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BIM-LCA Construction Project

Case study report

UTCN CASE STUDY BIM models of a building structure and a road section carrying out a life cycle sustainability assessment of different materials and waste materials

Part 2

1 – Aims

This presentation provides a comprehensive analysis of how Building Information Modelling (BIM) works in road infrastructure projects. The presentation explores the history and basic principles of BIM, highlighting its benefits and potential for road infrastructure development. It discusses the use of BIM for road design, construction and maintenance, highlighting its role in improving collaboration, optimising project outcomes and supporting asset management. In addition, the presentation examines the specific features and capabilities of BIM in Civil Site Design software. It concludes by discussing the opportunities and challenges of implementing BIM in road infrastructure projects and provides insight into the future of BIM in the industry. Overall, this analysis outlines the transformative potential of BIM in revolutionizing road infrastructure development, ultimately leading to more sustainable and efficient transportation networks.

2 – Description of the case study

The

3 – State of the art use of BIM to assess the sustainability of a road desing

Building Information Modelling - BIM has emerged as a transformative technology in the construction industry, revolutionising the way projects are planned, designed, built and managed. Initially BIM was used in civil construction projects, but its application has expanded to the field of road infrastructure, offering several benefits for the design, construction and maintenance of transport networks.

BIM in road infrastructure enables stakeholders to use advanced digital tools and processes to enhance collaboration, improve design accuracy, streamline construction operations and optimise asset management. This presentation explores the potential and significance of BIM in road infrastructure, examining its history, defining its core principles, and delving into its far-reaching applications and benefits. By understanding the capabilities and benefits of BIM in road infrastructure, we can assess its potential to reshape the industry, improving project outcomes and contributing to more sustainable and efficient transport networks.

4 – Regulations and standards

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5 – Case study methodology.

Building Information Modelling - BIM has emerged as a transformative technology in the construction industry, revolutionising the way projects are planned, designed, built and managed. Initially BIM was used in civil construction projects, but its application has expanded to the field of road infrastructure, offering several benefits for the design, construction and maintenance of transport networks.

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reshape the industry, improving project outcomes and contributing to more sustainable and efficient transport networks.

The concept of Building Information Modelling (BIM) has been around since the 1970s, with the introduction of the first computer-aided design (CAD) systems, but it was not until the 1990s that the concept of BIM as we know it today began to take shape.

The development of BIM has been influenced by advances in computer technology, 3D modelling and collaborative tools. Over the years, BIM has evolved from a 3D modelling tool to a comprehensive process that integrates data, information, and workflows throughout the lifecycle of a construction project.

In the early 2000s, governments and industry organisations recognised the potential of BIM to improve the efficiency and productivity of the construction industry. As BIM has gained ground, industry standards and protocols have been developed to ensure interoperability and collaboration between different stakeholders.

The evolution of BIM has also been driven by technological advances such as cloud computing, mobile devices and artificial intelligence. These advances have facilitated real-time collaboration, improved data analysis capabilities and better accessibility to BIM models.

Today, BIM is recognised as a fundamental component of the digital transformation of the construction industry. It has become an integral part of project delivery, enabling stakeholders to create, analyse and manage digital representations of physical assets. BIM is not just limited to civil construction projects, but has expanded to include infrastructure projects such as roads, bridges and utilities.

At its core, BIM is guided by several fundamental principles that shape its methodology and implementation. The first principle of BIM is the creation of a common digital representation of a building throughout its lifecycle. This means that BIM encompasses not only the physical geometry of the building, but also the relevant data and information associated with its design, construction and operation.

The second principle is the collaborative nature of BIM, which encourages teams to work together in a coordinated way. BIM fosters collaboration through the exchange and integration of data and information between different stakeholders, enabling efficient decision-making and reducing errors or conflicts.

The third principle of BIM is the use of parametric modelling, which allows the creation of intelligent and dynamic objects that can be modified and updated throughout the project lifecycle. Parametric modelling allows changes to one aspect of the model to automatically update other related aspects, ensuring consistency and accuracy.

The fourth principle is the incorporation of data interoperability, ensuring that information can be exchanged and shared between different platforms and software systems. This enables the integration of different datasets and promotes efficient collaboration.

Finally, BIM emphasises the importance of information management and the use of structured data, allowing stakeholders to extract valuable information and make informed decisions based on reliable and up-to-date information. By adhering to these core principles, BIM enables stakeholders to optimise project outcomes, improve collaboration and increase the overall efficiency and effectiveness of the construction process. Figure 1 shows the BIM concept.

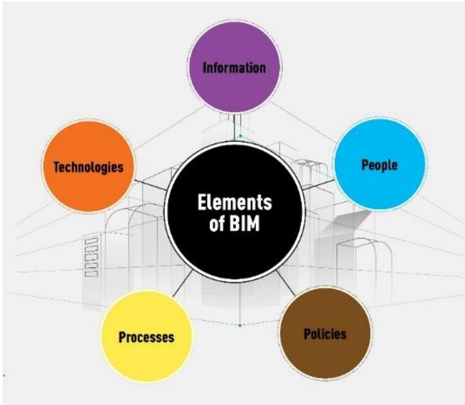

Figure 1 BIM concept

BIM offers a number of possibilities and advantages when applied to road infrastructure projects. One of the key possibilities is the ability to create accurate and detailed 3D models of road networks. These models can include alignments, curves, bridges, tunnels and other elements, providing a comprehensive digital representation of the entire infrastructure. With BIM, stakeholders can visualise the road project in a virtual environment, allowing them to assess project feasibility, identify potential conflicts and optimise the project before construction begins.

Another possibility of BIM for road infrastructure is the integration of different domains and data sources. BIM enables the exchange and integration of data from different sources such as topography, geotechnical analysis, utilities and environmental factors. By incorporating this data into the BIM model, stakeholders can gain understanding of the road project, leading to better informed decision making and better coordination between different teams.

BIM also offers opportunities to improve project collaboration and communication. With BIM, all stakeholders can access and contribute to a central, shared digital model, fostering effective collaboration and reducing information loss. This enables real-time communication, conflict detection and coordination between designers, engineers, contractors and other project participants. Improved collaboration can lead to reduced errors, better sequencing of construction and better overall project efficiency.

In addition, BIM opens up possibilities for simulation and analysis of road construction and maintenance processes. By incorporating time-based data into the BIM model, stakeholders can simulate construction sequences, analyse traffic flow and optimise construction schedules. This allows identification of potential bottlenecks, cost saving opportunities and efficient resource allocation.

BIM also has the potential to support asset management and maintenance throughout the lifecycle of road infrastructure. By integrating asset information into the BIM model, road owners and operators can access critical data such as maintenance schedules, asset condition and performance history. This facilitates proactive maintenance planning, enables predictive analytics, and supports informed decision making to maximize the life and efficiency of the road network.

6 – Development of the case study.

6.1 – BIM models.

Civil Site Design software, which incorporates Building Information Modelling (BIM) principles, offers a number of powerful features that enhance the design and analysis of civil engineering projects. One of the key features is the integration of intelligent objects and parametric modelling capabilities. Users can create and manipulate objects such as roads, alignments, surfaces and drainage systems. This enables dynamic design changes, where changes to an object automatically update related components, ensuring consistency throughout the design process (Figure 2).

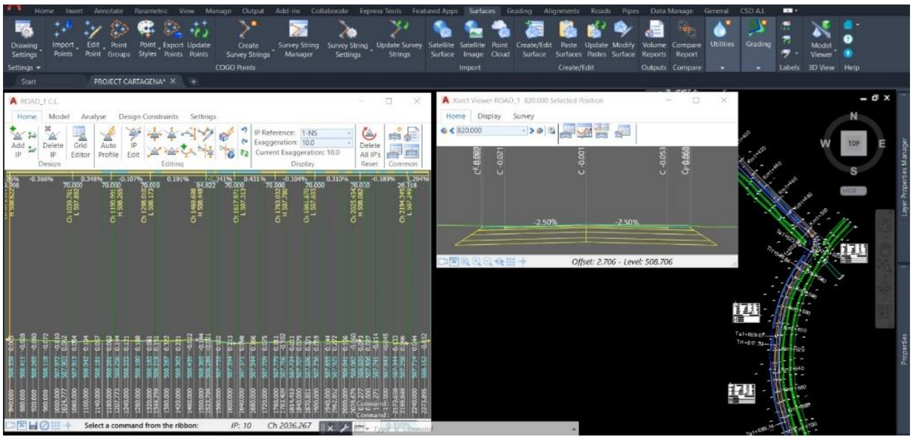

Figure 2

Another important feature of BIM in Civil Site Design software is the ability to generate full 3D models of the site (Figure 3). These models incorporate topographic data, terrain analysis, and engineering design elements, providing a visual representation of the project. With the 3D model, users can perform analyses such as earthwork calculations, excavation and fill estimates, visibility analysis, and visualize the impact of the project on the surrounding environment.

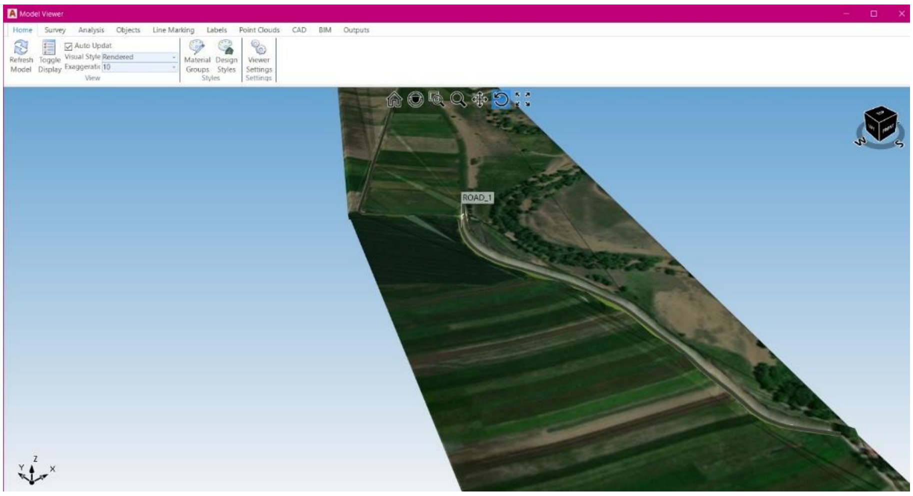

Figure 3

Civil Site Design also enables effective collaboration and coordination between project stakeholders. The software allows design data to be shared in a common data environment, facilitating collaboration between civil engineers, surveyors, architects and other professionals. This collaborative environment streamlines information sharing, reduces errors and conflicts, and improves communication throughout the project lifecycle.

In addition, the software provides advanced analysis tools for optimizing design decisions. For example, users can perform hydraulic analysis to assess stormwater runoff and determine the optimal size and location of drainage systems. In addition, BIM features in the software enable analysis of road alignments, allowing users to assess design suitability, analyse sight lines, and optimize roadway configuration for safety and efficiency.

Integration with geospatial data and surveying systems is another notable feature of BIM in Civil Site Design software. By incorporating data from geographic information systems (GIS), users can overlay site plans over existing topographic information, visualize project constraints, and incorporate site-specific data for more accurate design and analysis.

5.3 – Case study

The following case study involves the process of design of a road of category II using Civil Site Design. The aim of the study is to explore some main features of the software including BIM.

The design process starts with creating a surface using topographic points.

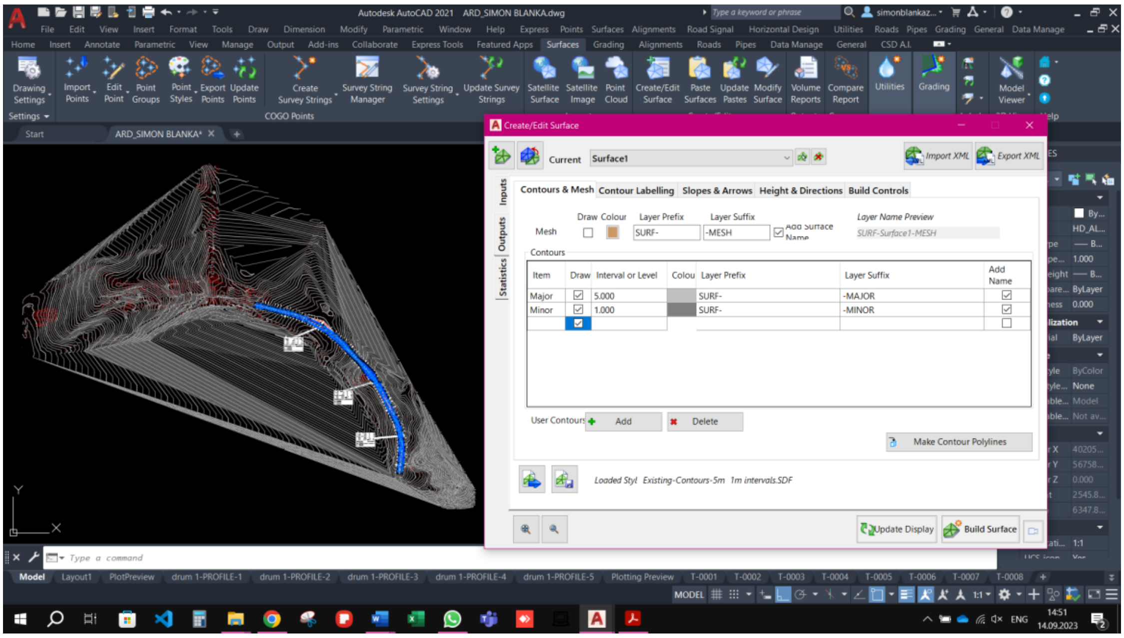

Figure 4

As soon as we have created the surface we can move on to create the alignment of the road. Once we created the alignment, the IPs are editable, we can set the radius of the curves. We can also add annotation and labels.

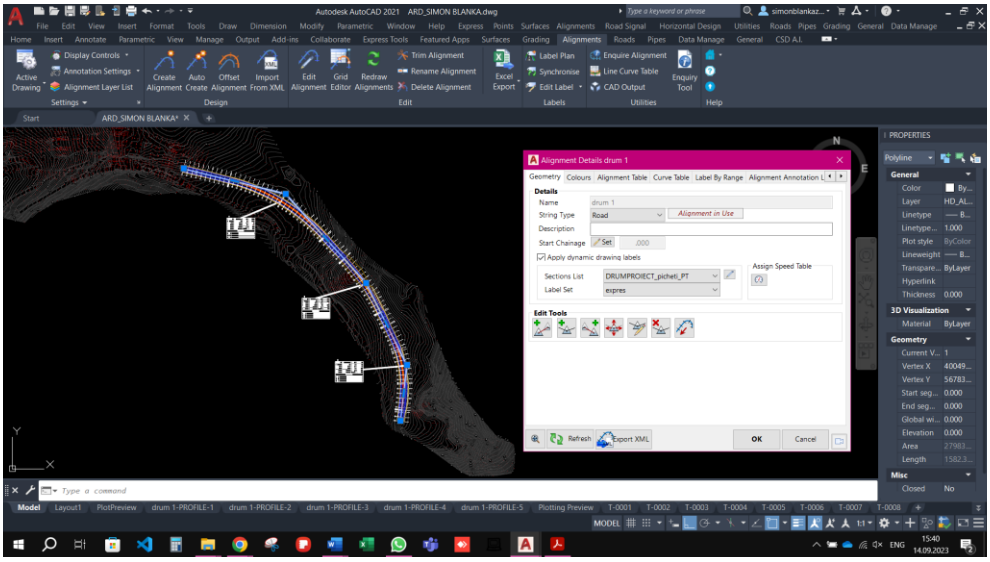

Figure 5

The software works with strings and codes. We can build the typical sections of the road than move on to designing the longitudinal and cross sections.

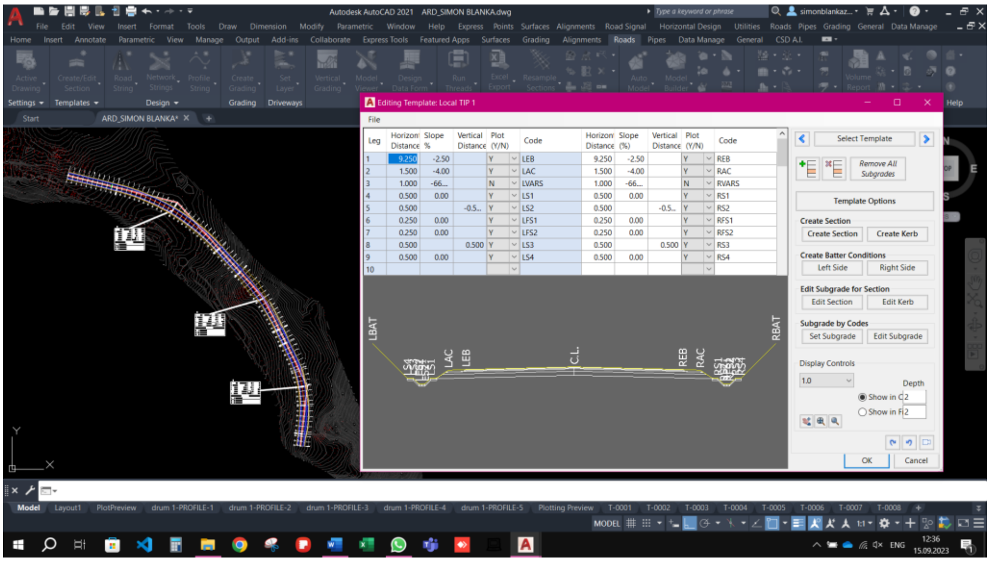

Figure 6

The main advantage of the software is that the user can easily follow the changes in all three views (plain view, longitudinal section, cross section). It is recommended to use multiple monitors when working with CSD.

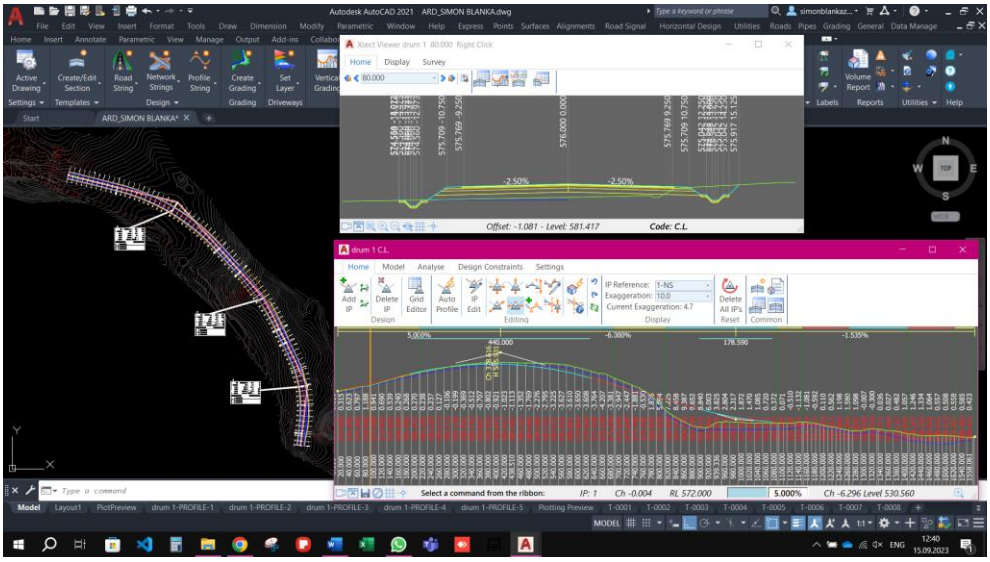

Figure 7

The software has a model viewer tab, which will generate the 3D model of the project using all the data given in the previos steps. Furthermore, the model regenerates itself if any modification is made. Basically, a forth view is introduced to the user.

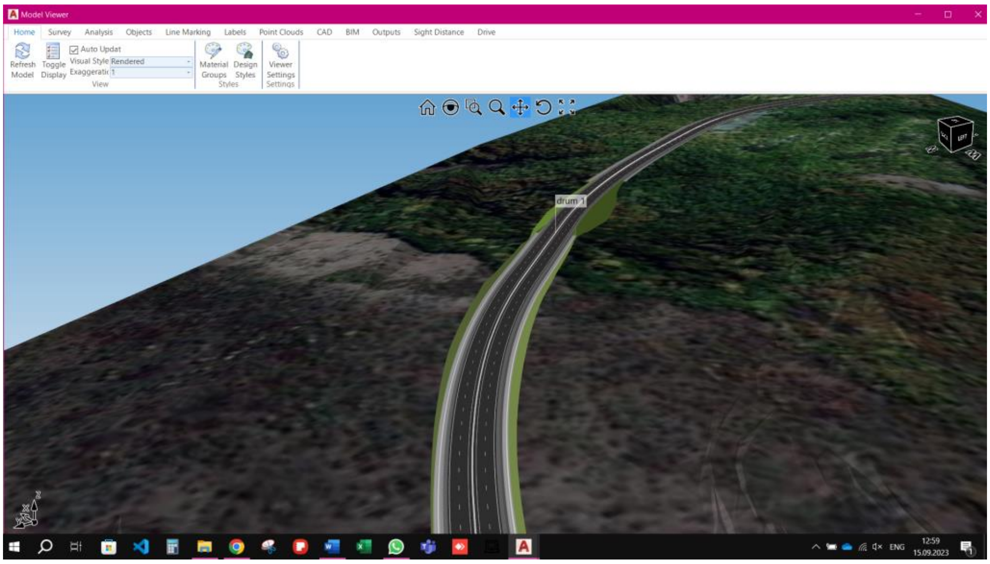

Figure 8

The model viewer tool allows us to see from the drivers viewpont. We can make sight distance analysis, based on which we can specify the lane markings and the road signs.

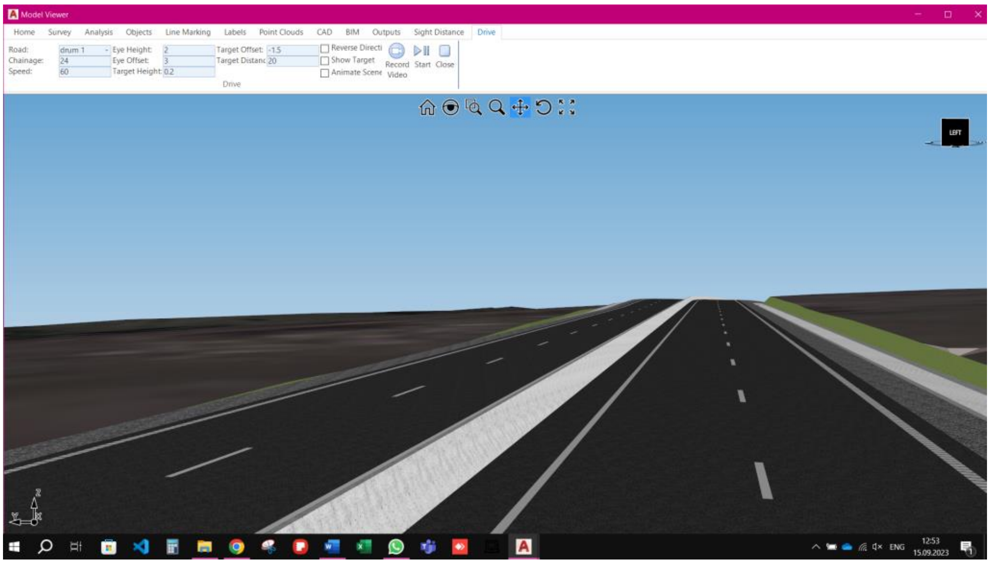

Figure 9

The software allows the user to import other CAD elements in the Model Viewer.

The BIM features of the software allows the user to create a BREP solid from the 3D model. The BREP method is used to represent 3D shapes by defining the limits of its volume. A solid is represented as a collection of connected surface elements, which define the boundary between interior and exterior points.

The Export IFC function allows users to output a Civil Site Design Model to an IFC file format (.IFC4) for interaction with other software packages and integration into BIM model environments.

A Loft is defined in the software as a 2D shape (closed polyline) extruded along a String, referencing a Code by offset and elevation. This is very useful for representing features such as guard rail, jersey barriers and other linear features.

Extrusions provides the ability to use a 2D polyline (closed or unclosed, with or without elevation) to create vertical extrusions. These are useful to create simple building shapes, fences, posts and other features.

The software creates and stores a collection of calculations and figures. Many of these items are able to be included in report and long section outputs. Reports can be generated as a text file, to a .csv format file or placed in AutoCAD as an AutoCAD table.

7 – Analysis of the different alternatives studied.

Three types of road structures were analysed: flexible, semi-rigid and rigid. The structures are composed of:

- Flexible structure:
  - 4 cm surface course of BA16
  - 5 cm binder course of BAD20
  - 8 cm base layer of AB31.5
  - 20 cm sub-base layer of crushed stone
  - 35 cm sub-grade layer of aggregate optimal mixture 0-63mm
- Semi-rigid structure:
  - 4 cm surface course of BA16
  - 5 cm binder course of BAD20
  - 8 cm base layer of AB31.5
  - 20 cm aggregates stabilized with hydraulic binder
  - 25 cm sub-grade layer of aggregate optimal mixture 0-63mm
- Rigid structure:
  - 24 cm concrete pavement of BcR4,5
  - 20 cm base layer of crushed stone
  - 35 cm sub-grade layer of aggregate optimal mixture 0-63mm

Volume reports can be generated using the software which helps udentifying the optimal structure.

Flexible structure	
Material	Volume (m^2)
BA16	1156.77
BAD20	1456.65
AB31.5	2355.35
crushed stone	6937.57
aggregate optimal mixture 0-63mm	12598.12
crushed stone road margin	747.87
C30/37	685.7
aggregate optimal mixture 0-63mm drainage	685.7
crushed stone road margin	747.87

Semi-rigid structure	
Material	Volume (m^2)
BA16	1156.77
BAD20	1456.65
AB31.5	2355.35
aggregates stabilized with hydraulic binder	6937.57
aggregate optimal mixture 0-63mm	8939.26
crushed stone road margin	747.87
C30/37	685.7
aggregate optimal mixture 0-63mm drainage	685.7

Rigid structure	
Material	Volume (m^2)
BcR4.5	6917.79
crushed stone	5764.83
aggregate optimal mixture 0-63mm	10088.45
crushed stone road margin	747.87
C30/37	685.7
aggregate optimal mixture 0-63mm drainage	685.7

Taking into consideration the prise difference betwen concrete and asphalt pavement as well as the comfort of travellers, the flexible road structure is more feaseble.

8 – Conclusions and recommendations.

In conclusion, BIM can change the field of road infrastructure projects. Adopting BIM in this sector offers a multitude of benefits, from improved design to streamlined construction operations and better asset management. By leveraging advanced digital tools and processes, stakeholders can use the full potential of BIM to optimise project outcomes, enhance collaboration and contribute to more sustainable and efficient transport networks.

By integrating different domains and creating detailed 3D models, BIM enables stakeholders to visualise road infrastructure projects in a virtual environment, facilitating better decision-making and reducing conflicts. The collaborative nature of BIM fosters effective communication and coordination between different teams, leading to reduced errors, improved construction sequencing and increased project efficiency. In addition, the ability to simulate and analyse road construction and maintenance processes enables stakeholders to optimise construction schedules, analyse traffic flow and improve resource allocation. However, the successful implementation of BIM in road infrastructure projects requires overcoming challenges such as the need for standardised protocols, interoperability between different software platforms and skills development among professionals. Looking ahead, the future of BIM in road infrastructure offers promising opportunities for innovation.