

Road Design with Information Modeling adopting ifc 4X3



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The authors



Mauro Coletto



SierraSoft Srl



Founder and CEO of SierraSoft I have been working in the field of infrastructure and topography software for more than 30 years.

At SierraSoft I am involved in the processes of technological innovation, software development and BIM work methodology.

Pordenone, ITALY



Alessio Gori



Politecnica Ingegneria ed Architettura Soc. Coop



Civil engineer and associate of the Italian Company "Politecnica Ingegneria ed Architettura", specialized in the design and management of civil works, linear infrastructures and road safety.

Project Manager and Designer/Works Supervisor for strategic works in Europe, West Africa and Central-South America.

Certified BIM Manager and BIM Specialist for Infrastructure according to the UNI 11337-7:2017

Florence, ITALY



The companies



SierraSoft

SierraSoft is a company that creates and markets BIM software solutions for the surveying, infrastructure design and construction industries.

SierraSoft products are available in several languages (Italian, English, German, Spanish, Portuguese, French, etc.), they include the main international standards and have been adapted to comply with the specific requirements of several countries (Italy, USA, Germany, Spain, Portugal, France, etc.).

SierraSoft products are used in more than 15 countries by surveyors, architects, engineers, engineering companies, architecture companies, construction companies, research institutes, public bodies.



Politecnica Ingegneria ed Architettura

Politecnica is one of the top Italian firms providing integrated service in architecture, engineering and urban planning since 1972.

It is independent and fully controlled by its 45 cooperative associates, mainly engineers and architects, who have worked on projects in over 50 countries worldwide.

Politecnica, among the pioneering companies in designing by BIM (Building Information Modelling), provides services ISO 9001 Quality System and ISO 14001, 45001 certified, is credited with the Legality Rating highest score, is member of Green Building Council and promotes the best practices for environmental sustainability in compliance with LEED protocols. Moreover, many associates in Politecnica are certified with Envision and qualify for Project Management Professional.

Road design with information modeling adopting IFC 4x3

Mauro Coletto - SierraSoft

The beginning

Birth of the project

The project between Politecnica and SierraSoft was born within the BuildingSMART Italy working group:

"IFC Road Italy working group to verify the IFC4x3 operating standard for its use during the life cycle of the road work (design, checking and validation, implementation and maintenance)"

Politecnica and SierraSoft took the opportunity to go beyond the main goals of the work group and combine our experience in infrastructure design and software development, with the openBIM process as the common denominator.

The project: *"Road Design with Information Modeling adopting IFC 4x3"*

Aim of our project

The aim of our project was to identify a road design method in openBIM that ensures:

- 1. High quality of information models**
Consistent with: the design approach and standard, detailed drawings and client's requirements.
- 2. Better and direct collaboration**
Exchange of information useful for co-design, analysis and construction.
- 3. Optimization of costs and resources**
Control of costs and time needed for design and modeling.
- 4. Improved design quality (in terms of geometry and data)**
Achieve higher quality design compared to traditional design.
- 5. Continuous flow of the BIM process**
Avoid loss of information and time-consuming tasks between design phases

Getting the advantages of BIM in the design phase

Interoperability with openBIM



IFC 4x3

- It is an All-purpose format.
- Fundamental in design to share information among different professionals.
- To analyze geometries and data, support design choices, anticipate and correct errors in construction.



LandXML

- Easier to read and write.
- Land surveying (Points, measures, constraints, triangles).
- Road and Railways design (horizontal and vertical alignments, cross sections, surfaces)
- Construction (Machine control).

The findings

The 3 key elements

We identified and developed 3 key and interconnected elements that allowed us to meet the objectives:

1. **Workflow**

The workflow centered on road design.

2. **Road design software**

The fundamental features of road design software.

3. **Road design in BIM**

The BIM activities that are part of road design.

**Road design at the heart of smart and bidirectional
collaboration between disciplines**

1. The workflow

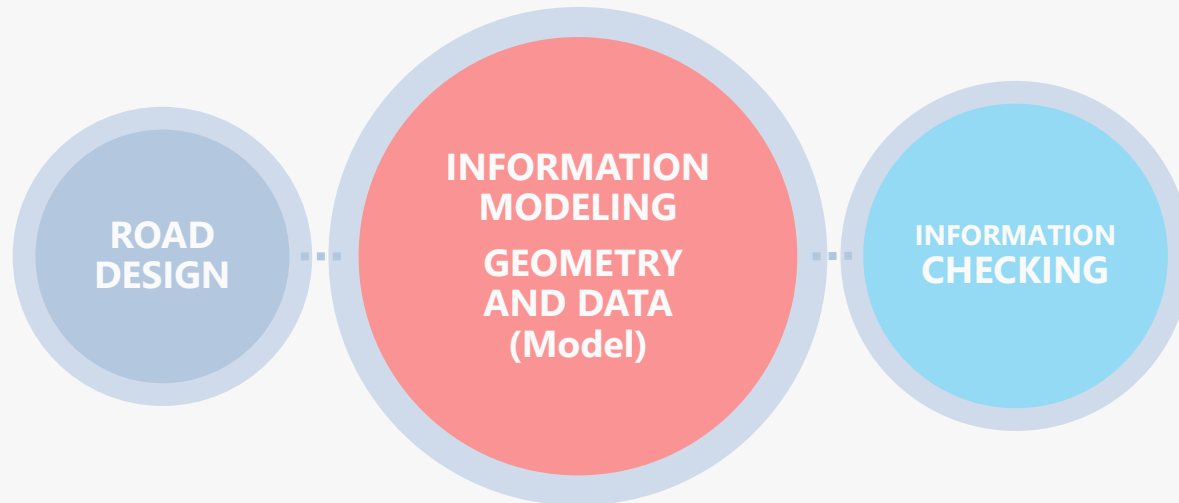
Centered on road design:

- BIM Workflow for road design
- BIM Workflow in multidisciplinary context

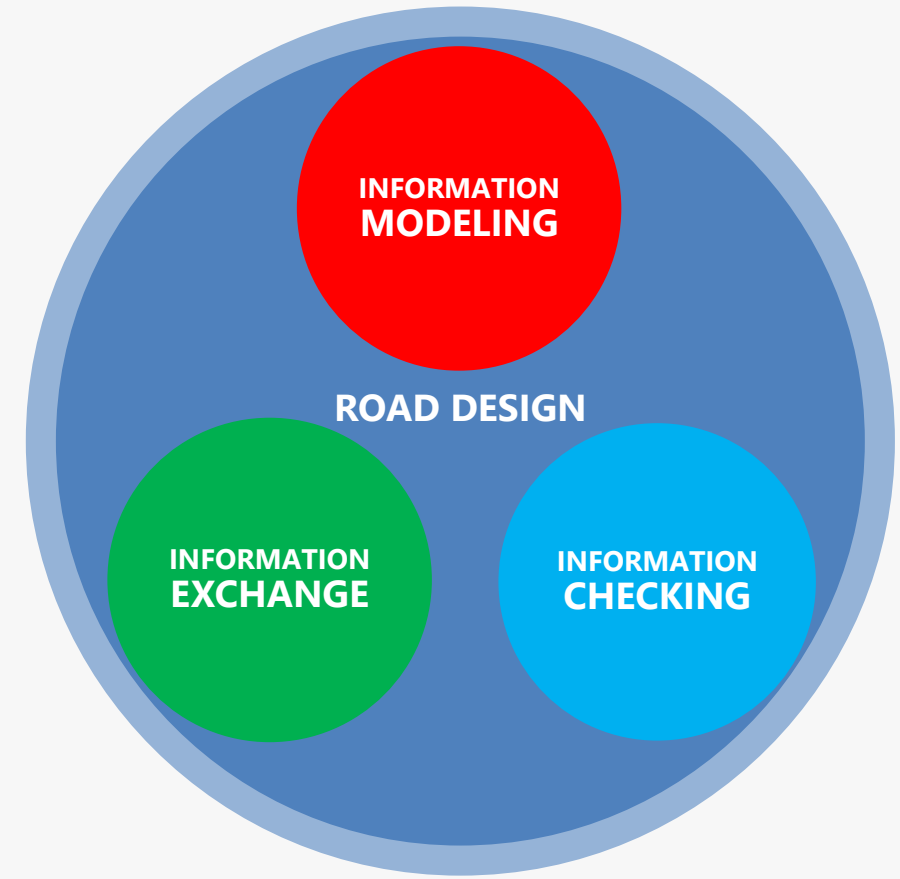
The workflow > Road design software > Road design in BIM

BIM Workflow for road design

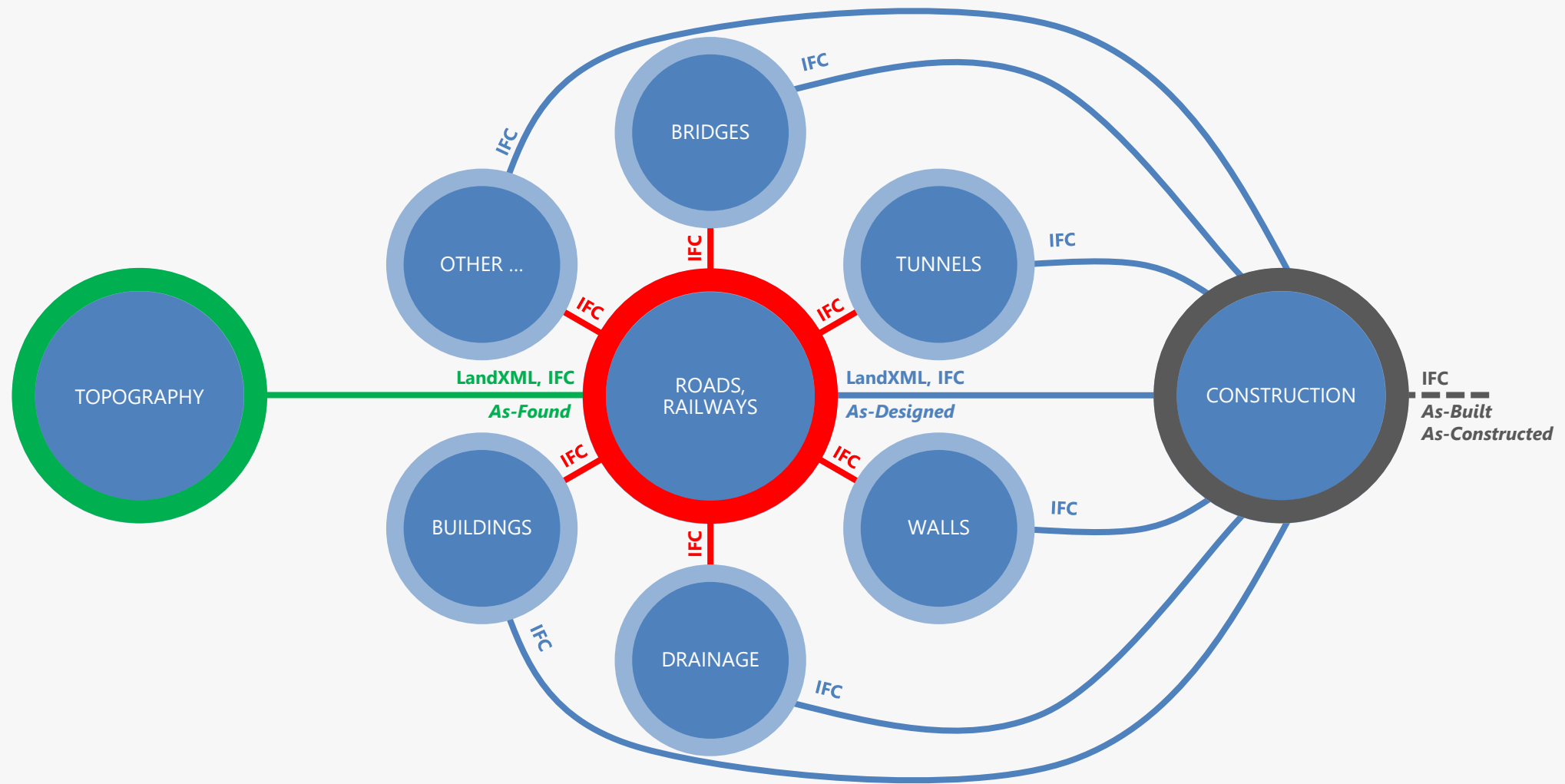
In the past we had a
“**One at a time**” approach. Design, Model, Check



The future we have a
“**All in one**” approach. Design+Model+Check



BIM Workflow in multidisciplinary context



2. The road design software

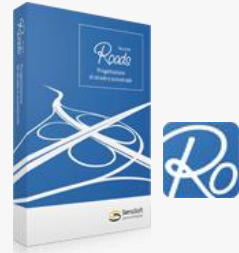
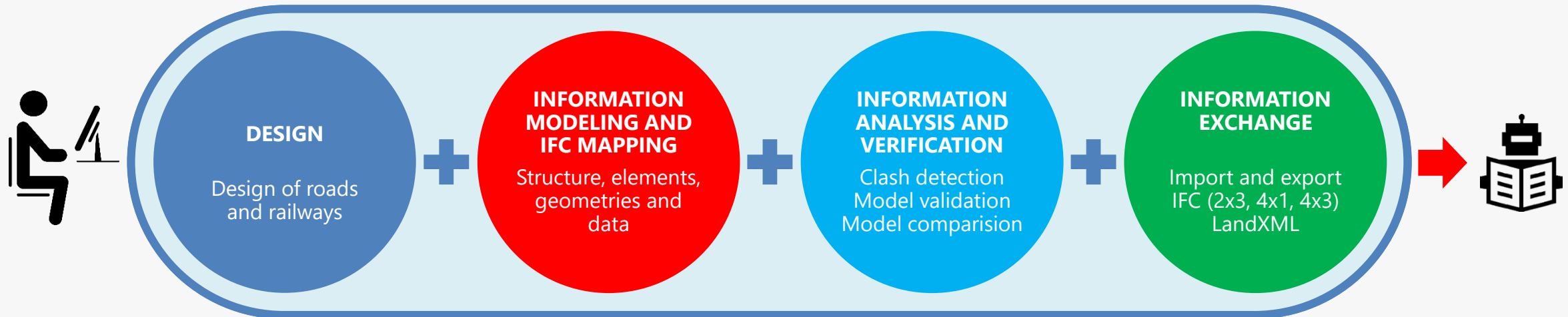
The key element to sustain workflow and ensure consistent information

The workflow > **Road design software** > Road design in BIM

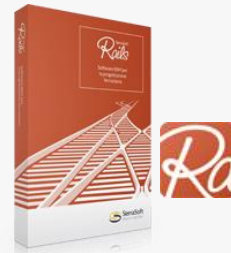
The road design software

SOFTWARE FOR INFRASTRUCTURE DESIGN IN IFC

(Design, BIM Authoring and IFC Management)



SierraSoft Roads



SierraSoft Rails



SierraSoft Hydro

3. Road design in BIM

Activities that are part of the new way of designing roads with BIM methodology

The workflow > Road design software > **Road design in BIM**

The activities when designing in BIM

1. ROAD DESIGN

- **Road design and geometry modeling**
The quality and level of detail of geometries is much higher than in traditional design.
- **Verification of standards (code checking)**
Verification of standards is mandatory for design and geometric modeling activities.

2. INFORMATION EXCHANGE AND INFORMATION CHECKING

- **Information exchange and model federation**
Interoperability between different design software (roads, railways, hydraulics, bridges, tunnels,...).
- **Analysis and checking of information models**
To be done at the road design stage.

3. INFORMATION MODELING AND IFC MANAGEMENT

- **Spatial decomposition and generation of elements**
- **Management of properties of model elements**
- **Mapping of entities in IFC**

Road design with information modeling adopting IFC 4x3

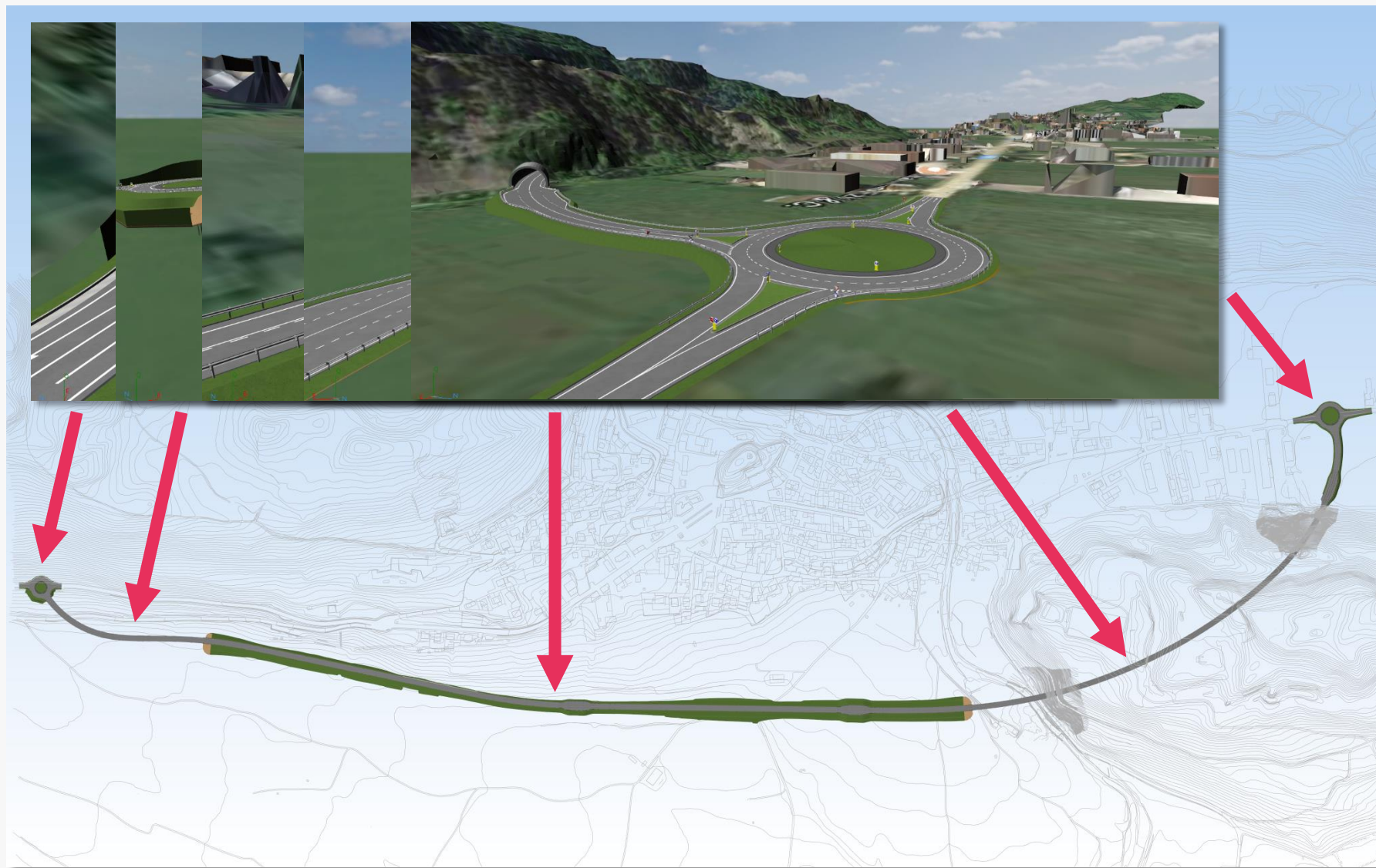
Alessio Gori - Politecnica Ingegneria ed Architettura

Work organization

The project case

Provided by Anas (Italian State Railway Group) - buildingSMART Italy

The project case



West Roundabout
Bridge
Main road
Tunnel
East Roundabout

How the work was divided

1. Working Group

Defining the Italian guidelines of IFC 4x3 format for road infrastructure design: Spatial structure, elements, properties, mapping.

2. Politecnica Ingegneria ed Architettura

Design and modeling of roads using SierraSoft Roads software.

Verification of the validity of the method and tools adopted by SierraSoft and Politecnica.

3. SierraSoft

Provider of SierraSoft Roads and SierraSoft Hydro software.

Adapting, where necessary, its software to meet the requirements of Politecnica and the working group.

4. Other participants in the working group

Design and modeling of ancillary works: Bridge, tunnel, drainage.

Information requirements for IFC 4x3 format



The information requirements for information modeling are defined by the working group and published in the "IFC guide for road infrastructure design".

The specifications include:

- Spatial structure
- Elements
- Properties
- Mapping

The specification coordinated with other stakeholders includes spatial structure, elements mapping and properties association for the Italian market.

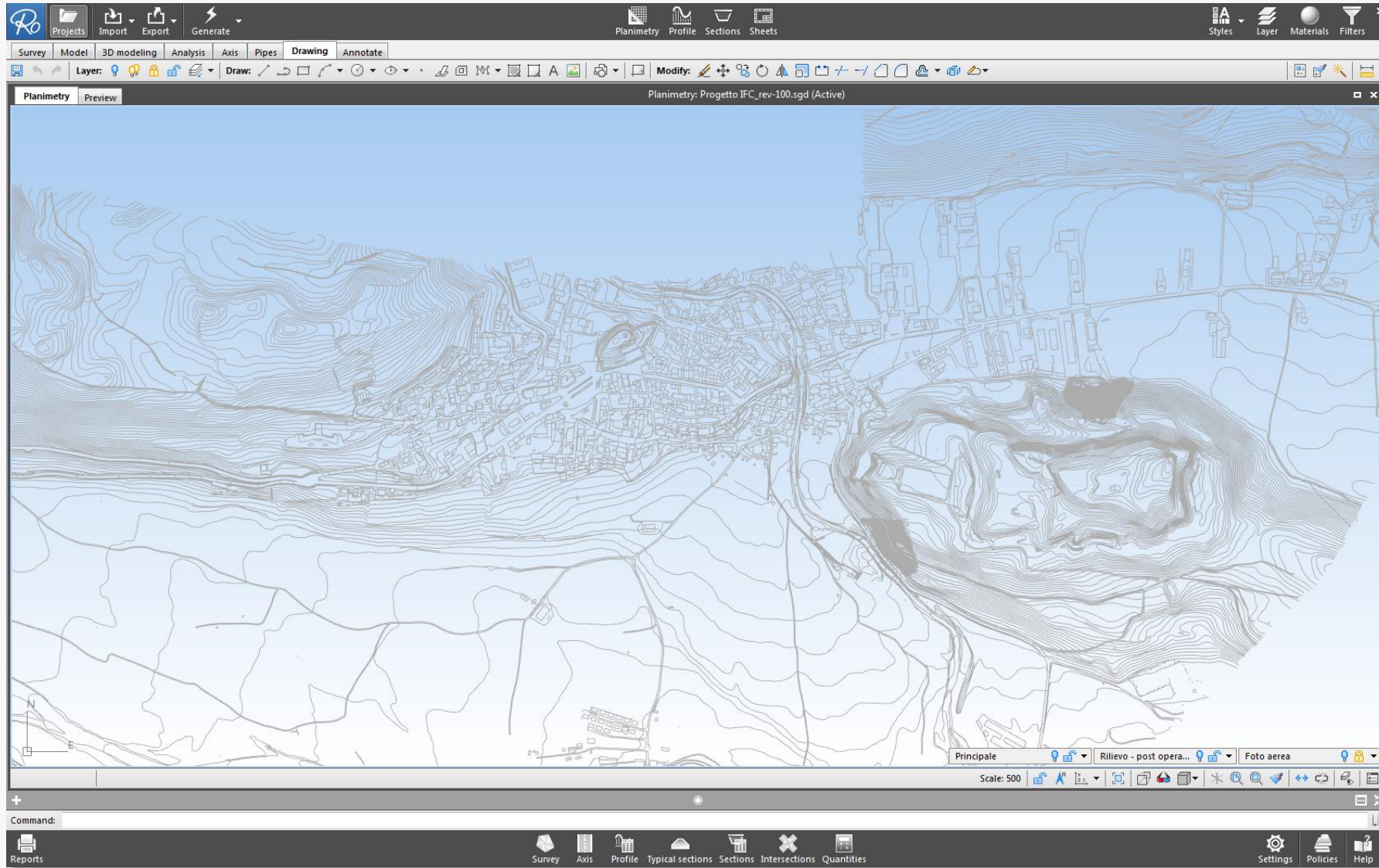
The land survey

Digital cartography

Imported and processed in SierraSoft Roads

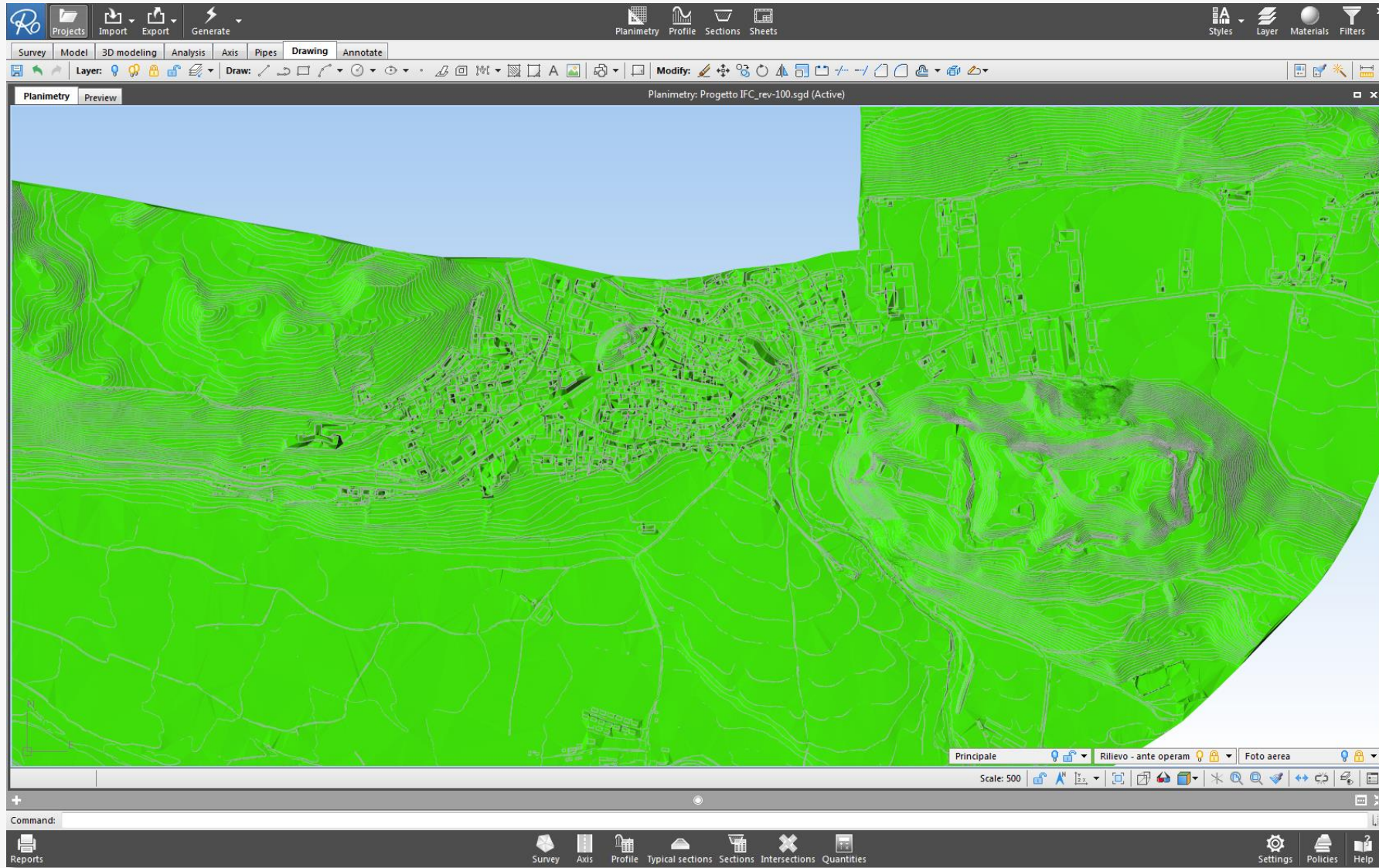
Model by Politecnica Ingegneria ed Architettura - buildingSMART Italy

The land survey



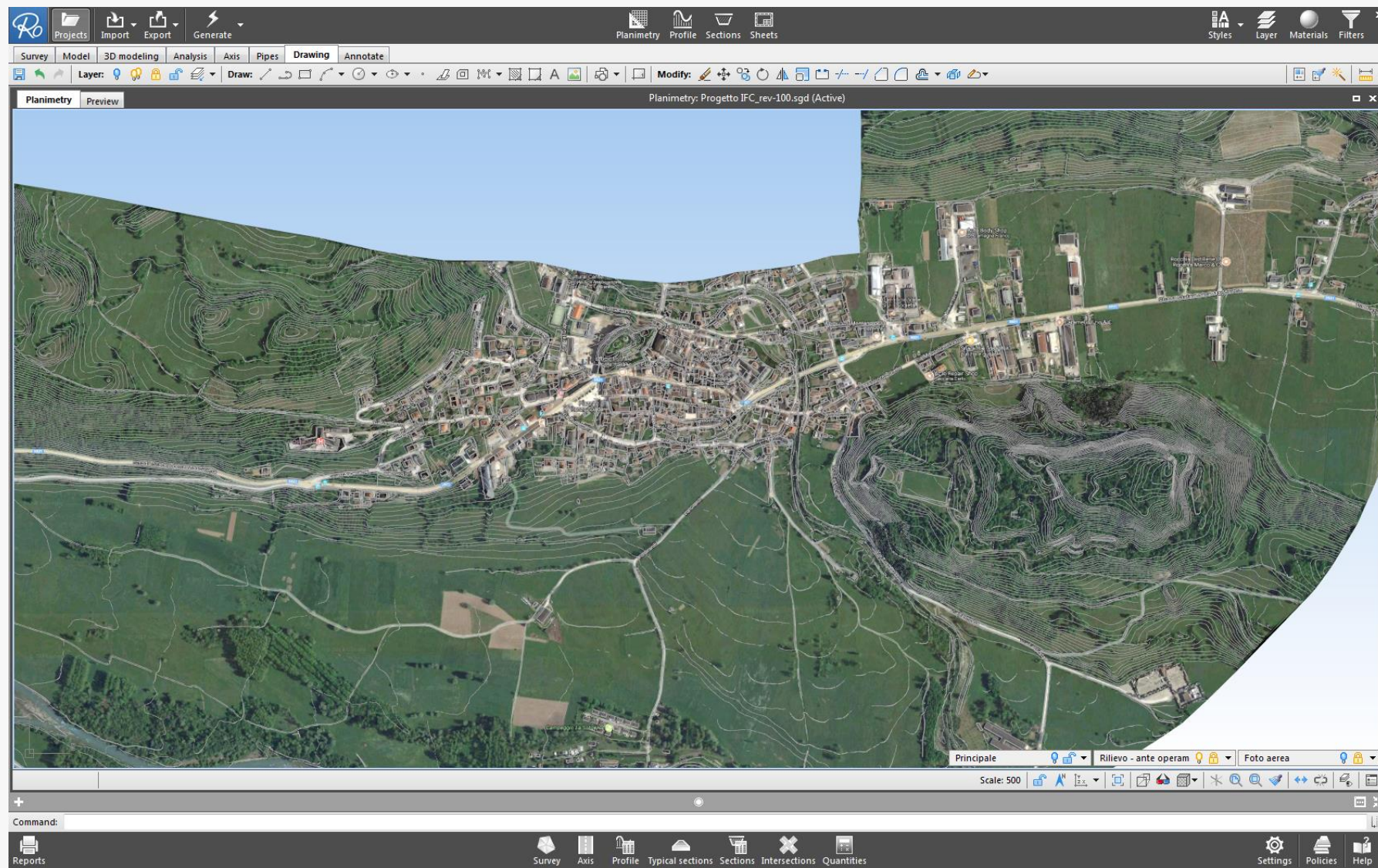
Topographic information was provided through digital cartography that was uploaded to SierraSoft Roads.

The land survey



The digital terrain model as an interpolation and fine-tuning of available digital data.

The land survey



Satellite imagery overlapped on the cartography and digital terrain model.

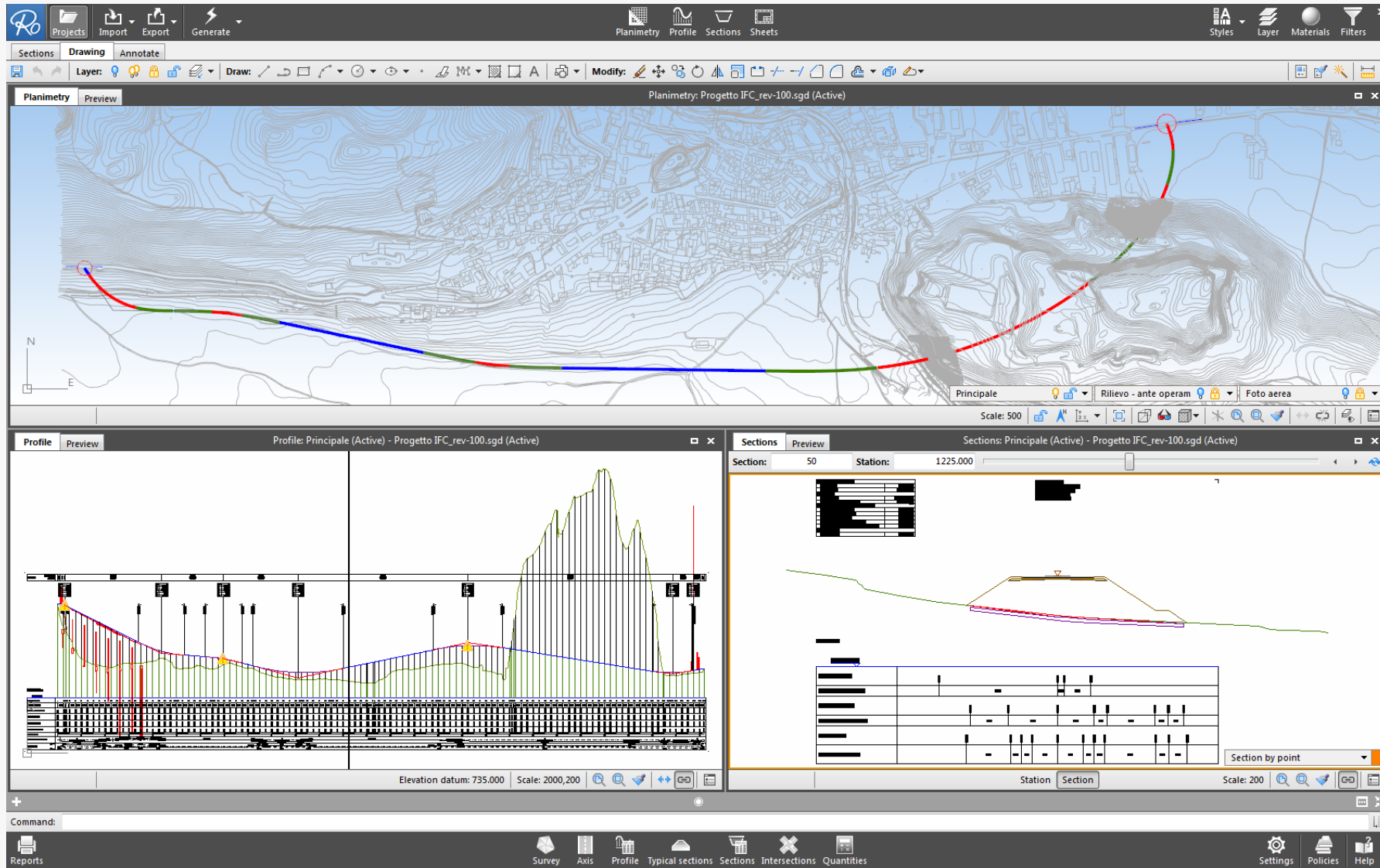
The road

Designed with SierraSoft Roads

Shared Road information model in IFC 2x3, 4x1, 4x3

Design and Model by Politecnica Ingegneria ed Architettura - buildingSMART Italy

The design of the alignment and road shape



Road design was done using SierraSoft Roads.

The following were designed:
the horizontal alignment, the vertical alignment and the typical sections of the different segments.

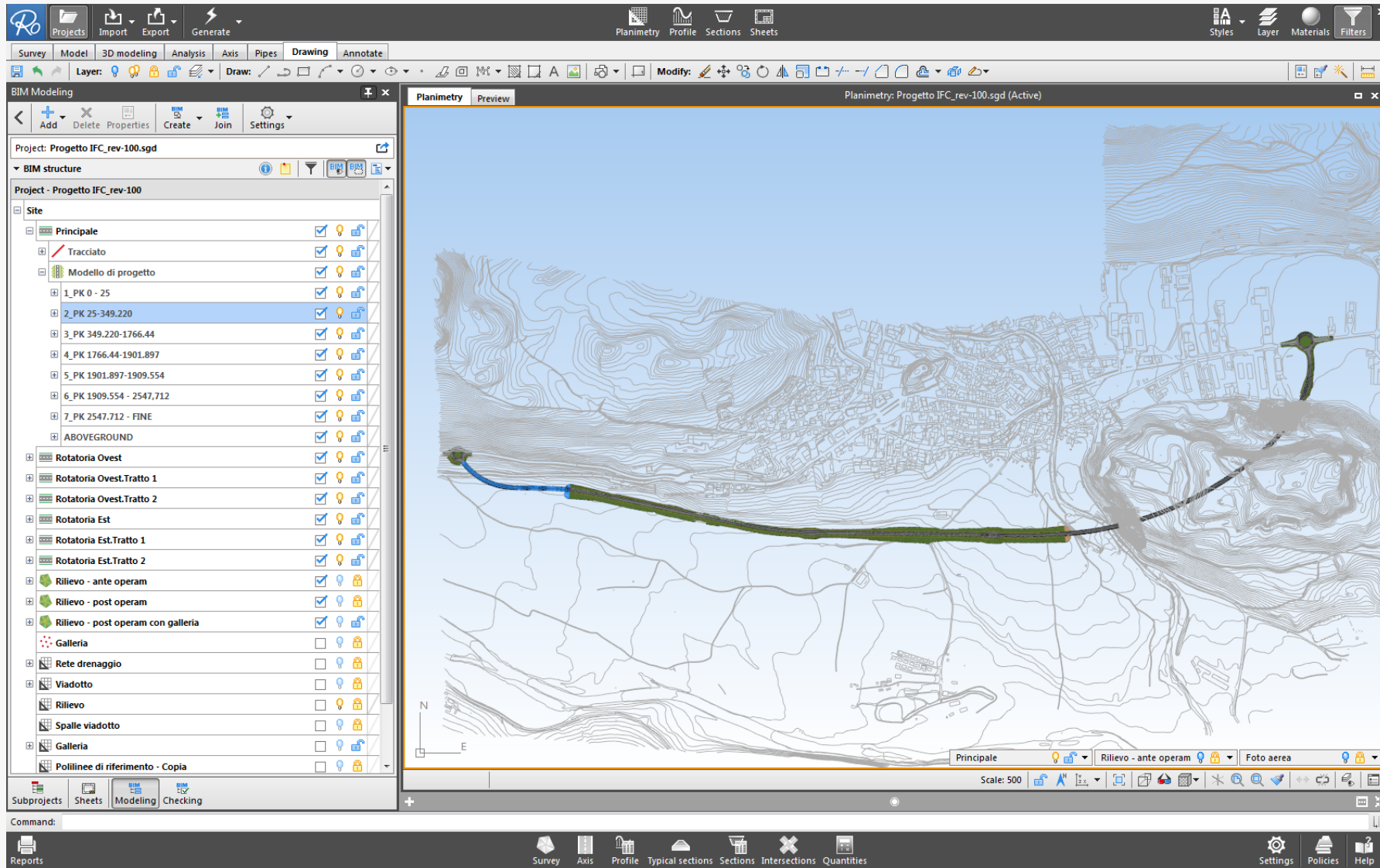
Real-time and repeated checking was performed to bring the road up to standard.

The information model was obtained automatically from the design.

The road

Model breakdown and element generation

Longitudinal breakdown

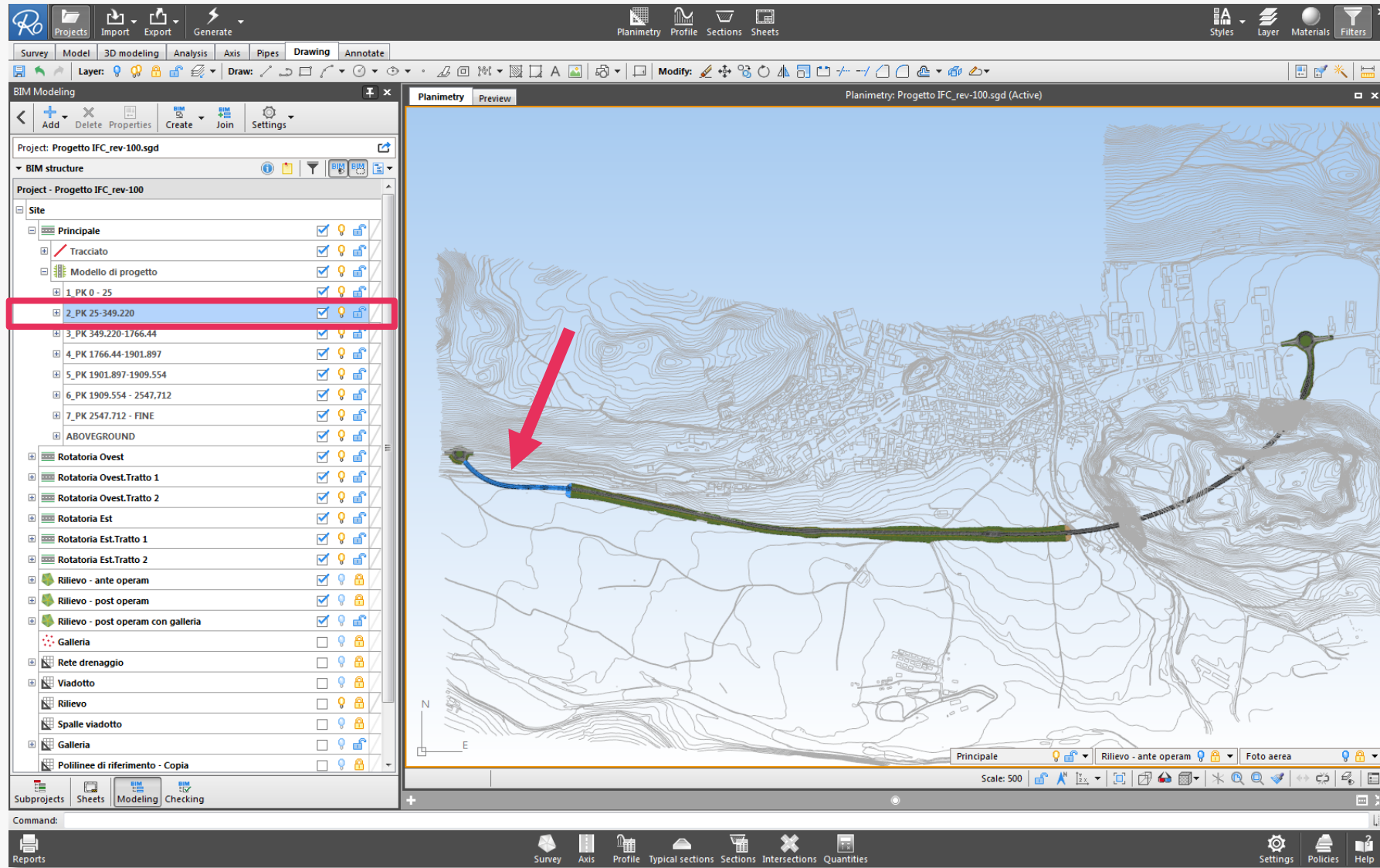


The information model is created by the road designer based on the client's information needs.

The information modeling is controlled by the road designer through parametric design and modeling.

Single lane 2-way road, width 10.50m

Longitudinal breakdown



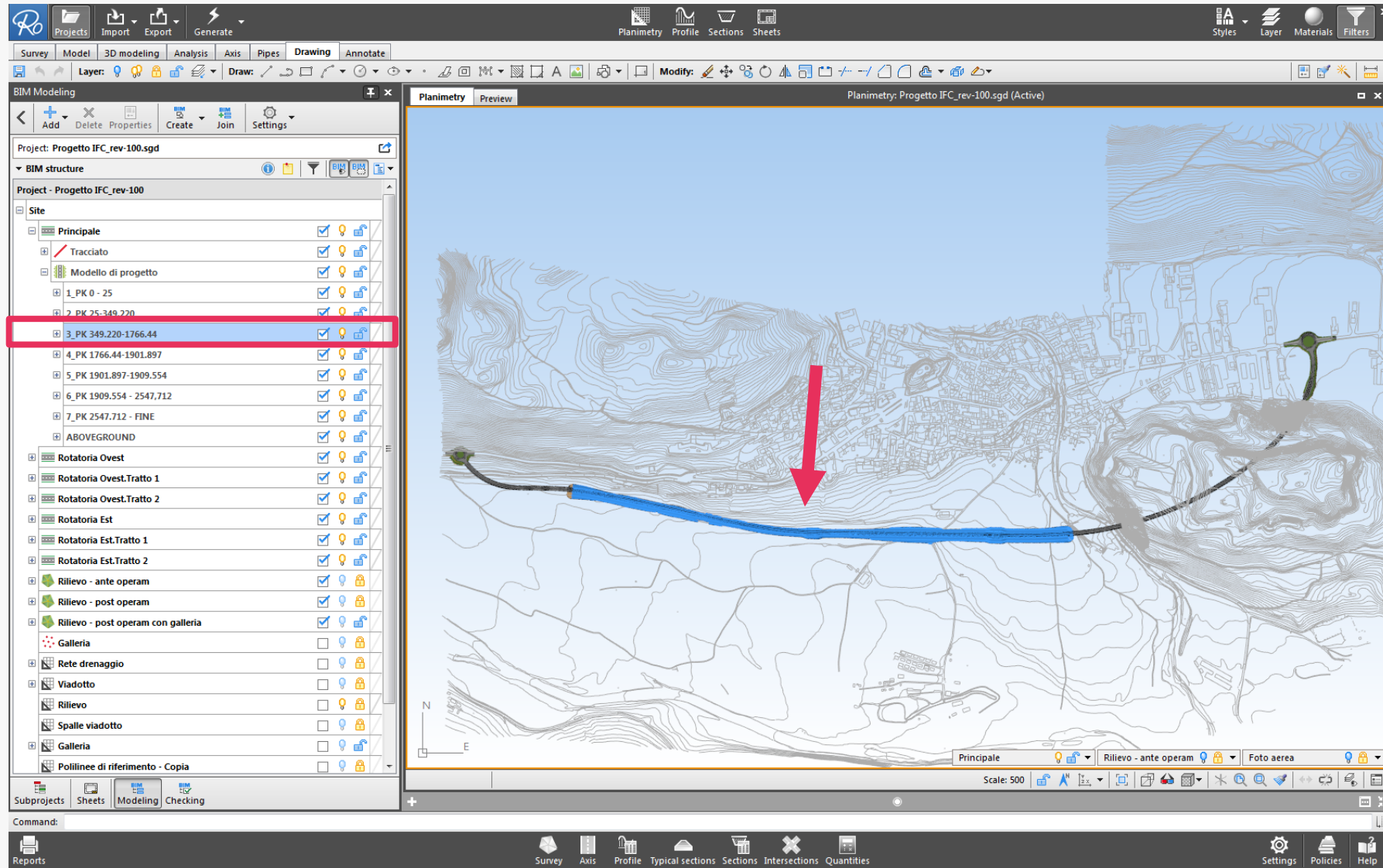
WBS 1

Bridge 1

(L = 324.22 m)

- Circul arc R=175m
- Clothoid A=120
- Straight L=2,39m
- Clothoid A=250
- Circul arc R=750m

Longitudinal breakdown



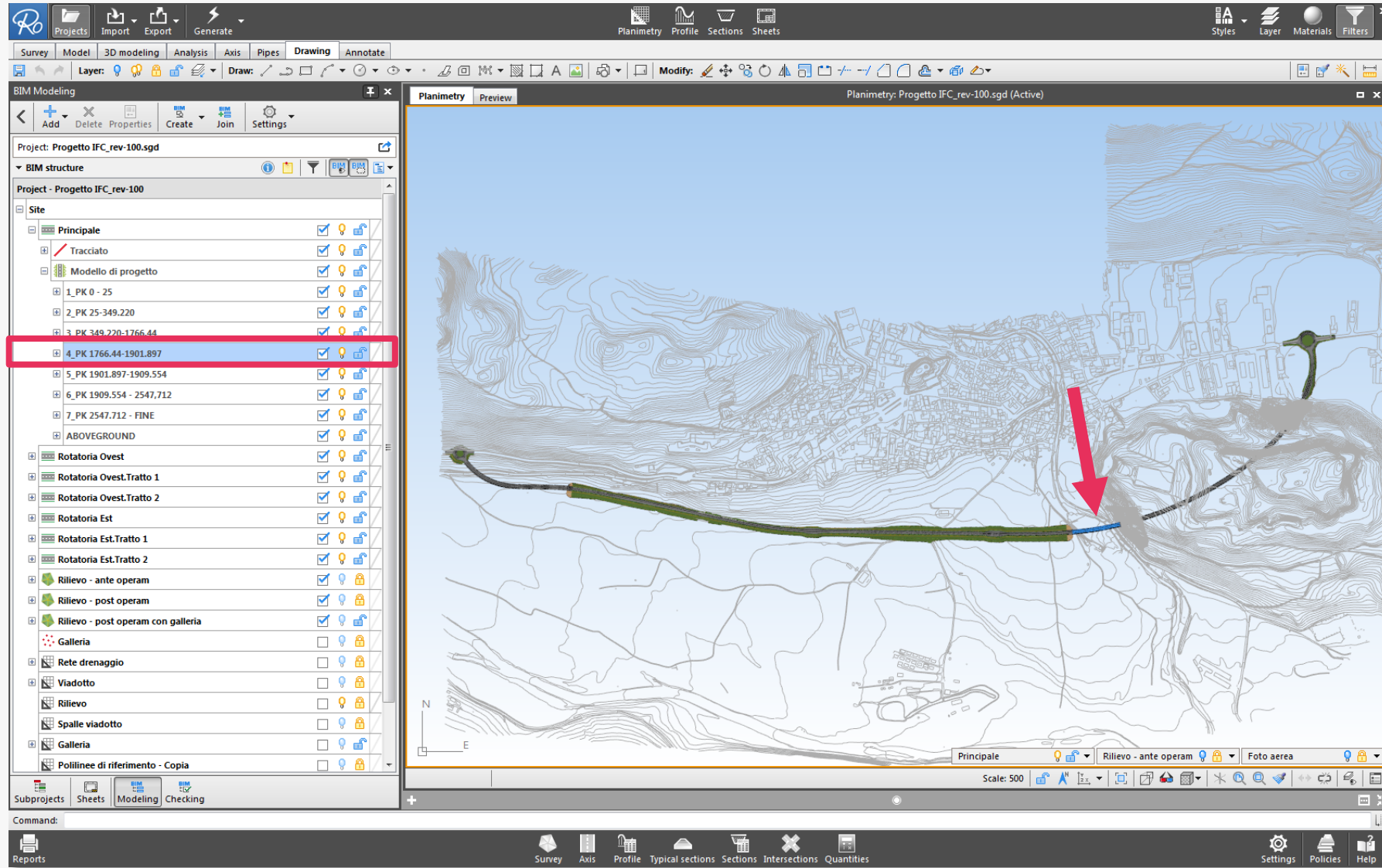
WBS 2

Road segment 1

(L = 1417.22 m)

- Circul arc R=750m
- Clothoid A=250
- Straight L=323.88m
- Clothoid A=340
- Circul arc R=1000m
- Clothoid A=340
- Straight L=449.17m
- Clothoid A=483.68

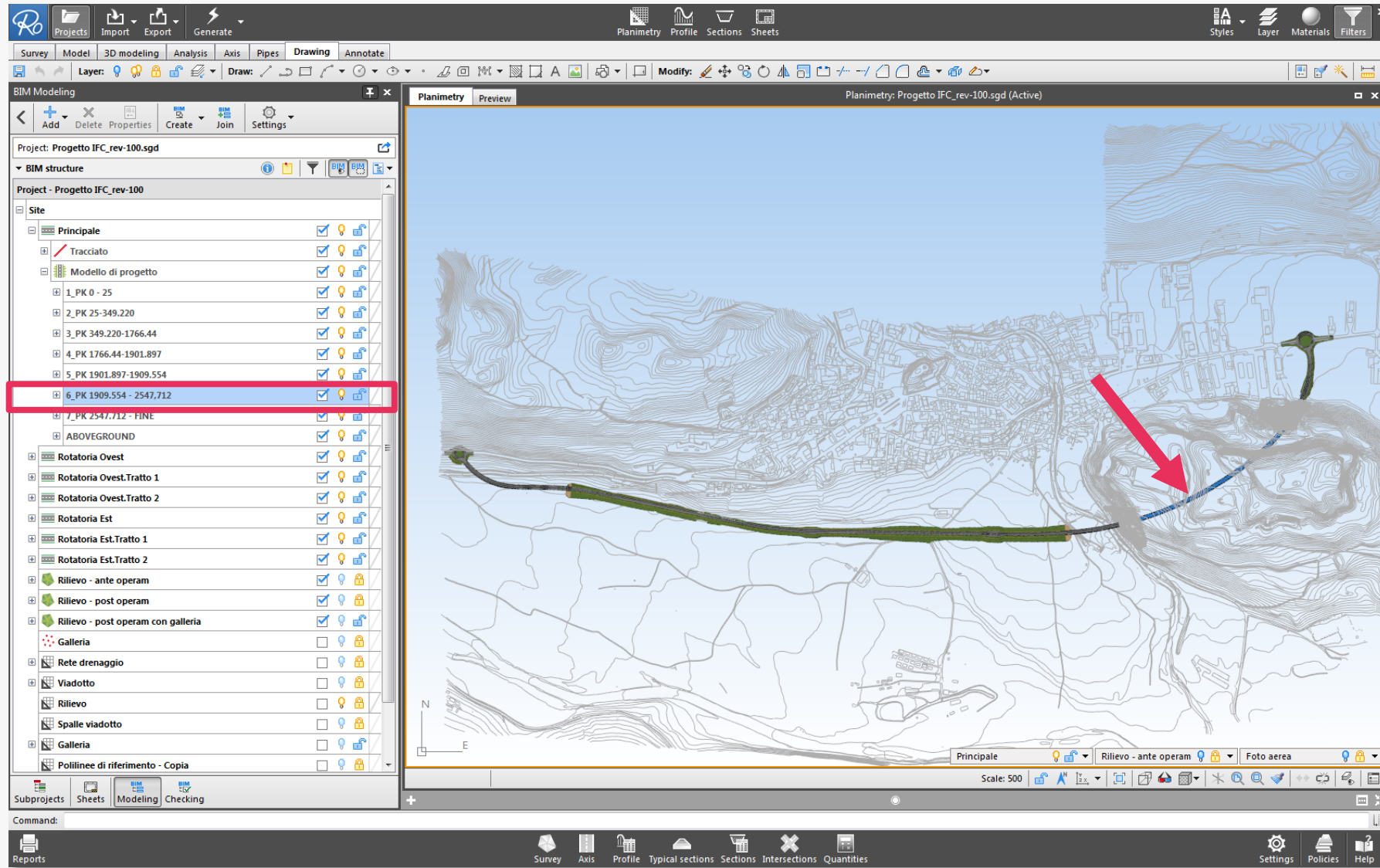
Longitudinal breakdown



WBS 3
Bridge 2

(L = 135.46 m)
- Clothoid A=483.68
- Circul arc R=950m

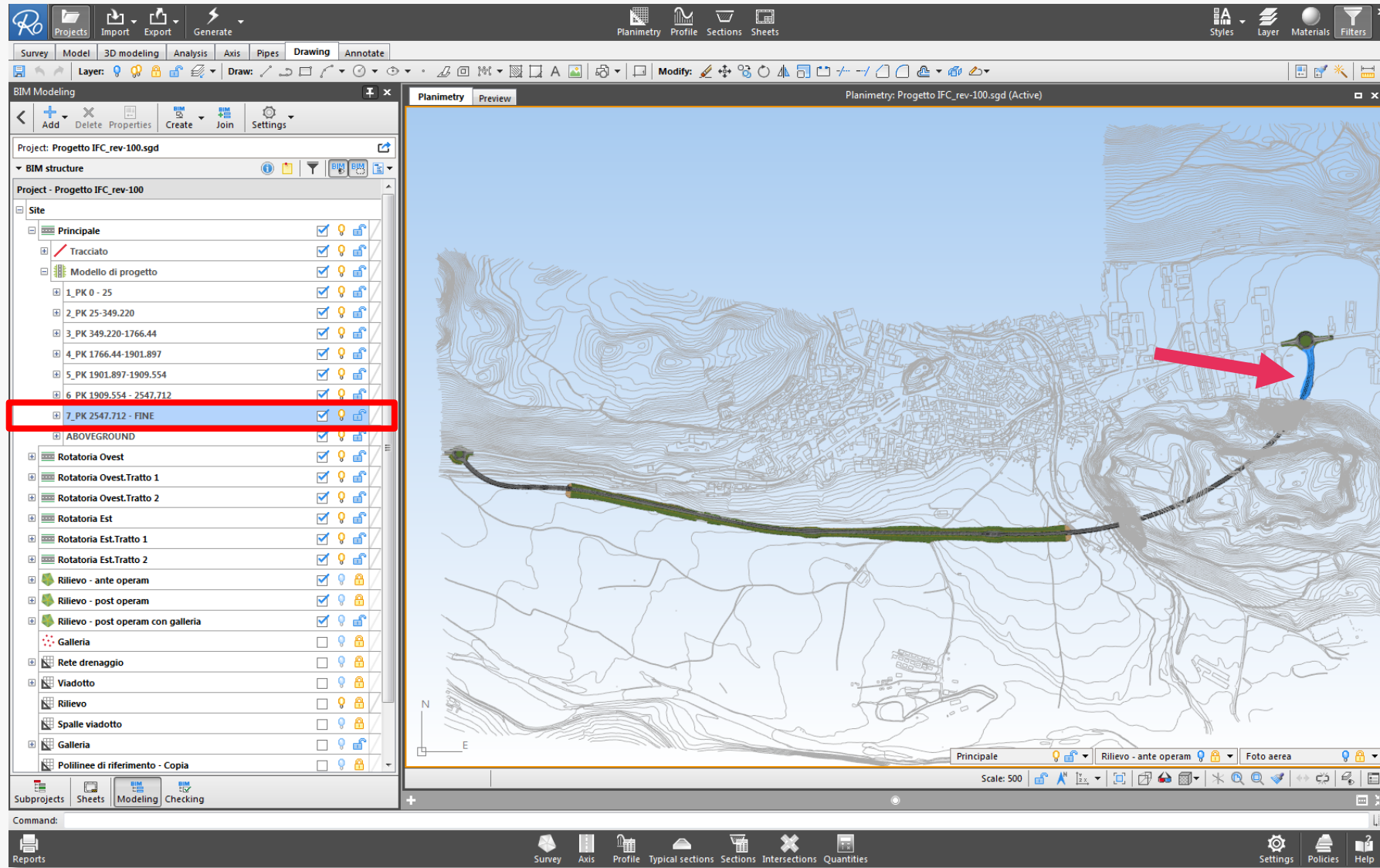
Longitudinal breakdown



WBS 4 Tunnel

- (L = 638.16 m)
- Circul arc R=950m
 - Clothoid A=348.92
 - Circul arc R=350m

Longitudinal breakdown



WBS 5

Road segment 2

(L = 170.21 m)

- Circul arc R=350m
- Clothoid A=142.91
- Circul arc R=150m

Longitudinal breakdown

WBS IFC Mapping

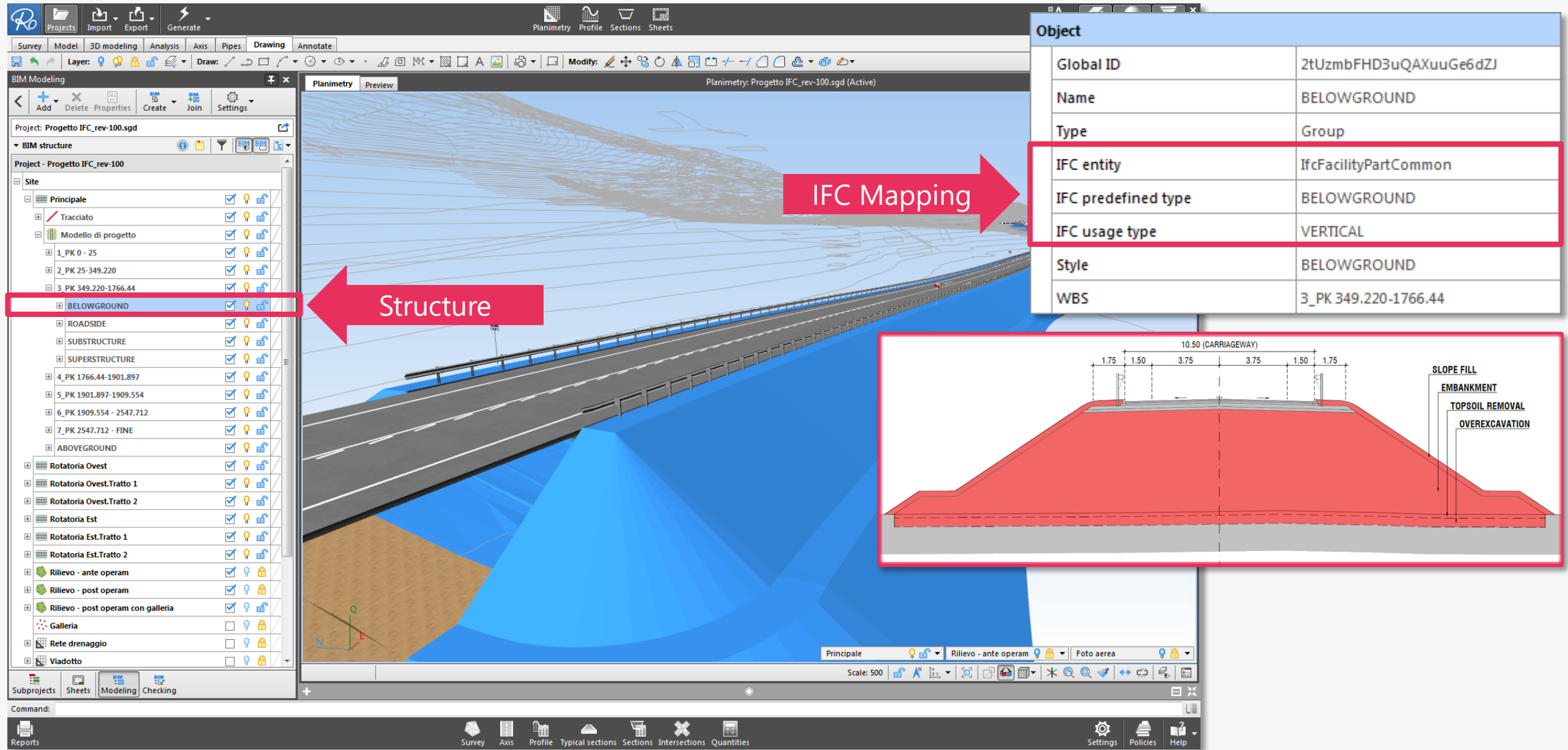
Structure by WBS

Quantity by WBS

Object	
Global ID	2Y9uo053LCruKdJgzCTbT4
Name	3_PK 349.220-1766.44
Type	WBS interval
IFC entity	IfcRoadPart
IFC predefined type	ROADSEGMENT
IFC usage type	LONGITUDINAL
Style	Intervallo WBS
WBS	3_PK 349.220-1766.44

Properties	
Elementi_Posizionamento	
Start station	25.000 m
End station	349.220 m
Qto_Quantities	
Base course	323.629 m³
Binder course	194.178 m³
Curb	0.394 m³
Foundation	15.832 m³
Fill	50016.734 m³
Stripping line	25.630 m³
Topsoil	143.358 m³
Wearing course	160.789 m³

Lateral and vertical breakdown: Belowground



IFC Mapping

Structure

Object	
Global ID	2tUzmbFHD3uQAXuuGe6dZJ
Name	BELOWGROUND
Type	Group
IFC entity	IfcFacilityPartCommon
IFC predefined type	BELOWGROUND
IFC usage type	VERTICAL
Style	BELOWGROUND
WBS	3_PK 349.220-1766.44

10.50 (CARRIAGEWAY)

1.75 1.50 3.75 3.75 1.50 1.75

SLOPE FILL
EMBANKMENT
TOPSOIL REMOVAL
OVEREXCAVATION

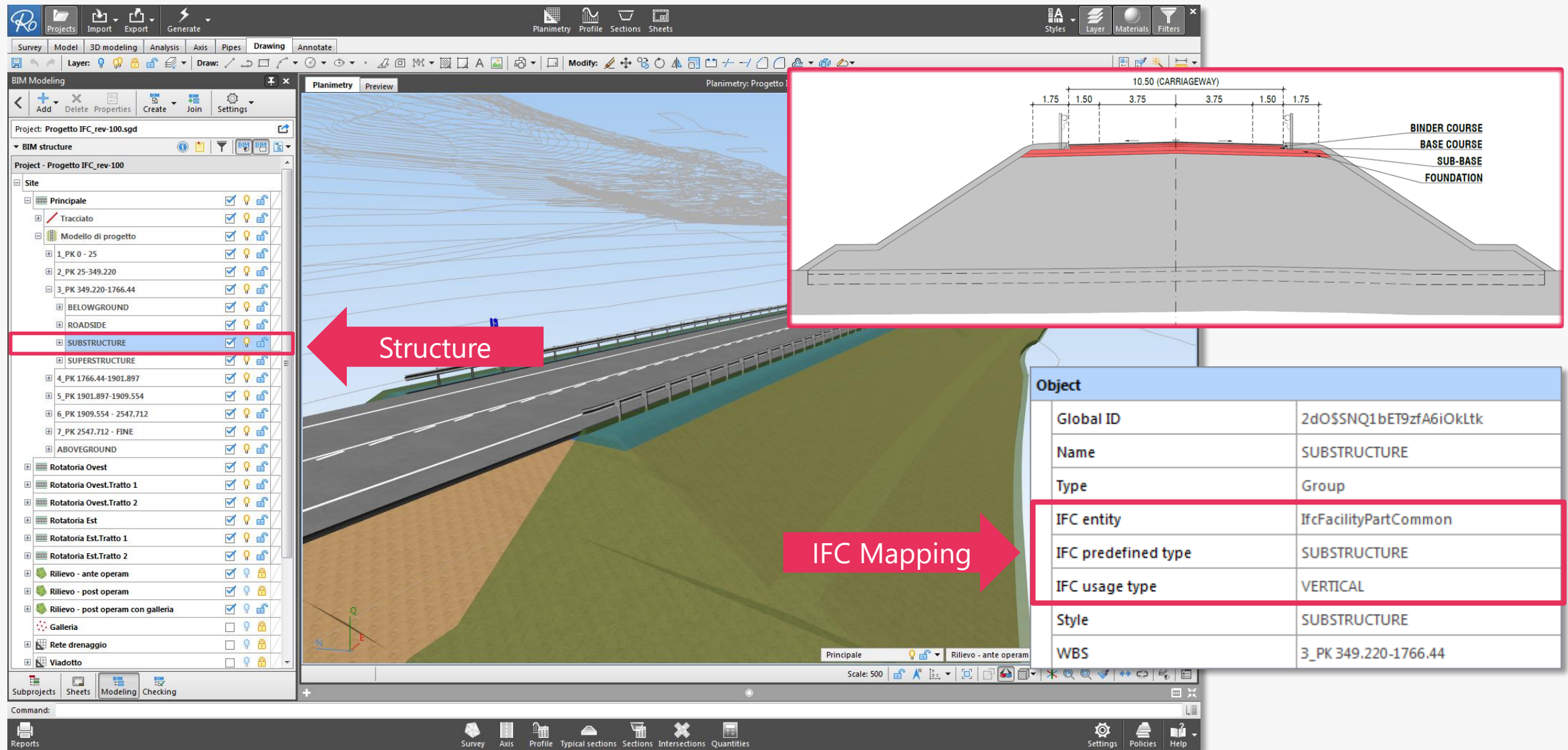
Lateral and vertical breakdown: Roadside

Structure

IFC Mapping

Object	
Global ID	1_537ZriH8ahkVTPzFYZ9S
Name	ROADSIDE
Type	Group
IFC entity	IfcRoadPart
IFC predefined type	ROADSIDE
IFC usage type	LATERAL
Style	ROADSIDE
WBS	3_PK 349.220-1766.44

Lateral and vertical breakdown: Substructure



Structure

IFC Mapping

Object	
Global ID	2dO\$SNQ1bET9zfA6iOkLtk
Name	SUBSTRUCTURE
Type	Group
IFC entity	IfcFacilityPartCommon
IFC predefined type	SUBSTRUCTURE
IFC usage type	VERTICAL
Style	SUBSTRUCTURE
WBS	3_PK 349.220-1766.44

10.50 (CARRIAGEWAY)

1.75 1.50 3.75 3.75 1.50 1.75

BINDER COURSE
BASE COURSE
SUB-BASE
FOUNDATION

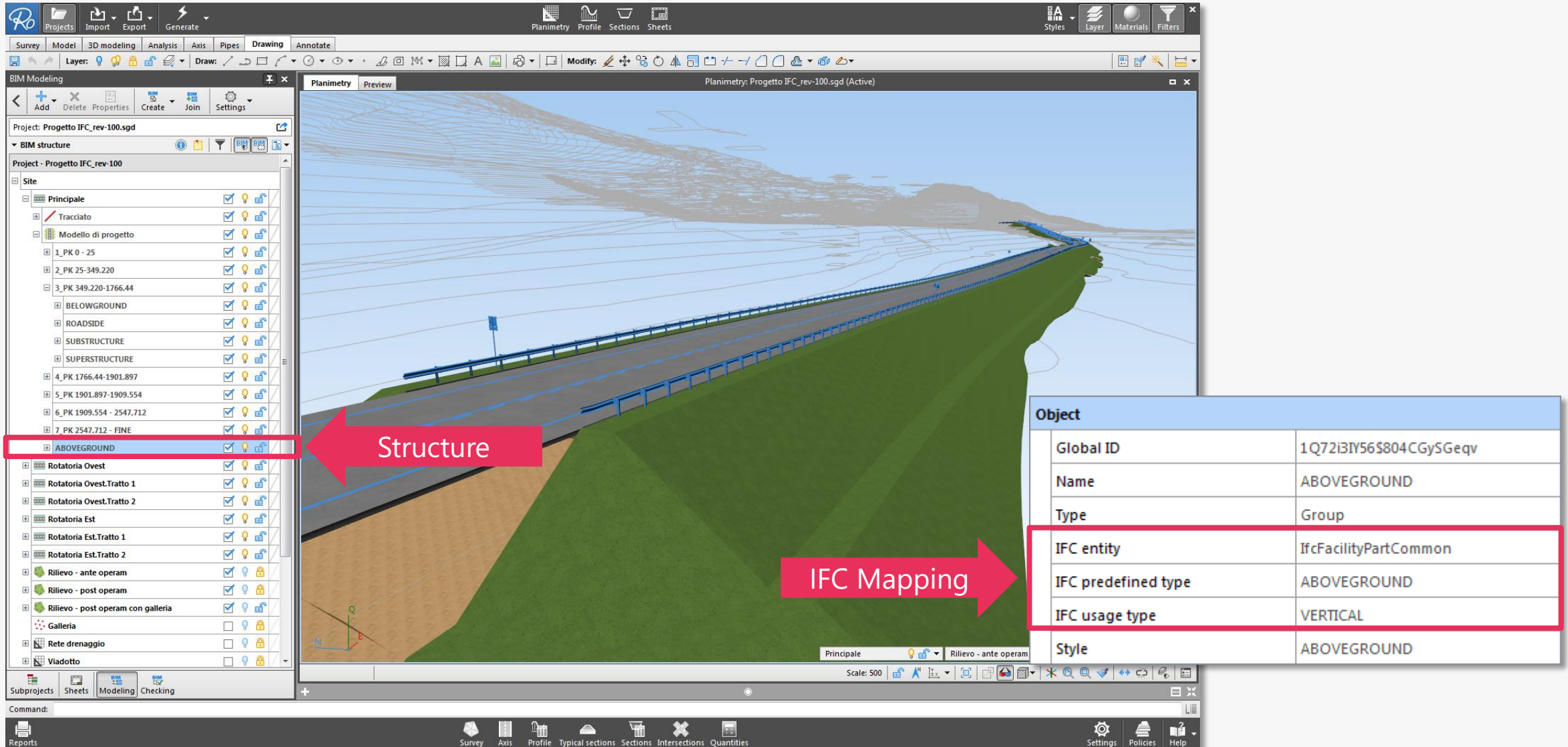
Lateral and vertical breakdown: Superstructure

Structure

IFC Mapping

Object	
Global ID	3YegQdzfr629uBROG3YjVW
Name	SUPERSTRUCTURE
Type	Group
IFC entity	IfcFacilityPartCommon
IFC predefined type	SUPERSTRUCTURE
IFC usage type	VERTICAL
Style	SUPERSTRUCTURE
WBS	3_PK 349.220-1766.44

Lateral and vertical decomposition: Aboveground



Structure

IFC Mapping

Object	
Global ID	1Q72i3IV56\$804CGySGeqv
Name	ABOVEGROUND
Type	Group
IFC entity	IfcFacilityPartCommon
IFC predefined type	ABOVEGROUND
IFC usage type	VERTICAL
Style	ABOVEGROUND

The road

The elements and properties

Elements: Sideslope

IFC Mapping

Object	
Global ID	1Y3C1UsufBxBFEed2SVFbz\$
Name	TERRENO VEGETALE [TVEG]
Type	Element by code
IFC entity	IfcEarthworksFill
IFC predefined type	SLOPEFILL
Style	Terreno vegetale
WBS	3_PK 349.220-1766.44

Structure

Properties

Elementi_Struttura progetto	
WBS	3_PK 349.220-1766.44
WBS 01 Lotto	01
Elementi_Posizionamento	
Start station	349.220 m
End station	1751.188 m
Attributo	
Description	
Qto_CourseBaseQuantities	
Thickness	0.300 m
Total quantity	143.358 m ³

Elements: Wearing course

IFC Mapping - Userdefined

Structure

Properties

Object	
Global ID	1gsJDq3M10Dvg1w9F7TtMd
Name	STRATO DI USURA [USURA]
Type	Element by code
IFC entity	IfcCourse
IFC predefined type	WEARINGCOURSE
Style	Strato di usura
WBS	3_PK 349.220-1766.44

Properties	
Elementi_Struttura progetto	
WBS	3_PK 349.220-1766.44
WBS 01 Lotto	01
Elementi_Posizionamento	
Start station	349.220 m
End station	1751.188 m
Attributo	
Description	Strato di usura in conglomerato ...
Qto_CourseBaseQuantities	
Spessore	0.050 m
Volume	263.268 m³
Materiale_MixDesign	
Percentuale aggregato ...	90 %
Durezza aggregato	15 %
Coefficiente appiattime...	10 %
Microrugosità aggregato	55

Elements: Guard rail

Structure

IFC Mapping

Properties

Object	
Global ID	3zqxNjNx07Fu1zv7V5MWd
Name	Barriera sicurezza
Type	SmartPolyline model
IFC entity	IfcRailing
IFC predefined type	GUARDRAIL
Style	Barriera di sicurezza

Properties	
Qto_RailingBaseQuantities	
Sviluppo	1404.589 m
Barriere_Caratteristiche prestazionali	
Livello di contenimento	H2
Livello di larghezza opera...	W5
Livello di intrusione del v...	VI5

Elements: Road markings

Object

Global ID	1z9W4xinX6uBAy9ptgXI9q
Name	Segnaletica orizzontale
Type	SmartPolyline model
IFC entity	IfcSurfaceFeature
IFC predefined type	LINEMARKING
Style	Segnaletica orizzontale continua-tr...

Properties

Qto_SurfaceFeatureBaseQuantities	
Sviluppo	287.547 m
Segnaletica_Caratteristiche prestazionali	
Tratteggio	Continua di separazione dei sensi ...
Tratteggio	Tipo B
Luminanza retroriflessa RL	180 mcd lx-1 m-2

Structure

IFC Mapping

Properties

Elements: Road signs

The screenshot displays the InfraBIM OPEN software interface. The central 3D view shows a road model with a vertical sign. Three red arrows highlight key features: one points from the sign to the 'IFC Mapping' panel, another points from the 'Properties' panel to the sign, and a third points from the 'Structure' list to the sign. The 'Structure' list on the left shows a hierarchy of elements, with 'Segnaletica verticale' selected. The 'IFC Mapping' panel on the right shows the mapping of the selected element to IFC entities. The 'Properties' panel on the right shows the properties of the selected element, including performance and qualitative characteristics.

Structure

IFC Mapping

Properties

Object	
Global ID	0_9h2PO3zFFhw1\$u8Ok_BF
Name	Segnaletica verticale
Type	SmartPolyline model
IFC entity	IfcSign
IFC predefined type	PICTORAL
Style	Segnaletica verticale quadrata

Properties	
Segnaletica_Caratteristiche prestazionali	
Classe pellicola retroriflet...	2
Altezza carattere	
Descrizione	Quadrato medio
Segnaletica_Caratteristiche qualitative	
Tipo supporto	Monopalo

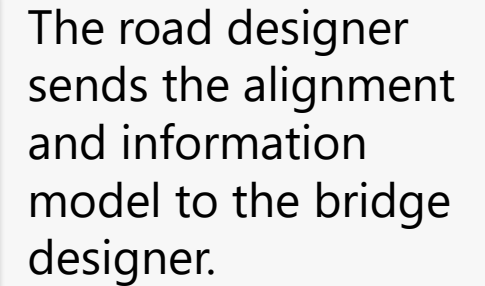
The bridge

Modeled with Autodesk Revit

Shared bridge information model in IFC 4

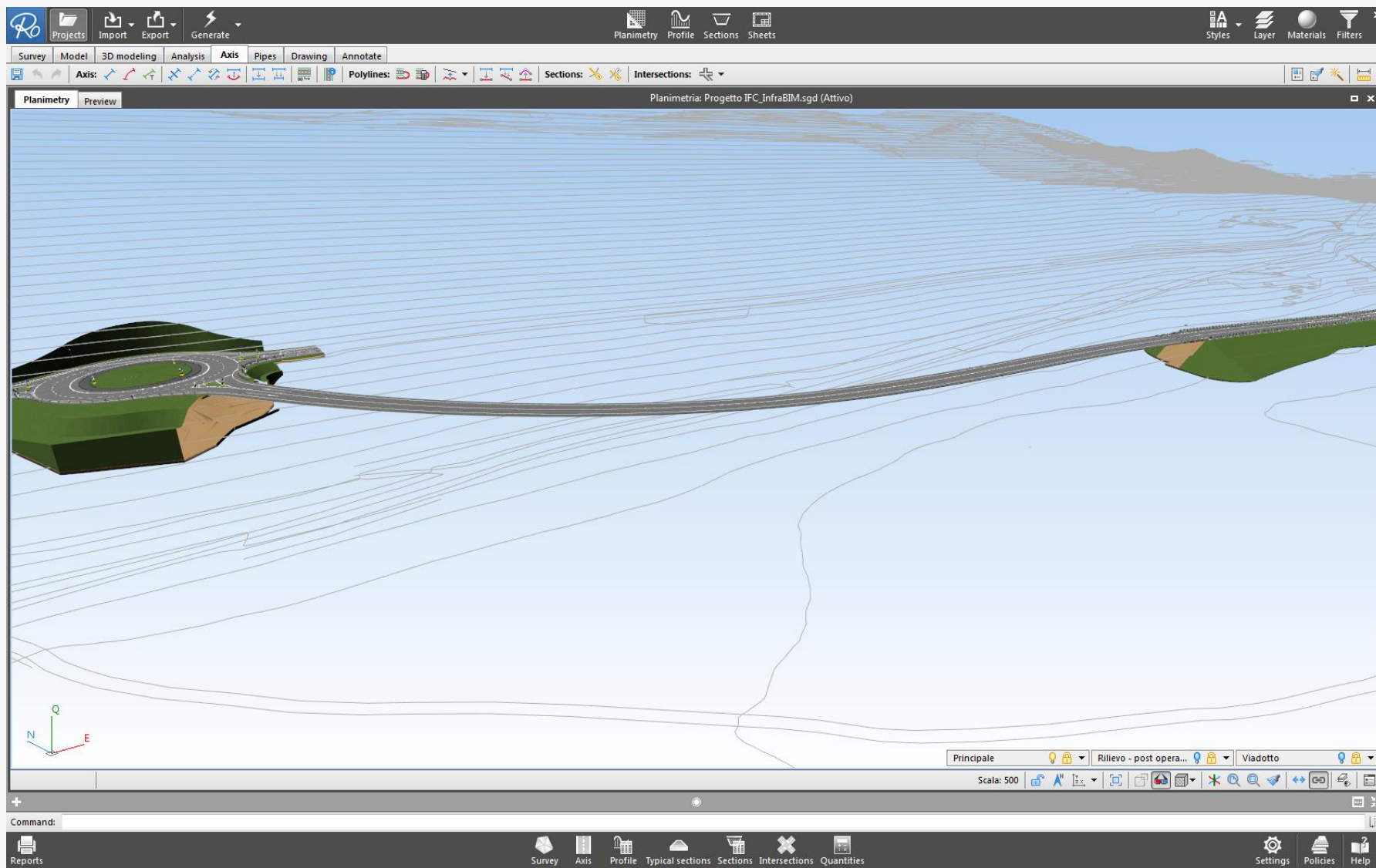
Model by Rachele A. Bernardello Unipd - buildingSMART Italy

**infra
BIM
OPEN**



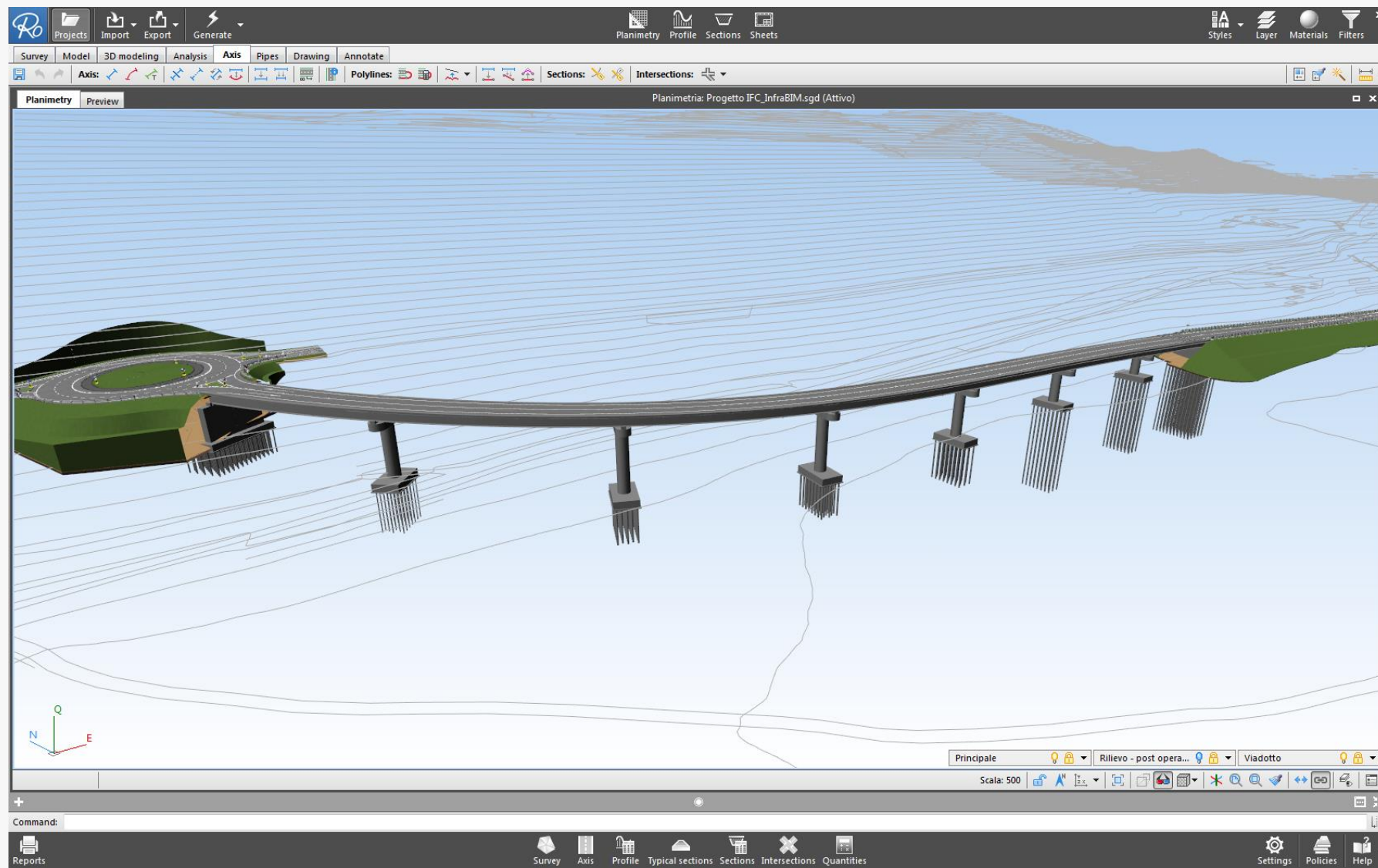
The bridge designer does the design and sends it back to the road designer in IFC format, so that he can integrate it into the design.

The bridge



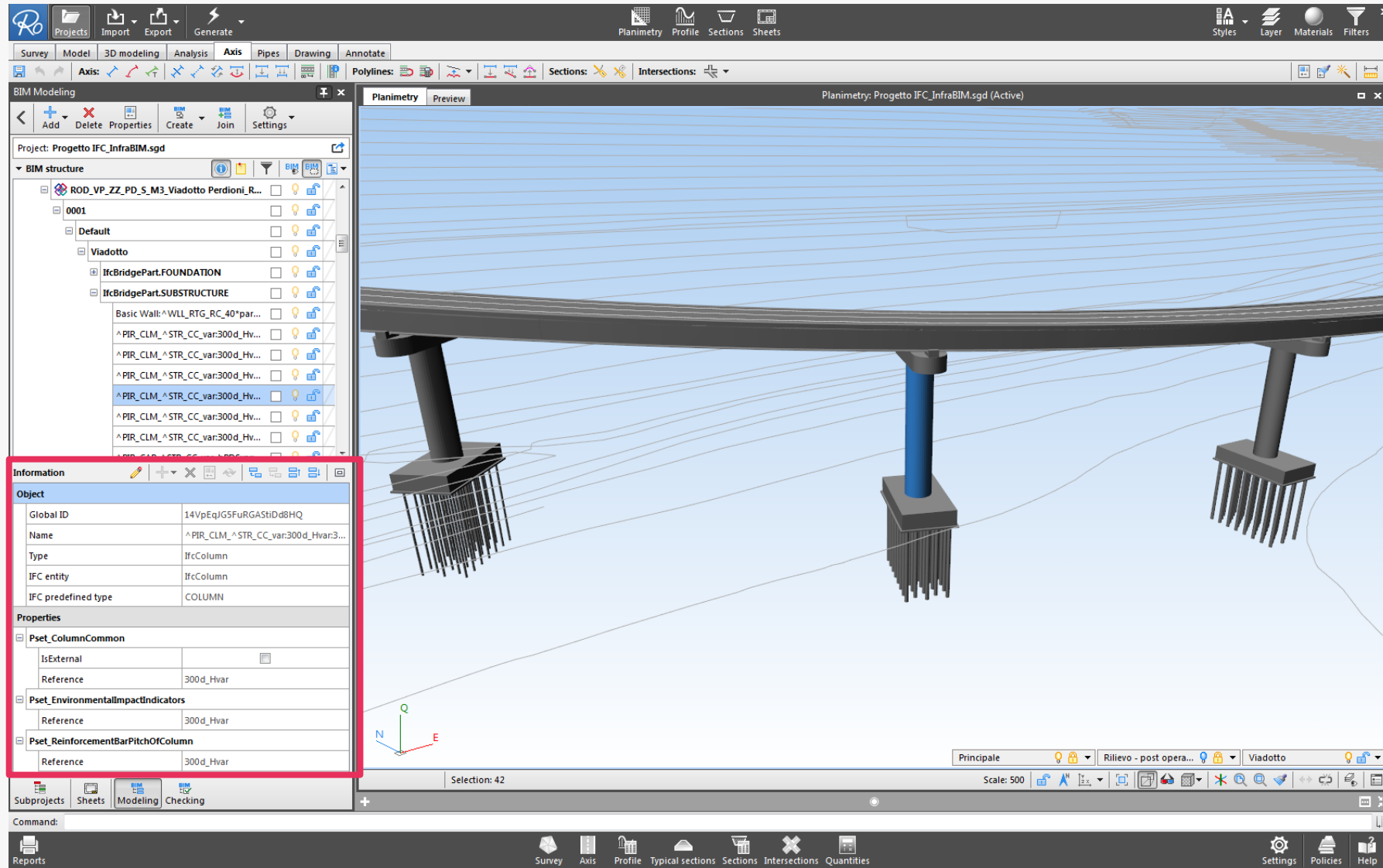
In SierraSoft Roads the bridge is imported.

The bridge



The bridge is inserted and georeferenced.

The bridge: Access to all information in the model

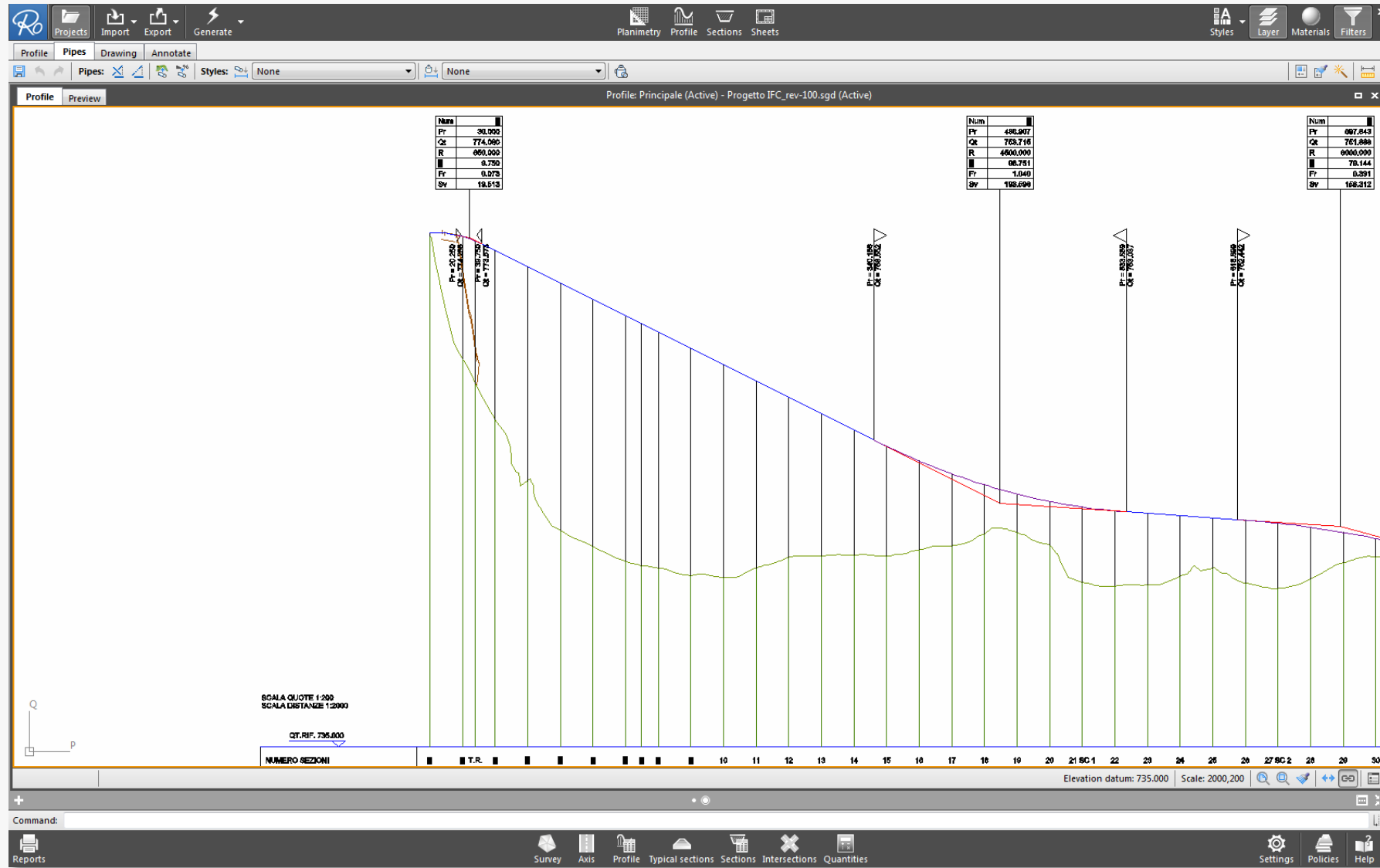


Bridge information model becomes part of the project.

You can query the information model and get all the information you need.

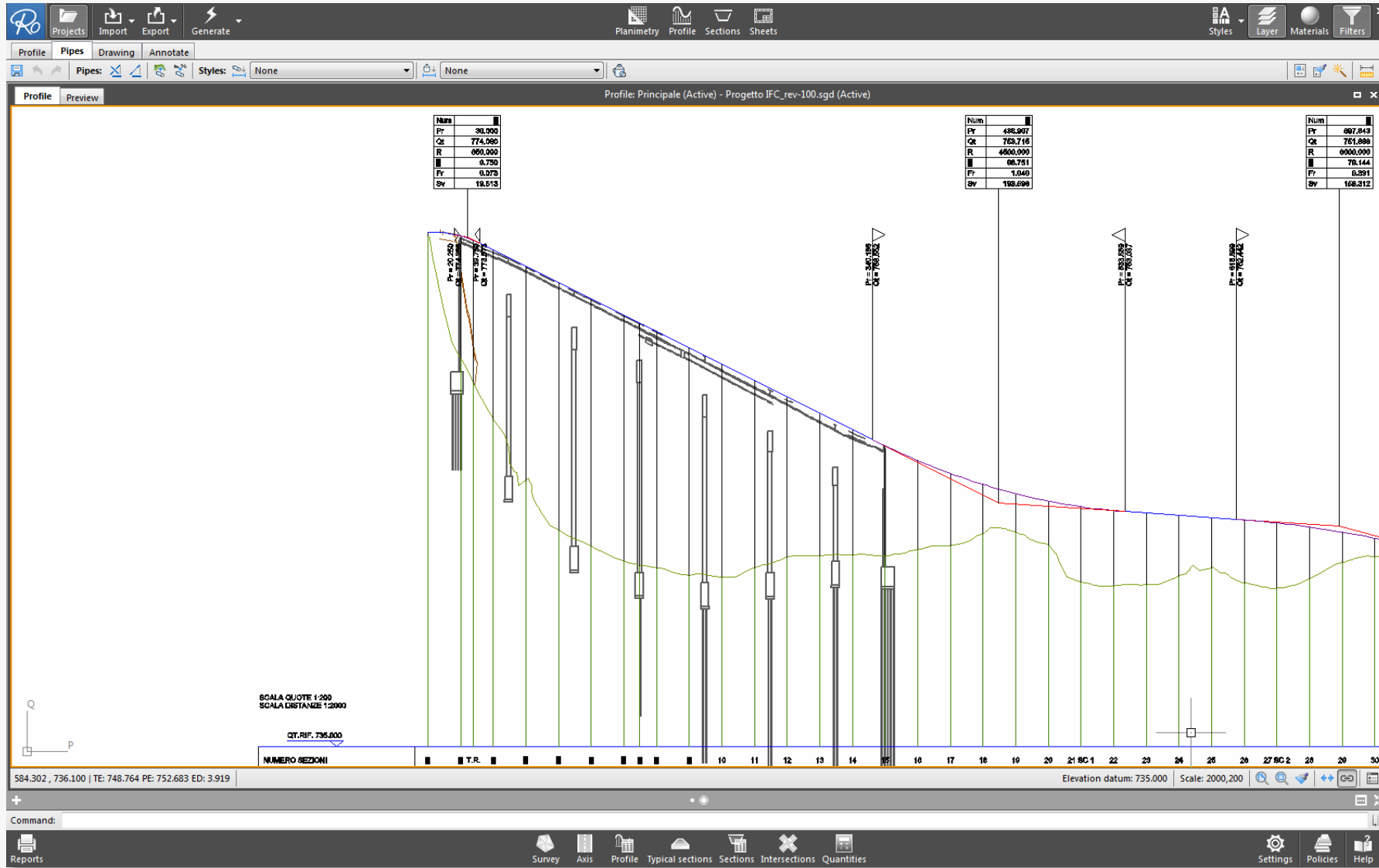
Bridge information model becomes a support for road design.

The bridge: longitudinal profile

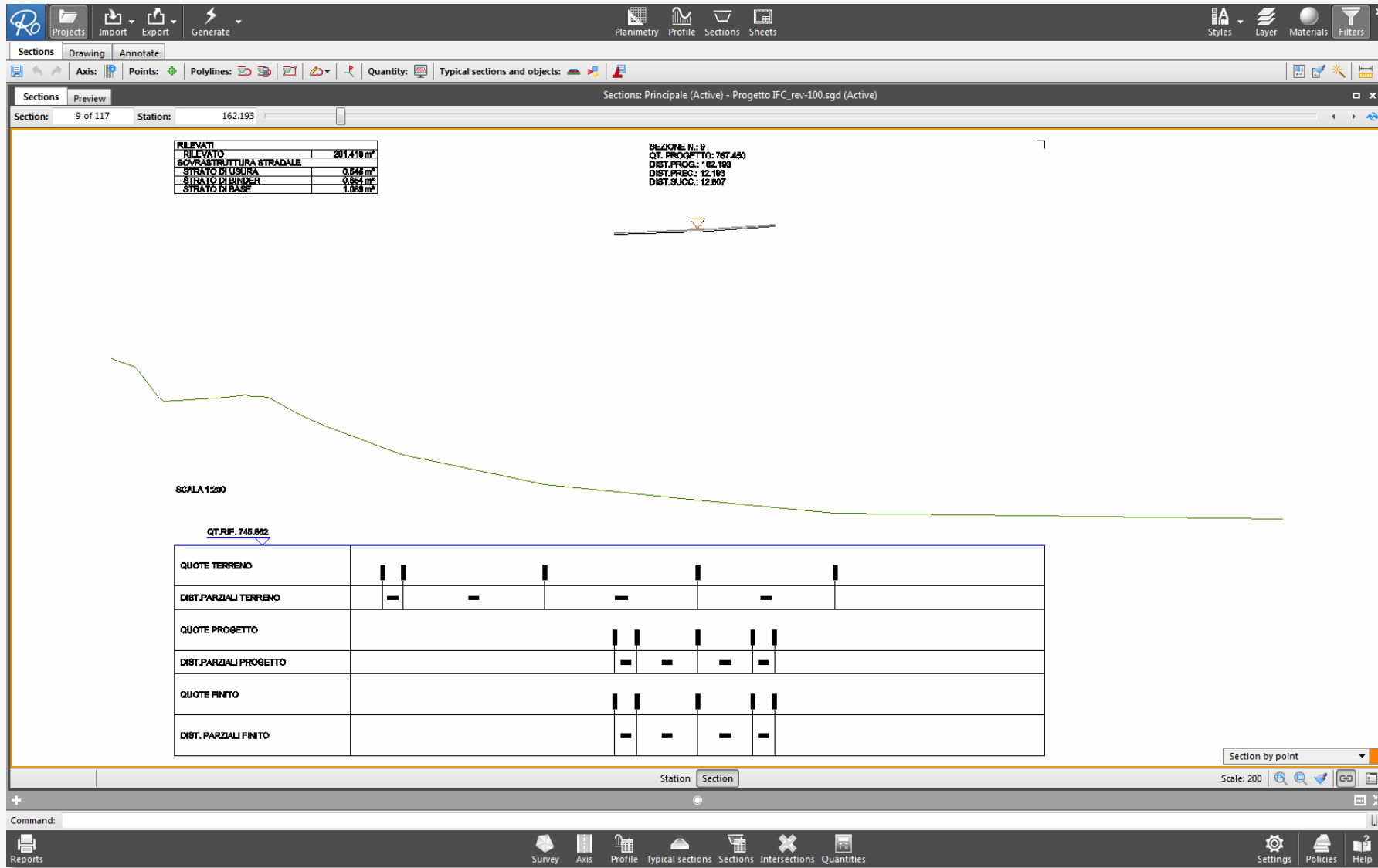


In longitudinal profile management, bridge references can be obtained automatically.

The bridge: longitudinal profile

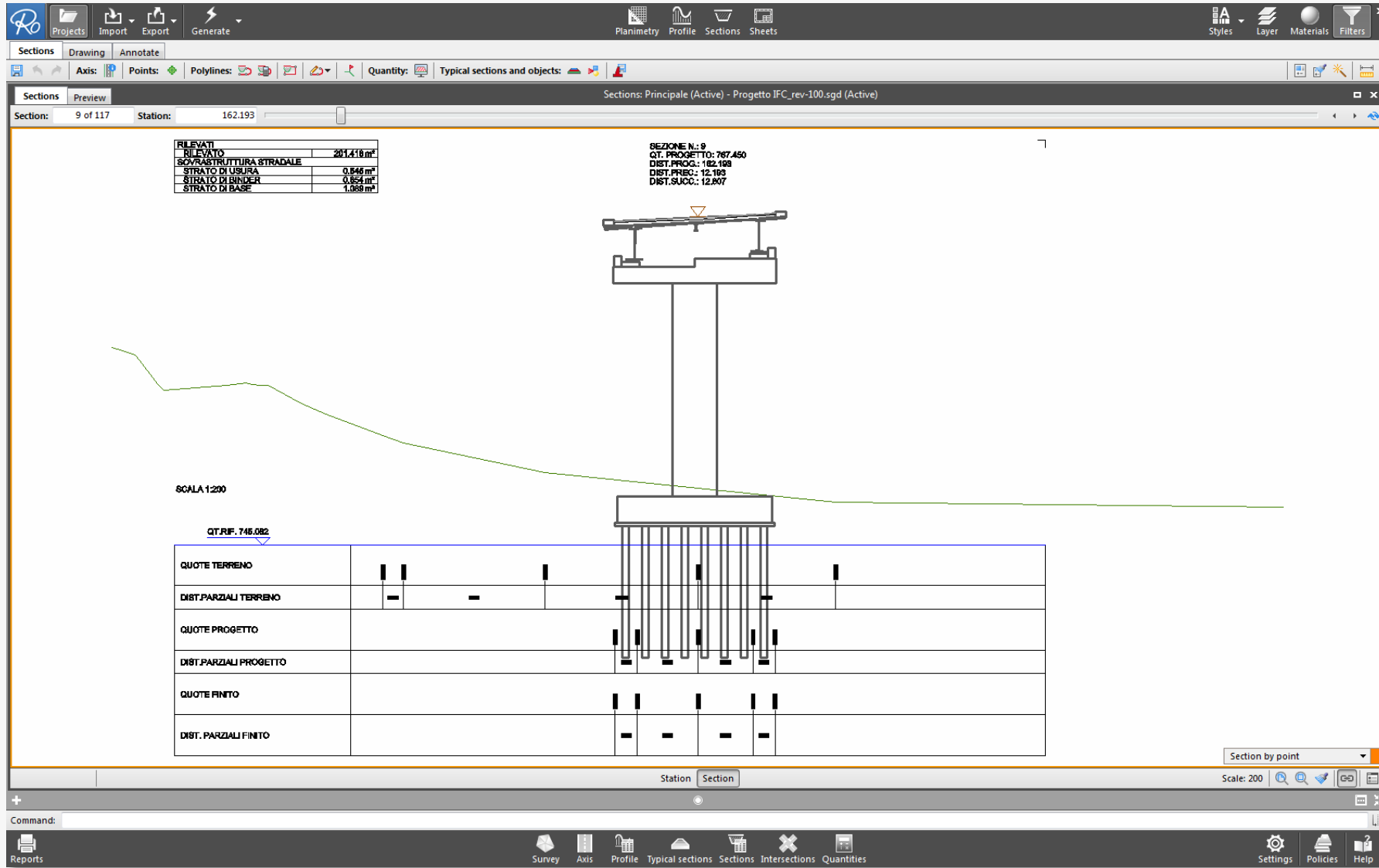


The bridge: Cross-sections

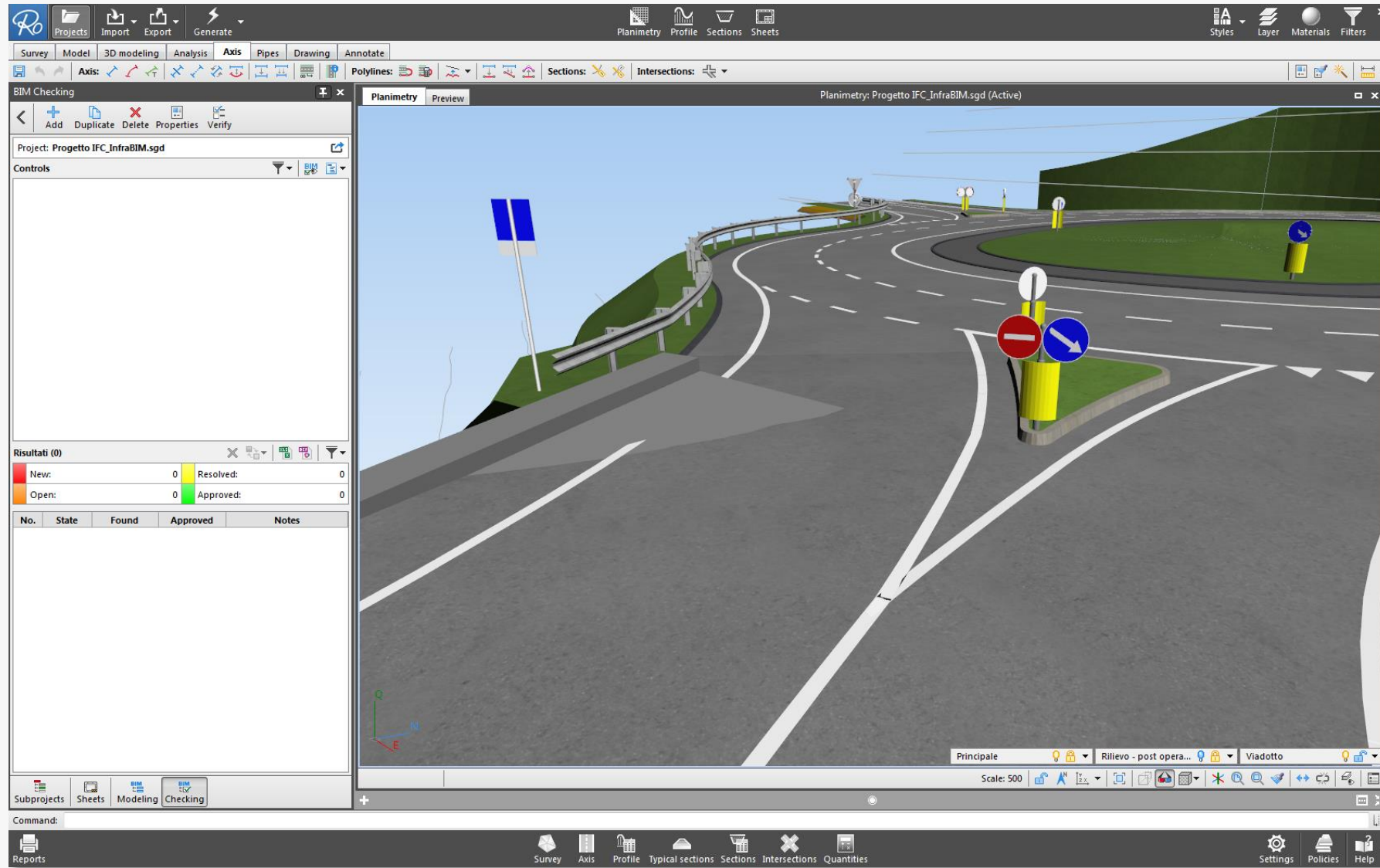


Cross-section management can also be integrated with information extracted from bridge geometries.

The bridge: Cross-sections

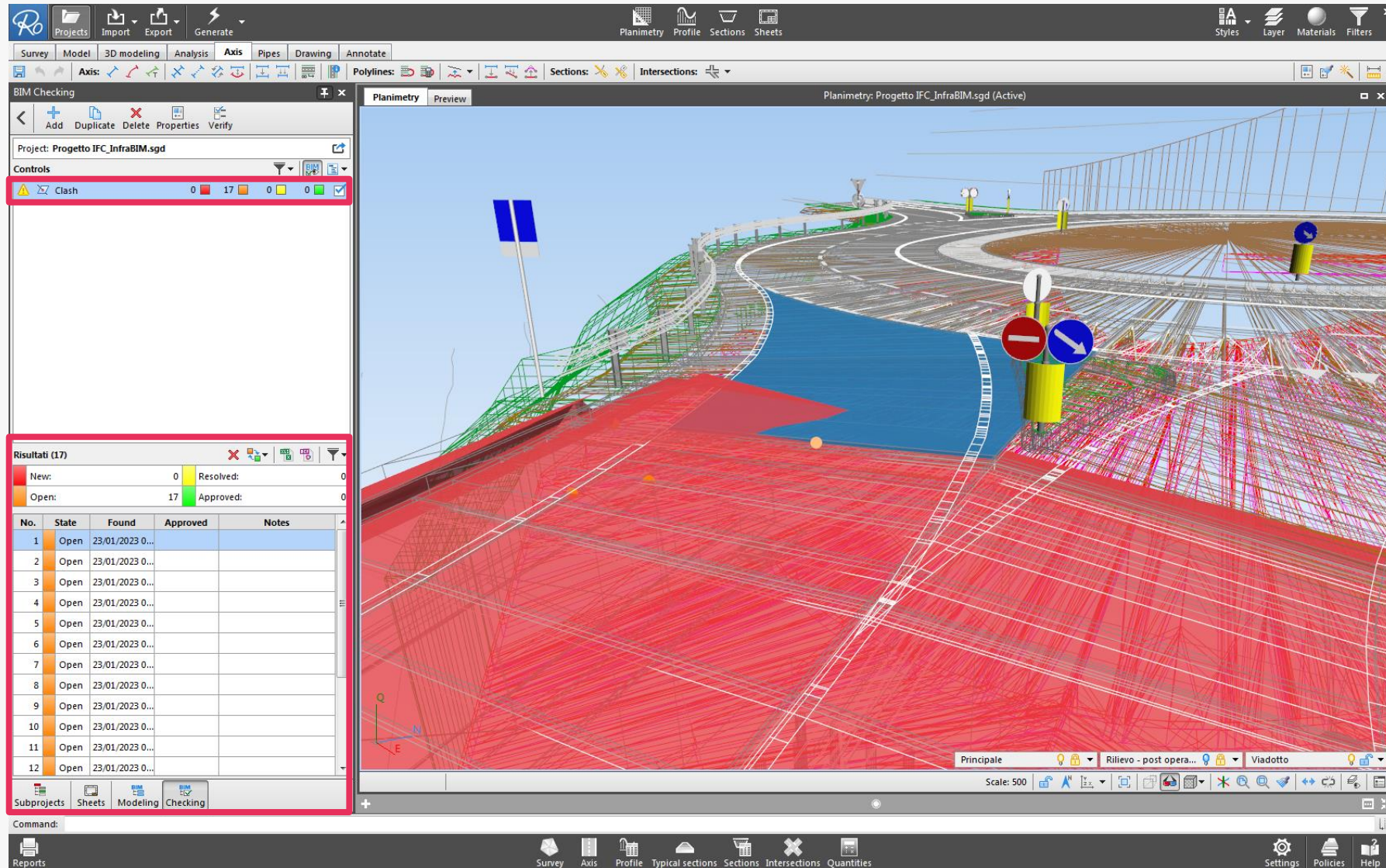


The bridge: Clash detection in the design phase



The analysis and verification of the models is performed in SierraSoft Roads in the same phase as the road and bridge design.

The bridge: Clash detection in the design phase



The analysis and verification of the models is performed in SierraSoft Roads in the same phase as the road and bridge design.

Problems are identified at the beginning and solved immediately with a significant reduction in time and cost.

The bridge: Clash detection in the design phase

BIM Checking

Project: Progetto IFC_InfraBIM.sgd

Controls

Clash: 0 New, 17 Open, 0 Resolved, 0 Approved

No.	State	Found	Approved	Notes
1	Open	23/01/2023 0...		
2	Open	23/01/2023 0...		
3	Open	23/01/2023 0...		
4	Open	23/01/2023 0...		
5	Open	23/01/2023 0...		
6	Open	23/01/2023 0...		
7	Open	23/01/2023 0...		
8	Open	23/01/2023 0...		
9	Open	23/01/2023 0...		
10	Open	23/01/2023 0...		
11	Open	23/01/2023 0...		
12	Open	23/01/2023 0...		

Numero	Tipo	Stato	Data rilevamento	Assegnato a	Punto di interferenza	Entità A	Entità B	Immagine	Data approvazione	Approvato da
1	Interferenza 3D	Aperto	18/01/2023 10:56		E: 299059.653 N: 507070.336 Q: 774.143	STRATO DI USURA [USURA]	Floor: ^FLR_DCK_RC_35*deck:372640			
2	Interferenza 3D	Aperto	18/01/2023 10:56		E: 299057.771 N: 507067.977 Q: 774.214	STRATO DI USURA [USURA]	Floor: ^FLR_DCK_RC_35*deck:372640			
3	Interferenza 3D	Aperto	18/01/2023 10:56		E: 299059.975 N: 507068.028 Q: 774.157	STRATO DI USURA [USURA]	Floor: ^FLR_DCK_RC_35*deck:372640			
4	Interferenza 3D	Aperto	18/01/2023 10:56		E: 299175.467 N: 507002.843 Q: 767.406	STRATO DI USURA [USURA]	Floor: ^FLR_DCK_RC_35*deck:390030			
5	Interferenza 3D	Aperto	18/01/2023 10:56		E: 299225.283 N: 506999.056 Q: 764.902	STRATO DI USURA [USURA]	Floor: ^FLR_DCK_RC_35*deck:390315			

Risultati (17)

New: 0 Resolved: 0
Open: 17 Approved: 0

Command: Reports

Survey Axis Profile Typical sections Sections Intersections Quantities

Settings Policies Help

The analysis and verification of the models is performed in SierraSoft Roads in the same phase as the road and bridge design.

Problems are identified at the beginning and solved immediately with a significant reduction in time and cost.

Reports with critical issues can be shared with other designers.

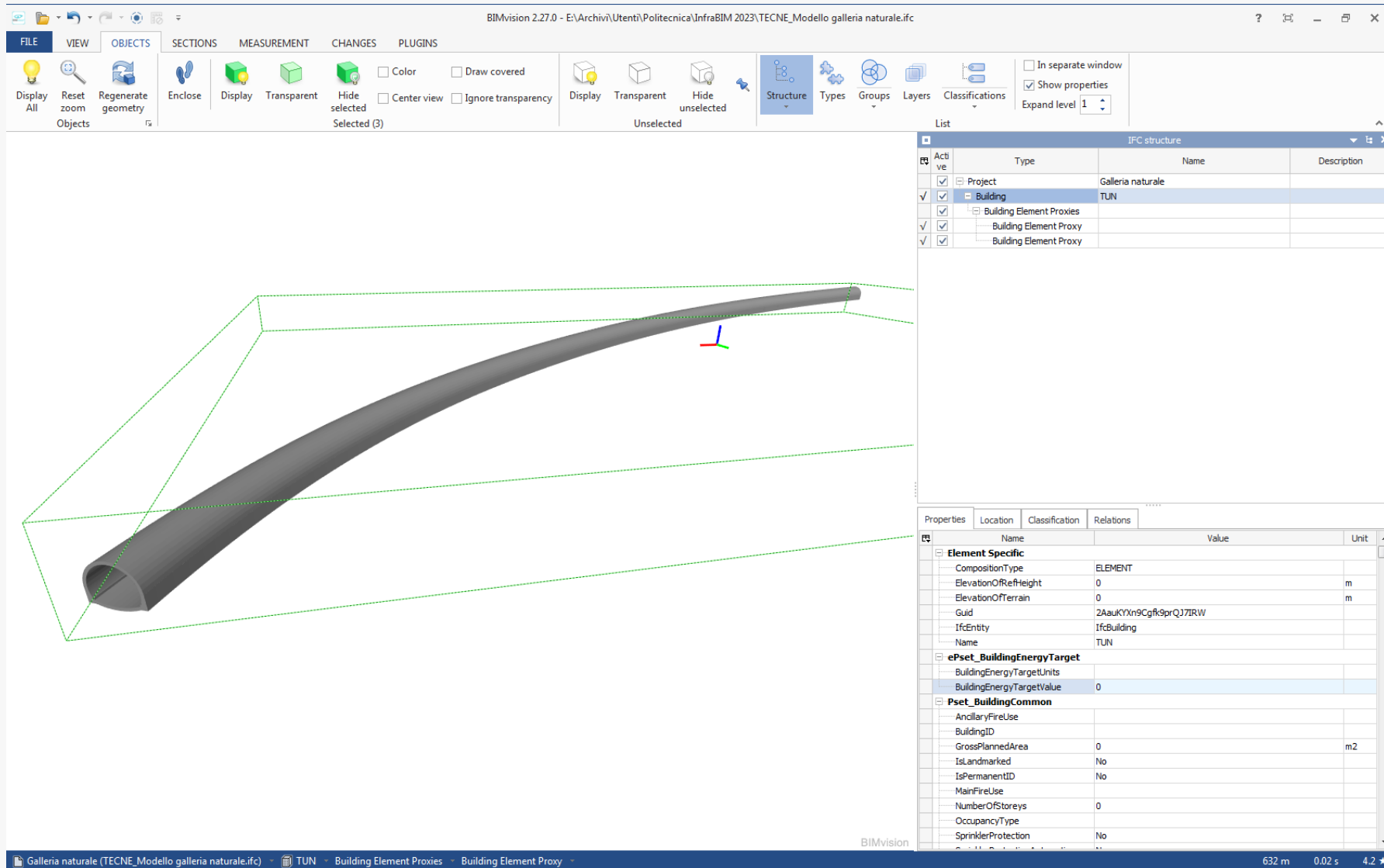
The tunnel

Modeled with Autodesk Civil 3D

Shared tunnel information model in IFC 4

Model by Tecne - Autostrade per l'Italia - buildingSMART Italy

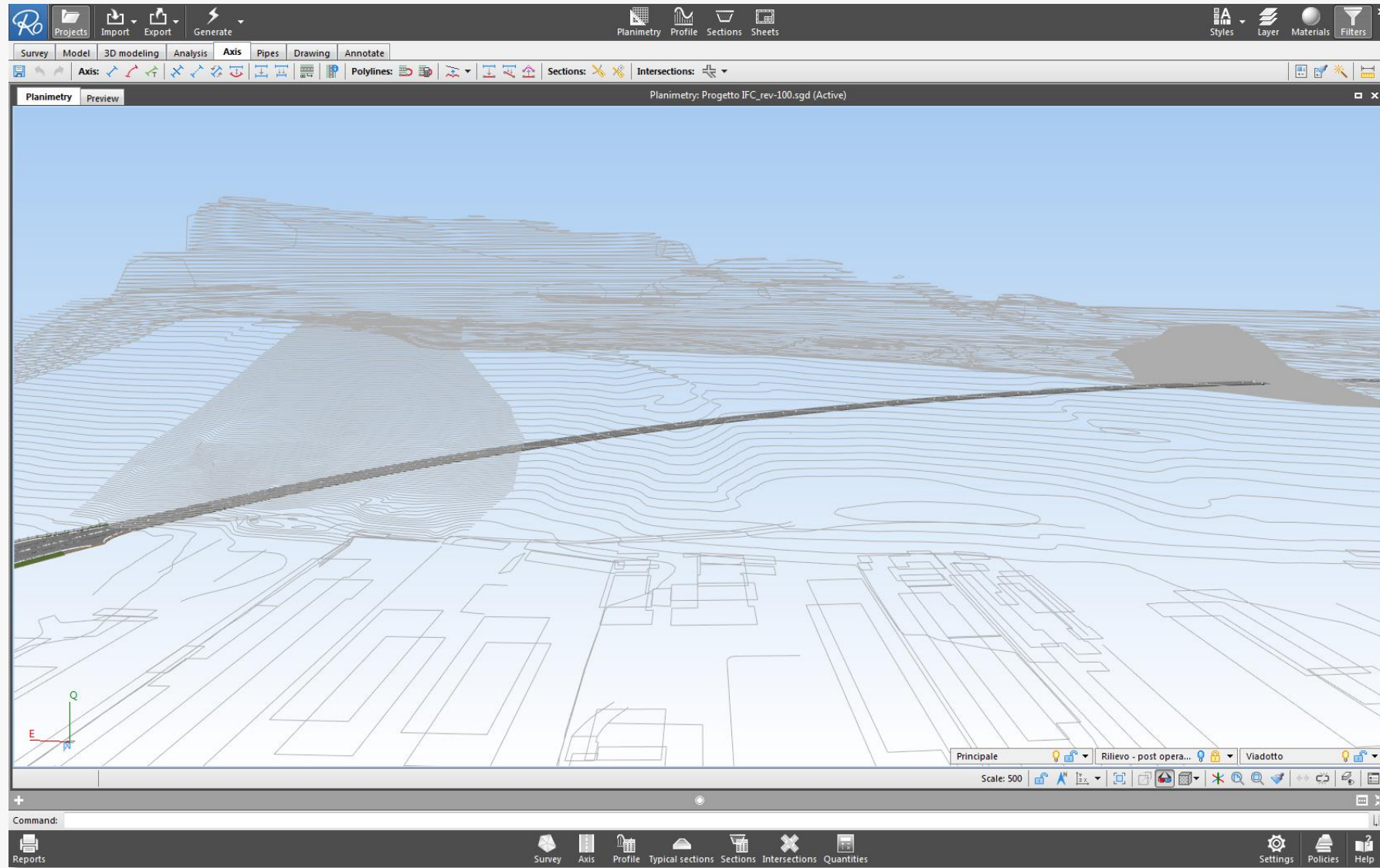
The tunnel



The road designer sends the alignment and information model to the tunnel designer.

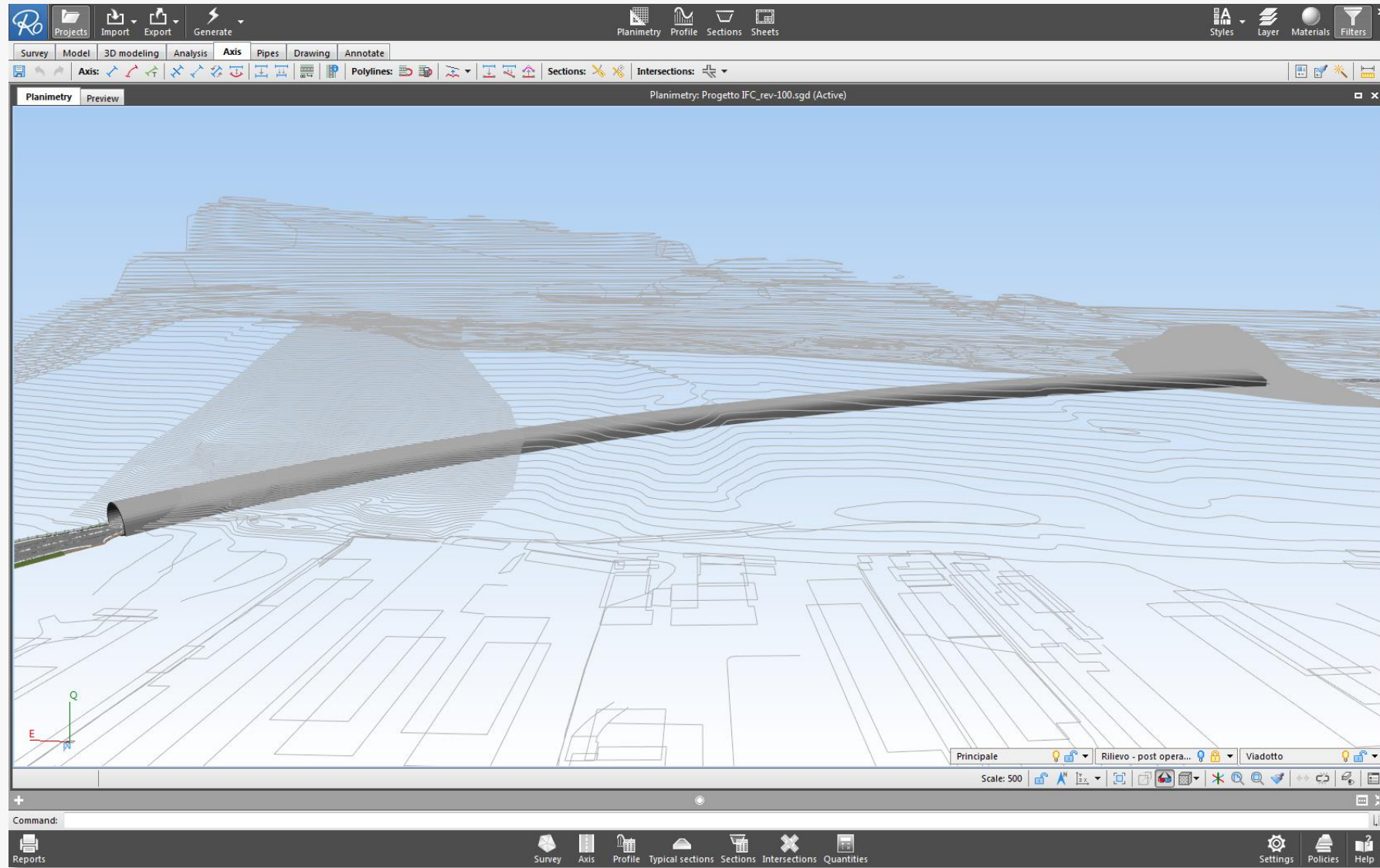
The tunnel designer does the design and sends it back to road designer in IFC format, so that he can integrate it into the design.

The tunnel



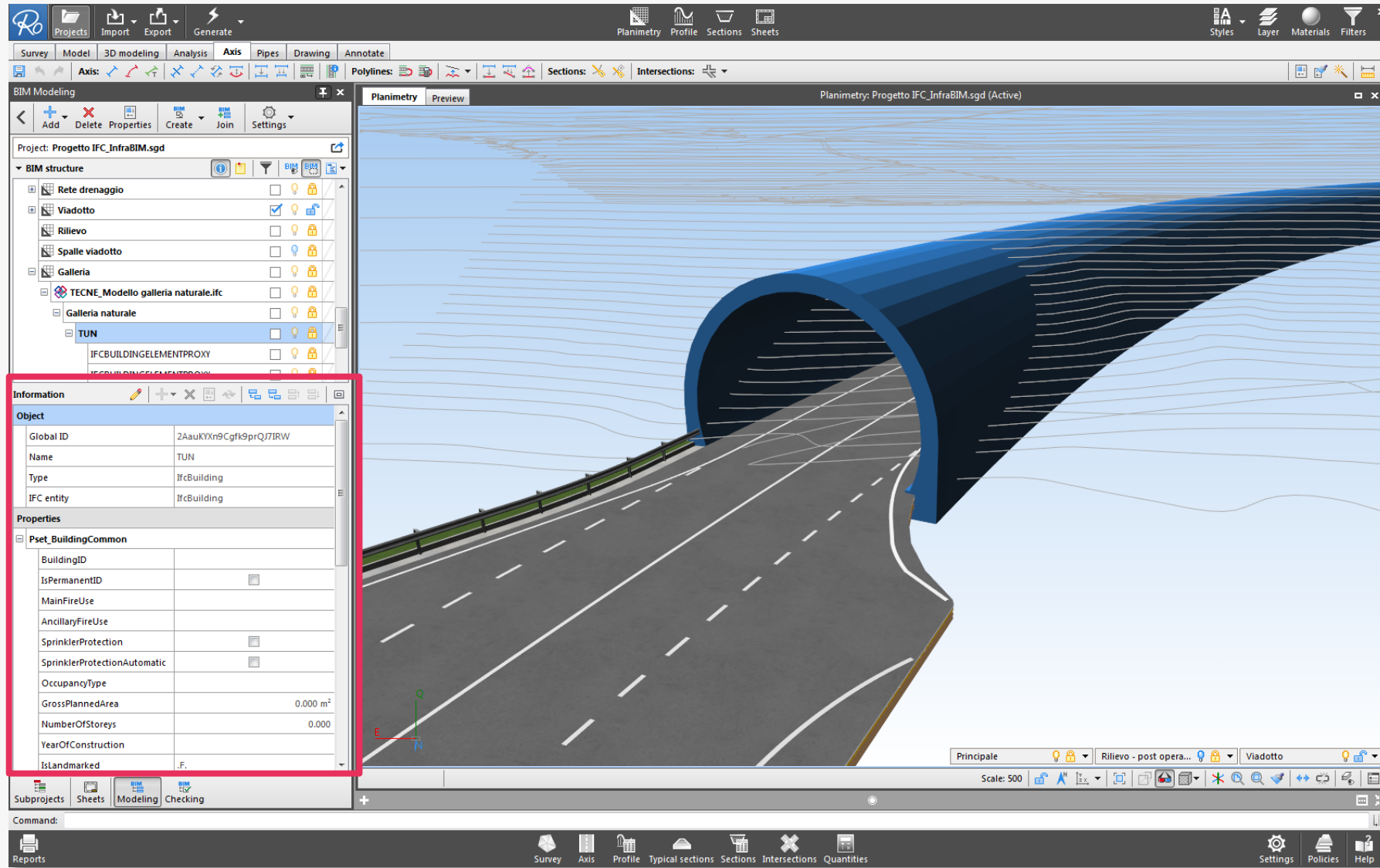
In SierraSoft Roads the tunnel is imported.

The tunnel



The tunnel is inserted and georeferenced.

The tunnel: Access to all information in the model

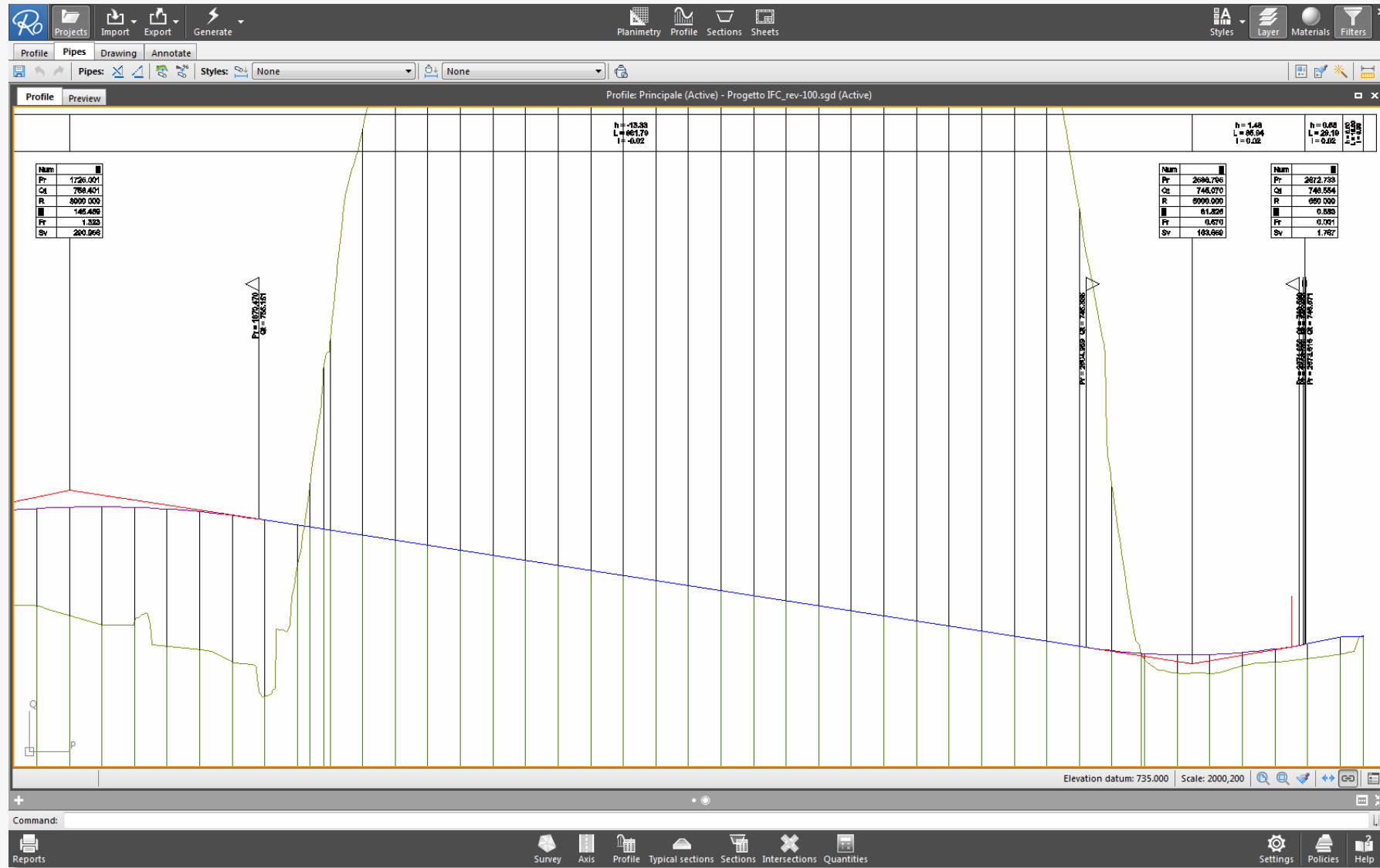


Tunnel information model becomes part of the project.

You can query the information model and get all the information you need.

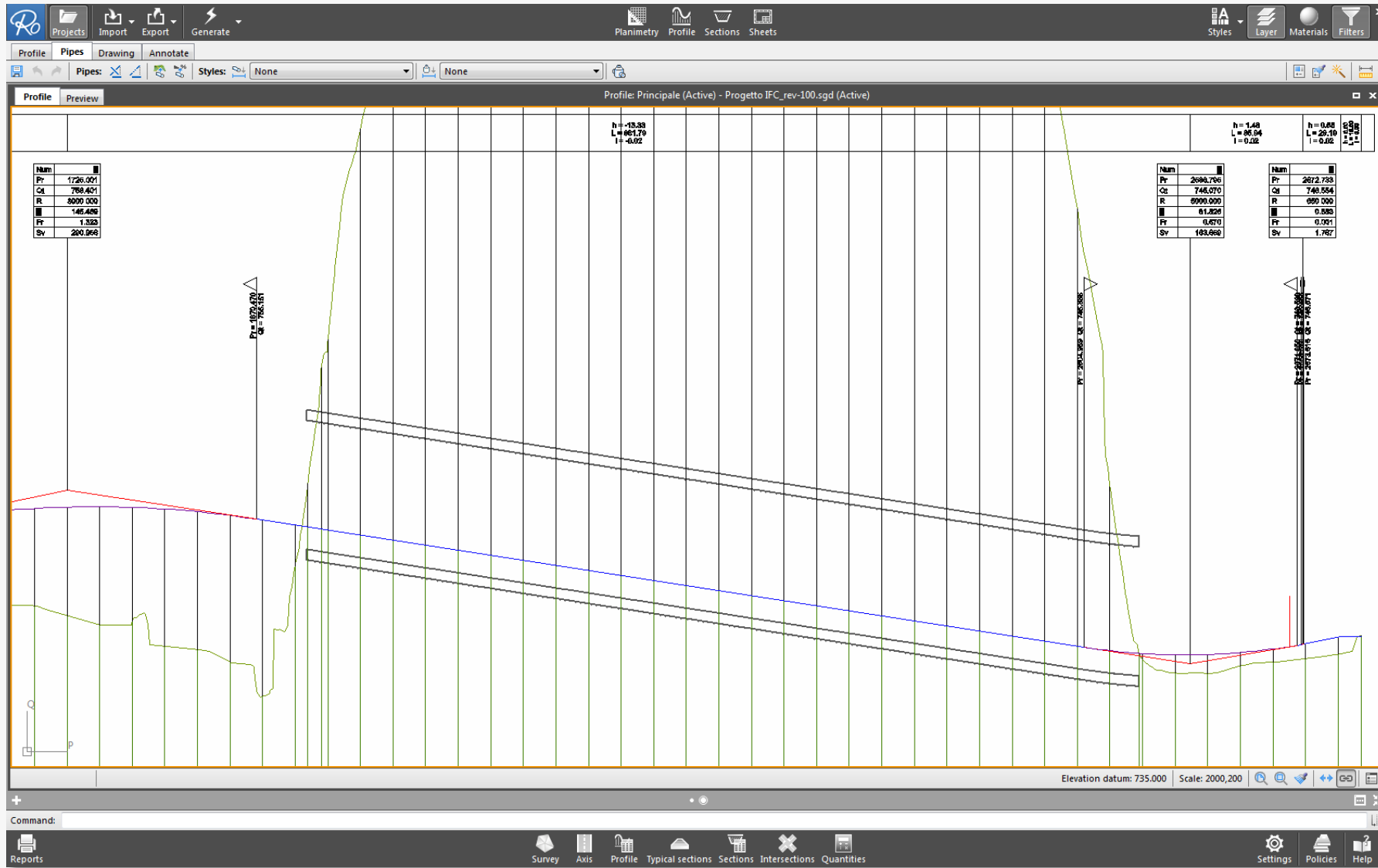
Tunnel information model becomes a support for road design.

The tunnel: longitudinal profile



In longitudinal profile management, tunnel references can be obtained automatically.

The tunnel: longitudinal profile



**Infra
BIM
OPEN**

The screenshot displays the 'Sezioni' software interface. At the top, there are tabs for 'Sections', 'Drawing', and 'Annotate'. Below these are various tool icons and a status bar showing 'Section: 78' and 'Station: 1925.000'. The main workspace shows a cross-section profile with a green line representing the ground surface. To the left of the profile is a table of quantities:

SCAVI E BONIFICHE	
STERRO	158.052 m³
RILEVATO	5.692 m³
SOVRASTRUTTURA STRADALE	
STRATO DI USURA	0.625 m³
STRATO DI BINDER	0.883 m³
STRATO DI BASE	1.050 m³
STRATO DI FONDAZIONE	2.100 m³
STRATO DI SOTTOFONDAZIONE	1.676 m³

To the right of the profile, there is a section summary:

SEZIONE N.: 78
 QT. PROGETTO: 755.307
 DIST. PROG.: 1825.000
 DIST. PREG.: 5.000
 DIST. SUCC.: 25.000

Below the profile, there is a small diagram of the road cross-section with a scale of 1:200. Below this is a table of quantities for the road structure:

	QT. RIF. 751.799
QUOTE TERRENO	
DIST. PARZIALI TERRENO	
QUOTE PROGETTO	
DIST. PARZIALI PROGETTO	
QUOTE FINITO	
DIST. PARZIALI FINITO	

The bottom of the interface shows a 'Command' line and a 'Reports' section with icons for 'Survey', 'Axis', 'Profile', 'Typical sections', 'Sections', 'Intersections', and 'Quantities'.

**Infra
BIM
OPEN**

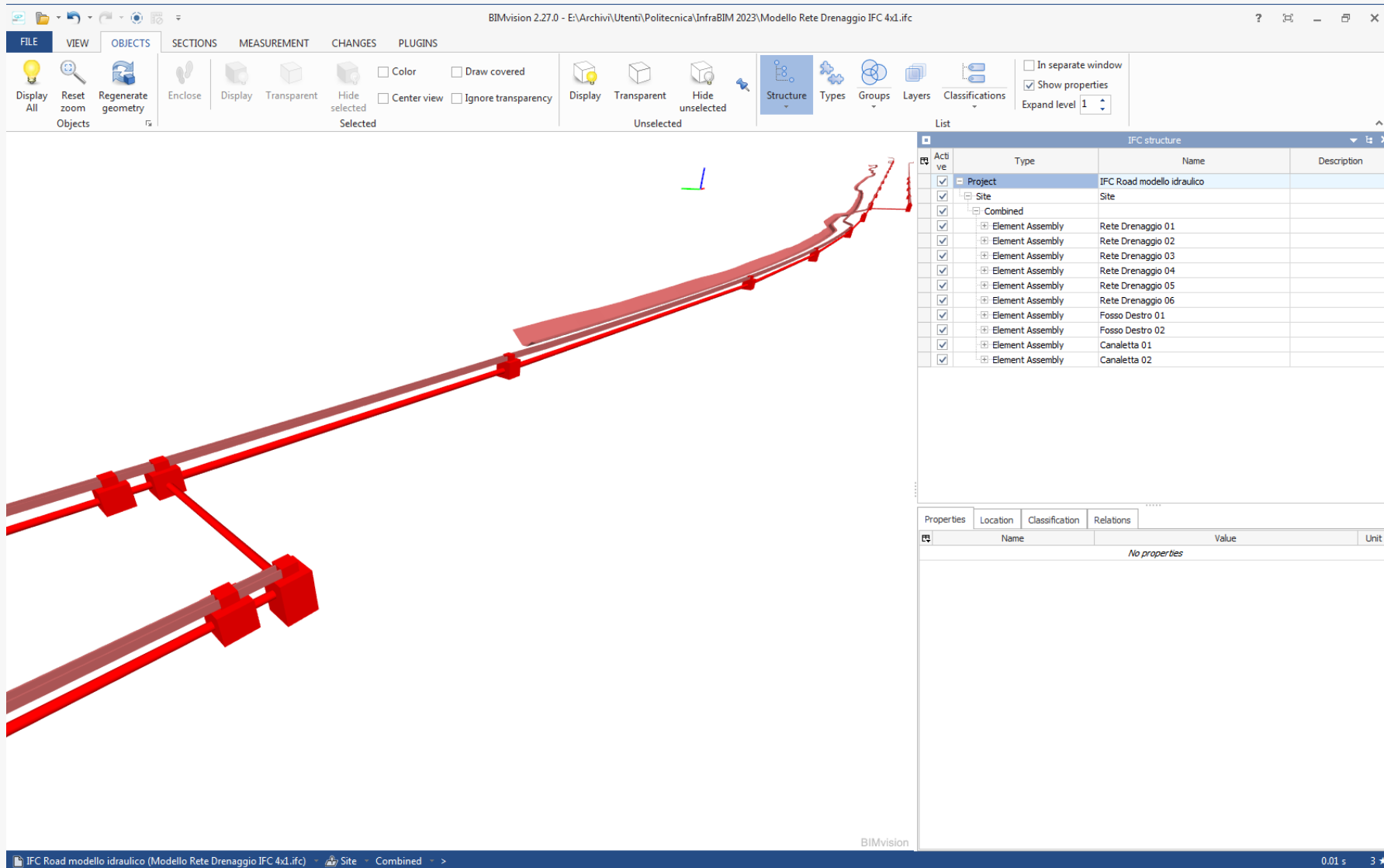
The drainage

Designed with SierraSoft Hydro

Shared drainage information model in IFC 2x3, IFC 4x1
and IFC4x3

Model by Davide Clauser - Systra SWS - buildingSMART Italy

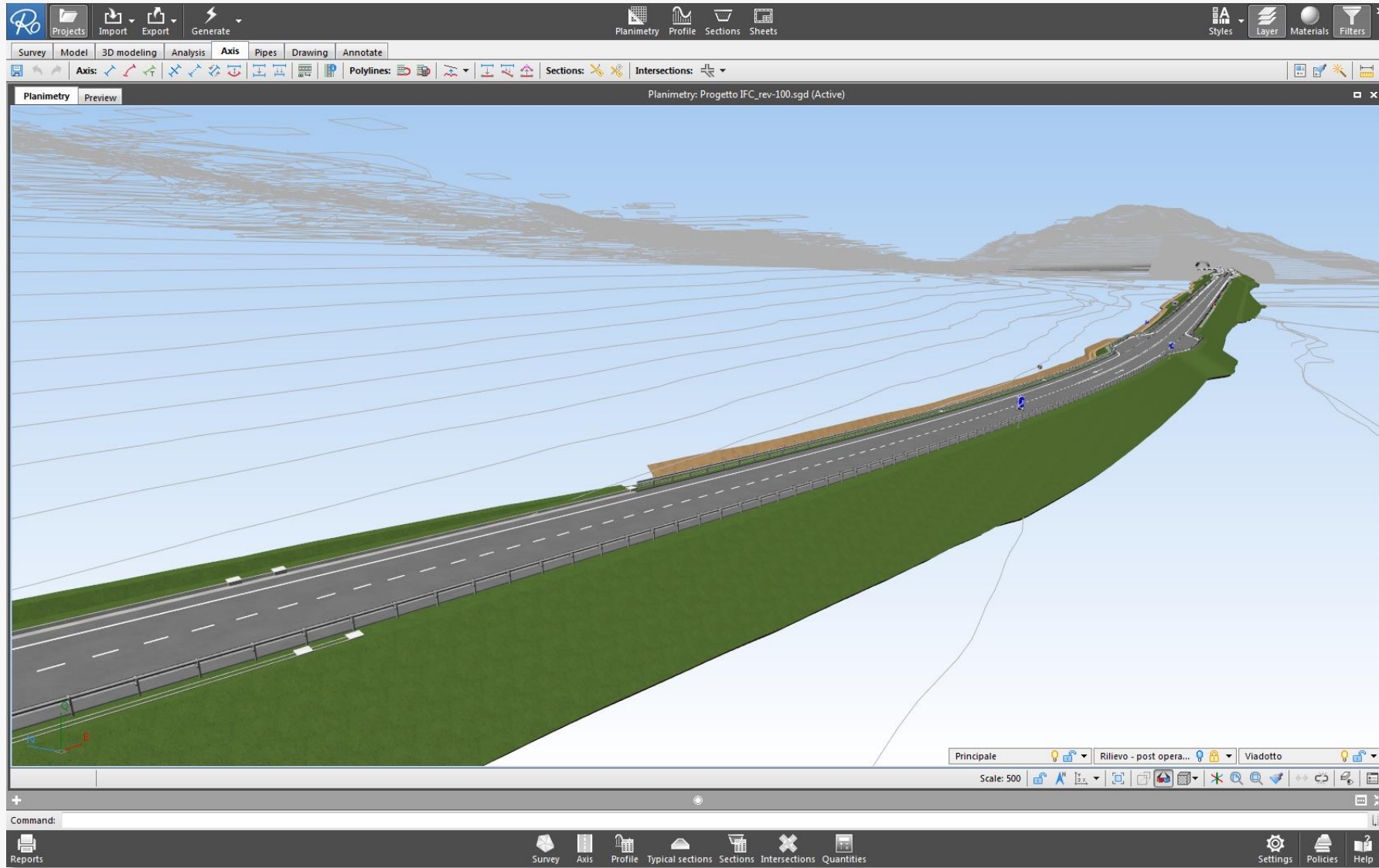
Drainage



The road designer sends the road information model to the hydraulic designer.

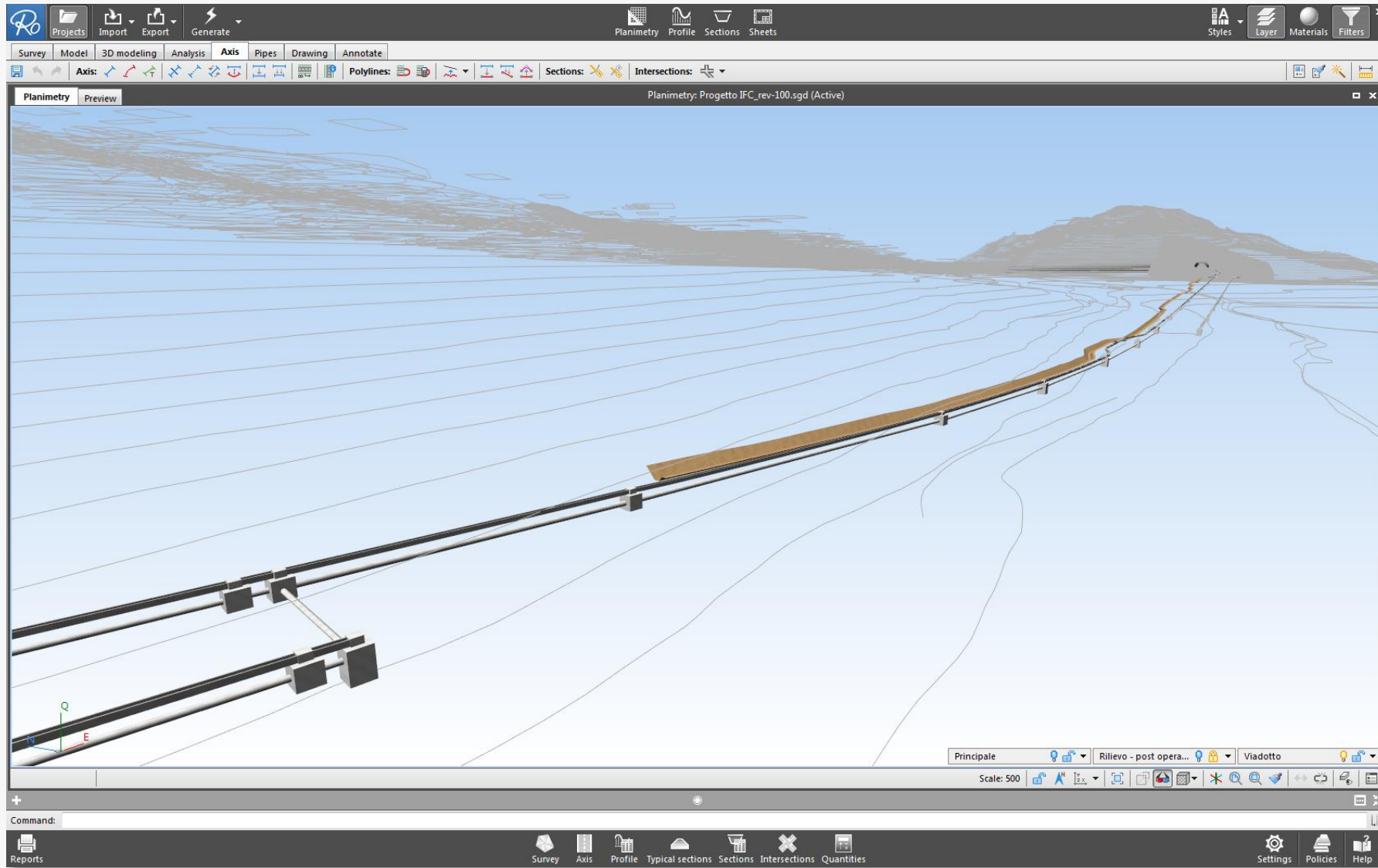
The hydraulic designer does the design and sends it back to road designer in IFC format, so that he can integrate it into the design.

Drainage



In SierraSoft Roads the drainage design is imported.

Drainage



The drainage information model becomes part of the project.

You can query the information model and get all the information you need.

The drainage information model becomes a support for road design.

Conclusions

Conclusions

The openBIM road design method used gives us:

- ✓ **High quality of information models**
Consistent with: the design approach and standard, detailed drawings and client's requirements.
- ✓ **Better and direct collaboration**
Exchange of information useful for co-design, analysis and construction.
- ✓ **Optimization of costs and resources**
Control of costs and time needed for design and modeling.
- ✓ **Improved design quality (in terms of geometry and data)**
Achieve higher quality design compared to traditional design.
- ✓ **Continuous flow of the BIM process**
Avoid loss of information and time-consuming tasks between design phases.

✓ **The advantages of BIM are all in the design phase**

Road design with information modeling adopting IFC 4x3



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Thank you very much for your attention

Road design with information modeling adopting IFC 4x3



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Please let us have any questions you may have