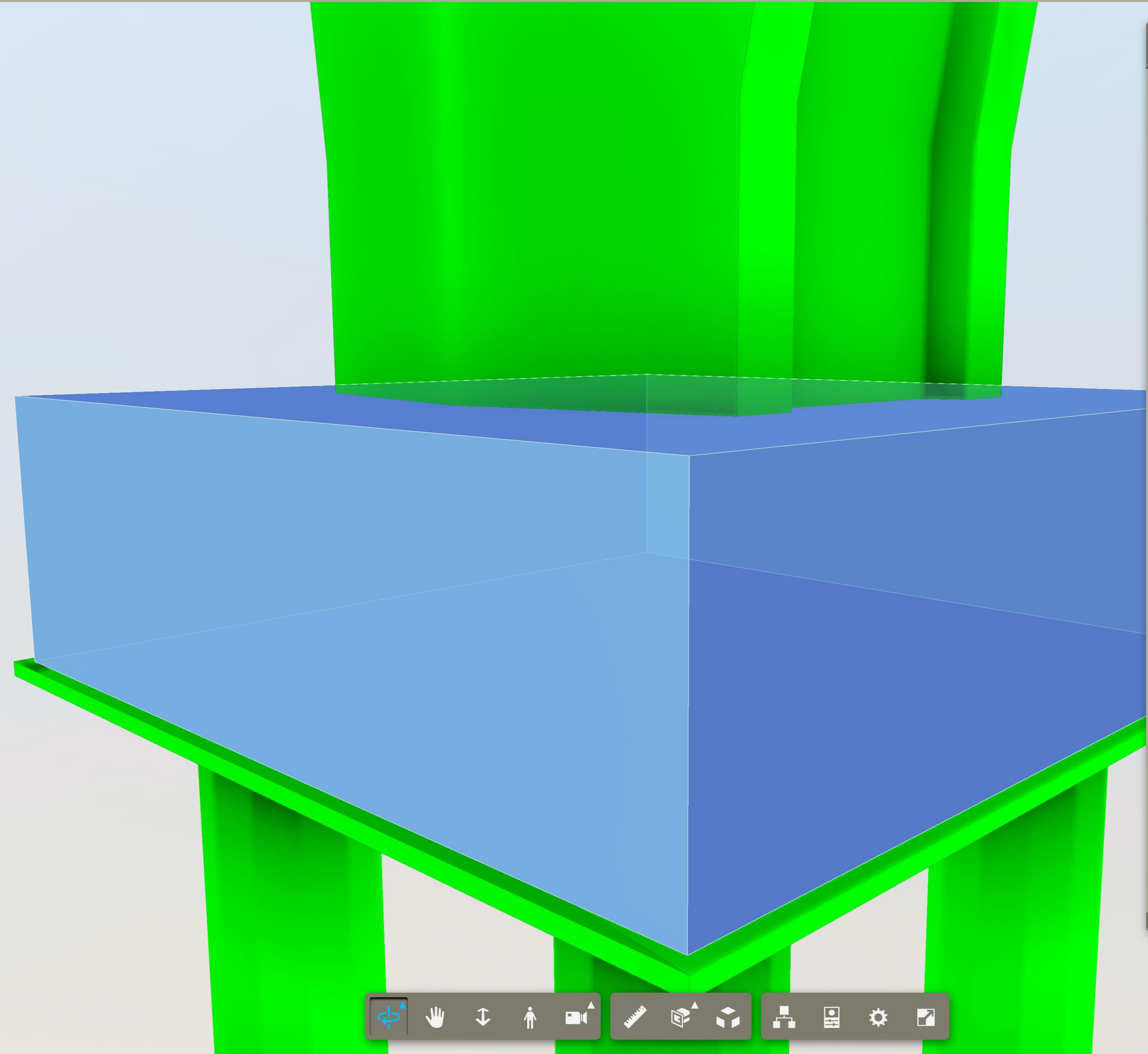
Property Name

Options

Group Issues by Object
 Include Object Screenshots

EXPORT

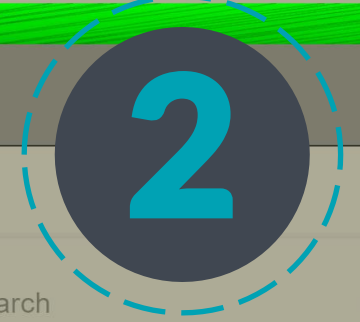
- Settings
- Home
- Help
- Search
- Refresh
- Share



- Rotate
- Hand
- Zoom
- Person
- Camera
- Measure
- 3D View
- 2D View
- Layers
- Info
- Settings
- Print

Legend

- Validated Elements
- Not classified or asset Tagged Elements
- Not validated elements



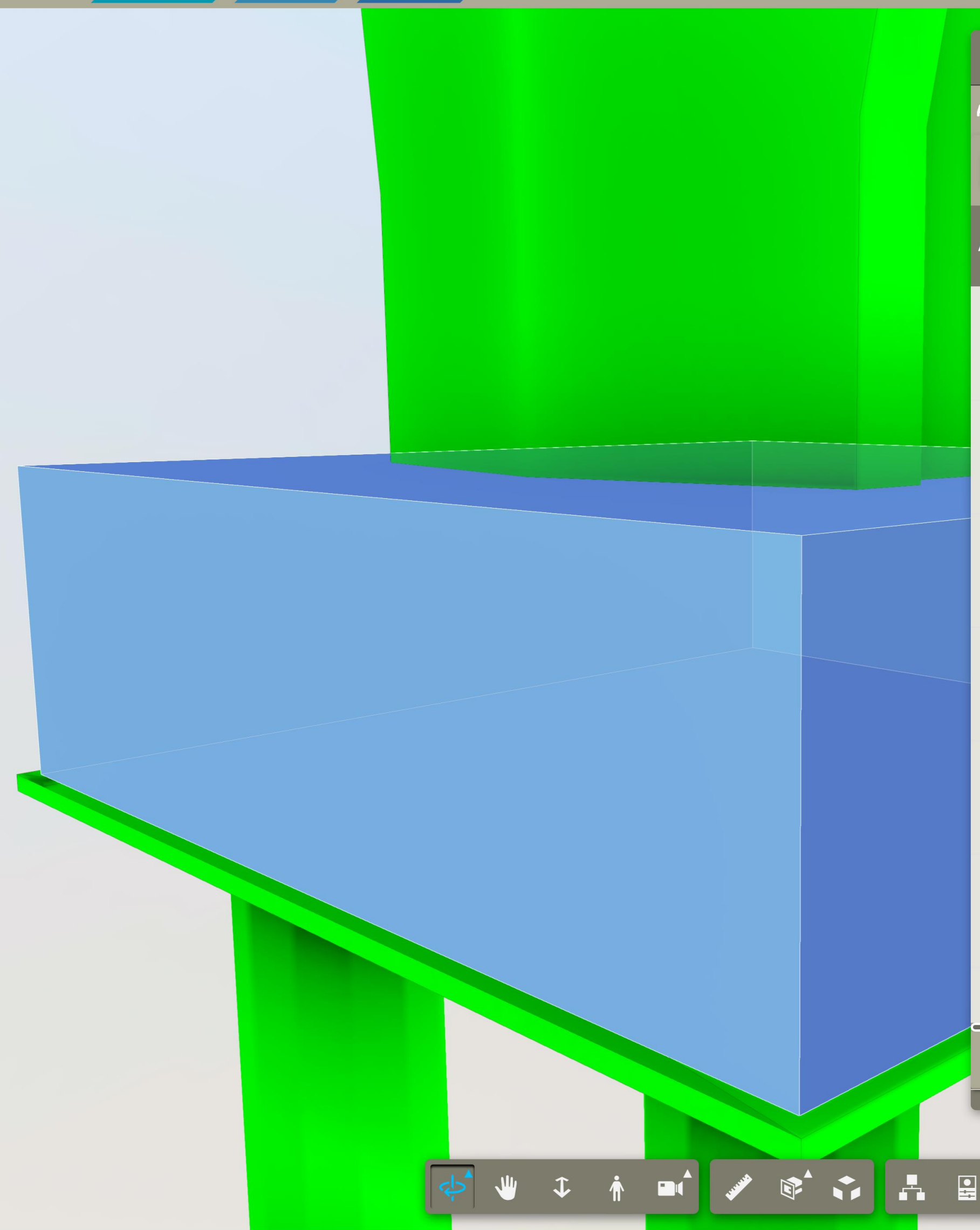
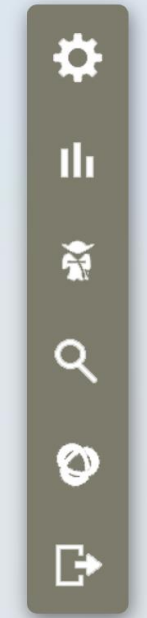
Export Quantities To DB

Asset Selection : FRP-000001259 Type Concrete

EXPORT Search

Actions	id	Component Code	Asset Code	filename	Classification Value	Volume	Reinforce Ratio
🔍	5	CIN-GEN-08	FRP-000001259	1MC09-FRP-BR-DM3-NS05_NL13-164701.ifc	CB-Ss_20_50_20_70-M_PierConcreteInsitu	80.57	
🔍	7	CIN-GEN-08	FRP-000001259	1MC09-FRP-BR-DM3-NS05_NL13-164701.ifc	CB-Ss_20_50_20_70-M_PierConcreteInsitu	89.27	
🔍	9	CIN-GEN-08	FRP-000001259	1MC09-FRP-BR-DM3-NS05_NL13-164701.ifc	CB-Ss_20_50_20_70-M_PierConcreteInsitu	92.81	
🔍	11	CIN-GEN-08	FRP-000001259	1MC09-FRP-BR-DM3-NS05_NL13-164701.ifc	CB-Ss_20_50_20_70-M_PierConcreteInsitu	90.23	
🔍	13	CIN-GEN-08	FRP-000001259	1MC09-FRP-BR-DM3-NS05_NL13-164701.ifc	CB-Ss_20_50_20_70-M_PierConcreteInsitu	80.86	
🔍	15	CIN-GEN-08	FRP-000001259	1MC09-FRP-BR-DM3-NS05_NL13-164701.ifc	CB-Ss_20_50_20_70-M_PierConcreteInsitu	72.16	
🔍	17	CIN-GEN-08	FRP-000001259	1MC09-FRP-BR-DM3-NS05_NL13-164701.ifc	CB-Ss_20_50_20_70-M_PierConcreteInsitu	70.01	

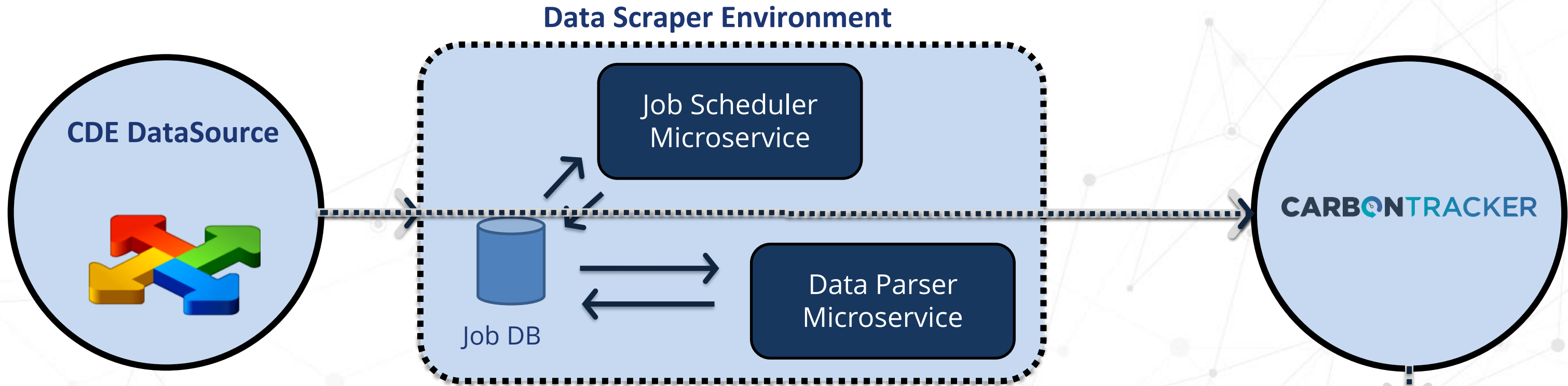
100 rows | 1-100 of 2544



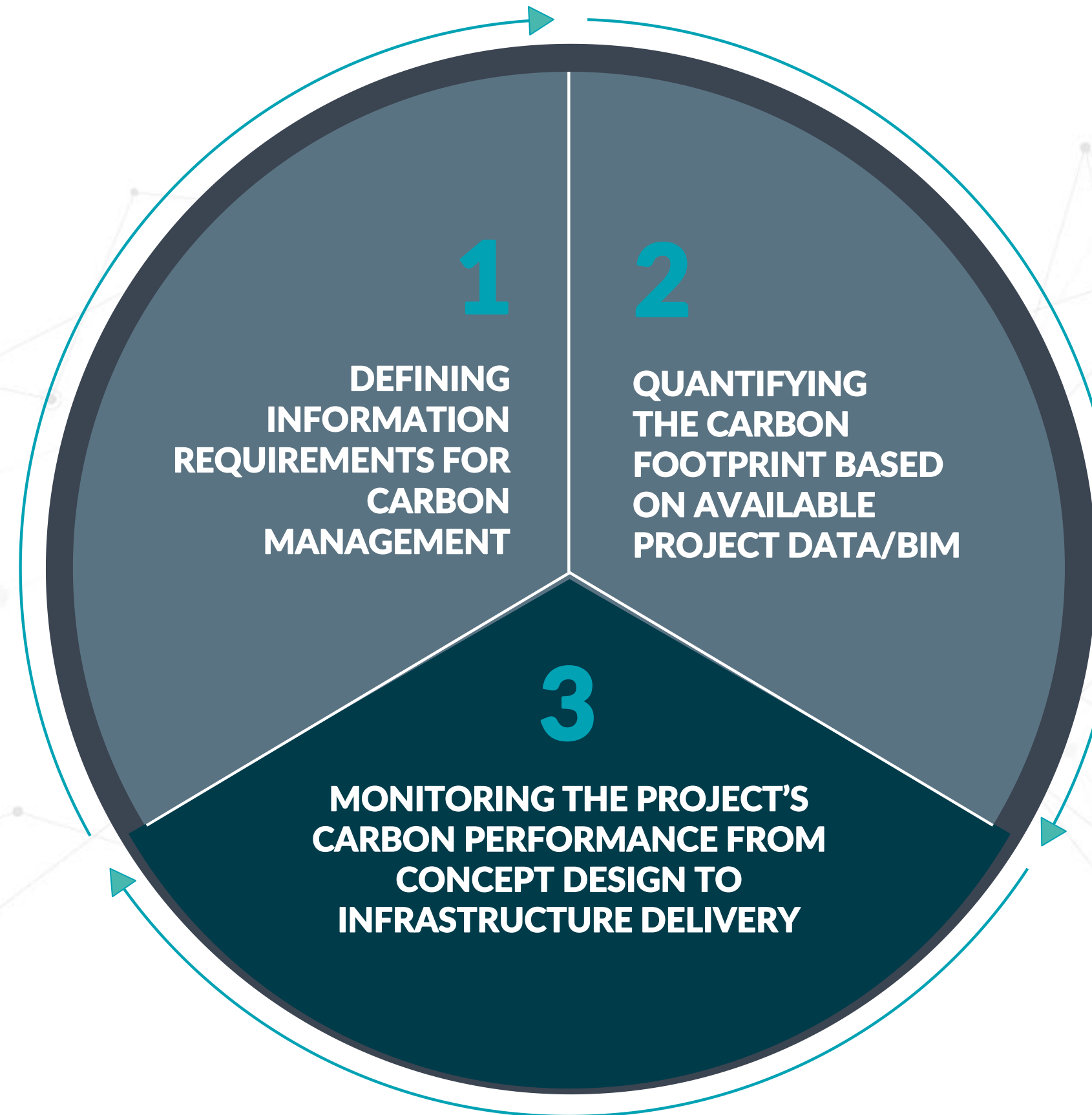
Validated Elements (Green square) Not classified or asset Tagged Elements (Blue square)

Not validated elements (Red square)

Project Integration – Monitoring of Validated Design



Tracking the carbon footprint in 3 steps



Monitoring the Project's Carbon Performance from Concept Design to Infrastructure Delivery

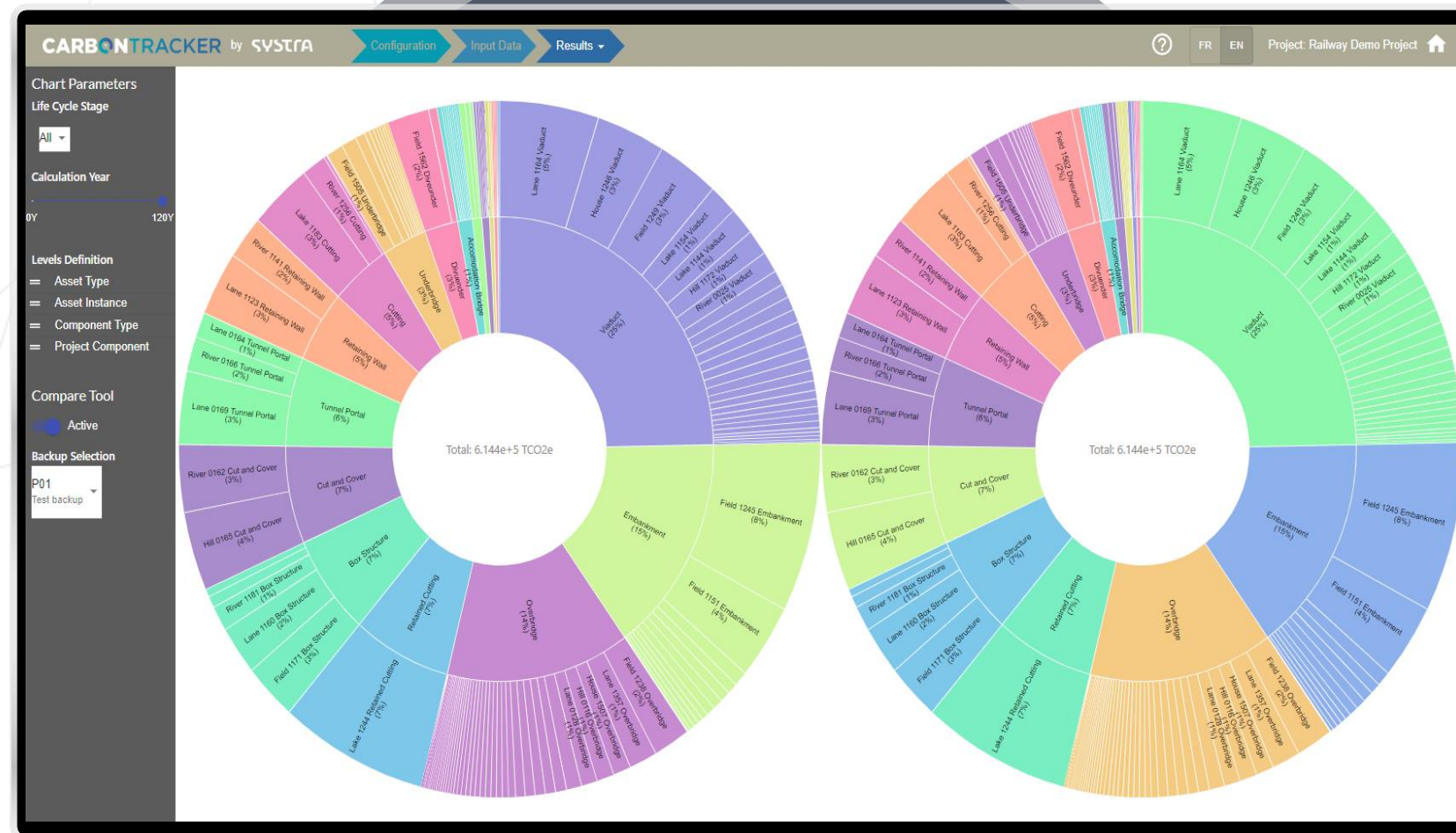


Visualising and managing the carbon footprint throughout design and delivery by:

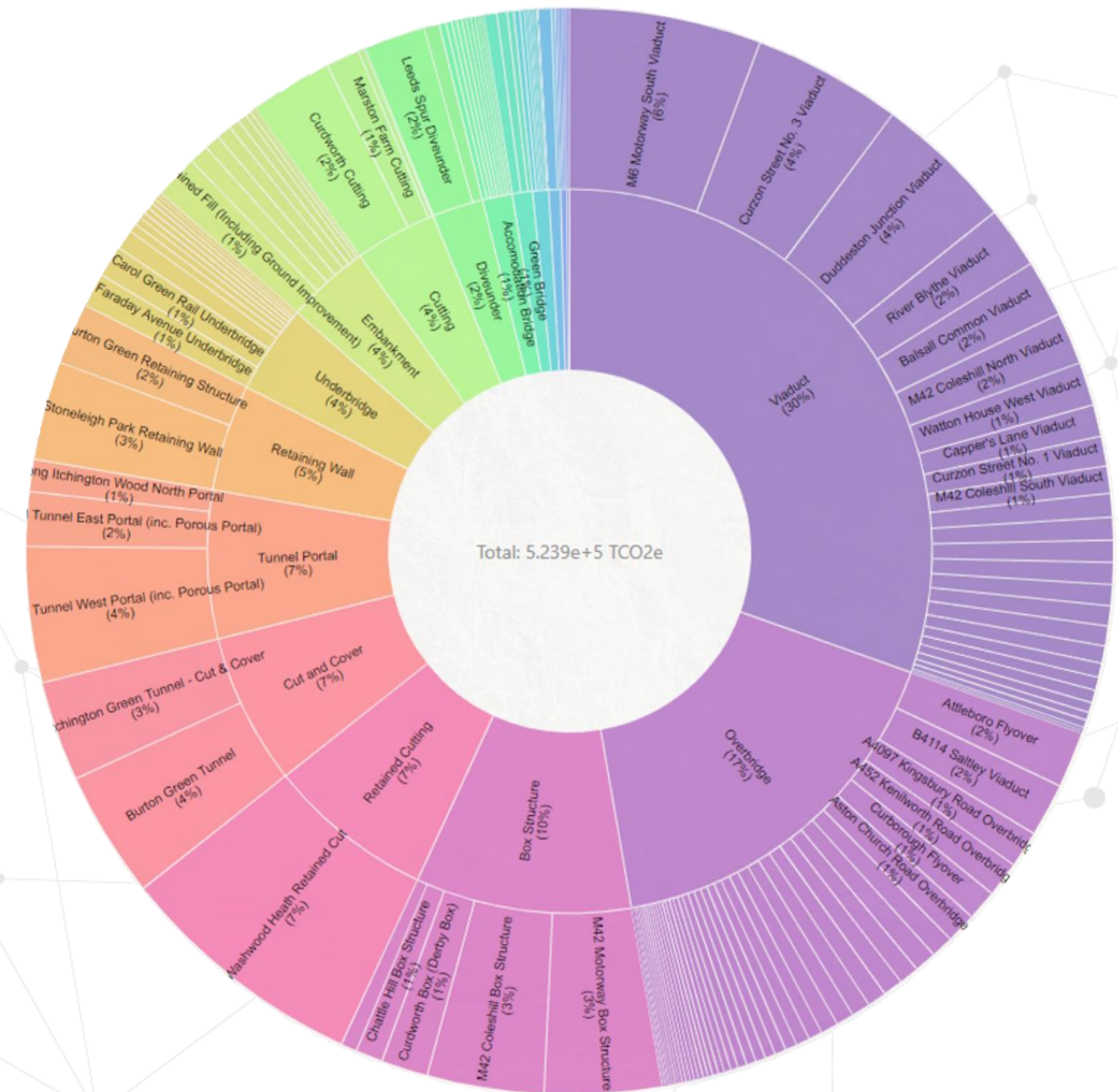
- Calculating the carbon footprint in real time with the design
- Analysing carbon emissions per asset to identify alternative, lower carbon solutions and assess avoided emissions
- Monitoring performance towards achieving carbon reduction targets

Anticipate the impacts of your project and make the right decisions as early as possible in the design process

A multi-level analysis of emissions for a comprehensive and systematic review of carbon reduction opportunities

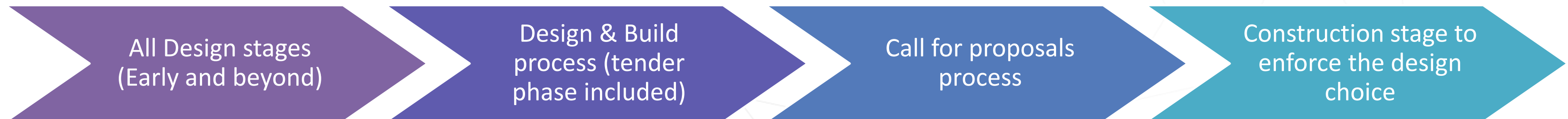


Compare the carbon footprint of different assets for any lifecycle stage to identify hotspots and optimise design



When to Use CARBONTRACKER ?

- To define or review a baseline against new assumptions and context
- To compare the carbon impact for alternative design options
- To optimise the carbon performance by identifying hotspots and testing alternative scenarios
- To optimise as the design evolves (early, preliminary, detailed)
- To anticipate and assess the impacts of construction works (incl. excavation materials management, transport, materials supply, ...)



Technical assistance to the client for the East Line of metro 15, Grand Paris Express, France



- 10 Major Stations + 23 Ancillary Structures + 1 Maintenance Center + Tunnel (23 km)
- Use of BIM & non-BIM data
- *Mission description*
 - Carbon assessment to update and set the baseline for the Carbon reduction plan of the Project
 - Focus on major concrete/steel elements in civil engineering structures and traction systems (tracks, power supply)
 - Integration of transport of excavated materials



2 scenarios assessed : standard concrete and steel VS low carbon concrete and 100% recycled steel



25% reduction achieved for the carbon footprint and the baseline is defined as the optimised scenario

Design for the Nagpur-Mumbai Super communication Expressway (Package II), India

- 58 km long and a total of 155 major and minor structures (bridges, interchanges, viaducts, Culverts, ...)
- Penalty on any excess in overall project cost OR Bonus on any savings in design quantities
- Use of Bill of Quantities
- **Objective:** Achieve materials efficiency and assess the carbon footprint of the proposed material optimization solutions



9% cost savings compared to initial design via materials efficiency



Around 11% reduction in the carbon footprint for the detailed design compared to tender phase



What comes next ?

- Integration of other KPIs such as water, reuse of materials, etc.
- Proof of concept to evaluate the distances, waste, etc, through GIS
- Mock-Up to manage the carbon emission for asset owners and project investments

Questions





Because sustainable design is **everyone's business**,

Because everything happens at the **design phase**,

Because project teams miss the **right information**,

Be **pro-active!**

Ensure **transparency of your commitments** to reduce CO2 emissions

SYSTRA



CONFIDENCE MOVES THE WORLD