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CI10681

Create Your Local Design Rules and Content for InfraWorks 360

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Learning Objectives

- Learn how to create localized roadway design rules in InfraWorks 360
- Learn how to create localized content for pavement drainage networks in InfraWorks 360
- Learn about Project Kameleon

Description

In this session we will have a look at how to create localized design rules for the design roads created with the roadway Design Module for InfraWorks 360 software. We will also look at how to localize the rules used for inspecting a drainage pipe network. And finally we will have an introduction in Project Kameleon preview, which enables you to create localized content for manholes and inlets for use with the drainage design module for InfraWorks 360 software and AutoCAD Civil 3D software.

Your AU Experts

Peter Ingels is a technical specialist focusing on Autodesk, Inc.'s, Civil Engineering and Infrastructure Solutions. He has a background in engineering and surveying, and over 13 years' experience implementing Autodesk solutions. The last couple of years he has been talking to customers, explaining the advantages for their companies of implementing Autodesk's Building Information Modeling (BIM) for infrastructure strategy.

Introduction

During the past years, when talking to customers about InfraWorks 360, I often get the same type of questions. These questions are very often related to localization of Infraworks 360, something similar to the Country kits for AutoCAD Civil 3D.

In this class I want to provide an answer to some of these questions. The purpose of this class is to show how we can localize bits and pieces of the software and/or add local content to the software in its current state.

Part 1: create localized roadway design rules in InfraWorks 360

Do you really want/need to do this?
One of the first questions to ask when you think about creating localized design standards for Infraworks is: “Do I really need these localized roadway Design standards?”

The reason for that is that in my experience the design standards for roads in the US and in many other countries are not that different as we all seem to think.

As an example I have taken The Netherlands. A collector road following the AASHTO 2011 Design standards requires a minimum radius of 252 meter for a speed of 80 km per hour.

For the Netherlands a radius between 260 meter and 305 meter depending on the applied superelevation is required.

Tabel 8-11. Minimum boogstraal naar ontwerpsnelheid en verkantingen van +2,0%, +2,5% en +5%

V_0 (km/h)	R_h minimaal (m) +2,0%	+2,5%	+5%
90	410	400	350
80	305	295	260
70	215	210	185
60	150	145	130
50	100	96	85

FIGURE 1: DUTCH DESIGN STANDARDS TABLE

The minimum radius in The Netherlands is only 8 meter off with the minimum radius in AASHTO 2011.

And I’m able to manually modify the radius once the deign road is created.

Another thing to consider is the fact that Infraworks 360 currently does not support superelevation. So you need to decide yourselves what value you want to use in the design rule you are creating as well.

More things to consider is the fact that the format of the design rule files that we are about to create can change when a new version of the product is released. This will require the need to update these design rule files as well.

Although these are reasonable concerns raise and question to ask, in many cases it definitely is very useful or even necessary to have local design rules at hand. And this is why I wanted to give this class.

Design rule files and framework

The design rules are a series of files that can be found on the computer that has InfraWorks 360 installed.

The location for Roadway design rules is:

C:\ProgramData\Autodesk\InfraWorks 360\Resources\Standards\Roads

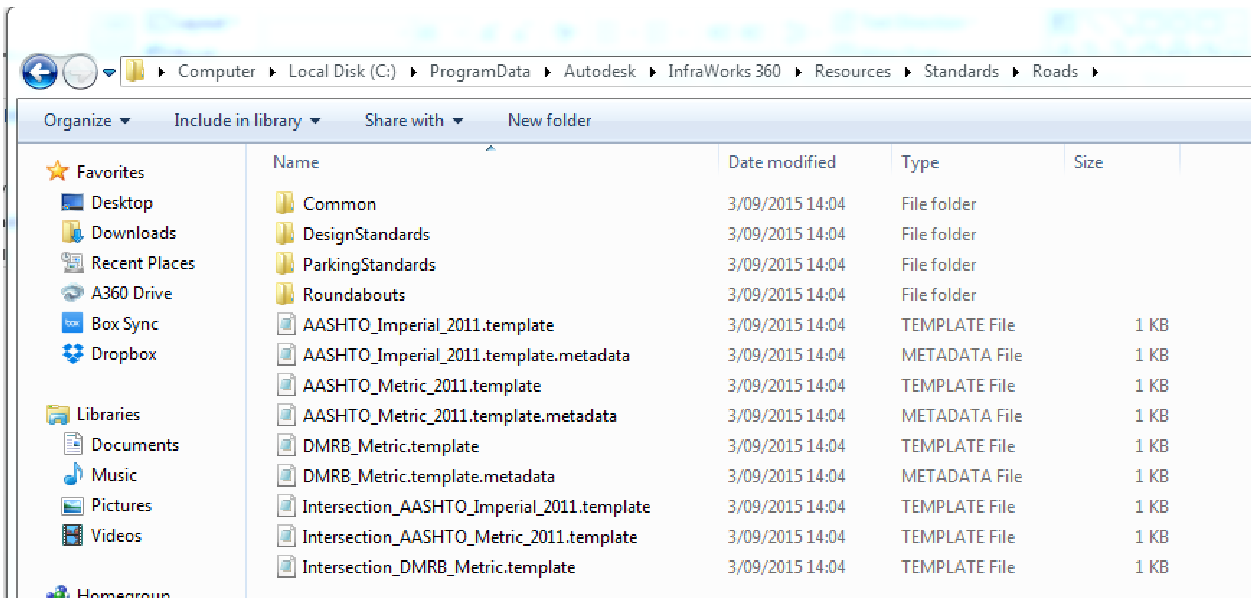


FIGURE 2: ROADWAY DESIGN FILES AND FOLDER

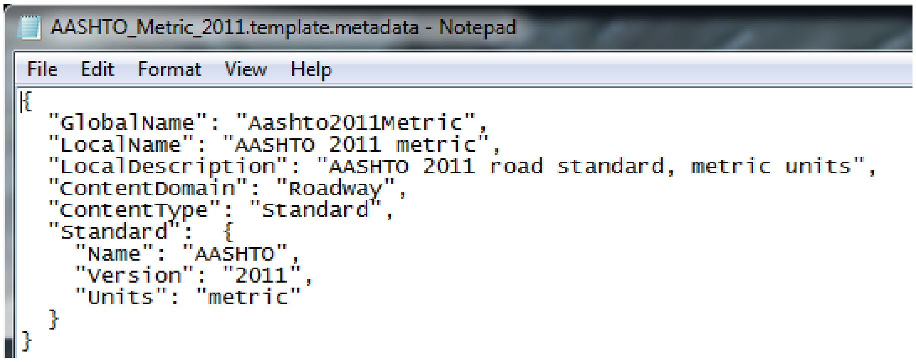
Each Design Rule has 2 files in this folder

AASHTO_Metric_2011.template

→ this files contains links to other files used in this design rule

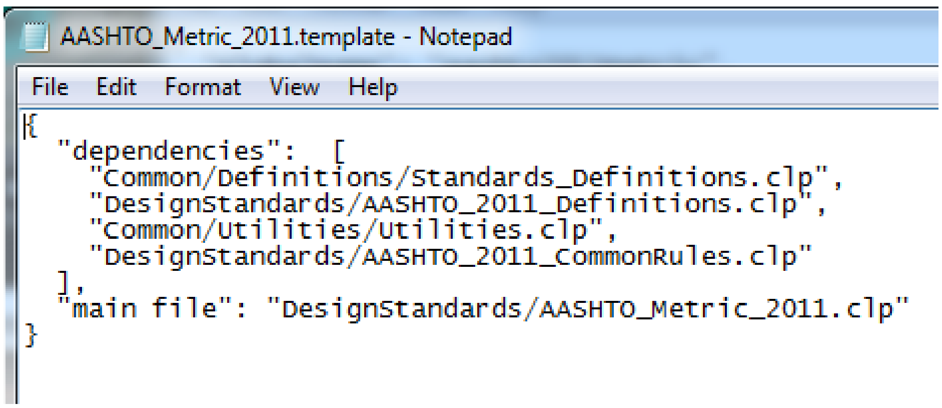
AASHTO_Metric_2011.template.metadata

→ this files contains metadata of the design rule




```
{
  "GlobalName": "Aashto2011Metric",
  "LocalName": "AASHTO 2011 metric",
  "LocalDescription": "AASHTO 2011 road standard, metric units",
  "ContentDomain": "Roadway",
  "ContentType": "Standard",
  "Standard":  {
    "Name": "AASHTO",
    "Version": "2011",
    "Units": "metric"
  }
}
```

FIGURE 3: TEMPLATE.METADATA FILE




```
{
  "dependencies":  [
    "Common/Definitions/Standards_Definitions.clp",
    "DesignStandards/AASHTO_2011_Definitions.clp",
    "Common/Utilities/Utilities.clp",
    "DesignStandards/AASHTO_2011_CommonRules.clp"
  ],
  "main file": "DesignStandards/AASHTO_Metric_2011.clp"
}
```

FIGURE 4: TEMPLATE FILE

If you want to create Localized design rules, it all begins with these 2 files and secondly with the files being referred too.

To create my own design rules I always start by copying the original files and renaming it to what I want it to be.

With regards to naming, of the file, there are some limitations, things to know.

- Do not start with special characters like "_" , "$"
- First character should be in [A-G,a-g]
- Numbers as first character are allowed

In this class I have created 2 files based on the AASHTO_Metric_2011 standard

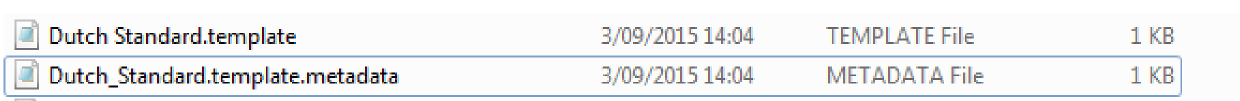


FIGURE 5: LOCALIZED STANDARD TEMPLATE FILES

This is just the first step. At this point the Dutch design Standard is not showing up in Infraworks360. This because it is till referring to the AASHTO_Metric_2011 as main file. See figure 4 and look for main file.

The main file is the file containing the actual data like speed tables, min. radius calculation etc.

So in this case we need to create a main file for the Dutch standard as well. Therefore we will go to the ***"DesignStandards"*** folder and copy the **AASHTOO_Metric_2011.clp** and **AASHTOO_Metric_2011.clp.metadata** files and rename the copies to **Dutch_Standard.clp** and **Dutch_Standard.clp.metadata**

FIGURE 6: LOCALIZED STANDARD FILES

Last step in the process is to edit the **Dutch_Standard.template** file to refer to these newly created clp file.

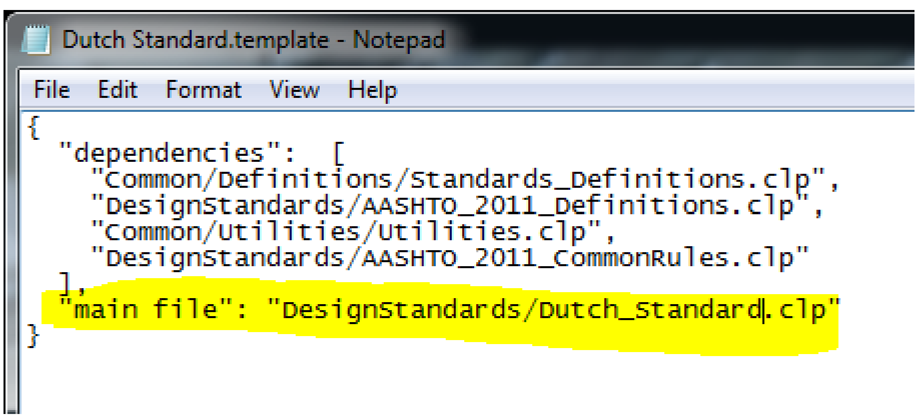


FIGURE 7: LOCALIZED CONTENT IN STANDARD TEMPLATE FILE

Once this is done, you will see the result in Infraworks360 as shown in Figure 8.

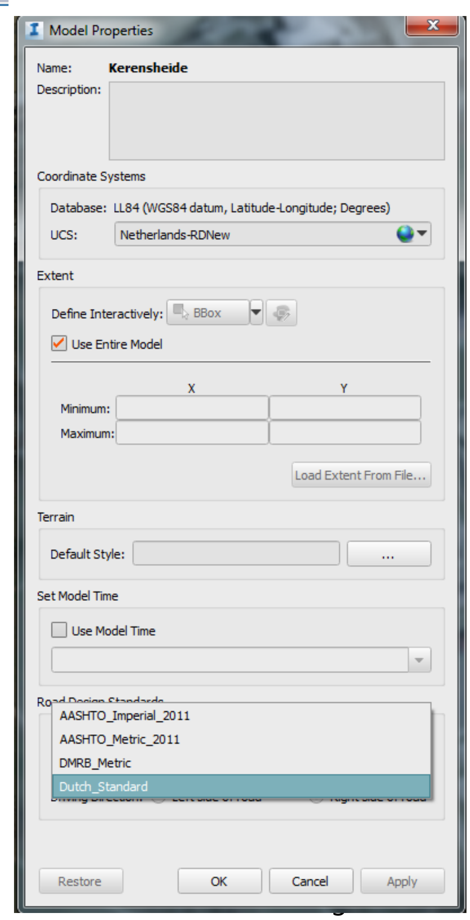


FIGURE 8: LOCALIZED STANDARDS IN INFRAWORKS360 ->

So far we have created a framework for the localized design rules. Now is the time to start modifying the existing formulas and tables to follow the local design rule.

The Design Standard (*.clp) file

In this chapter we will have a look at the actual design standard file itself.

The clp file is well structured and well documented!

A lot of explanation is added as comment (everything behind ";" is a comment in the file) as well references to the Design standard document so it is easy to check the file against the design standard.

As a best practice, I would recommend doing the same for your design standard

The first part of the file are again references to other files needed for and used in the design rule.

```
;-------------------------------------------------------------------------------
; Metric Reference Standard
;-------------------------------------------------------------------------------
(defmodule MAIN
  (import standards.roads.definitions        ?ALL)    ; type definitions
  (import standards.roads.definitions.custom  ?ALL)    ; AASHTO common definitions
  (import standards.roads.utilities          ?ALL)    ; utilities
  (import standards.roads.AASHTO.common.rules ?ALL)    ; AASHTO common rules
)
```

These files can be found in the "common" subfolder
C:\ProgramData\Autodesk\InfraWorks 360\Resources\Standards\Roads\Common

Next is a part where global variables are defined. That will be used further in the document.
These global variables have a default value coming from the design standard as well

```
; ##################################################################################
; Globals
; ##################################################################################

(defglobal ?*uses-imperial-units* = ?*False*
        ?*default-lane-width* = 3.6                    ; AASHTO 2011, pg. 4-7
        ?*driver-eye-height* = 1.08                    ; AASHTO 2011, pg. 3-14
        ?*stopping-sight-object-height* = 0.60         ; AASHTO 2011, pg. 3-15
        ?*passing-sight-object-height* = 1.08          ; AASHTO 2011, pg. 3-15
        ?*intersection-sight-object-height* = 1.08     ; AASHTO 2011, pg. 3-15
        ?*decision-sight-object-height* = 0.60         ; AASHTO 2011, pg. 3-15
        ?*headlight-height* = 0.60                     ; AASHTO 2011, pg. 3-157
        ?*headlight-angle* = 1.0                       ; AASHTO 2011, pg. 3-157
```

```
        ?*pmax* = 1.0                                    ; AASHTO 2011, pg. 3-72, maximum
lateral offset between tangent and circular curve
        ?*default-minimum-tangent-grade* = 0.5           ; AASHTO 2011, pg. 3-119
        ?*default-minimum-tangent-length* = 10.0         ; no citation
        ?*default-maximum-tangent-length* = 1000.0       ; no citation
        ?*disallow-spirals* = ?*False*
                ?*intersection-standard-name* = "Intersection_AASHTO_Metric_2011")
```

Minimum Radius

The following part is where it begins to be interesting, as the “Rules” section contains the formulas being used to calculate min curve radius etc.

Let’s look at an example we need to change for the Dutch Design Standards, which is the minimum radius.

This is how it looks like in the clp file:

```
;===============================================================================
; Find minimum radius (AASHTO 2011, pg. 3-31)
;===============================================================================
(defrule find-minimum-radius
   ?inst <- (object (is-a StdRoad)
                  (design-speed          ?speed&:(neq ?speed ?*Unavailable*))
                  (side-friction-factor  ?side-friction&:(neq ?side-friction ?*Unavailable*))
                  (eMax                  ?eMax&:(neq ?eMax ?*Unavailable*))
                  (min-curve-radius      ?radius&:(eq ?radius ?*Unavailable*)))
=>
   (bind ?denom (* 127.0 (+ (* 0.01 ?eMax) ?side-friction)))
   (if (<> ?denom 0.0)
      then (modify-instance ?inst (min-curve-radius (/ (* ?speed ?speed) ?denom)))
   )
)
```

design-speed, side-friction-factor, eMax are all parameters used in the formula to calculate the minimum curve radius.

The formula for calculation the minimum curve radius is: *(/ (* ?speed ?speed) ?denom)))*
Where the variable *?denom* is: *(* 127.0 (+ (* 0.01 ?eMax) ?side-friction)))*

Before we change the formula or the values of the formula, let’s have a look at where all these variables and values come from.

Design Speed

With the AASHTO_Metric_2011 design rules, for a collector the default speed is 60 km/h

FIGURE 9: DEFAULT DESIGN SPEED FOR A COLLECTOR ROAD

This value is defined in the design rules as well.

In the design rule file, just above the section where the minimum radius is calculated, a section is available called "Find default design speed".

In the extract of the design rule file below, the default design speeds for the different road types are indicated with a yellow background

```
;==========================================================================
; Find default design speed
;==========================================================================
; Local road
(defrule find-speed-Local
   (declare (salience 100))
   ?inst <- (object (is-a StdRoad)
                 (function Local)
                 (default-design-speed ?speedx&:(eq ?speedx ?*Unavailable*)))
=>
   (modify-instance ?inst (default-design-speed 45.0))
)

; Collector
(defrule find-speed-Collector
   (declare (salience 100))
   ?inst <- (object (is-a StdRoad)
                 (function Collector)
                 (default-design-speed ?speedx&:(eq ?speedx ?*Unavailable*)))
=>
   (modify-instance ?inst (default-design-speed 60.0))
```

```
)

; Arterial road
(defrule find-speed-Arterial
   (declare (salience 100))
   ?inst <- (object (is-a StdRoad)
               (function Arterial)
               (default-design-speed ?speedx&:(eq ?speedx ?*Unavailable*)))
=>
   (modify-instance ?inst (default-design-speed 80.0))
)

; Freeway
(defrule find-speed-Freeway
   (declare (salience 100))
   ?inst <- (object (is-a StdRoad)
               (function Freeway)
               (default-design-speed ?speedx&:(eq ?speedx ?*Unavailable*)))
=>
   (modify-instance ?inst (default-design-speed 110.0))
)
```

So this is the place to change the default design speeds for the different road types to align with the local design rules you are implementing.

side-friction-factor

For the side-friction-factor we need to refer to a section at the bottom of the design rules file which is called "Tabular data for various information". The section is structured as shown below

```
; **************************************************************************
; AASHTO tabular data for various information
; **************************************************************************
(definstances SpeedTables
   (of SpeedTable
      (design-speed          20.0)
      (side-friction-factor     0.176)
      (max-relative-gradient    0.80)
      (minimum-k-value-for-HSD  3)
      (minimum-k-value-for-SSD  1)
      (design-stopping-sight-distance 20.0)
      (no-control-intersection-sight-distance 20.0)
      (stop-intersection-left-turn-sight-distance 45.0)
      (stop-intersection-right-turn-sight-distance 40.0)
               (yield-intersection-left-or-right-turn-sight-distance 45.0)
```

```
                    (yield-intersection-crossing-turn-minor-road-approach-length 20.0)
    )
    .......
    (of SpeedTable
        (design-speed          60.0)
        (side-friction-factor    0.15)
        (max-relative-gradient    0.60)
        (minimum-k-value-for-PSD  38.0)
        (minimum-k-value-for-HSD  18)
        (minimum-k-value-for-SSD  11)
        (design-stopping-sight-distance 85.0)
        (design-passing-sight-distance 180.0)
        (no-control-intersection-sight-distance 55.0)
        (stop-intersection-left-turn-sight-distance 130.0)
        (stop-intersection-right-turn-sight-distance 110.0)
                    (yield-intersection-left-or-right-turn-sight-distance 135.0)
                    (yield-intersection-crossing-turn-minor-road-approach-length 65.0)
    )
```

For 60 km/h the side friction factor defined is 0.15

eMax

Another file in the DesignStandards folder contains information on eMax. The file is "AASHTOO_2011_CommonRules.clp"

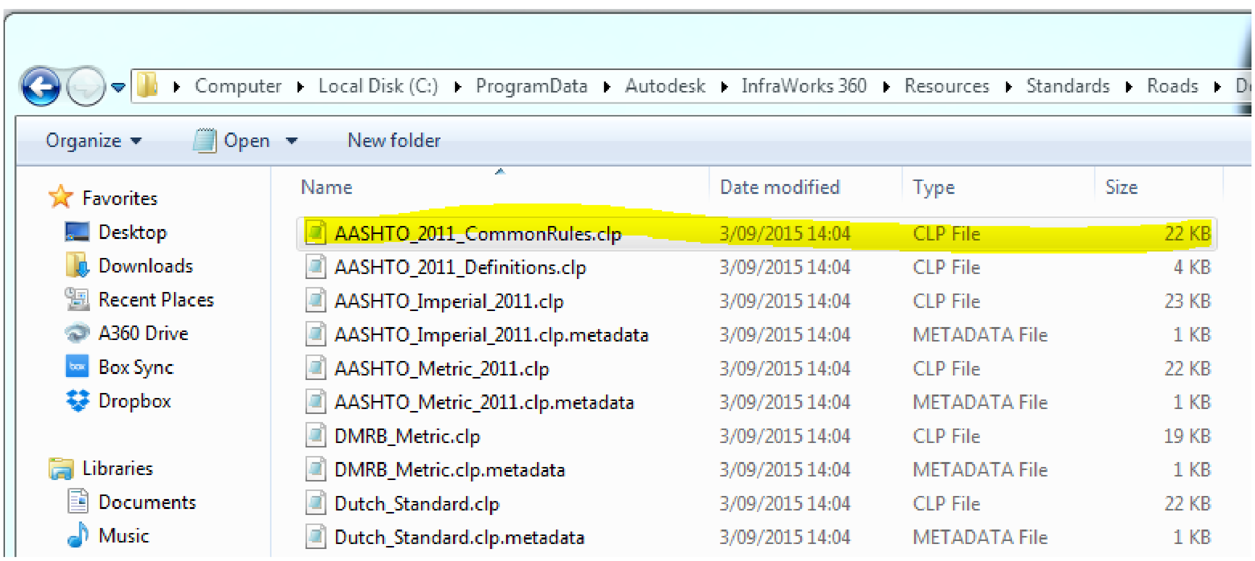
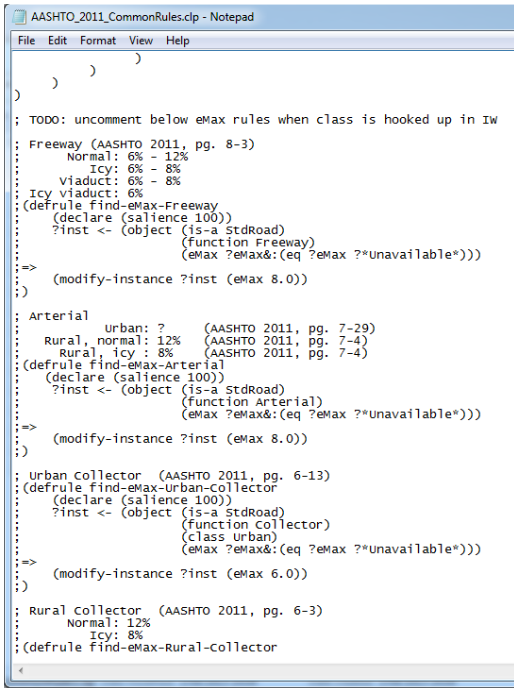


FIGURE 10: AASHTO_2011_COMMONRULES.CLP

In this file, you can find eMax values for the different road types. As of today, the part defining eMax is commented out.



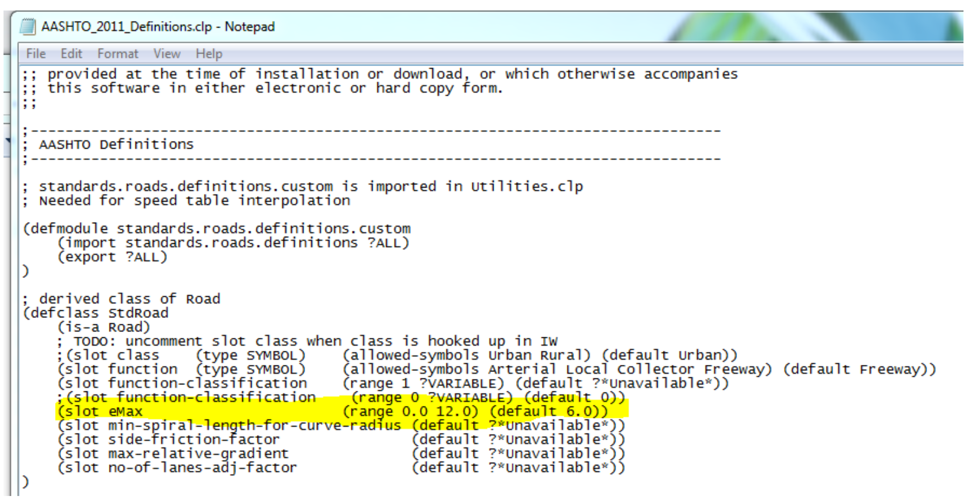
AASHTO_2011_CommonRules.clp - Notepad

```
                )
            )
    )
)

; TODO: uncomment below eMax rules when class is hooked up in IW

; Freeway (AASHTO 2011, pg. 8-3)
;       Normal: 6% - 12%
;          Icy: 6% - 8%
;      Viaduct: 6% - 8%
; Icy viaduct: 6%
;(defrule find-eMax-Freeway
;    (declare (salience 100))
;    ?inst <- (object (is-a StdRoad)
;                     (function Freeway)
;                     (eMax ?eMax&:(eq ?eMax ?*Unavailable*)))
;=>
;    (modify-instance ?inst (eMax 8.0))
;)

; Arterial
;           Urban: ?     (AASHTO 2011, pg. 7-29)
;   Rural, normal: 12%   (AASHTO 2011, pg. 7-4)
;     Rural, icy : 8%    (AASHTO 2011, pg. 7-4)
;(defrule find-eMax-Arterial
;   (declare (salience 100))
;    ?inst <- (object (is-a StdRoad)
;                     (function Arterial)
;                     (eMax ?eMax&:(eq ?eMax ?*Unavailable*)))
;=>
;    (modify-instance ?inst (eMax 8.0))
;)

; Urban Collector  (AASHTO 2011, pg. 6-13)
;(defrule find-eMax-Urban-Collector
;    (declare (salience 100))
;    ?inst <- (object (is-a StdRoad)
;                     (function Collector)
;                     (class Urban)
;                     (eMax ?eMax&:(eq ?eMax ?*Unavailable*)))
;=>
;    (modify-instance ?inst (eMax 6.0))
;)

; Rural Collector  (AASHTO 2011, pg. 6-3)
;      Normal: 12%
;         Icy: 8%
;(defrule find-eMax-Rural-Collector
```

FIGURE 11: AASHTO_2011_COMMONRULES CONTENT

This tells me it is a fixed value. But what is that value?

In yet another file "AASHTO_2011_Definitions.clp", the file where all variables are defined, a default value for **eMAx** of **6.0** an be found.



AASHTO_2011_Definitions.clp - Notepad

```
;; provided at the time of installation or download, or which otherwise accompanies
;; this software in either electronic or hard copy form.
;;

;--------------------------------------------------------------------------------
; AASHTO Definitions
;--------------------------------------------------------------------------------

; standards.roads.definitions.custom is imported in Utilities.clp
; Needed for speed table interpolation

(defmodule standards.roads.definitions.custom
    (import standards.roads.definitions ?ALL)
    (export ?ALL)
)

; derived class of Road
(defclass StdRoad
    (is-a Road)
    ; TODO: uncomment slot class when class is hooked up in IW
    ;(slot class    (type SYMBOL)    (allowed-symbols Urban Rural) (default Urban))
    (slot function  (type SYMBOL)    (allowed-symbols Arterial Local Collector Freeway) (default Freeway))
    (slot function-classification    (range 1 ?VARIABLE) (default ?*Unavailable*))
    ;(slot function-classification    (range 0 ?VARIABLE) (default 0))
    (slot eMax                       (range 0.0 12.0) (default 6.0))
    (slot min-spiral-length-for-curve-radius (default ?*Unavailable*))
    (slot side-friction-factor               (default ?*Unavailable*))
    (slot max-relative-gradient              (default ?*Unavailable*))
    (slot no-of-lanes-adj-factor             (default ?*Unavailable*))
)
```

FIGURE 11: AASHTO_2011_DEFINITIONS CONTENT

Adding all these values to the formula at page 7 gives a minimum curve radius of:

(/ (?speed ?speed) ?denom)))*
?denom is: *(* 127.0 (+ (* 0.01 ?eMax) ?side-friction)))*

(/ (60 60) ?denom)))*
?denom is: *(* 127.0 (+ (* 0.01 6.0) 0.15)))*

134.98312 or rounded is **135 m**

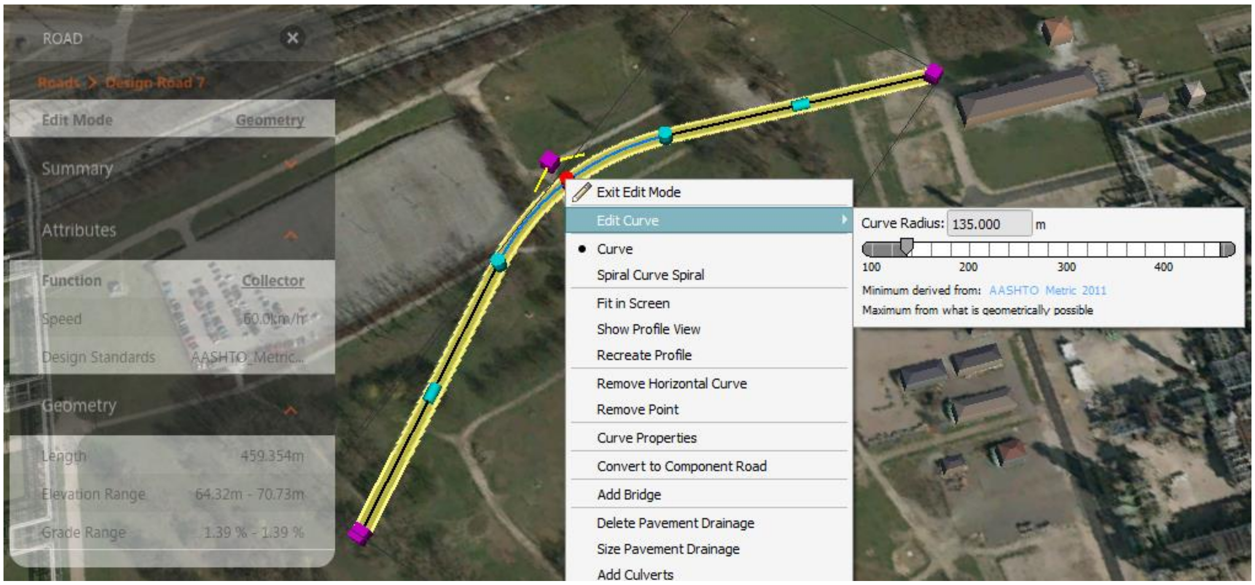


FIGURE 12: AASHTO 2011, COLLECTOR, MINIMUM CURVE RADIUS

Interesting to say here is that you can always see in the UI what standard is being used for both minimum and maximum curve radius:

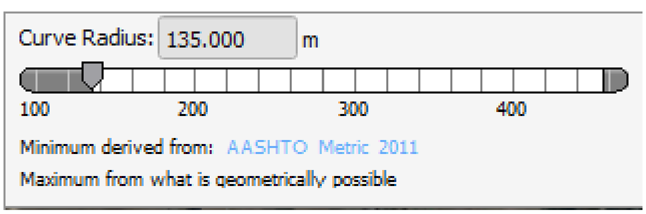


FIGURE 12: MIN. AND MAX VALUES FOR CURVES

Most often the maximum comes from what is geometrically possible rather than from a design standard.

Now we know and understand all this it is time to look at our local design standards we are implementing.
What does the Dutch Design standard tells us about the minimum curve radius

$$R_h \geq \frac{\left(\frac{V_o}{3,6}\right)^2}{\left(f_z+\frac{i}{100}\right)g}$$

FIGURE 13: MIN. RADIUS FORMULA

At first sight this is not really similar to what we have found in the design rule files:

```
(bind ?denom (* 127.0 (+ (* 0.01 ?eMax) ?side-friction)))
(if (<> ?denom 0.0)
    then (modify-instance ?inst (min-curve-radius (/ (* ?speed ?speed) ?denom)))
)
```

Tip: try to see if the formula can be transformed to something similar to what is in the design rule as changing just values is easier than creating a complete new formula in the correct syntax.

So looking again at the formula in the local design standard gives us:

$$R_h \geq \frac{\left(\frac{V_o}{3,6}\right)^2}{\left(f_z+\frac{i}{100}\right)g} = \frac{V_o^2}{127\left(f_z+\frac{i}{100}\right)}$$

FIGURE 14: TRANSFORMED MIN. RADIUS FORMULA

Where:

- R_h = Radius
- V_o = Design speed
- G = 9.81 m/s2 (acceleration of Gravity)
- F_z = side friction
- I = Superelevation (%)

V_0(km/h)	50	60	70	80	90
f_z	0,180	0,169	0,157	0,146	0,134

FIGURE 15: DUTCH SIDE FRICTION VALUES

The second formula is much more similar to the one in the design rule file.

Now it is just a matter of changing values in the correct location!

In the speeds table we now can add the values from Figure 15

```
    (of SpeedTable
        (design-speed            50.0)
        (side-friction-factor    0.16)
        (max-relative-gradient   0.65)
        (minimum-k-value-for-PSD 30.0)
        (minimum-k-value-for-HSD 13)
        (minimum-k-value-for-SSD 7)
        (design-stopping-sight-distance 65.0)
        (design-passing-sight-distance 160.0)
        (no-control-intersection-sight-distance 45.0)
        (stop-intersection-left-turn-sight-distance 105.0)
        (stop-intersection-right-turn-sight-distance 95.0)
             (yield-intersection-left-or-right-turn-sight-distance 115.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 55.0)
    )
    (of SpeedTable
        (design-speed            60.0)
        (side-friction-factor    0.15)
        (max-relative-gradient   0.60)
        (minimum-k-value-for-PSD 38.0)
        (minimum-k-value-for-HSD 18)
        (minimum-k-value-for-SSD 11)
        (design-stopping-sight-distance 85.0)
        (design-passing-sight-distance 180.0)
        (no-control-intersection-sight-distance 55.0)
        (stop-intersection-left-turn-sight-distance 130.0)
        (stop-intersection-right-turn-sight-distance 110.0)
             (yield-intersection-left-or-right-turn-sight-distance 135.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 65.0)
    )
    (of SpeedTable
        (design-speed            70.0)
        (side-friction-factor    0.15)
        (max-relative-gradient   0.50)
        (minimum-k-value-for-PSD 51.0)
        (minimum-k-value-for-HSD 23)
        (minimum-k-value-for-SSD 17)
        (design-stopping-sight-distance 105.0)
        (design-passing-sight-distance 210.0)
        (no-control-intersection-sight-distance 65.0)
        (stop-intersection-left-turn-sight-distance 150.0)
        (stop-intersection-right-turn-sight-distance 130.0)
             (yield-intersection-left-or-right-turn-sight-distance 160.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 80.0)
    )
    (of SpeedTable
        (design-speed            80.0)
        (side-friction-factor    0.14)
        (max-relative-gradient   0.50)
        (minimum-k-value-for-PSD 69.0)
        (minimum-k-value-for-HSD 30)
        (minimum-k-value-for-SSD 26)
        (design-stopping-sight-distance 130.0)
        (design-passing-sight-distance 245.0)
        (no-control-intersection-sight-distance 75.0)
        (stop-intersection-left-turn-sight-distance 170.0)
        (stop-intersection-right-turn-sight-distance 145.0)
             (yield-intersection-left-or-right-turn-sight-distance 180.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 100.0)
    )
    (of SpeedTable
        (design-speed            90.0)
        (side-friction-factor    0.13)
        (max-relative-gradient   0.47)
        (minimum-k-value-for-PSD 91.0)
        (minimum-k-value-for-HSD 38)
        (minimum-k-value-for-SSD 39)
        (design-stopping-sight-distance 160.0)
        (design-passing-sight-distance 280.0)
        (no-control-intersection-sight-distance 90.0)
        (stop-intersection-left-turn-sight-distance 190.0)
        (stop-intersection-right-turn-sight-distance 165.0)
             (yield-intersection-left-or-right-turn-sight-distance 205.0)
```

```
        (design-speed            50.0)
        (side-friction-factor    0.18)
        (max-relative-gradient   0.65)
        (minimum-k-value-for-PSD 30.0)
        (minimum-k-value-for-HSD 13)
        (minimum-k-value-for-SSD 7)
        (design-stopping-sight-distance 65.0)
        (design-passing-sight-distance 160.0)
        (no-control-intersection-sight-distance 45.0)
        (stop-intersection-left-turn-sight-distance 105.0)
        (stop-intersection-right-turn-sight-distance 95.0)
             (yield-intersection-left-or-right-turn-sight-distance 115.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 55.0)
    )
    (of SpeedTable
        (design-speed            60.0)
        (side-friction-factor    0.169)
        (max-relative-gradient   0.60)
        (minimum-k-value-for-PSD 38.0)
        (minimum-k-value-for-HSD 18)
        (minimum-k-value-for-SSD 11)
        (design-stopping-sight-distance 85.0)
        (design-passing-sight-distance 180.0)
        (no-control-intersection-sight-distance 55.0)
        (stop-intersection-left-turn-sight-distance 130.0)
        (stop-intersection-right-turn-sight-distance 110.0)
             (yield-intersection-left-or-right-turn-sight-distance 135.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 65.0)
    )
    (of SpeedTable
        (design-speed            70.0)
        (side-friction-factor    0.157)
        (max-relative-gradient   0.50)
        (minimum-k-value-for-PSD 51.0)
        (minimum-k-value-for-HSD 23)
        (minimum-k-value-for-SSD 17)
        (design-stopping-sight-distance 105.0)
        (design-passing-sight-distance 210.0)
        (no-control-intersection-sight-distance 65.0)
        (stop-intersection-left-turn-sight-distance 150.0)
        (stop-intersection-right-turn-sight-distance 130.0)
             (yield-intersection-left-or-right-turn-sight-distance 160.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 80.0)
    )
    (of SpeedTable
        (design-speed            80.0)
        (side-friction-factor    0.146)
        (max-relative-gradient   0.50)
        (minimum-k-value-for-PSD 69.0)
        (minimum-k-value-for-HSD 30)
        (minimum-k-value-for-SSD 26)
        (design-stopping-sight-distance 130.0)
        (design-passing-sight-distance 245.0)
        (no-control-intersection-sight-distance 75.0)
        (stop-intersection-left-turn-sight-distance 170.0)
        (stop-intersection-right-turn-sight-distance 145.0)
             (yield-intersection-left-or-right-turn-sight-distance 180.0)
             (yield-intersection-crossing-turn-minor-road-approach-length 100.0)
    )
    (of SpeedTable
        (design-speed            90.0)
        (side-friction-factor    0.134)
        (max-relative-gradient   0.47)
        (minimum-k-value-for-PSD 91.0)
        (minimum-k-value-for-HSD 38)
        (minimum-k-value-for-SSD 39)
        (design-stopping-sight-distance 160.0)
```

FIGURE 16: AASHTO_METRIC_2011 VERSUS DUTCH SIDE FRICTION VALUES

Lastly we need to decide on the eMax value we want to use for our Design rule. As mentioned before, this is a fixed default value that will be applied for all road types.

Tabel 8-11. Minimum boogstraal naar ontwerpsnelheid en verkantingen van +2,0%, +2,5% en +5%

V_0 (km/h)	R_h minimaal (m) +2,0%	+2,5%	+5%
90	410	400	350
80	305	295	260
70	215	210	185
60	150	145	130
50	100	96	85

FIGURE 16: EMAX IN RELATION WITH RADIUS (DUTCH STANDARD)

I decided to go for the smallest radius possible and implemented an eMax of 5%.

That value can be inserted in the formula itself or in the AASHTO_2011_Definitions.clp file. If you want to change it in the definitions file be aware that changing it for the local design rule will also impact the AASHTO rules. So make sure to make a copy and rename it. This also requires you to change the references in the clp files.
Therefore I have chosen to add the value in the formula as a quick solution. The most flexible will require a bit more work, but will be better in the longer term.

```
;==============================================================================
; Find minimum radius (AASHTO 2011, pg. 3-31)
;==============================================================================
(defrule find-minimum-radius
    ?inst <- (object (is-a StdRoad)
                     (design-speed         ?speed&:(neq ?speed ?*Unavailable*))
                     (side-friction-factor ?side-friction&:(neq ?side-friction ?*Unavailable*))
                     (eMax                 ?eMax&:(neq ?eMax ?*Unavailable*))
                     (min-curve-radius     ?radius&:(eq ?radius ?*Unavailable*)))
=>
    (bind ?denom (* 127.0 (+ (* 0.01 5.0) ?side-friction)))
    (if (<> ?denom 0.0)
         then (modify-instance ?inst (min-curve-radius (/ (* ?speed ?speed) ?denom)))
    )
)
```

FIGURE 17: MODIFIED FORMULA ACCORDING TO DUTCH STANDARD

The result in InfraWorks360 is now:

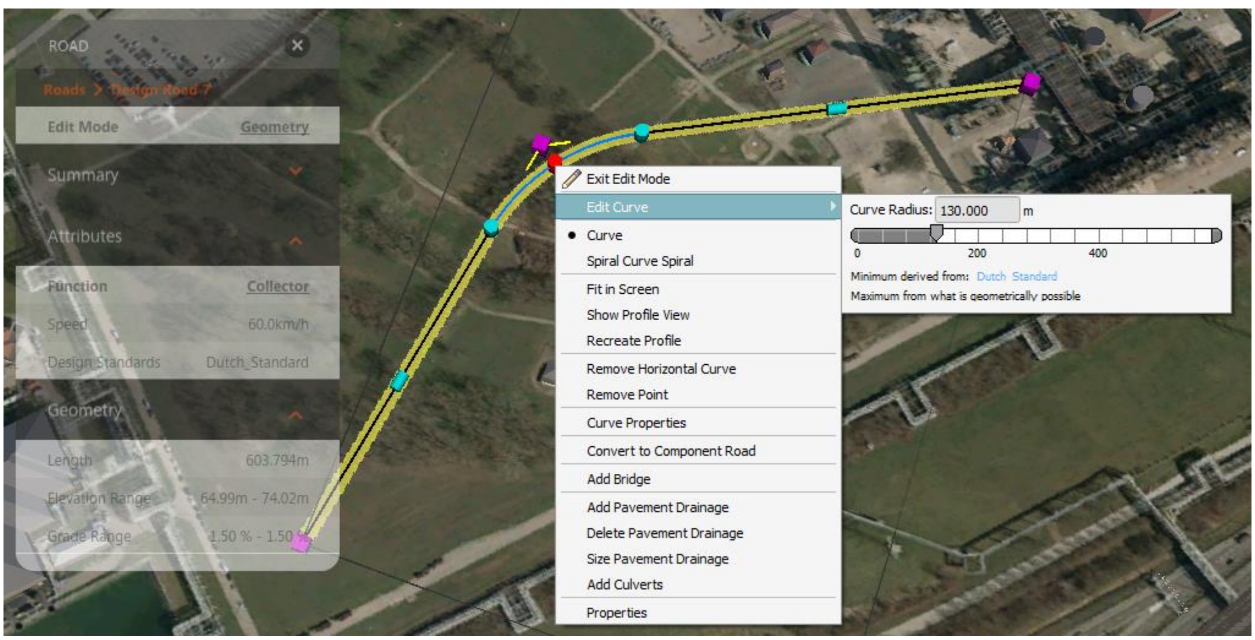


FIGURE 17: RESULT IN INFRAWORKS360

Note: If the InfraWorks360 model already have design roads with other design rules attached, these roads will not be impacted and still use the original design rules.

minimum spiral length

So far we have only looked at the minimum radius for design roads, which is independent on the road type. So everything we have done applies highways as well.

For this type of road we also require to look at transition curves or spirals as part of the alignment geometry. The followed methodology is exactly the same the formulas and values different.

There are multiple ways of calculation the spiral length. One is by defining the minimum length using formulas. The other one is calculating the default super elevation runoff length and setting the spiral length to the same value.

By default the super elevation runoff length is being used. The sections of the design rule file with the calculations can be found below.

```
;================================================================================
; Force default spiral length
; (Setting to superelevation runoff length. To change to minimum spiral length,
;  replace super-elevation-runoff-length with min-spiral-length)
;================================================================================
(defrule force-default-spiral-length-to-minimum
   ?inst <- (object (is-a StdRoad)
              (default-horiz-spiral-length       ?length&:(eq ?length ?*Unavailable*))
              (super-elevation-runoff-length  ?minlength&:(neq ?minlength ?*Unavailable*)))
=>
   (modify-instance ?inst (default-horiz-spiral-length ?minlength))
)


;
================================================================================
; Find Super Elevation Runoff Length
;
================================================================================
(defrule find-super-elevation-runoff-length
   ?inst <- (object (is-a StdRoad)
              (eMax                        ?eMax&:(neq ?eMax ?*Unavailable*))
              (no-of-lanes-rotated     ?no-of-lanes-rotated&:(neq ?no-of-lanes-rotated
?*Unavailable*))
              (lane-width               ?lane-width&:(neq ?lane-width ?*Unavailable*))
```

```
                (no-of-lanes-adj-factor          ?adj-factor&:(neq ?adj-factor ?*Unavailable*))
                (max-relative-gradient           ?rel-gradient&:(neq ?rel-gradient ?*Unavailable*))
                (super-elevation-runoff-length   ?runoff&:(eq ?runoff ?*Unavailable*)))
 =>
   (modify-instance ?inst (super-elevation-runoff-length
               (/ (* ?lane-width ?no-of-lanes-rotated ?eMax ?adj-factor) ?rel-gradient)))
)

;=============================================================================
; Force minimum spiral length to Super Elevation Runoff Length
;=============================================================================
(defrule force-minimum-spiral-length
   ?inst <- (object (is-a StdRoad)
                (min-spiral-length               ?length&:(eq ?length ?*Unavailable*))
                (super-elevation-runoff-length   ?minlength&:(neq ?minlength ?*Unavailable*)))
=>
   (modify-instance ?inst (min-spiral-length ?minlength))
)
```

In the local design rule we are developing in this class we need to use the calculated minimum spiral length rather than the calculated super elevation runoff length.

Therefore we need to make 2 small adjustments in the to the design rule file

```
;=============================================================================
; Force default spiral length
; (Setting to superelevation runoff length. To change to minimum spiral length,
;  replace super-elevation-runoff-length with min-spiral-length)
;  Modified for NL to use min-spiral-length
;=============================================================================
(defrule force-default-spiral-length-to-minimum
    ?inst <- (object (is-a StdRoad)
                     (default-horiz-spiral-length    ?length&:(eq ?length ?*Unavailable*))
                     (min-spiral-length              ?minlength&:(neq ?minlength ?*Unavailable*)))
=>
    (modify-instance ?inst (default-horiz-spiral-length ?minlength))
)
```

FIGURE 18: MODIFIED DEFAULT SPIRAL LENGTH SECTION

```
;==============================================================================
; Force minimum spiral length to Super Elevation Runoff Length
; Modified for NL not to use super-elevation-runoff-length but
; use min-spiral-length-for-curve-radius
;==============================================================================
(defrule force-minimum-spiral-length
    ?inst <- (object (is-a StdRoad)
                     (min-spiral-length                   ?length&:(eq ?length ?*Unavailable*))
                     (min-spiral-length-for-curve-radius  ?minlength&:(neq ?minlength ?*Unavailable*)))
=>
    (modify-instance ?inst (min-spiral-length ?minlength))
)
```

FIGURE 19: MODIFIED MINIMAL SPIRAL LENGTH SECTION

The actual calculation of the minimum spiral length will happen as described below:

```
;==============================================================================
; Find minimum spiral length for curve radius (AASHTO 2011, pg.3-70)
;==============================================================================
(defrule find-minimum-spiral-length-for-curve-radius
   ?inst <- (object (is-a StdRoad)
               (design-speed                          ?speed&:(neq ?speed ?*Unavailable*))
               (increase-lateral-acceleration         ?inc-lat-acc&:(neq ?inc-lat-acc ?*Unavailable*))
               (curve-radius                          ?radius&:(neq ?radius ?*Unavailable*))
               (min-spiral-length-for-curve-radius    ?minLength&:(eq ?minLength ?*Unavailable*)))
=>
   (bind ?denom (* ?radius ?inc-lat-acc))
   (if (<> ?denom 0.0)
      then (modify-instance ?inst (min-spiral-length-for-curve-radius (/ (* 0.0214 (** ?speed 3)) ?denom)))
   )
)
```

For spirals, the used parameters are: design speed, curve radius and the lateral acceleration.

The value for the lateral acceleration can also be found in the design rules file, just below the minimum radius section.

```
;==============================================================================
; Force default increase of lateral acceleration to be 0.3 (AASHTO 2011, pg. 3-70)
;==============================================================================
(defrule force-lateral-acceleration
```

```
    ?inst <- (object (is-a StdRoad)
                 (increase-lateral-acceleration ?acc&:(eq ?acc ?*Unavailable*)))
  =>
    (modify-instance ?inst (increase-lateral-acceleration 0.3))
  )
```

If the local design rule uses another value, it can be modified in this section. For the Dutch standard we use a value of **0.5** for design speeds of 90 or 120 km/h.

```
;===========================================================================
; Force default increase of lateral acceleration to be 0.5 (Modified for NL)
; originally 0.3
;===========================================================================
(defrule force-lateral-acceleration
    ?inst <- (object (is-a StdRoad)
                     (increase-lateral-acceleration ?acc&:(eq ?acc ?*Unavailable*)))
=>
    (modify-instance ?inst (increase-lateral-acceleration 0.5))
)
.
```

FIGURE 20: MODIFIED LATERAL ACCELERATION SECTION

Let's have a look at the formula that is being used for the calculation of the spiral length for a given radius.
De Dutch Design Standard describes 2 formulas

$$A_{min}(m) = 0.146 \sqrt{\frac{V_0^3}{C_{toelaatbaar}}}$$

FIGURE 21: FORMULA 1 FOR A VALUE OF SPIRAL (DUTCH STANDARD)

V_o = Design speed
A_{min} = spiral parameter
C = Lateral acceleration value

$$A^2 = R.L.$$

FIGURE 22: FORMULA 2 FOR A VALUE OF SPIRAL (DUTCH STANDARD)

A = Spiral parameter
R = horizontal radius
L = Spiral length

The calculated A values for the different design speeds are:

V_o = 120 km/h: A = 270 m; L = 96 m
V_o = 90 km/h: A = 175 m; L = 88 m
V_o = 70 km/h: A = 95 m; L = 48 m
V_o = 50 km/h: A = 60 m. L = 41 m

FIGURE 23: CALCULATED A AND L VALUES (DUTCH STANDARD)

To be able to calculate the spiral length we will combine and transform both formula in a way they look similar to the existing formula in the design rule file.

(bind ?denom (?radius ?inc-lat-acc))*
(if (<> ?denom 0.0)
then (modify-instance ?inst (min-spiral-length-for-curve-radius (/ (0.0214 (** ?speed 3)) ?denom)))*
)

Formula transformation:

- ⇒ $L = A^2/R$
- ⇒ $L = 0.146 * (sqrt(V_o^3 / C))^2)/R$
- ⇒ $L = 0.0213 * V_o^3 / C * R$
- ⇒ $L = 0.0213 * V_o^3 / 0.5 * R$

The above formula is again similar to what we already have in the design rule file, now it is again just a matter of adding the correct values.

The modified formula looks like:

```
;================================================================================
; Find minimum spiral length for curve radius (AASHTO 2011, pg.3-70)
;================================================================================
(defrule find-minimum-spiral-length-for-curve-radius
    ?inst <- (object (is-a StdRoad)
                     (design-speed                    ?speed&:(neq ?speed ?*Unavailable*))
                     (increase-lateral-acceleration ?inc-lat-acc&:(neq ?inc-lat-acc ?*Unavailable*))
                     (curve-radius                    ?radius&:(neq ?radius ?*Unavailable*))
                     (min-spiral-length-for-curve-radius  ?minLength&:(eq ?minLength ?*Unavailable*)))
=>
    (bind ?denom (* ?radius ?inc-lat-acc))
    (if (<> ?denom 0.0)
        then (modify-instance ?inst (min-spiral-length-for-curve-radius (/ (* 0.0213 (** ?speed 3)) ?denom)))
    )
)
```

FIGURE 24: MODIFIED DESIGN RULES FILE (DUTCH STANDARD)

The result in InfraWorks360 is:

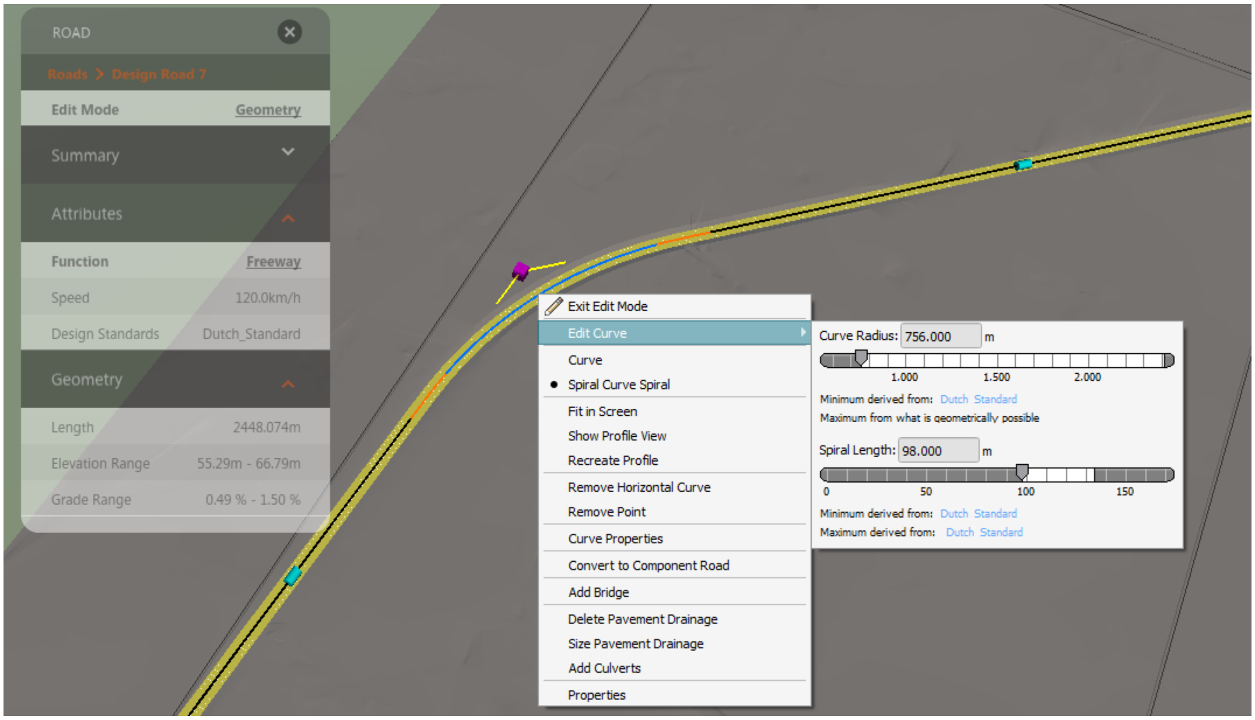


FIGURE 25: INFRAWORKS360 RESULT (DUTCH STANDARD)

maximum spiral length
Besides the minimum spiral length, we also have the option to calculate the maximum spiral length

```
;==============================================================================
; Find maximum spiral length for curve radius (AASHTO 2011, pg.3-72)
;==============================================================================
(defrule find-maximum-spiral-length-for-curve-radius
   ?inst <- (object (is-a StdRoad)
              (curve-radius          ?radius&:(neq ?radius ?*Unavailable*))
              (max-spiral-length     ?sp-len&:(eq ?sp-len ?*Unavailable*)))
=>
   (modify-instance ?inst (max-spiral-length ( sqrt (* 24.0 ?*pmax* ?radius ))))
)
```

Again, the methodology is the same, variables and values are different.
The variable to look at in this case, is the pmax value.
The value for this variable is defined in the Globals section of the design rule file.

```
; ##############################################################################
; Globals
; ##############################################################################

(defglobal ?*uses-imperial-units* = ?*False*
           ?*default-lane-width* = 3.6                      ; AASHTO 2011, pg. 4-7
           ?*driver-eye-height* = 1.08                      ; AASHTO 2011, pg. 3-14
           ?*stopping-sight-object-height* = 0.60           ; AASHTO 2011, pg. 3-15
           ?*passing-sight-object-height* = 1.08            ; AASHTO 2011, pg. 3-15
           ?*intersection-sight-object-height* = 1.08       ; AASHTO 2011, pg. 3-15
           ?*decision-sight-object-height* = 0.60           ; AASHTO 2011, pg. 3-15
           ?*headlight-height* = 0.60                       ; AASHTO 2011, pg. 3-157
           ?*headlight-angle* = 1.0                         ; AASHTO 2011, pg. 3-157
           ?*pmax* = 1.0                                    ; AASHTO 2011, pg. 3-72, maximum lateral offset
           ?*default-minimum-tangent-grade* = 0.5           ; AASHTO 2011, pg. 3-119
           ?*default-minimum-tangent-length* = 10.0         ; no citation
           ?*default-maximum-tangent-length* = 1000.0       ; no citation
           ?*disallow-spirals* = ?*False*
                   ?*intersection-standard-name* = "Intersection_AASHTO_Metric_2011")
```

FIGURE 26: GLOBALS SECTION IN DESIGN RULE FILE

If your local design rule uses another value, it can be modified here.

conclusion of this section

We have seen 2 examples using the same methodology for modifying the existing design rule files to accommodate local standards.

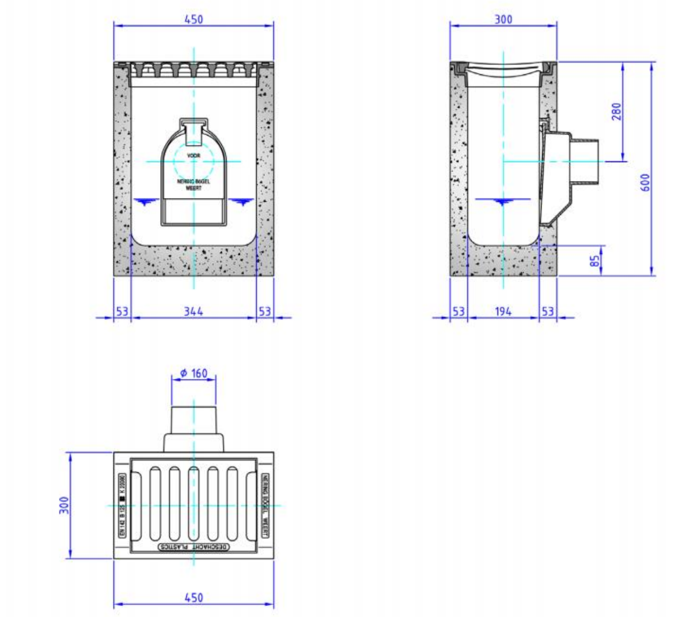
The design rule files contains information about other design criteria as well such as

Vertical gradient, stopping sight distance, etc.

If the local standards require changes to the default it can be done using the same methodology.

Part 2: Create localized content for pavement drainage networks in InfraWorks 360

In this section, I will explain how to create a new part library with the Project Kameleon Parts Editor. As an example I have taken an example from a local inlet vendor's catalogue.

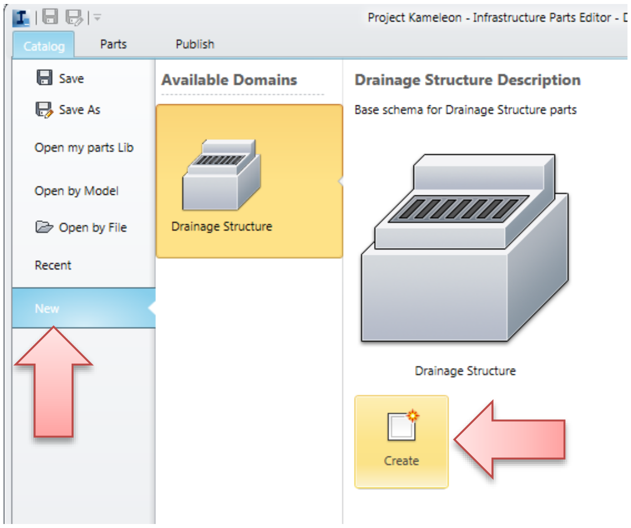


The following steps will be needed to complete the whole process and have the parts available in both InfraWorks 360 and AutoCAD Civil 3D.

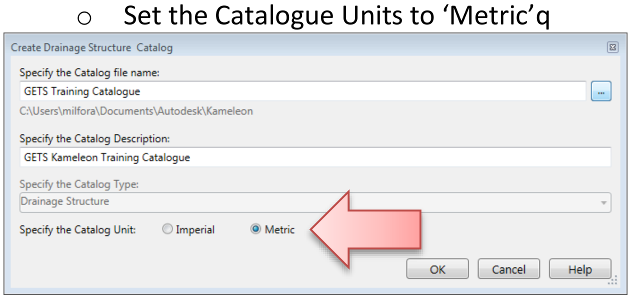
- Create a new Drainage Structure parts library catalog
- Create new rectangular structure (Grates, Surface Structure, and Underground Structure)
- Create an assembly from the components
- Publish the catalogue to InfraWorks 360
- Publish the catalogue to Civil 3D
- Create a new parts list in Civil 3D

Create new Drainage Structure Parts Library

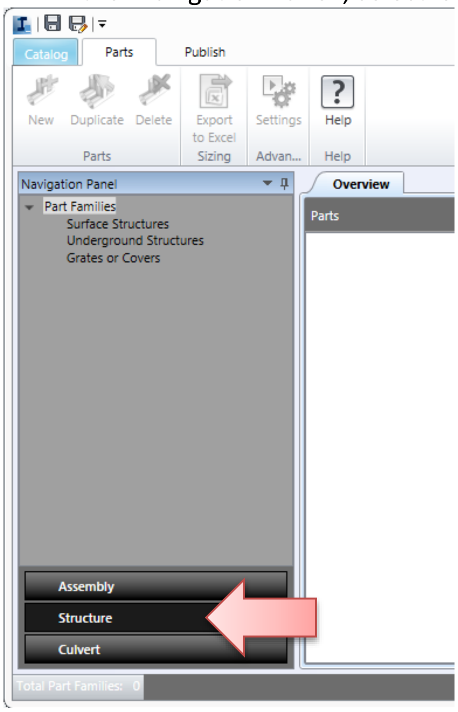
- Start the ‘Kameleon Parts Editor’
- From the ‘Catalog’ tab, on the left menu, select ‘New’, then select ‘Create’ under the ‘Drainage Structure Definition’

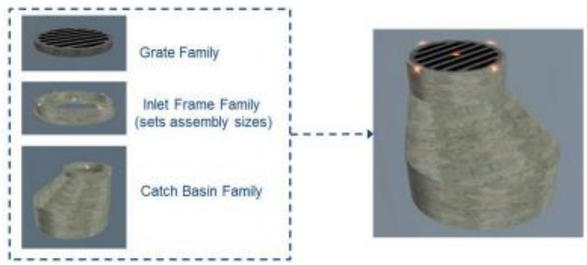


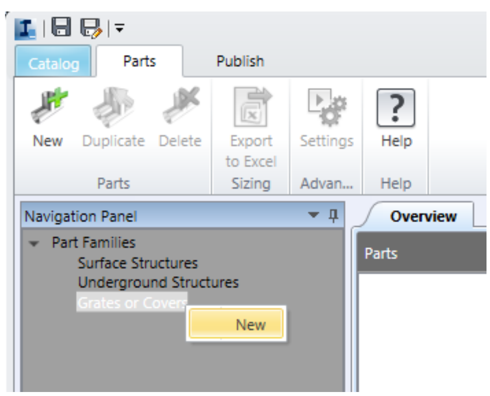
- In the ‘Create Drainage Structure Catalog’, enter the following:
  - ‘***NE Parts Catalog’*** for the catalog file name
  - ‘***NE Parts Catalog for Drainage Structures’*** for the description
  - Set the Catalogue Units to ‘Metric’q



- In the 'Navigation Panel', select 'Structure' from the part families



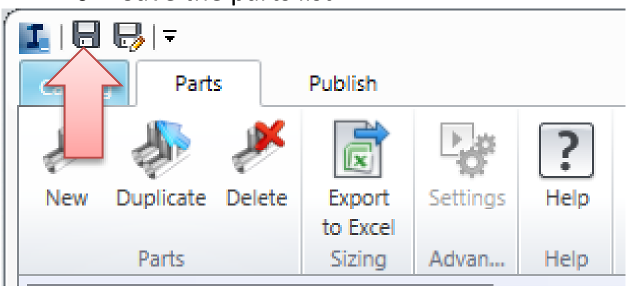


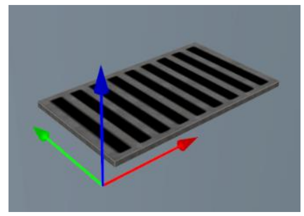


- Right click on the 'Grates or Covers' category and select 'New'
  - In the 'Part Family Properties' tab, change the 'Part Family Name to '***S 1300/ 60-80 GB1 -Grate***'. Click Next
  - In the 'Graphics' tab, select '***Grate – Rectangular Design***'. Click Next
  - In the 'Detailed Properties' tab, add the short description '***S 1300/ 60-80 GB1'***.
    Change the 'Cover or Grate Type' pulldown to '***Grate B***', and the '***Grate or Cover Form***' to '***Rectangular Grate or Cover Form***'. Click Next
  - In the 'Part Editing' tab, click 'Add Row'. Change the following parameters in Row 1 (* indicates mandatory field)
    Part Size Local Name
    S 1300/ 60-80 GB1 -Grate450x300
    Size ***450x300***
    CGLength ***400***

CGWidth ***250***
CGHeight ***25***

- Click Next
- Highlight the new row in the 'Size Table', and verify the grate sizes in the 'Sizes View'
- Save the parts list





- Right click on the 'Surface Structures' category and select 'New'
  - In the 'Part Family Properties' tab, change the 'Part Family Name to ' ***S 1300/60-80 GB1 -SS***'. Click Next
  - In the 'Graphics' tab, select '***Inlet Grate - (Rectangular –Rectangular)***'. Click Next
  - In the 'Detailed Properties' tab, add the short description 'S_1300_60_80_GB1'. Change the 'Inlet Form' pulldown to '***Rectangular Inlet Form***', and select the '***Curb Inlet'*** checkbox. Click Next
  - In the 'Part Editing' tab, click 'Add Row'. Change the following parameters in Row 1 (* indicates mandatory field)

    Part Size Local Name

    S 1300/60-80 GB1 -SS,450x300

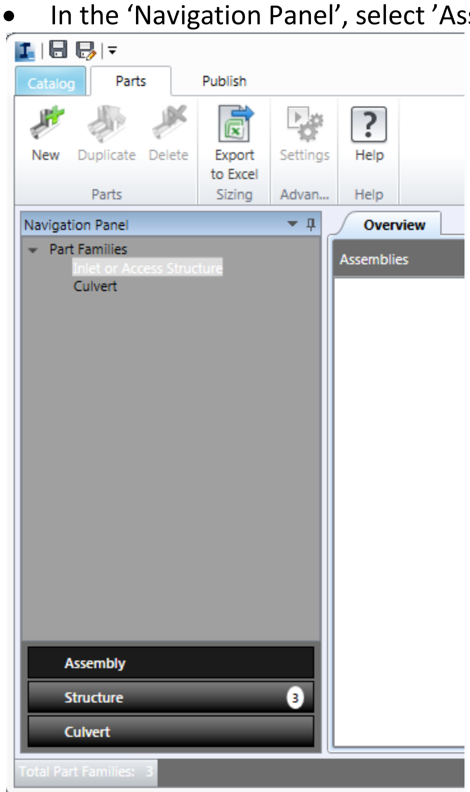
    GutterSlope ***0***
    CrossSlope ***0***
    SSLength ***450***
    SSWidth ***300***
    SSHeight ***25***
    CurbWidth ***25***
    CurbHeight ***25***
    WallTh ***25***
    SPLength ***450***
    SPWidth ***300***
    CGLength ***400***
    CGWidth ***250***
    CGHeight ***25***
  - Click Next
  - Highlight the new row in the 'Size Table', and verify the surface structure sizes in the 'Sizes View'
  - Save the parts list

- Right click on the 'Underground Structures' category and select 'New'
  - In the 'Part Family Properties' tab, change the 'Part Family Name' to 'S 1300/60-80 GB1 - US'. Click Next
  - In the 'Graphics' tab, select 'Catchment Structure (Rectangular)'. Click Next

- In the 'Detailed Properties' tab, add the short description 'S 1300/60-80 GB1'.
  Change the 'Structure Base Form' pulldown to 'Rectangular Underground Structure Form'. Click Next
- In the 'Part Editing' tab, click 'Add Row'. Change the following parameters in Row 1 (* indicates mandatory field)

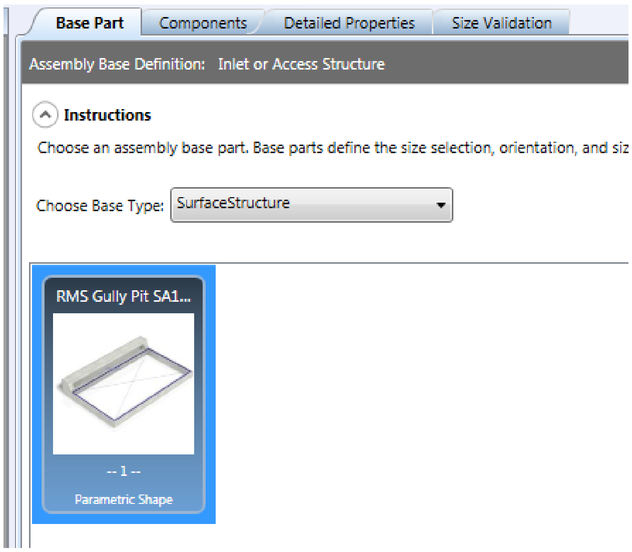
- Part Size Local Name
  S 1300/60-80 GB1 - US,450x300
  USLength 450
  USWidth 300
  USHeight 600
  BaseTh 85
  WallTh 53
  SPLength 550
  SPWidth 300
- Click Next
- Highlight the new row in the 'Size Table', and verify the grate sizes in the 'Sizes View'
- Save the parts list

- In the 'Navigation Panel', select 'Assembly' from the part families

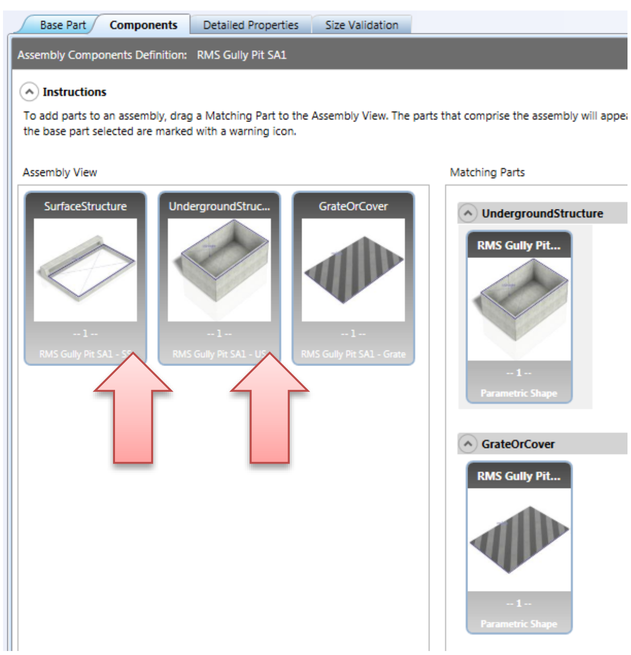


- Right click on the 'Inlet or Access Structure' category and select 'New'

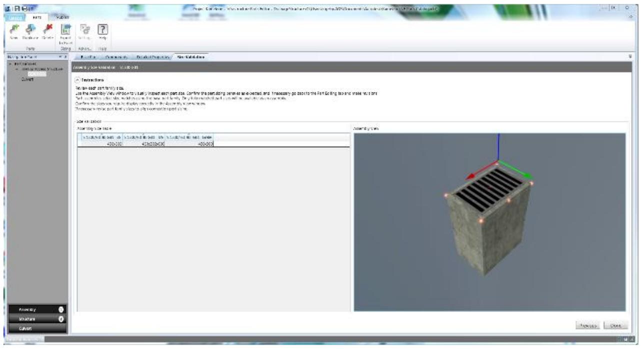
- In the 'Base Part' tab, change the 'Assembly Name to ' S1300 GB1'. Select the 'S 1300/60-80 GB1 - SS' diagram from the definition screen.
  Click Next



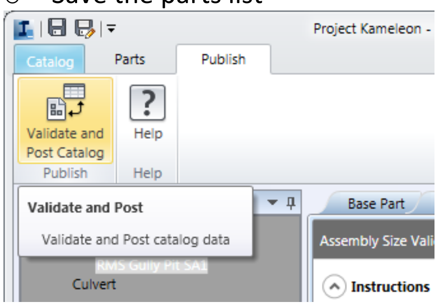
- In the 'Components' tab, drag and drop the 'S 1300/60-80 GB1 - US' from the 'Underground Structure' matching parts to the blank 'Underground Structure' panel.
- Drag and drop the 'S 1300/60-80 GB1 - Grate' from the 'GrateOrCover' matching parts to the blank 'GrateOrCover' panel.
- Click Next



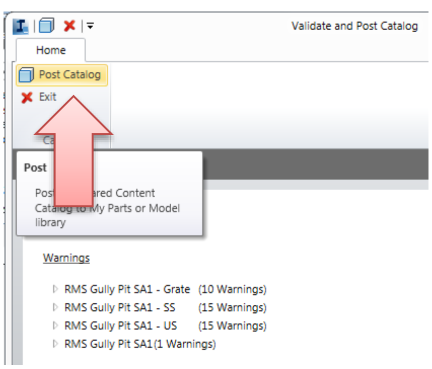
- In the ‘Detailed Properties’ tab, add the short description ‘***S1300_GB1_METRIC***’. Click the checkboxes for ‘Has Sump’ and ‘In Inlet’
- Click Next



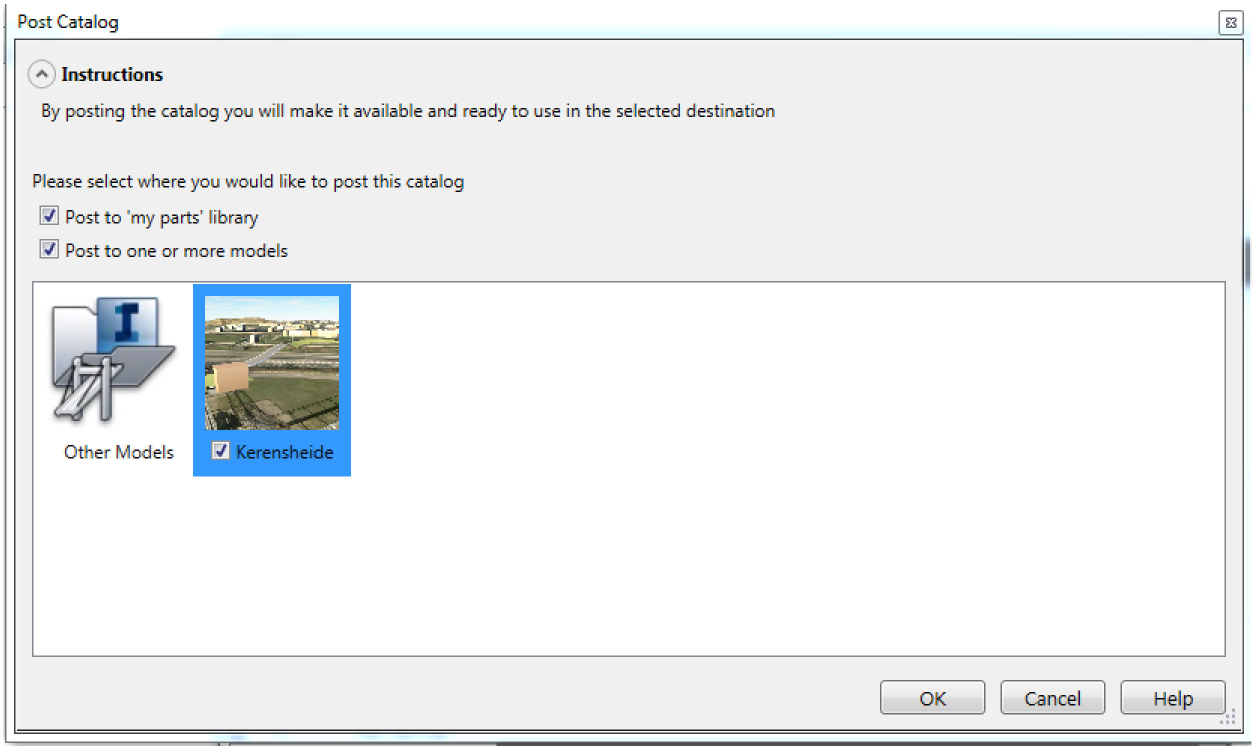
- Highlight the new row in the ‘Assembly Size Table’, and verify the grate sizes in the ‘Sizes View’
- Save the parts list

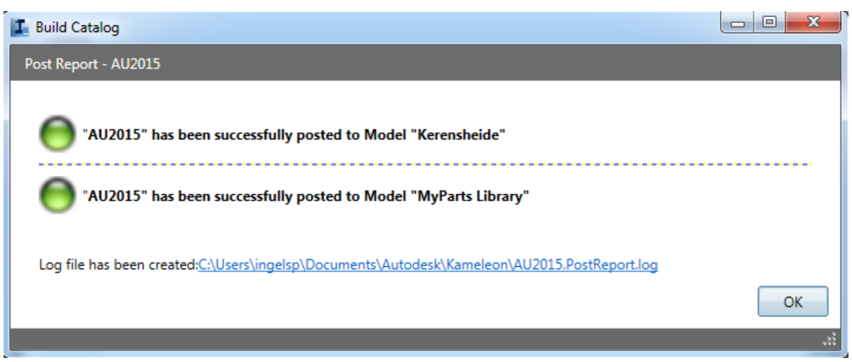


- In the ‘Publish’ tab, click ‘Validate and Post Catalog’
- Click ‘Post Catalog’

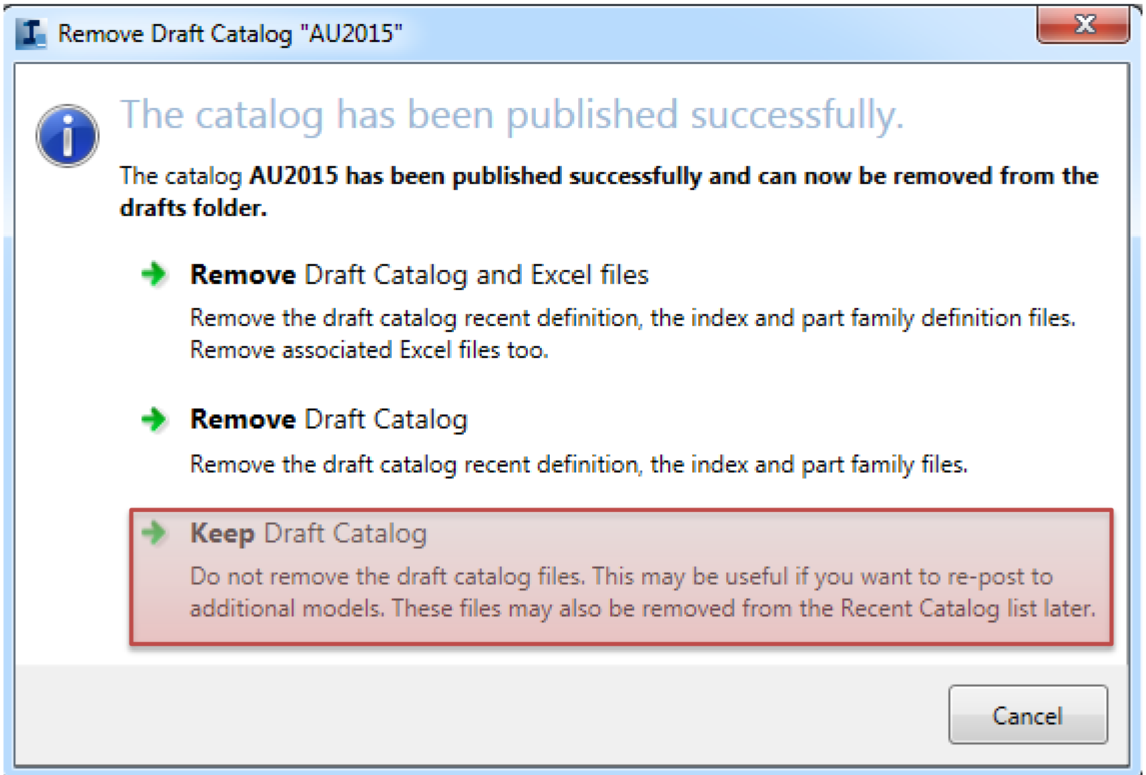


- In the ‘Post Catalog’ dialog, select the ‘Post to my parts library’ and or select an Infraworks360 Model
- If you selected to publish to an InfrWorks360 Model, select the model to export to.
- Click OK
- Click OK again to exit the ‘Build catalog’ dialog





○ In the 'Remove Draft Catalog' dialog, select 'Keep Draft Catalog'

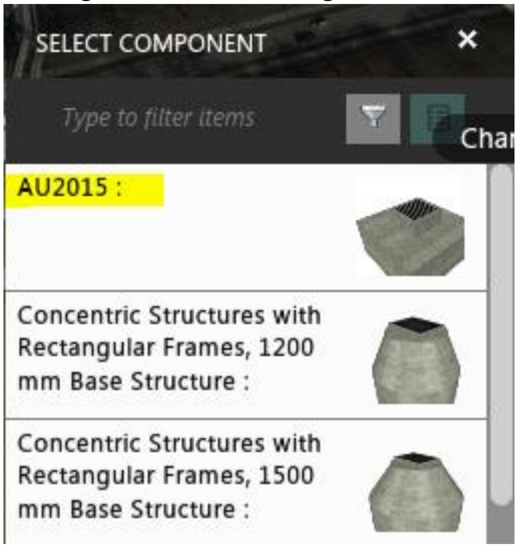


- This creates a Catalogue Folder:
  'C:\Users\%username%\Documents\Autodesk\Kameleon\AU2015,
  and a Catalogue Index File:
  'C:\Users\%username%\Documents\Autodesk\Kameleon\ AU2015.icbt'
- Exit the Parts Editor

Use the catalog in infraWorks360

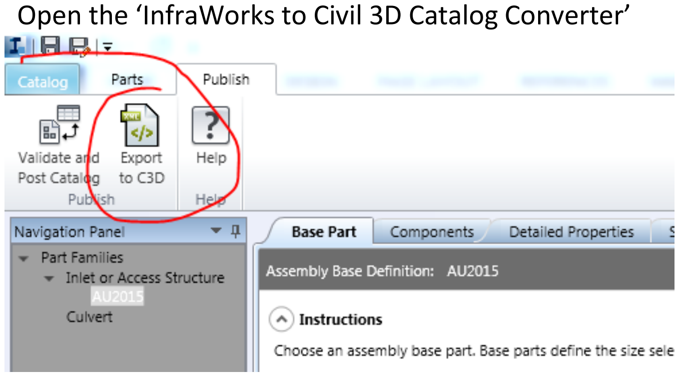
As part of the publication process we have added the new catalog to existing Infraworks360 Models.

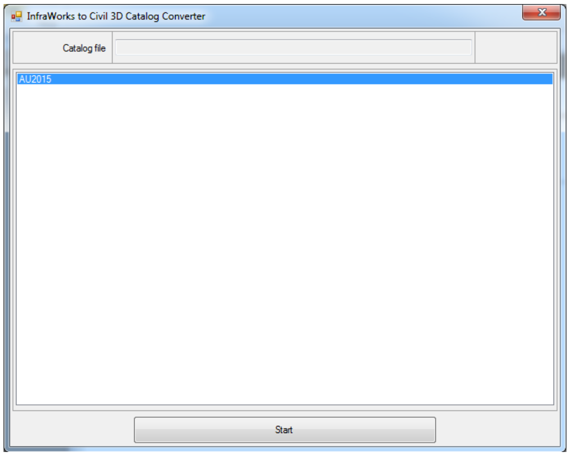
Now I have added a part catalog to an Infraworks model, I can add these elements to a avement drainage network of a design road.



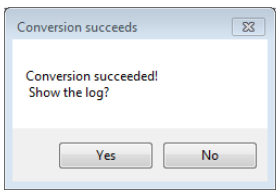
Publish the catalog to Civil 3D

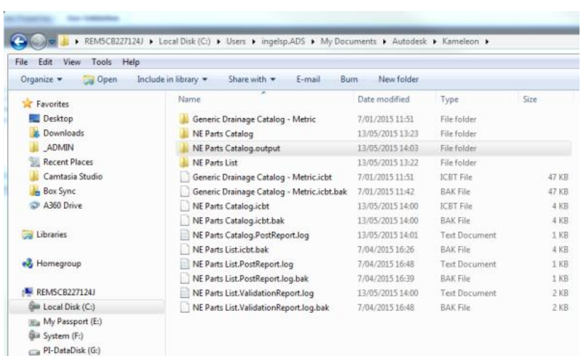
- Open the 'InfraWorks to Civil 3D Catalog Converter'



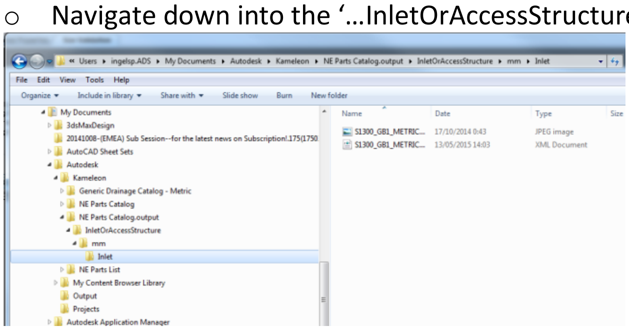


○ Click Start
○ Click Yes to show the log file

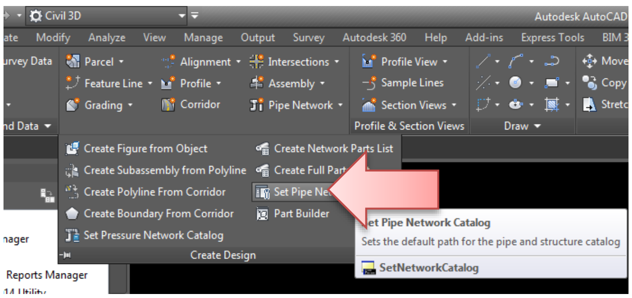


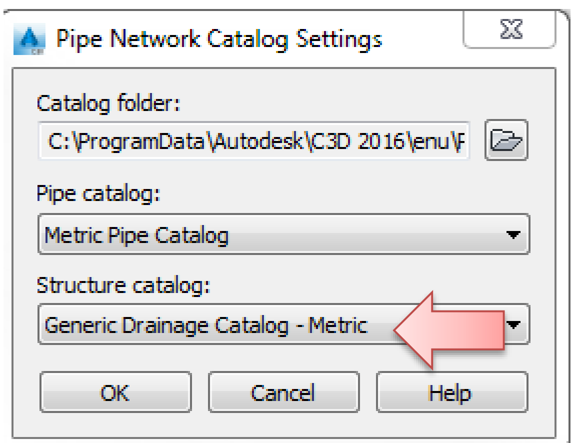


- Navigate to the local folder 'C:\Users\%username%\Documents\Autodesk\Kameleon\AU2015.output'
  - Navigate down into the '…InletOrAccessStructure\mm\Inlet' folder

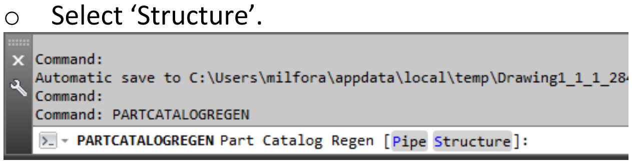


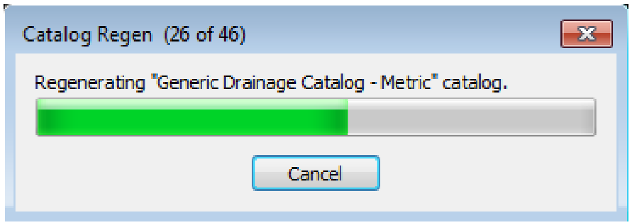
- Copy the 2 files to the generic parts catalog
    - C:\ProgramData\Autodesk\C3D 2016\enu\Pipes Catalog\Generic Drainage Catalog - Metric\Inlet
- Start Civil 3D using any template
- In the 'Home' tab on the ribbon, expand the 'Create Design' and select 'Set Pipe Network Catalog'
    - In the 'Pipe Network Catalog Settings' dialog, ensure the catalog folder is set to 'C:\ProgramData\Autodesk\C3D 2016\enu\Pipes Catalog'
    - Pipe Catalog set to 'Metric Pipe Catalog'
    - Structure Catalog set to 'Generic Drainage Catalog - Metric'
    - Click OK



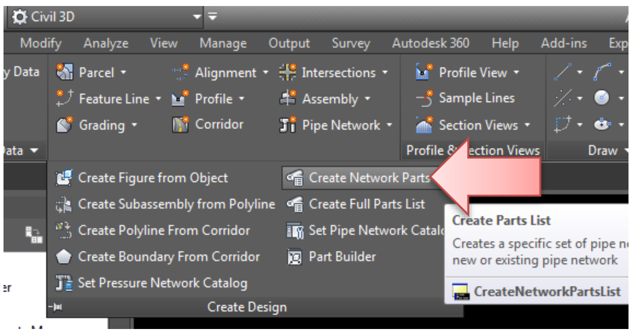


- Now type in 'PARTCATALOGREGEN' on the command line
    - Select 'Structure'.
    - Hit 'Enter' to end the command
- Back in Civil 3D, type in 'PARTCATALOGREGEN' on the command line
    - Select 'Structure'.

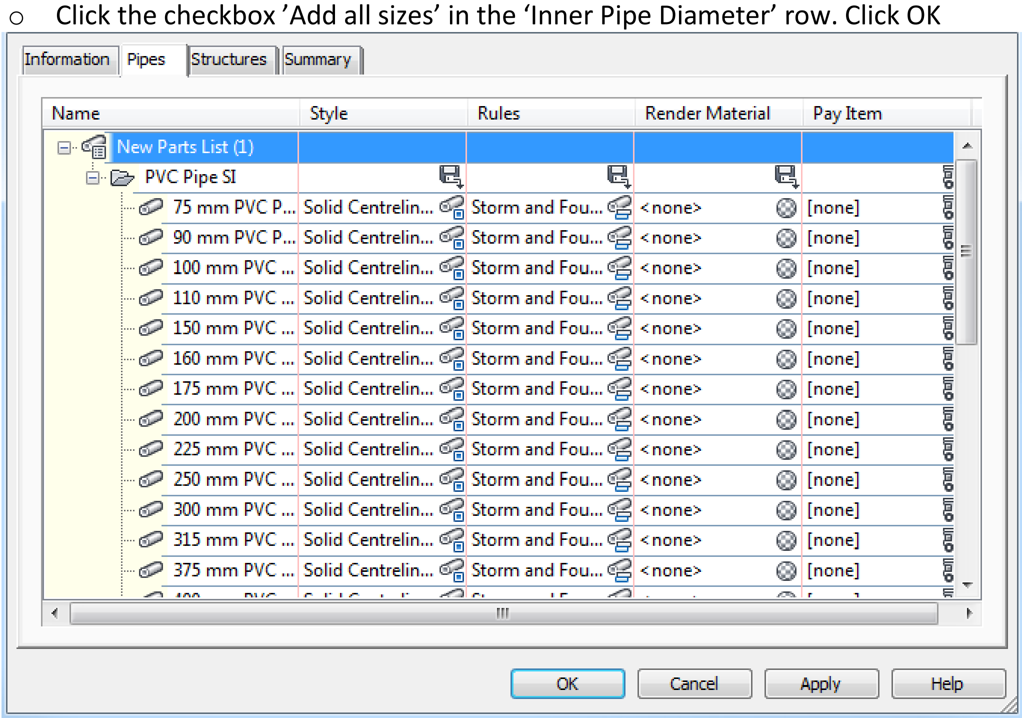




- From the 'Home' tab on the ribbon, open the 'Create Design' expansion, and select 'CreateNetworkPartsList'

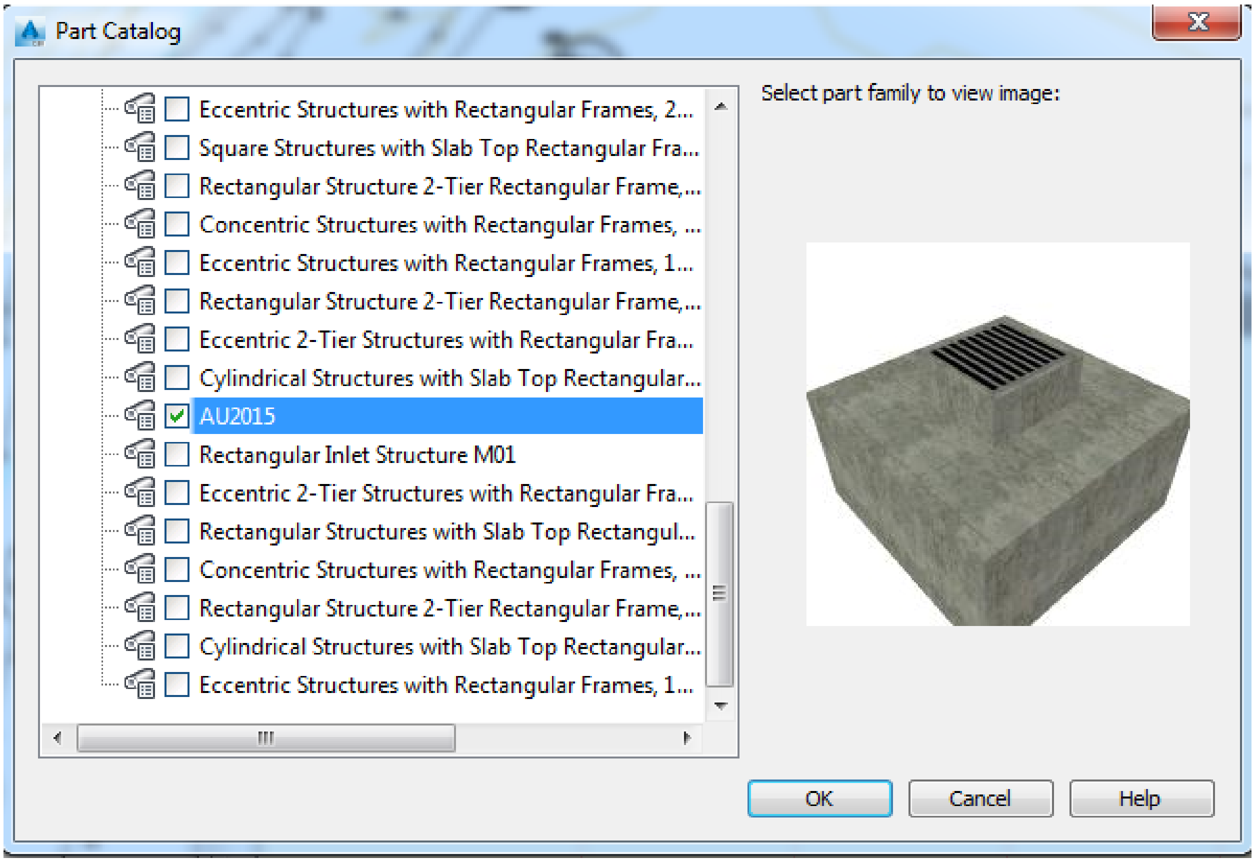


  - On the 'Information' tab, change the name to 'NE Parts List'
  - Select the 'Pipes' tab, right-click on 'New Parts List' add a part family.
    - Select 'PVC Pipe SI'
    - Click OK
  - Right-click the 'PVC Pipe SI' folder and select 'Add part size…'
  - Click the checkbox 'Add all sizes' in the 'Inner Pipe Diameter' row. Click OK



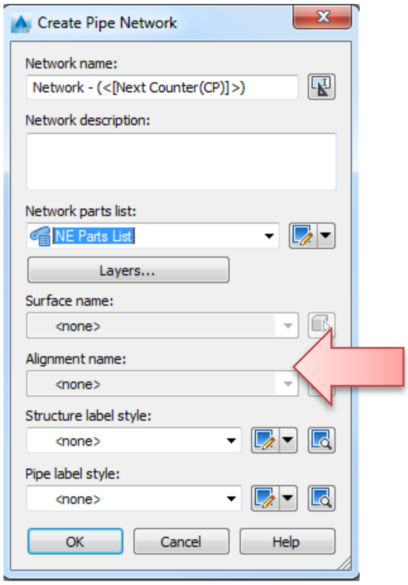
- Select the 'Structures' tab, right-click on 'New Parts List' add a part family.
  - Select 'S1300 GB1'

- Click OK



- Right-click the AU2015 family and select 'Add part size…'
- Click OK to accept the default size
- Change the style to 'Basic'
- Click OK to exit the 'Network Parts List'

- Create a new pipe network, change the parts list to 'AU2015



- Orbit the view in 3D, set the visual style to 'Realistic' and verify the RMS style pit is shown correctly