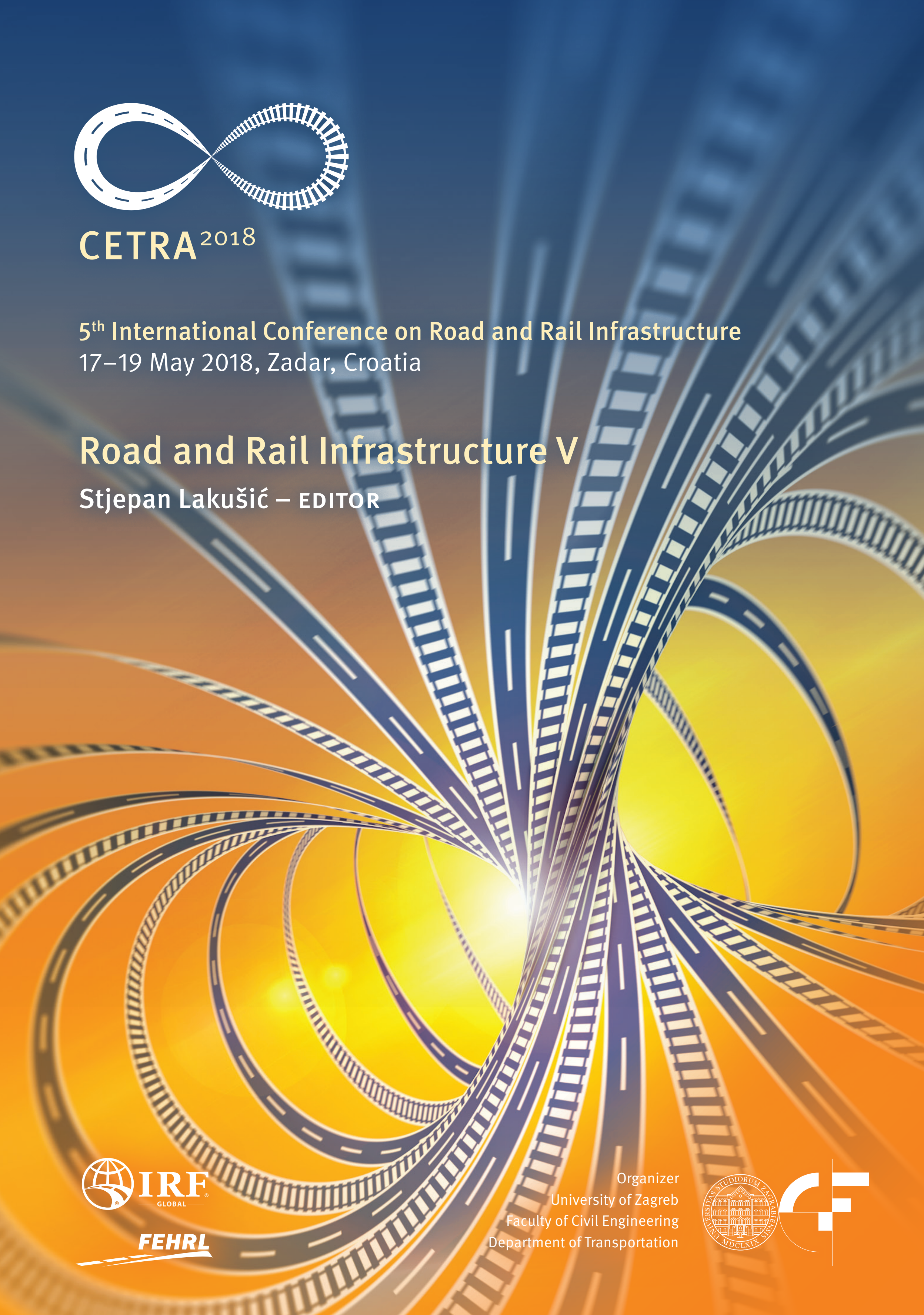
CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR



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BIM IN INFRASTRUCTURE

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Abstract

Paper lists modern approach of designing for infrastructure projects using BIM (Building Information Modelling) technologies. Constantly evolving and growing importance of BIM is expanding rapidly also in infrastructure projects, as it is almost standardly used in architecture. First part of paper is more or less theoretically oriented and presents some well-known facts about BIM. About BIM 3D, 4D and 5D which is important to design engineers and contractors. The theoretical part of paper is then illustrated also on a practical example – new state connecting road near town of Trebnje, Slovenia. With a range of few Autodesk and other software, the process of designing using some fields of BIM technologies is presented.

Keywords: Road infrastructure, Road dewatering, sewage, BIM in infrastructure BIM 3D, BIM 4D, BIM 5D, IFC.

1 Introduction

Talking about BIM is nothing new nowadays. We can also say that design teams (architects, landscape architects, surveyors, civil, structural and building services engineers, etc.) used "BIM" even before acronym BIM was globally recognised. By saying this I mean, even two-dimensional plans, which are result of design teams work, have information about dimensions, material used, special characteristic of materials, … Today the package of BIM has different formats and new 3D views and renders, which is result of ever-evolving and constantly growing capabilities of computers software. We can also say that BIM is a result of digitalisation of construction industry [1]. Hereinafter paper presents some theoretical facts about BIM, which will be presented in use on a specific example according to our company workflows and procedures in infrastructure projects.

2 About BIM

2.1 General

Let's focus firstly on question "What is BIM?" BIM stands for Building Information Modeling. BIM is an intelligent 3D model-based process that gives architecture, engineering and construction professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure [2]. According to US Nation Building Information Model Standards Project Committee definition of BIM is: Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.
Traditional building design was largely reliant upon two-dimensional technical drawings (plans, elevations, sections, etc.). Building information modeling (BIM) extends this beyond 3D, augmenting the three primary spatial dimensions (width, height and depth) with time as

the fourth dimension (4D) and cost as the fifth dimension (5D). BIM therefore covers more than just geometry. It also covers spatial relationships, light analysis, geographic information, and quantities and properties of building components (for example, manufacturers' details), any many more [3]. For the professionals involved in a project, BIM enables a virtual information model to be handed from the design team (architects, landscape architects, surveyors, civil, structural and building services engineers, etc.) to the main contractor and subcontractors and then on to the owner/operator; each professional adds discipline-specific data to the single shared model. This reduces information losses that traditionally occurred when a new team takes 'ownership' of the project, and provides more extensive information to owners of complex structures.

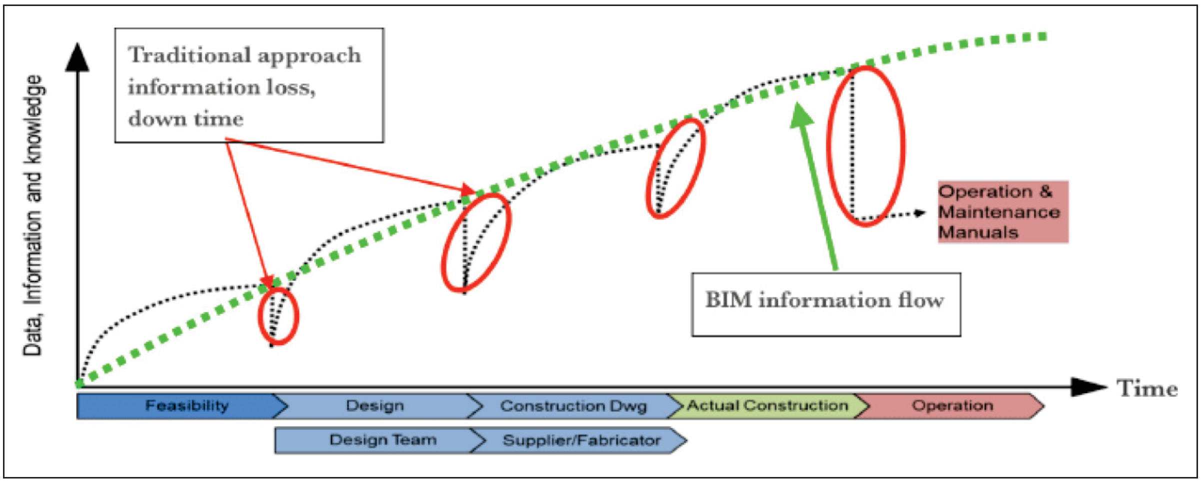

Figure 1 Information losses in comparison between traditional and BIM approach to the projects

Figure 1 represents information losses between different team 'ownership' of the project or different design phases of project (it could happen, that each design phase is prepared by different company). If information is transferred with BIM models, this reduces information losses in comparison to traditional transfer of plans, technical reports, analysis, etc.

2.2 The BIM maturity level

The BIM is gradually introduced in the construction industry. Each company can determine its degree of implementation using BIM maturity level. Figure 2 below describes the BIM maturity level in a best way [4].

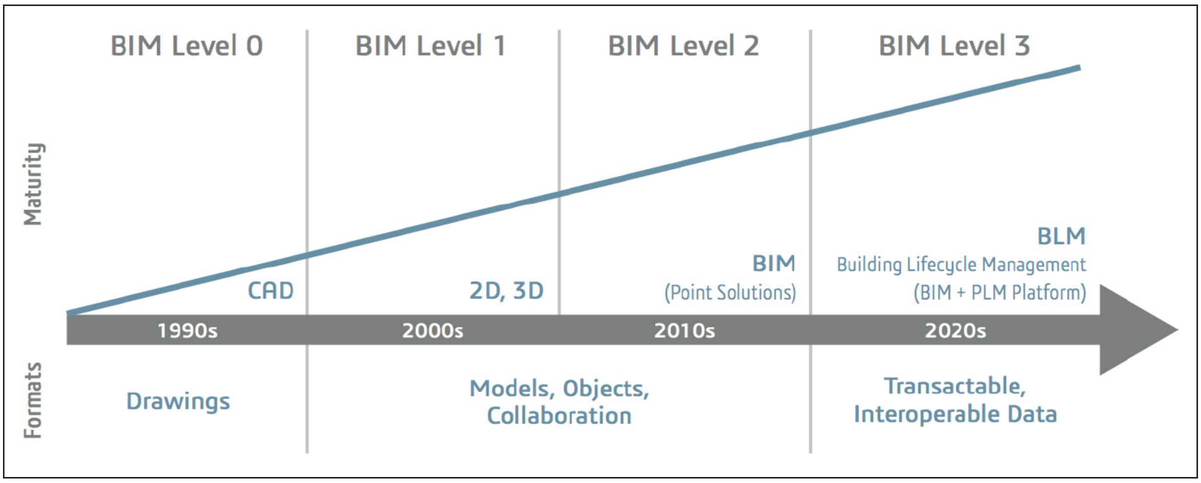

Figure 2 The BIM maturity level by Mark Bew and Mervyn Richards

2.2.1 BIM level 0

Unmanaged computer aided design (CAD) including 2D drawings, and text with the paper-based or electronic exchange of information but without common standards and processes. Essentially this is a digital drawing board [5].

2.2.2 BIM level 1

Managed CAD, with the increasing introduction of spatial coordination, standardised structures and formats as it moves towards BIM level 2. This may include 2D information and 3D information such as visualisations or concept development models. BIM Level 1 can be described as 'Lonely BIM' as models are not shared between project team members [5].

2.2.3 BIM level 2

Managed 3D environment with data attached, but created in separate discipline-based models. These separate models are assembled to form a federated model but do not lose their identity or integrity. Data may include construction sequencing (4D) and cost (5D) information. This is sometimes referred to as 'pBIM' (proprietary BIM) [5].

2.2.4 BIM level 3

A single collaborative, online, project model with construction sequencing (4D), cost (5D) and project life-cycle information (6D). This is sometimes referred to as 'iBIM' (integrated BIM) and is intended to deliver better business outcomes [5].

2.3 The benefits of BIM

Much has been written about the benefits of using BIM. My intention is not to write about specific Figures regarding benefits of using BIM in terms of reducing costs. Best way to describe benefits of using BIM is well known Patrick MacLeamy graphic which compares BIM with traditional workflow and shows ability to impact cost/performance and cost of design changes in different stages of project life-cycle, Figure 3.

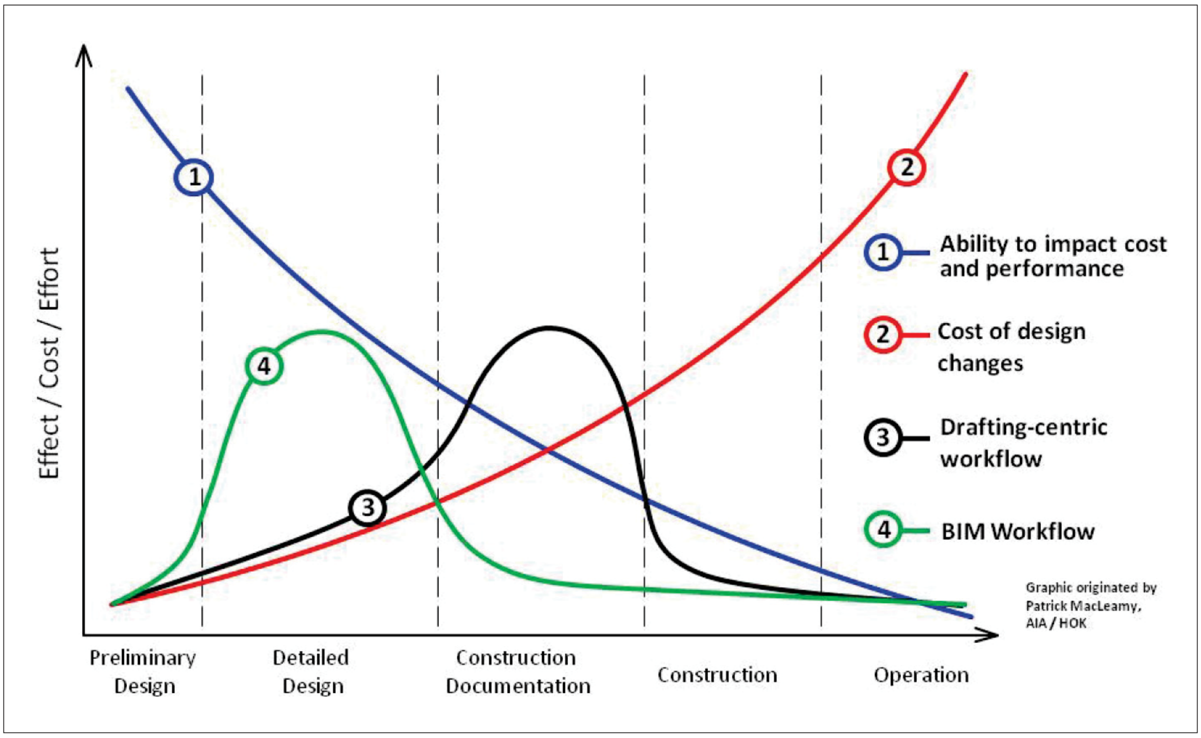

Figure 3 Patrick MacLeamy workflow comparison (The MacLeamy Curve [6])

2.4 3D BIM model

The preparation of a good 3D BIM model is the basis for further planning. It represents visualization and at the same time provides information about the object. Each element within a 3D model is described by parametric geometric properties and non-geometric properties. The geometric properties of an element cover the shape, size and position. The non-geometric properties include the identification number of the elements, descriptions, types of material, basic properties of the material, technology and others [7].

2.5 4D BIM model

The 4D BIM model is an upgrade of the 3D BIM model with a time dimension. In the design stage of the 3D BIM model development, individual elements are attributed according to building technology, which can be associated with building standards. Through the norms we calculate the necessary resources that are needed to carry out the work. After determining the total amount of resources that we will use during construction, we can calculate the times of individual activities and prepare a timetable for construction [7].

2.6 5D BIM model

In the 3D modeling phase, quantities for individual elements are obtained. For those individual elements time for execution is determined in the 4D modeling phase. In the 5D modeling, a cost component is added. Materials, workforce and mechanization are linked to the current price lists, and then, depending on the amount of material needed and the time needed for the implementation of one unit, we determine the prices of individual elements of the model, which together determine the value of the construction of the building [7].

3 Practical example

Hereinafter, some fields of BIM usage will be presented on a practical example. This is new state connecting road near town of Trebnje, Slovenia, Figure 4.

Figure 4 Location of new state connecting road near town of Trebnje, Slovenia

The practical example is based on road design. This was handed over to the designer of dewatering using IFC standard (Industry foundation Classes standard is open BIM standard owned by buildingSMART organization, https://www.buildingsmart.org/). According to IFC standard of road design, designer of dewatering designed sewage along the road, which serves to controlled dewatering of the road. Sewage was designed according to all information that was hanged over to it from road designer. Designer of dewatering then exported his design to IFC standard. The role of BIM Manager is then to made a federated BIM model and check all clashes and collisions between both designs.

3.1 Road design

Road design follows, more or less, in next steps:
- 2D alignment of road axis,
- Designing of longitudinal profile, which gives information about height to alignment of road axis,
- Assigning of one or multiple characteristic cross section to road alignment,
- Modeling of 3D pavement structure with cuts and embankments,
- Defining of attributes and assigning to each element within a 3D road model and
- Exporting an IFC model of road.

(All of this was made using programs referenced with numbers [8], [9])

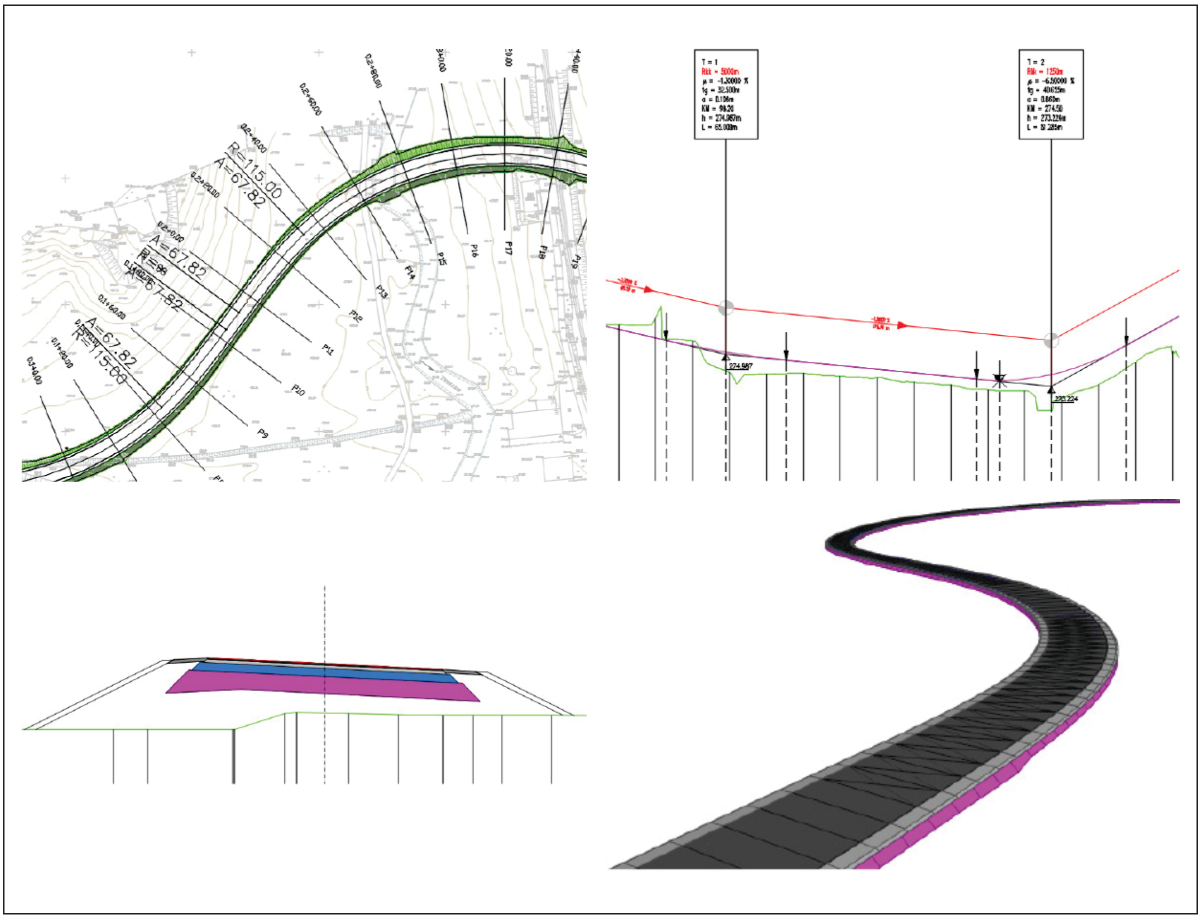

Figure 5 Cluster of Figures regarding steps of road design

3.2 Dewatering (sewage) design

Dewatering (sewage) design follows, more or less, in next steps:
- Receiving of road design,
- Planar layout of shafts and channels (2D sewage design),
- Longitudinal profile of sewage,
- Hydraulic dimensioning of pipe diameters,
- Defining of attributes and assigning to each element within a 3D sewage model and
- Exporting an IFC model of sewage.

(All of this was made using program referenced with number [10])

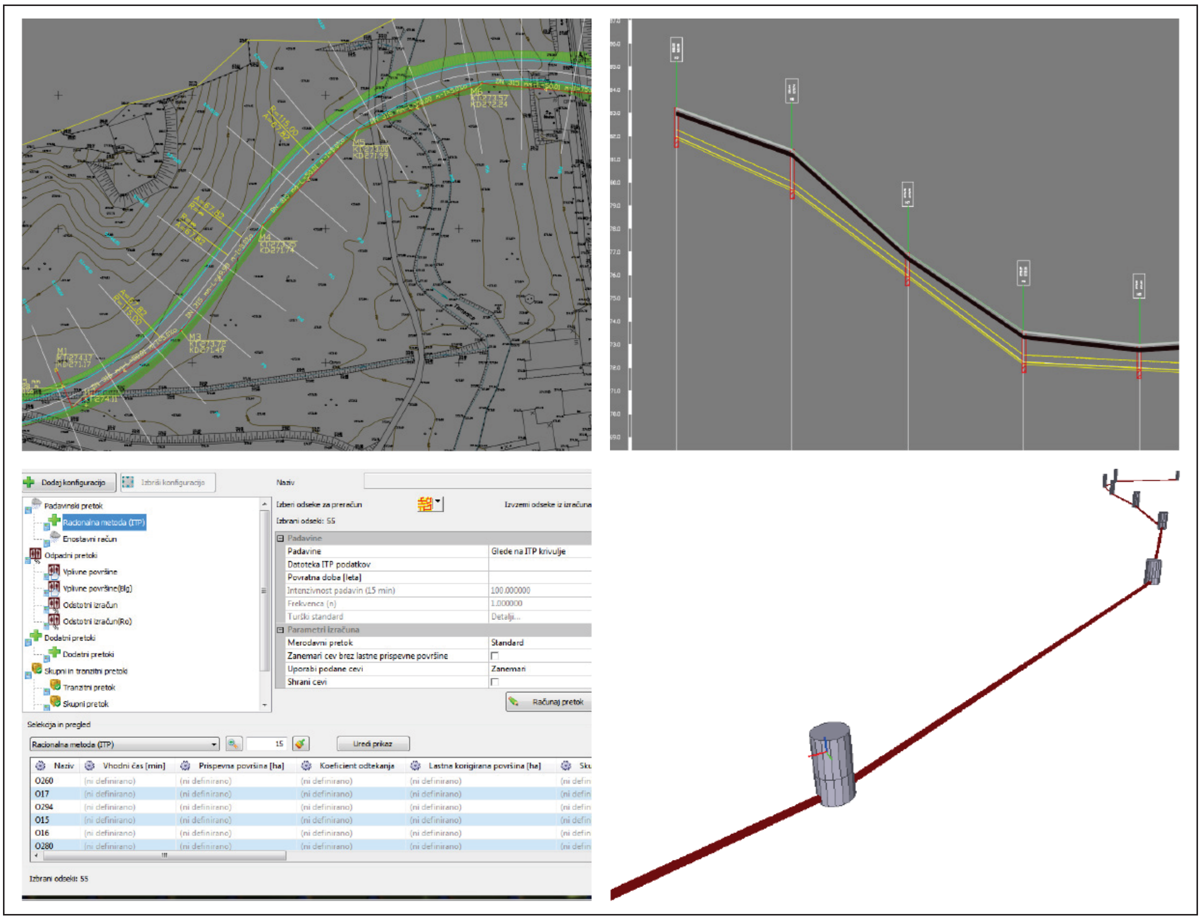

Figure 6 Cluster of Figures regarding steps of sewage design

3.3 Federated BIM model

When, in our case, both (road and sewage design) IFC model were generated the role of BIM Manager comes in front. It is his work to make a federated BIM model and check all possible conflicts and clashes between models. Not every conflict between pair of elements of a federated model is actual conflict. It is up to BIM Manager and his knowledge to confirm conflicts. All the conflicts are then assigned to individual designers, which should repair their models and send corrected IFC model back to another revision. If conflict is resolved, both, individual designer and BIM Manager has to accept this via special platforms that are used for BIM collaboration. There are many programs for BIM collaboration available on the marked. Here are just some of them listed. Autodesk BIM 360, Autodesk Navisworks, BIM Collab, BIM Track, Allplan Bimplus, …

4 Conclusion

The process of BIMs' evolving, growing importance and BIM usage is increasingly expanding also in all infrastructure projects (road, railway, sewage, bridges, water plants… designs). It is up to individuals or companies how fast they can adopt new way of designing, construction, maintenance… of newly designed infrastructure and all other projects dealing with the activities of the built environment. The practical example presented in a paper shows the process of BIM approach to designing of infrastructure projects. The example is very trivial. In the case of traditional approach to the designing of infrastructure projects, with federated IFC model uncovered clashes, may not be recognized. So, the final detailed design would not be correctly made and additional problems could occur during the construction.

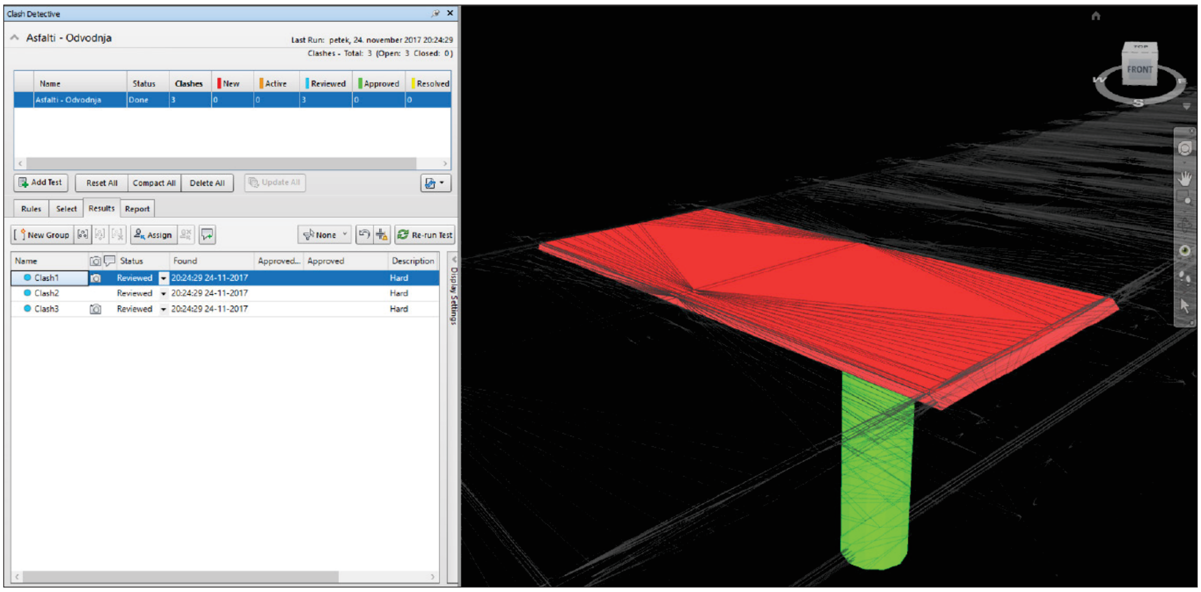

Figure 7 Clash detection and assignment [11]

References

[1] Turk, Ž. Personal communication, 17 May 2017, Professor in Construction Informatics at the Faculty of Civil and Geodetic Engineering at the University of Ljubljana, Slovenia.

[2] Autodesk BIM solutions, https://www.autodesk.com/solutions/bim, 12.03.2018.

[3] Building Information Modeling, https://en.wikipedia.org/wiki/Building_information_modeling, 12.03.2018.

[4] Svetina, G.: Uporaba BIM pri projektiranju ceste infrastrukture, Magistrsko delo, Ljubljana, pp. 3-25, 2017.

[5] BIM Maturity Level, https://thebimhub.com/2017/07/14/bim-maturity-level/, 13.03.2018

[6] The MacLeamy Curve, http://greghowes.blogspot.si/2012/06/macleamy-curve-real-world-bim-and-ipd.html

[7] Pirc, A.: Celostno informacijsko modeliranje projekta za izgradnjo kanalizacijskega Sistema v Krškem, Magistrsko delo, Maribor, pp. 14-26, 2017.

[8] CGS Labs, Plateia 2017, https://www.cgs-labs.si/, 11.03.2018

[9] Autodesk, AutoCAD Civil 3D 2018, https://www.autodesk.com/products/autocad-civil-3d/overview, 11.03.2018

[10] Studioars, Urbano Software Family 9.1, http://www.studioars.com/en/urbano_software_family/34/2, 11.03.2018

[11] Autodesk, Navisworks Manage 2018, https://www.autodesk.com/products/navisworks/overview, 11.03.2018