

# MEP COORDINATION AND CLASH MANAGEMENT IN BIM AND COMMON DATA ENVIRONMENT

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## PROFESSIONAL/PRACTICAL ARTICLE

### ABSTRACT

The coordination of Mechanical, Electrical and Plumbing (MEP) disciplines is one of the most important tasks of architects and engineers in any project. However, coordination using 2D drawing documentation is insufficient, as only clashes that are on main routes or easily visible on floorplans are removed in this way. Because of this, it is necessary to remove a lot of clashes later – on construction sites, which causes delays and increases the cost of construction. By using Building Information Modeling and Common Data Environment tools, the clash management process and overall MEP coordination is much more efficient, resulting in higher quality projects. The article describes the basic principles of Building Information Modeling of MEP and its coordination, as well as collision management based on BIM Collaboration Format (BCF) and CDE principles.

**Key words:** MEP, BIM, CDE, BCF, clash detection, clash management,

## 1 INTRODUCTION

Building Information Modeling (BIM) is the process of developing and using a virtual data model that not only documents the architectural design, but also simulates the construction and operation of a new or renovated building. The resulting virtual model is a data-rich, object-oriented, intelligent, and parametric digital representation of the object, from which information corresponding to various user needs can be obtained and analyzed to create feedback and improve the design of the object. It is therefore a suitable tool for demonstrating the complete life cycle of a building.

In the construction industry, BIM causes a fundamental change, which by efficient handling of information contributes to a higher quality project, saving construction time, supports a more precise construction process, easier control and, above all, contributes to the reduction of operating costs. We also assume that when using a virtual model, it is possible to automate the control of constructions in terms of their dimensions and position. [1, 2, 3, 4, 5, 6]

In BIM designing software, user creates intelligent, and parametric elements such as walls, windows, pipes, ducts, etc. Based on the regular annual research of BIM association Slovakia [7, 8], approximately 29% of respondents from Slovak architecture and engineering companies already use BIM. There is still relatively large shortage of MEP engineers that use BIM, but the number of them is increasing annually. [7, 8]

However, the BIM implementation brings several changes to the overall design workflow. Composition of the work team is different, as well as the time in which individual participants enter the process. On the one hand BIM helps to reduce some inefficient tasks, on the other hand creates new ones that need

to be solved by new experts like BIM managers and coordinators and by usage of a new tools by the whole team. [4]

### 1.1 MEP Modeling in BIM

The process of creating MEP geometry in BIM is a bit more complicated than in 2D CAD, because the engineer must solve the positioning of the elements (pipes, ducts, fittings, etc.) in more detail as it was used to in 2D. For example several pipes that are in the same X, Y location, but in different elevations is represented on the floorplan just as separate lines that are next to each other – easily done in 2D. In BIM, the engineer firstly creates the 1:1 representation of the element, after that he creates the drawings. So already during the modeling, he must think about the positions, fittings, and other details of the design. These limitations were usually solved on the construction site, which resulted into mistakes, delays and low quality. So despite the potential longer modeling, the MEP design in BIM is in better quality and shortens the time needed for design changes and quantity take-offs.

Currently, there are several software on the market that allow designing MEP in a BIM environment. Among the most common are e.g. Autodesk Revit, Graphisoft MEP Modeler, ACCA software Edificius MEP and others. [9, 10, 11]

Designers also have several online object libraries at their disposal, thanks to which they can download individual elements from specific manufacturers into their software. Individual product BIM libraries differ from each other in terms of geometric and informational details. [12, 13] Based on the recommendations of experts, the most appropriate way is to create your own object libraries with simple detail (LOD 200 to 300 - according to the specification by AIA and BIMforum [14, 15], because this can significantly reduce the size of the BIM model file. A common beginner mistake is a very detailed geometric representation of individual elements, which results in a significant slowdown of the software and reduced work efficiency. In addition, modeling elements in high detail is relatively time-consuming and can only be used for detailed photo-realistic visualizations [3, 4].

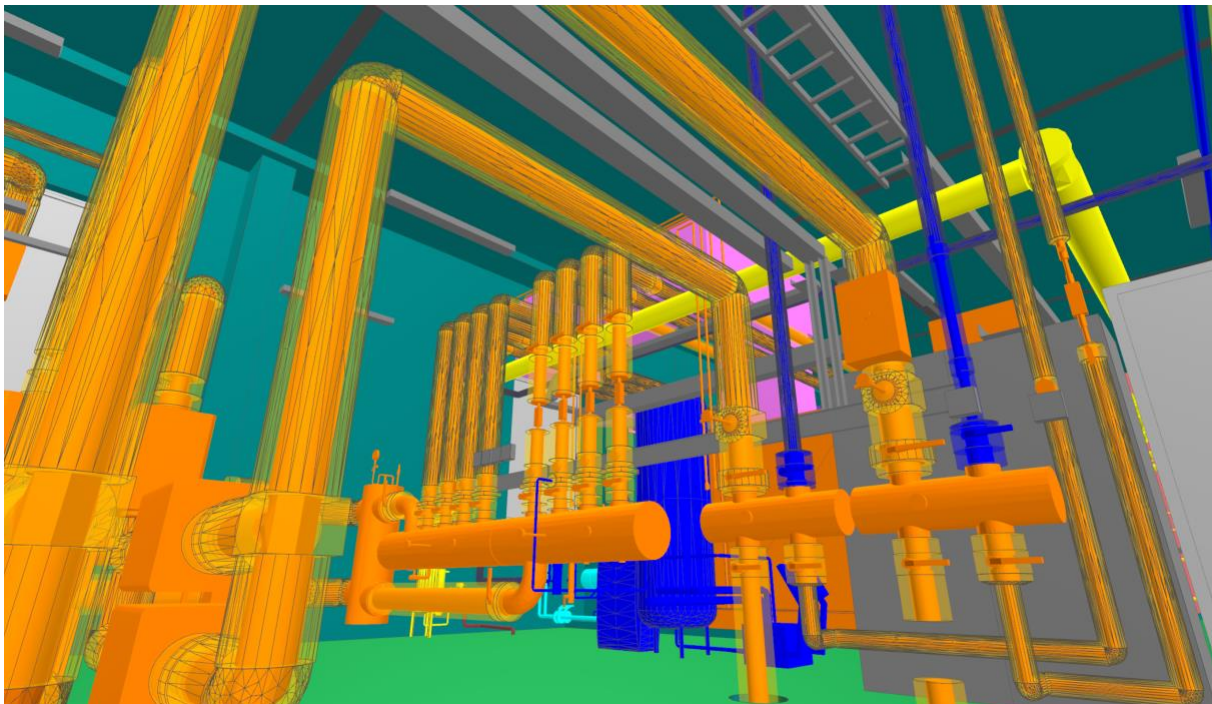


Fig. 1 MEP design (heating, water, electricity and gas) in BIM

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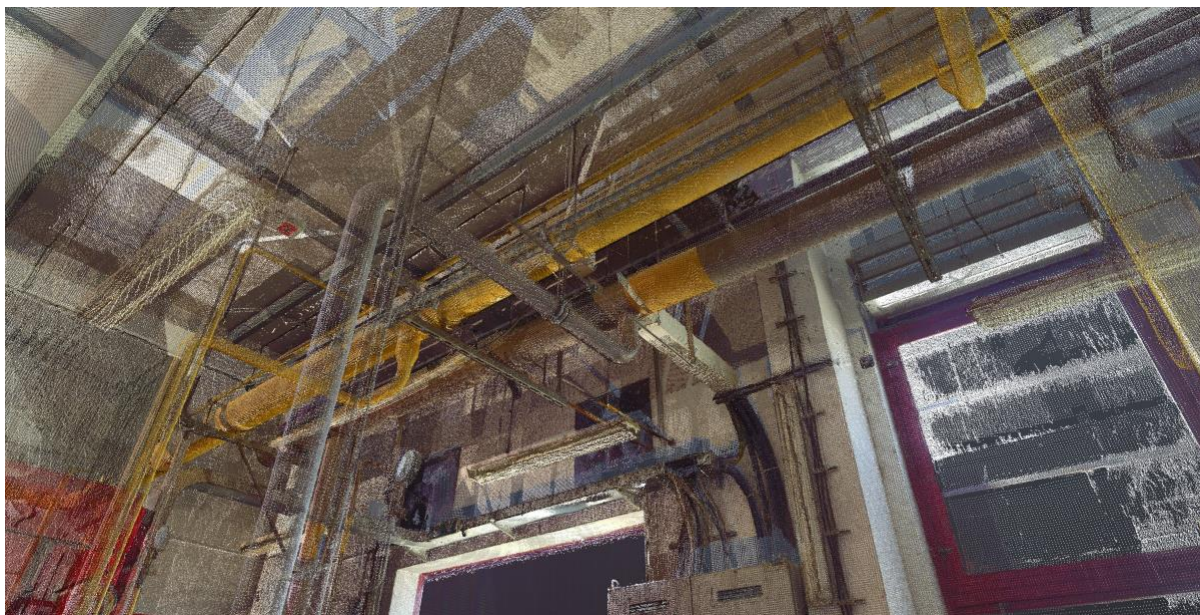
Another topic is the creation of drawings from the BIM model. BIM designing software enables this activity, but as it was common in CAD software, it is necessary to create your own types of marks, hatches, lines, etc.

Thanks to the fact that the elements in the BIM model contain technical information, many marks and descriptions needed on the drawing do not need to be entered in duplicate, but the information is transported to the description directly from the relevant parameter. Other activities, such as automatic dimensioning, automatic design of routes, semi-automatic design of hangers, or quantity take-offs of individual elements is possible by using add-ins and plug-ins - e.g., MagiCAD. [16]

## 1.2 MEP modeling in BIM from pointclouds

Some of the existing assets were digitized by using scan-to-BIM workflow. Firstly, the pointcloud from data collected and processed by terrestrial laser scanning is created. There are several options of how to collect the data, how to process them and how to export them to required state. The pointcloud can be black and white, or colored, the quantity of the points can be higher or lower, depending on the need of the client (usually architect, or engineer).

If the pointcloud is used for Building Information Modeling of MEP elements, it is recommended to use higher density of pointclouds (especially where are important details or many elements) and make more scanning positions. Often, the pipes and ducts are very close to each other and is not possible to register enough points from every element just from one position and one angle. However, too much density increases the file size, which slows down the work with the model. Sometimes, the files containing pointclouds are too big to be processed, or even to be opened in BIM software.



**Fig. 2 Pointcloud that contains several MEP elements (author)**

Secondly, the pointcloud must be imported into BIM design software, where the process of modeling starts. The points are used as the reference points when creating start and end position of the elements (such as pipes, ducts, etc.). When the pointcloud is colored, it is much easier for the modeler to distinguish the one element from another. It is also helpful, when the pointcloud contains the 360° photos, because some details can be recognized only from the photos. In the assets, where there are many MEP elements in one



location (such as on the Fig. 1) is scan-to-BIM the most suitable workflow to create the high-quality digital copy (or twin) of the real in-situ elements. [3, 17]

## 2 MEP COORDINATION IN BIM

### 2.1 Coordination of MEP in 2D, then in BIM

There are currently several approaches to the issue of coordination of MEP disciplines. Some coordinators prefer coordination in the form of regular checks of 2D drawings, where the main routes and corridors in which the respective professions must stick can be specified and designed at the beginning of the project. Subsequently, clash detections of BIM models are carried out and they are removed by various procedures. [3, 4]

### 2.2 Coordination of MEP in BIM

Another approach is regular clash detection of BIM models, their evaluation, coordination and sharing to responsible engineer. This process is very effective in achieving a high-quality BIM model, but also time-consuming, because it is necessary to evaluate individual clashes in 3D space. Paradoxically, finding out where in the model is the clash located, from where, to where the pipeline passes and what are the surrounding structures and what purpose they have is not that easy in 3D environment of some clash detection software.

Sometimes it is easier and more efficient to solve some main clashes in 2D floorplan (e.g., main routes). However, the correct BIM workflow is that the model is created firstly, and drawings are created afterwards, so this method of coordination is the only possible and suitable one for regular checks of BIM models of MEP disciplines until a certain stage of the project. [3, 4]

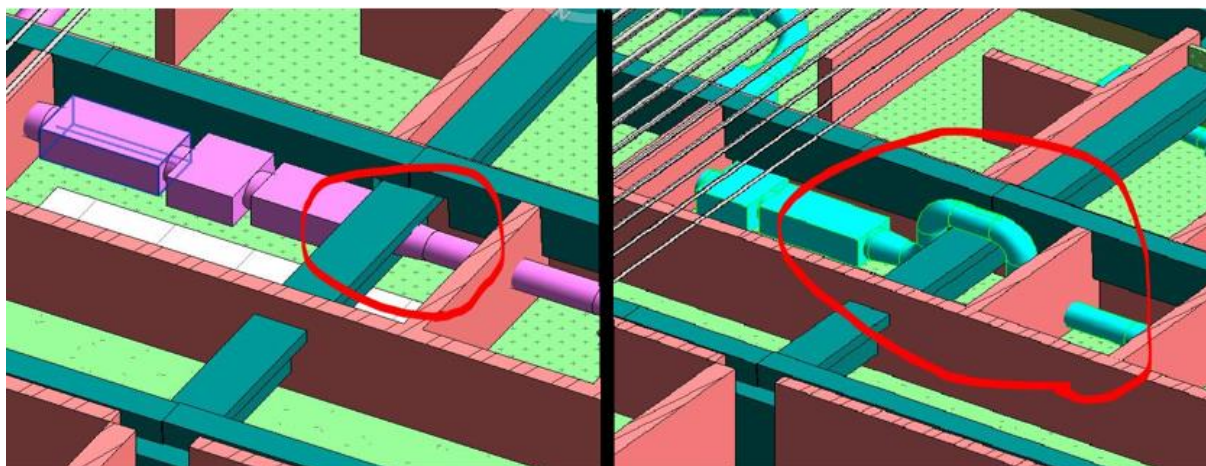


Fig. 3 Clash and its solution in BIM designing software (author)

### 2.3 Coordination of MEP in 2D and in BIM

It is most appropriate to combine the mentioned methods. At the beginning of the project, it is recommended to establish rules, main routes, and corridors for individual MEP disciplines. It is even more appropriate to model these routes and corridors in BIM and solve possible clashes in 2D and 3D views. During the project evaluation it is appropriate to make regular clash detections and solve the clashes in 3D. In final stages could be coordination in 2D also effective for some clashes - moving one main route

of ducts visible in the drawing can solve dozens of collisions found in the BIM model, that need to be checked, processed, shared and solved. [3, 4]

## 2.4 Team members responsible for coordination

Already in the initial phase of the investment plan, it is necessary to define the method of preparation of project documentation. All BIM requirements, such as the graphical and non-graphical detail of the elements, method of submitting project files, responsibility matrix, etc. must be specified in the document called Exchange Information Requirements. [18, 19]

The BIM manager is responsible for meeting the requirements. His competence is continuous supervision of modeling works and in certain cases he can be responsible for sharing some clashes. However, he is not the person responsible for the coordination of all disciplines and sharing all clashes, so this is the task for a responsible architect or engineer in the team. [3, 4]

## 3 CLASH SHARING AND SOLVING

The process of sharing clash results to architects, structural engineers and several MEP engineers is an activity that can be implemented in various forms. Few clashes can be communicated in person, by phone or by email and solved very quickly. For dozens of collisions, export of a table containing a list of collisions with their coordinates in 3D and a description of what structures and elements are involved is a common method. Sometimes, for better understanding of the position is good to attach a picture of the clash and draw a solution into it (something like is on the Fig. 3).

However, if there are more clashes, it is very time consuming to create the list of clashes and to search them in the model. That is why, this workflow is not very popular and is hard to implement in the companies. [3, 4]

### 3.1 Clash sharing and solving by using BCF and CDE

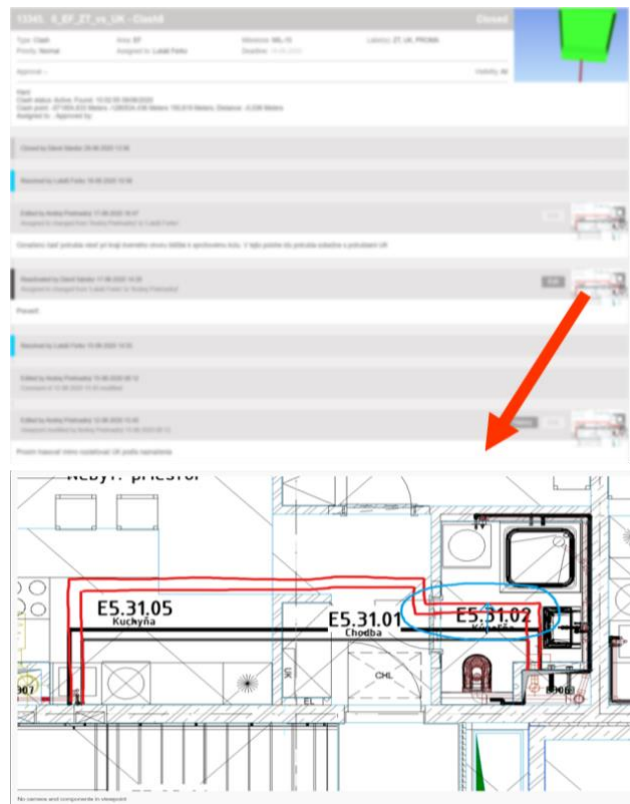
On larger projects, where it is necessary to distribute hundreds and thousands of clashes and issues between several project participants, it is the most suitable to use clash management software with an option to share the clashes in Common Data Environment. The process of clash detection consists of:

1. creation of federated models from individual models
2. set up the rules of clash tests (between the models, or between the groups of elements)
3. make a clash detection
4. evaluate the results
5. share the results in a BCF format
6. receive the models with solved clashes
7. make another clash detection to check if the clashes were solved

The BIM Collaboration Format (BCF) is open BIM format that contains information about the clash or issue: coordinates, snapshot of the clash and description about the elements in a collision, time of creating the issue, etc. The BCF is possible to export from a BIM clash detection software and import it to another BIM software, however, the communication about the issue (e.g. comments, edit of the screenshot, etc.) is made offline, so other participants can only see it after another export and import of the file. [20, 21]

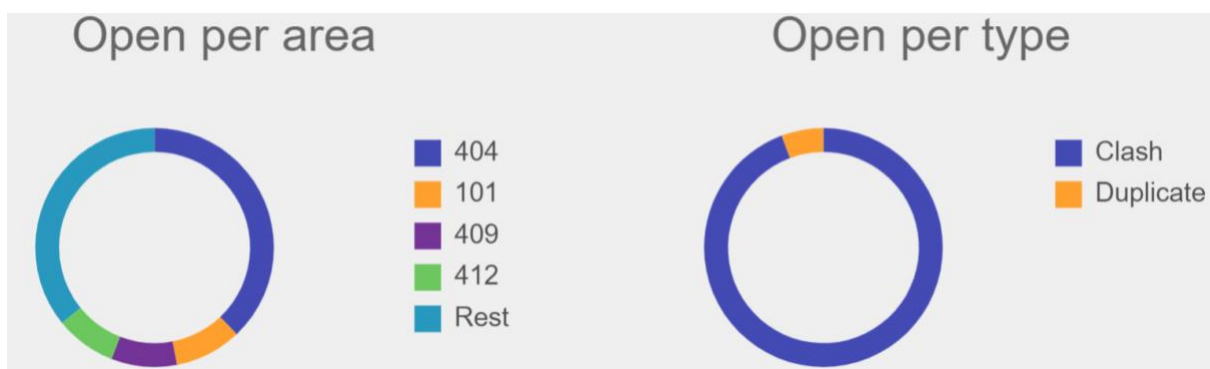
The more sophisticated way of sharing the results is by using BIMcollab Cloud platform and BIMcollab BCF manager plugins. BIMcollab Cloud is a CDE platform based on the BCF. The results can be <http://doi.org/10.51704/cjce.2022.vol8.iss2.pp54-63>

distributed in a bulk on the cloud and assigned to competent persons which should solve the clashes. The receivers can see the clashes and issues on the cloud platform or in their software – in BCF manager plugin. [22, 23]



**Fig. 4 Communication about the clash in the BCF manager plugin in the BIM design software (author)**

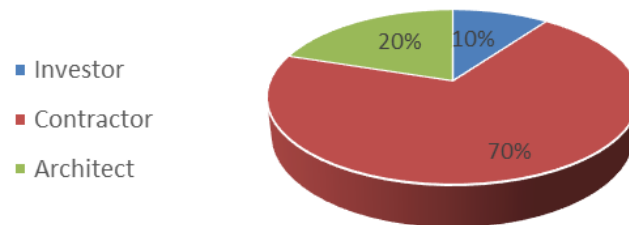
After the clicking on the issue in the BCF manager, the software zooms in and focus only on the two elements that are in the clash, so the user does not have to find them. After solving the clash, the user changes the status of the clash to solved and synchronized it back to the cloud. Collaboration over the clash is online, so it can be solved much more efficiently, as just using only the BCF in offline workflow. User can also add some comments, draw into the snapshot, or assign it to another project participant. It is recommended to perform collision detection periodically (e.g., every month) and usually there are several thousands of clashes found, so the most efficient way to share and solve them is by using mentioned workflow. [23, 24, 25, 26]



**Fig. 5 Graphs with data about the clashes in BIMcollab Cloud platform (author)**

### 3.2 MEP coordination – collaboration of the design team with the construction site

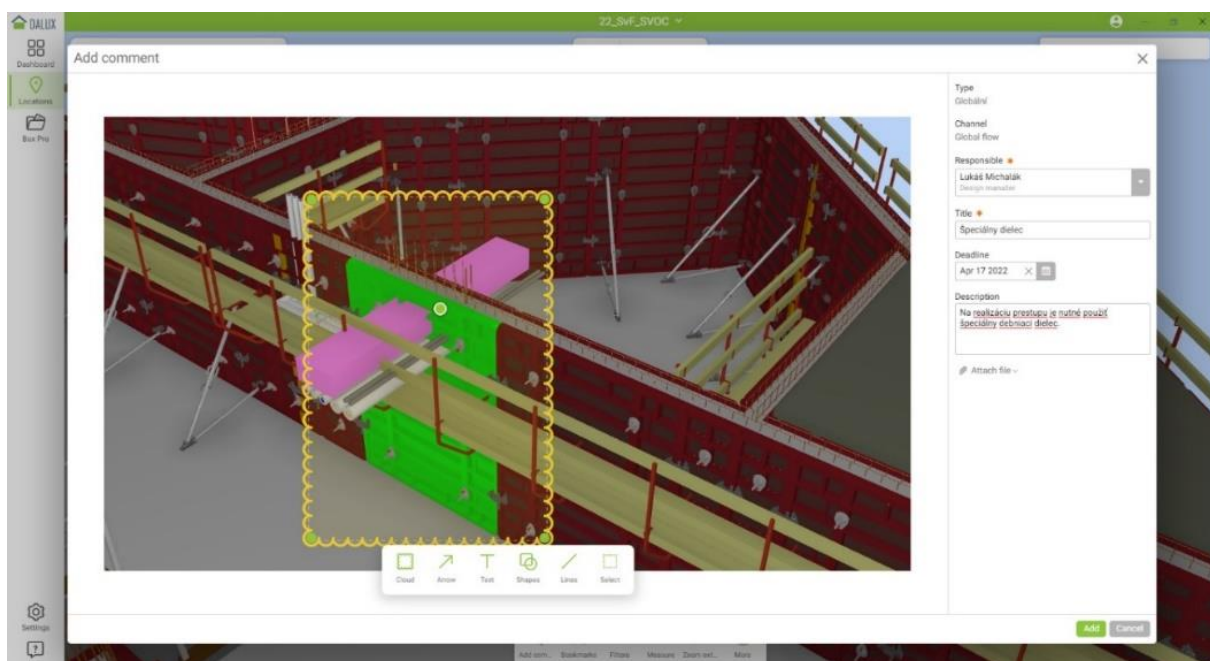
The importance of the clash detection will usually show on the construction site. Based on the data from the questionnaire by [27] it can be concluded that in today's practice, openings in the load-bearing structures are additionally made on every construction site. The expenses of these processes cost several thousand euros and the overall construction process may be delayed.



**Fig. 6 Graphic representation of the financial coverage of additional works [27]**

The Fig. 6 shows, that in 70% of cases, the costs are covered by the construction contractor. Only in 10% of cases the expenses are reimbursed by the investor. The data confirms the claims that by allocating more capital to the design phase, it is possible to save money in the construction phase. [27]

With the constant increase in the demand for a lower construction price and the search for optimization of the overall project costs and the time of the construction, it is necessary to proactively prevent the occurrence of clashes. On the construction site, these errors arising from the imperfection of the project and many times due to the absence of the third dimension, can grow to thousands of Euros and to a time delay.



**Fig. 7 Issue creation in a CDE Dalux [27]**

In the construction phase, it is also recommended to use the CDE software, which serves as a transfer point and viewer of BIM models and drawings. The CDE application is also used as a communication channel where comments can be added to the model elements or to the drawings. Contractors often collaborate in construction preparation process with a designer or with a sub-contractor. An example of



this workflow is shown on the Fig. 7 where a formwork provider, provides not only the supply of formwork material and equipment, but also design the formwork in BIM and collaborate in CDE in solution of the clash of MEP and structural wall. [27]

## 4 CONCLUSION

Current experience and data from already constructed projects confirm the importance of MEP coordination and clash management in the design phase, because solving them in the construction phase is much more expensive. Even though the effort and costs in the design phase resulting from the need for BIM coordinators and licenses for special software for clash detection and CDE are a little higher than in a standard 2D project, it is important to invest in this phase because the design is of much higher quality and the construction phase is therefore more efficient, with less errors and therefore cheaper.

Huge numbers of collisions should be solved in a sophisticated way - in software that supports export to BCF and cooperation in CDE, where different project participants can collaborate, assign the issues to others and solve problems together in the each phase of the project life-cycle.

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### References

- [1] BALDWIN, Mark. *The BIM-Manager: A Practical Guide for BIM Project Management*. 1st edition. B.m.: Beuth Verlag GmbH. 2019. ISBN 978-3-410-26821-5.
- [2] SMITH, Dana K. and Michael TARDIF. *Building information modeling: a strategic implementation guide for architects, engineers, constructors, and real estate asset managers*. Hoboken, N.J: Wiley. 2009. ISBN 978-0-470-25003-7.
- [3] FUNTÍK, Tomáš, Michal PASIAR, Ján ERDÉLYI, Janka HLAVATÁ, Pavol KALEJA and Pavol MAYER. *Building Information Modeling*. Bratislava. B.m.: Eurostav. 2018. ISBN 978-80-89228-56-0.
- [4] FUNTÍK, Tomáš and Pavol MAYER. *BIM v stavebno-technologickej praxi*. 1. B.m.: Tribun EU. 2021. ISBN 978-80-263-1695-4.
- [5] EASTMAN, Charles M., ed. *BIM handbook: a guide to building information modeling for owners, managers, designers, engineers, and contractors*. Hoboken, N.J: Wiley. 2008. ISBN 978-0-470-18528-5.
- [6] HARDIN, Brad and Dave MCCOOL. *BIM and construction management: proven tools, methods, and workflows. Second edition*. Indianapolis, Indiana: Sybex, a Wiley brand. 2015. ISBN 978-1-118-94276-5.
- [7] BIM ASSOCIATION SLOVAKIA. *Conference Brochure - National BIM Conference 2021* [online]. 2021. B.m.: JAGA. 2021. Available at: [https://99aed6de-ba7b-4cb5-a3ef-cdeac08fb88b.filesusr.com/ugd/3038c8\\_97565cd6569f4e139367d6b3bb9349b7.pdf](https://99aed6de-ba7b-4cb5-a3ef-cdeac08fb88b.filesusr.com/ugd/3038c8_97565cd6569f4e139367d6b3bb9349b7.pdf)
- [8] BIM ASSOCIATION SLOVAKIA. *National BIM Conference 2021*. [www.bimas.sk](http://www.bimas.sk) [online] [cit. 19.11.2021]. 2021. Available at: <https://www.bimas.sk/bim-konferencia-2021>



- [9] AUTODESK. *Revit Software* | Get Prices & Buy Official Revit 2022 | Autodesk [online] [cit. 14.5.2021]. 2021. Available at: <https://www.autodesk.com/products/revit/overview>
- [10] GRAPHISOFT. *Archicad*. GRAPHISOFT [online] [cit. 29.5.2021]. 2021 Available at: <https://graphisoft.com/solutions/products/archicad>
- [11] ACCA SOFTWARE. *Architecture, Engineering and Construction industries / ACCA software* [online] [cit. 29.5.2021]. 2021. Available at: <https://www.accasoftware.com/en/>
- [12] BIM OBJECT. BIM objects - Free to download! Revit families & BIM content | BIMobject. BIMobject® [online] [cit. 7.12.2022]. 2022. Available at: <https://www.bimobject.com/en>
- [13] BIM PROJECT. BIM Project | 100% Free BIM for Revit & Archicad. BIM Project [online] [cit. 7.12.2022]. 2022. Available at: <https://bimproject.cz/>
- [14] THE AMERICAN INSTITUTE OF ARCHITECTS. *G202-2013 Project BIM Protocol. AIA Contract Documents* [online] [cit. 19.11.2021]. 2013. Available at: <https://www.aiacontracts.org/contract-documents/19016-project-bim-protocol>
- [15] BIM FORUM. *Level of Development Specification. Level of Development Specification* [online] [cit. 19.11.2021]. 2020. Available at: <https://bimforum.org/lod/>
- [16] MAGICAD. *MagiCAD Group / Software solutions for the built environment*. MagiCAD [online] [cit. 7.12.2022]. 2022. Available at: <https://www.magicad.com/en/>
- [17] HONTI, Richard, Ján ERDÉLYI, Gabriela BARICZOVÁ, Tomáš FUNTÍK a Pavol MAYER. Automated Verification of Building Components Using BIM Models and Point Clouds. *Slovak Journal of Civil Engineering* [online]. 2020, Vol. 28, Iss. 3, p. 13–19. DOI:[10.2478/sjce-2020-0019](https://doi.org/10.2478/sjce-2020-0019)
- [18] SLOVAK OFFICE OF STANDARDS, METROLOGY AND TESTING. *STN EN ISO 19650-1 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling. Part 1: Concepts and principles* [online]. 1. jul 2020. [cit. 19.11.2021]. 2020. Available at: [https://normy.unms.sk/eshop/public/standard\\_detail.aspx?id=130893](https://normy.unms.sk/eshop/public/standard_detail.aspx?id=130893)
- [19] SLOVAK OFFICE OF STANDARDS, METROLOGY AND TESTING. *STN EN ISO 19650-2 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling. Part 2: Delivery phase of the assets* [online]. 1. jul 2020. [cit. 19.11.2021]. 2020. Available at: [https://normy.unms.sk/eshop/public/standard\\_detail.aspx?id=130894](https://normy.unms.sk/eshop/public/standard_detail.aspx?id=130894)
- [20] BUILDINGSMART. *buildingSMART/BCF-XML*. GitHub [online] [cit. 24.5.2021]. 2020. Available at: <https://github.com/buildingSMART/BCF-XML>
- [21] BUILDINGSMART. *BIM Collaboration Format (BCF)*. *buildingSMART International* [online] [cit. 30.5.2021]. 2021. Available at: <https://www.buildingsmart.org/standards/bsi-standards/bim-collaboration-format-bcf/>
- [22] BIMCOLLAB. *BCF Managers for Navisworks* [online] [cit. 24.5.2021]. 2021. Available at: <https://support.bimcollab.com/en/Support/Support/Downloads/navisworks>
- [23] BIMCOLLAB. *Free BCF Managers - BIMcollab* [online] [cit. 24.5.2021]. 2021. Available at: <https://www.bimcollab.com/en/products/bcf-managers>
- [24] AUTODESK. *Improve collaboration between BIM 360 and Revit using BCF / BIM 360 2021 | Autodesk Knowledge Network* [online] [cit. 26.5.2021]. 2019. Available at: <https://knowledge.autodesk.com/support/bim-360/learn->

- [explore/caas/simplecontent/content/improve-collaboration-between-bim-360-and-revit-using-bcf.html](https://www.solidworks.com/learn/revit-using-bcf.html)
- [25] SOLIBRI. *Get started with using the new BCF Live Connector*. Solibri [online] [cit. 24.5.2021]. 2020. Available at: <https://www.solibri.com/learn/solibri-assist-collaboration-with-bcf-live>
- [26] GRAPHISOFT. *Export/Import Markup Using BIM Collaboration Format (BCF) / User Guide Page / GRAPHISOFT Help Center* [online] [cit. 24.5.2021]. 2021. Available at: <https://helpcenter.graphisoft.com/user-guide/77194/>
- [27] FUNTÍK, Tomáš, Pavol MAYER, Lukáš MICHALÁK and Jakub KOZMON. Riešenie prestupov cez stavebné konštrukcie v BIM prostredí. In: *Zborník prednášok z 21. ročníka vedecko-odbornej konferencie Vzduchotechnika 2022*. B.m.: Slovenská spoločnosť pre techniku prostredia, p. 47–53. ISBN 978-80-89878-94-9.