WP-CAD-00120 March 2013

White Paper

Trevor Clayton

Passion Integrity Expertise Teamwork

Pipe Networks

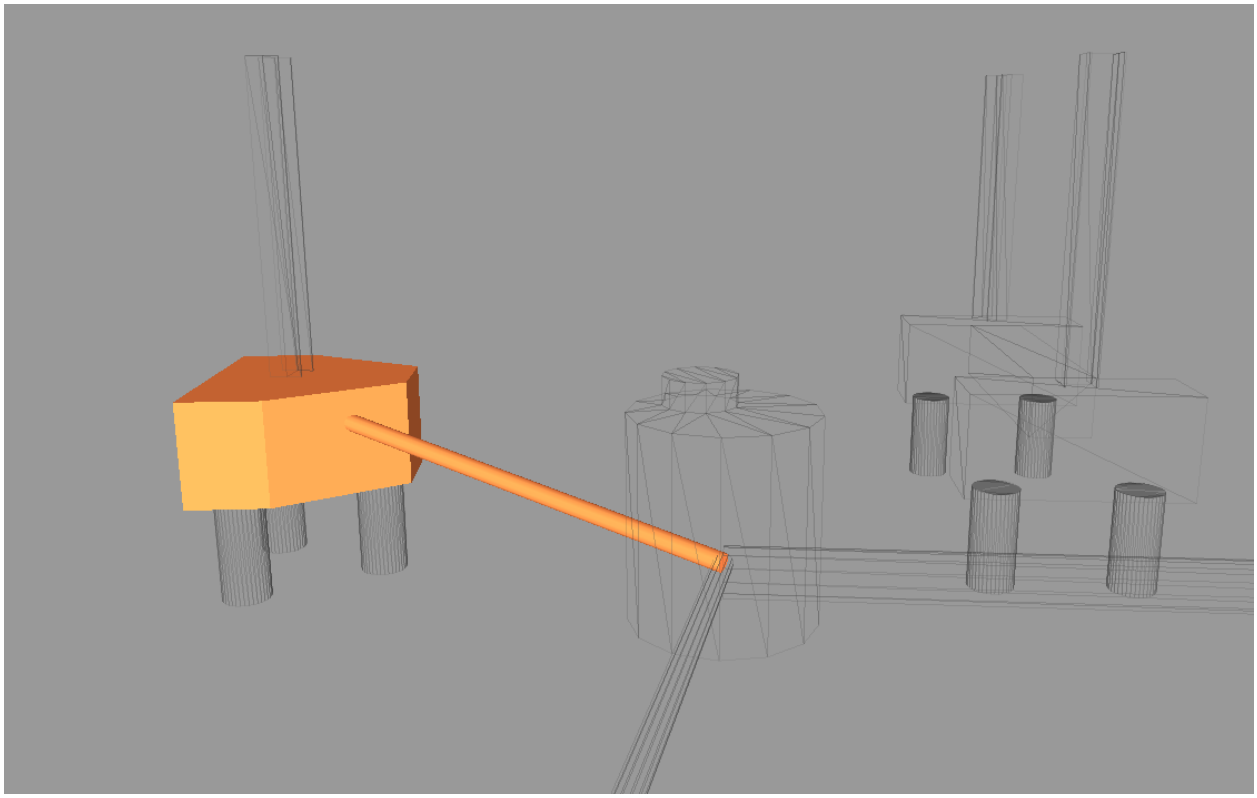
AutoCAD Civil 3D

All AutoCAD Civil 3D Users

With Autodesk making the task of creating 3D models of construction design increasingly easier and more accessible, it leaves me asking the question:

"*What exactly are the benefits of modelling in 3D over more traditional methods?*"

This white paper attempts to answer that question by demystifying a particular topic of designing pipe networks in AutoCAD Civil 3D, giving an honest and personal account on what can be done, where savings in time and efficiency can be made and where further development is required.



Data sharing and intelligent 3D models are the backbone of building information modelling (BIM). Whilst the two have undeniable advantages for the asset owner and other downstream contributors to the design and construction process, what are the benefits to the every-day design engineer? How does 3D design improve efficiency for a drainage engineer? In order for 3D modelling to be an efficient design tool it must be more accurate and faster than traditional methods. Below are some of the processes for designing pipe networks in AutoCAD Civil 3D that should go some way to identifying where those benefits can be found.

Country Kits & Parts Lists

AutoCAD Civil 3D gives us access to country kits. Country kits have been included within the Autodesk install in order to provide relevant design standards and parts list for the country in question. By having the correct country kit installed you can ensure your design is cross referenced against the appropriate design standards during the design, ensuring that your design is valid and meets all necessary design requirements.

Examples of this can be checking that the design of your road meets the design standards set out in TD9/93 and more relevant to this white paper the manhole pipes and structures created for Sewers for Adoption 6th Edition, which are a requirement for any public sewer design within the UK.

By utilising the country kits available within AutoCAD Civil 3D engineers can automate the design checking phase, ensuring that designs meet the appropriate design requirements.

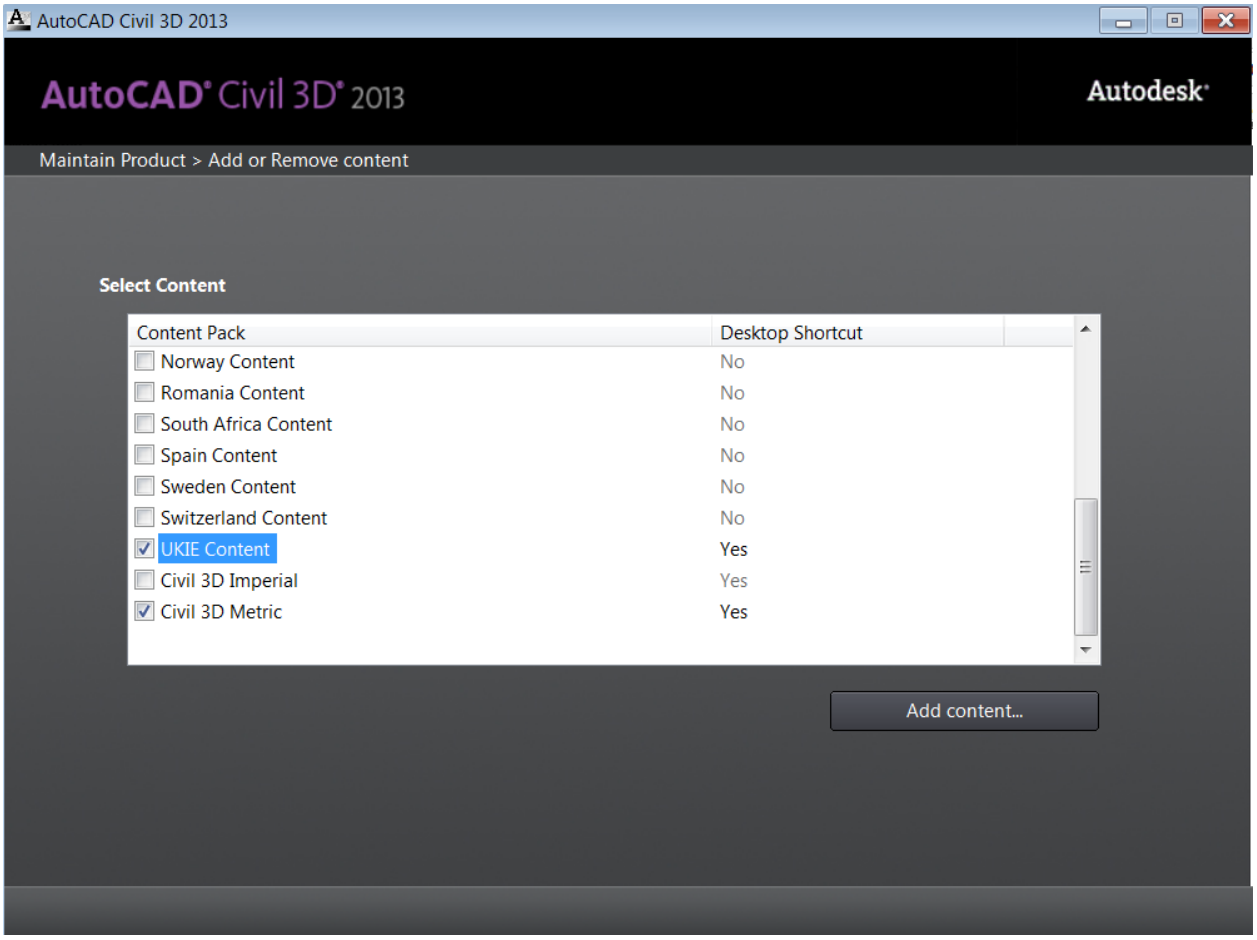


Figure 1 – Example country kits available within AutoCAD Civil 3D

AutoCAD Civil 3D Templates

Before anyone adopts a new way of working and committing to a new design delivery method, they must first be convinced that they are at least able to deliver what they can deliver already. Most companies have CAD standards that standardise drawing delivery and this is something that is made particularly easy within AutoCAD Civil 3D (C3D). New drawings in C3D can be started from .DWT drawing template. Drawing templates in C3D contain particular styles and settings that will control how certain design elements are built and displayed in the model. Using the UKIE .DWT, and customising it to suit your own company standards, maintaining CAD standards in drawing production will be automated based on that template

Let's take a surface for instance. A 3D triangulated surface may need to be displayed in a variety of styles, the standard triangulation style to understand how the surface has been created, a contour style with particular colours/line types for major and minor contours, or maybe even a style determining level ranges through a surface. All the aforementioned styles could be set up and saved within a .DWT template file that users can utilise to automate drawing production as they concentrate more on the actual design.

The same applies for most C3D design elements. So in the case of pipe networks, properties relating to a pipe such as colour, linetype, width can be contained within a .DWT for each material and diameter pipe. Also for manholes, styles can be created for different shape, size, and type of manhole.

The automation of the appearance of such elements means that drawings become a by-product of the design. The obvious advantage of this is that we spend more time designing and less time drafting and producing drawings.

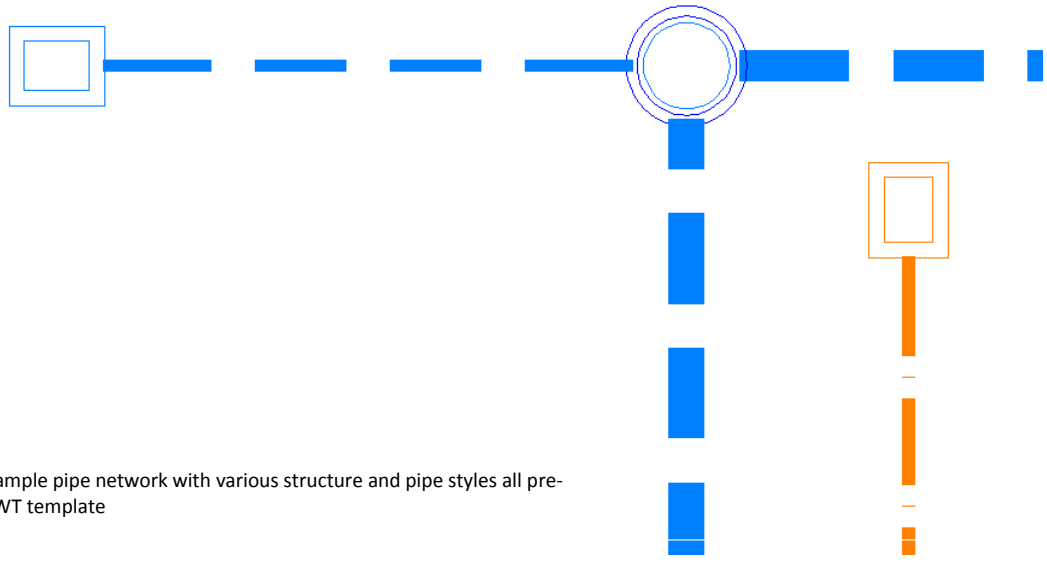


Figure 2 - Example pipe network with various structure and pipe styles all pre-set in the .DWT template

Creating Pipe Networks from Existing AutoCAD Objects

An important part of increasing the efficiency within design is to make the best use of the design data that is provided to you. AutoCAD Civil 3D gives users the opportunity to quickly convert existing AutoCAD objects into 3D civil objects. This is particularly beneficial in drainage design if needing to model an existing drainage system where you have received the general arrangement in an AutoCAD format. Rather than re-modelling the network as C3D pipes and structures you can convert the line work you already have, therefore reducing drafting time.

It is possible to convert 2D line work to pipe networks giving you the opportunity to go through and input the invert level data retrospectively; however it is also possible to convert 3D strings into pipe networks and utilise the 3D geometry of the line. You can select what part of the pipe these elevations relate to and automatically bring those levels through into the pipe network design when converting.

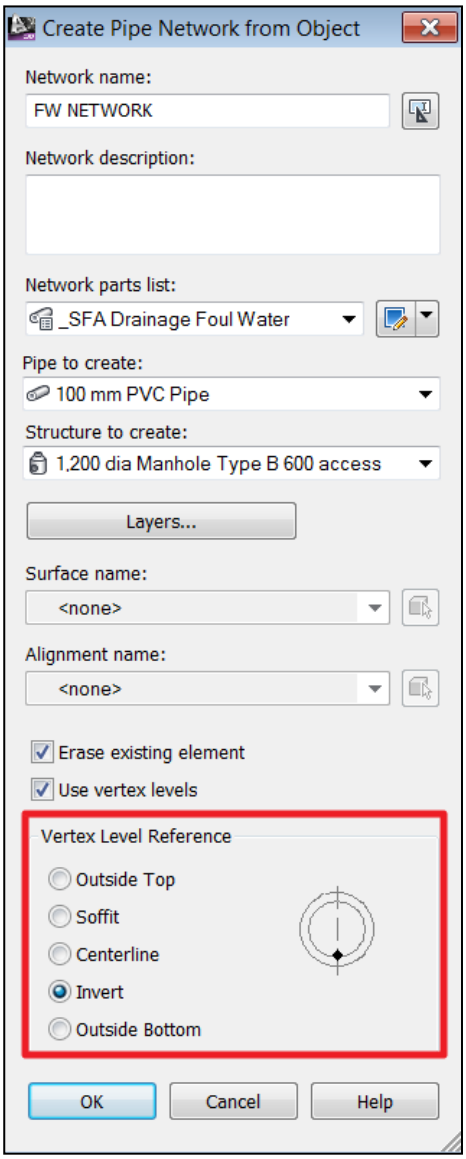


Figure 3 – Utilising vertex levels when converting objects to pipe networks

Applying Rules

As already mentioned the country kits supplied with AutoCAD Civil 3D gives designers the opportunity to check and validate their design against design standards, in this instance set out by the relevant governing body. With pipe networks in C3D you can also create a personalised set of rules relating to pipes and structures. These rules could be for example the maximum and minimum slope for a pipe or maximum and minimum depth of a manhole structure.

This personalised set of rules can be applied to their individual elements and will highlight when that rule has been violated within the design. This will provide an extra automated design check for the designer which should help reduce the chance of any costly errors in design.

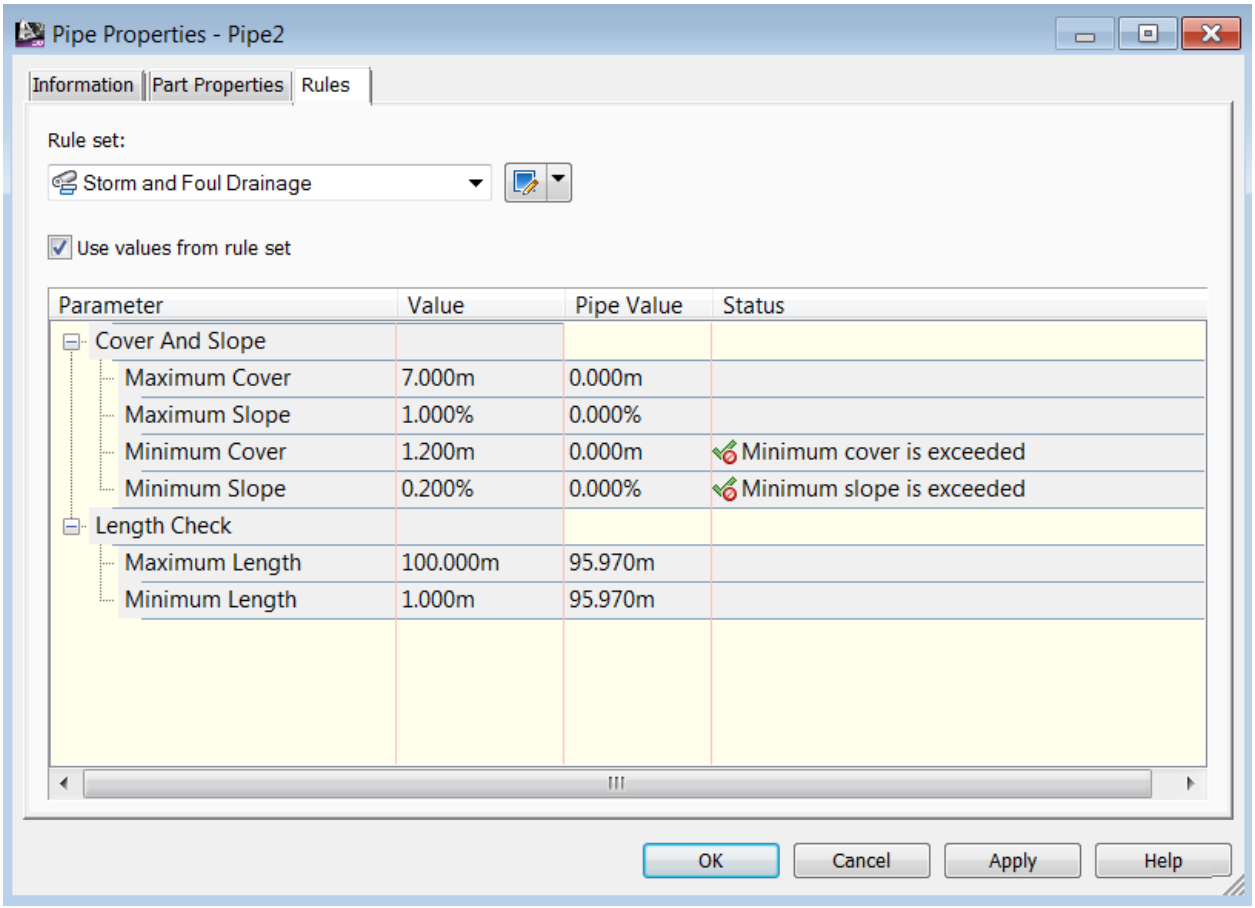


Figure 4 – Demonstrating violations against the pipe and structure rules in a pipe network design

Schedules and Reporting

The major contributors to inefficient design are the error strewn methods of creating schedules and reporting design. The current method is very disconnected with the drawn design and gives too many opportunities for misinterpretation and inaccuracy when manually copying and updating.

AutoCAD Civil 3D is driven by the philosophy of drawings and reports being a by-product of the design. Engineers should spend more time designing and less time worrying about drawing production, since most of the information needed for scheduling is already contained within the 3D model, it is quick and easy to extract that data in the necessary format. Not only that, but the schedule should have the capability to update automatically when the design changes, eradicating the common errors involved with having to manually update schedules to replicate changes to the design.

AutoCAD Civil 3D accommodates this for pipe networks by giving the provision to create table styles to replicate a manhole schedule for instance. Users can create a table style to display and extract all the relevant information from the design that they would like to display in a manhole schedule, a schedule that is dynamically linked to the model and will update automatically when design changes occur. This not only reduces the chance for error, but also speeds up schedule creation.

MANHOLE SCHEDULE						
MANHOLE REF.	MANHOLE SIZE, TYPE & ACCESS	APPROX. COVER LEVEL.	INVERT LVL. OF OUTLET PIPE.	APPROX. DEPTH.	COVER TYPE.	REMARKS.
MH6	Manhole Type B	55.000	53.645	1.355		
MH7	Manhole Type B	55.000	53.613	1.407		
MH8	Manhole Type B	55.000	53.561	1.459		
MH9	Manhole Type B	55.000	53.506	1.514		
MH10	Manhole Type B	55.000	53.460	1.560		
MH11	Manhole Type B	55.000	53.380	1.620		

Figure 5 – Example table style achievable in AutoCAD Civil 3D to automate manhole schedule creation

Visualisation

The most obvious benefit of modelling in 3D is the opportunity to visualise your design. 3D model design gives you the benefit of being able to communicate your design in 3D, which can be a priceless addition particularly when communicating with non-technical audiences, as many construction clients can be.

3D model-based design does not only benefit the non-technical eye, it also serves as an excellent design tool for reviewing the proposed design by visually highlighting any anomalies or errors in design. In the example of pipe networks in AutoCAD Civil 3D, visualisation allows the designer to check the implications of proposed drainage systems on any existing networks or neighbouring services designs. This sort of coordination and collaboration can be challenging in the 2D environment.

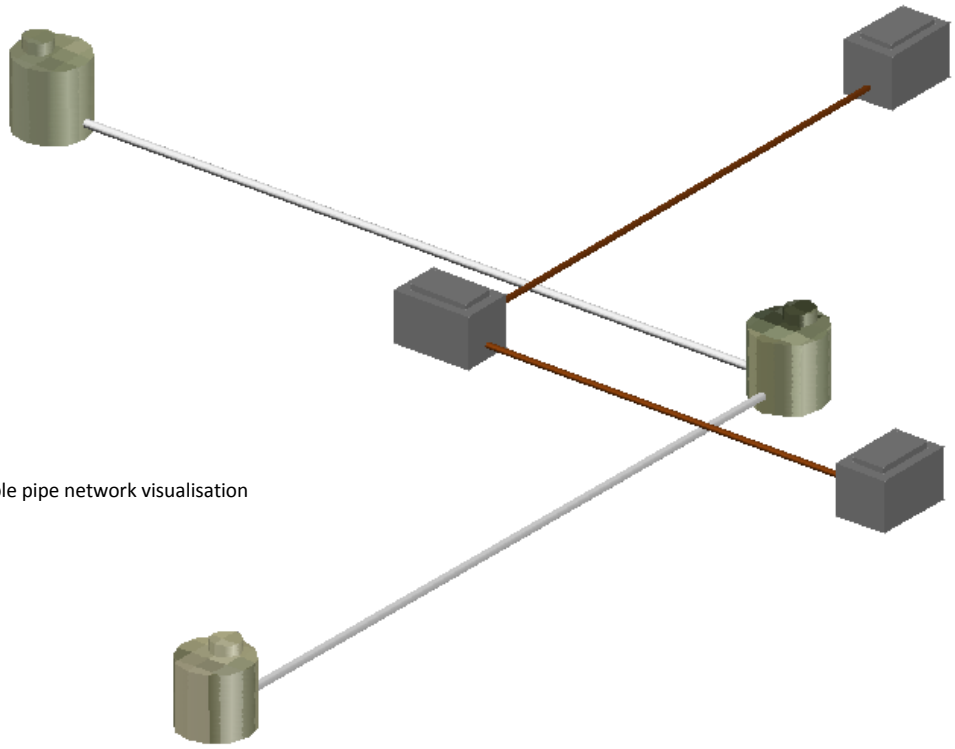


Figure 6 – Example pipe network visualisation

Interference Checks

Although visualisation will give designers the opportunity to check any potential clashes of crossing pipes or adjacent services, this is still a very user intensive method which will become time consuming on large networks and leave lots of opportunity for error. Autodesk have therefore provided an automated solution which will check for any positive clashes between pipe networks in an AutoCAD Civil 3D drainage model.

The interference check gives designers the opportunity to review their design for any physical clashes as well as being able to apply design tolerances to be notified where structures may not have the required clearance. The automated nature of the interference check cuts out any user errors when checking for clashes in pipe networks, assuming of course your models are designed correctly.

AutoCAD Civil 3D currently only provides the provision to perform clash checks between other C3D pipe networks.

Hydraulic Modelling

Hydraulic modelling is an important part of any drainage design. Drainage systems in the UK which discharge into a public drainage system need to be approved by the relevant water authority. The industry standard tool for hydraulic analysis calculations is widely accepted as Microdrainage. Since it is close to essential that Microdrainage specific calculations are supplied to the water authority to validate a drainage design discharging to a public network is was important that Autodesk supplied a link to export an AutoCAD Civil 3D pipe network to enable an import into Windes.

Autodesk supplied these tools in the form of automatic renaming of pipes to Microdrainage convention and supplied an exporter tool to a native Microdrainage file type that read off all the relevant data from a pipe network in C3D such as pipe lengths, pipe diameters, invert levels etc. that could then be imported straight into Microdrainage.

Although Autodesk have developed their own hydraulic modelling package called Storm and Sanitary Analysis (SSA) which is included in any purchase of AutoCAD Civil 3D, I personally believe that this has a way to go before being widely used with in industry, whether there will be any development on similar tools in the future only Autodesk will know the answer

Speculation aside, Autodesk will need to work closely with water authorities in the UK to get any software approved and recognised before engineers can consider it as an acceptable replacement for Microdrainage. Until they have done this, the export link from C3D to Windes is essential in order to utilise the 3D geometry from a pipe network created in AutoCAD Civil 3D for hydraulic modelling.

Multi-disciplinary Collaboration

AutoCAD Civil 3D provides coordination tools to check for clashes with other C3D pipe networks, but over the lifecycle of a project we will need to coordinate and collaborate design with many more disciplines to ensure that our own civil infrastructure design is valid. Coordination with below ground structure and services designed in other modelling packages are obvious requirements, as well as the need to place our below ground drainage design in the all-encompassing centralised data model which “BIM” is so reliant upon.
Autodesk provide this facility with their Navisworks products. Navisworks is a project review application concentrating on integrating, sharing and reviewing models from a multitude of AEC design platforms. It is possible to export C3D pipe networks to a format acceptable to Navisworks that will enable the possibility of hosting a drawing which contains our below ground drainage and other construction designs such as foundations and super structure. Within Navisworks you can then review your below ground drainage design in the context of the entire construction project. Clash detection is a notable advantage of this.

Figure 7 – Clash check in Navisworks between below ground drainage from AutoCAD Civil 3D and sub-structure from Revit showing nine clashes for review