JSWMM - Routing/dimensioning component

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Abstract

This pages teaches JSWMM-Routing component as OMS3 component. Some preliminary knowledge and installation of OMS is mandatory (see @Also useful). This component is part of Routing NET3 node. It evaluates the maximum discharge at the junction, then it evaluates the best commercial diameter for related conduit. Finally the component routes the full hydrograph, for each rainfall time (3, 5 and 10 minutes).

@Version:
0.1

@License:
GPL v.3

@Inputs:
SWMMobject dataStructure;

@Outputs:
HashMap<Integer, LinkedHashMap<Instant, Double>> routingFlowrate;

Keywords: OMS; JSWMM; JGrass-NewAGE Component

Code Information

Code repository

This points to the source code https://github.com/geoframecomponents/jswmm

Executables

This points to the jar file that, once downloaded can be used in the OMS console.
../build/libs

Also useful

Dependency of the source code:

- inpparser-all.jar
- oms-all.jar

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Component Algorithms and internals

Governing equations

Dimensioning the circular conduit

Manning formula:

$$u = \frac{k}{n} \cdot R_h^{2/3} \cdot S^{1/2} \tag{1}$$

The design of pipes main depends on maximum discharge, but other parameters influence the right dimension. The Manning's equation (eq. 1) is the base formula to get the dimension for a conduit.

The variables of this formulation are related to the shape and dimensions of the stream. The Manning formula gives:

$$D = \left[\frac{2^{13/3} \cdot Q_{max}}{k_s \cdot S^{1/2} \cdot (1 - \frac{\sin\theta}{\theta})^{2/3} \cdot (\theta - \sin\theta)} \right]^{3/8} \tag{2}$$

where k_s is the Gaucker-Stricker coefficient, S the conduit slope and θ is given by equation $\theta = 2 \cdot \arccos(1 - 2 \cdot G)$. θ is the angle in Figure 1.

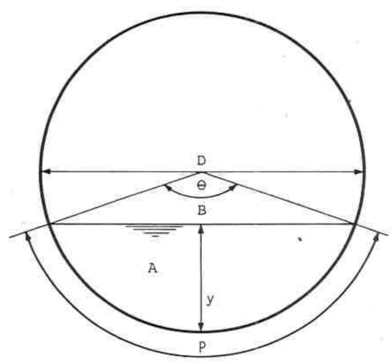


Figure 1 Circular cross-section partly full.

The inner diameter depends on following pipe's parameters:

- **discharge**: is the basic of all design. Must be evaluated taking into account: the runoff due to related area and the routing from the above part of the network;
- **slope**: is set as initial value. After practical checks updated if necessary;
- **roughness**: depends on the material of the conduit;
- **filling ratio**: is set as initial value. After the choice of a commercial diameter the filling ratio is evaluated and updated if necessary.

The diameter depends on slope, it follows that the design is iterative.

Routing on conduits

The hydraulic equations are a pair of partial differential equations: Saint Venant equations. SWMM allows two methods to solve them: dynamic wave and kinematic wave.

Continuity equation

Conservation form

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0$$

Nonconservation form

$$V\frac{\partial y}{\partial x} + y\frac{\partial V}{\partial x} + \frac{\partial y}{\partial t} = 0$$

Momentum equation

Conservation form

$$\frac{1}{A}\frac{\partial Q}{\partial t} + \frac{1}{A}\frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right) + g\frac{\partial y}{\partial x} - g(S_o - S_f) = 0$$

Local acceleration term	Convective acceleration term	Pressure force term	Gravity force term	Friction force term

Nonconservation form (unit width element)

$$\frac{\partial V}{\partial t} + V\frac{\partial V}{\partial x} + g\frac{\partial y}{\partial x} - g(S_o - S_f) = 0$$

Kinematic wave: $g(S_o - S_f) = 0$

Diffusion wave: $g\frac{\partial y}{\partial x} - g(S_o - S_f) = 0$

Dynamic wave: $\frac{\partial V}{\partial t} + V\frac{\partial V}{\partial x} + g\frac{\partial y}{\partial x} - g(S_o - S_f) = 0$

Figure 2 Summary of the Saint Venant equations. Credit: [1]

Dynamic wave analysis solves the complete form of equations. It takes into account:

- Channel storage;
- Backwater effects;
- entrance/exit losses;
- Culvert flow;
- Flow reversal;
- Pressurized flow.

It can be applied to any conditions, because of the solution is coupled between water levels and nodes. Even for networks with loops and diversions. This way to solve the equations is not allowed right now by this thesis work because of framework boundaries.

Kinematic wave analysis solves the continuity equation coupled with a simplified momentum equation at the conduit. The limits of this solution are:

- No backwater effects;
- No entrance/exit losses;
- No flow reversal;
- No pressurized flow.

This way permits the use of larger time step maintaining the numerical stability. The kinematic wave still a good solution if the effects above are not present in the network. The hypothesis of this solution are:

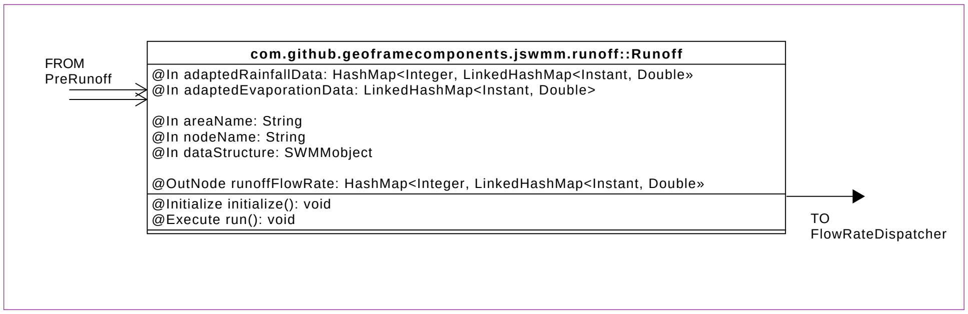
1 It analyzes only directed acyclic networks;
2 Junctions can have at most one outlet link.

Steady flow analysis is another way to find a solution to flow analysis. In this case in all time step the flow is uniform and steady. It simply translates inflow hydrograph from the upstream end to the downstream end of the conduit. It has the same limits of kinematic wave. As hypothesis it ignores the free surface wave propagation and so the solution is rough but it still good for design.

Sofware specifications

To evaluate circular conduits routing, using EPA SWMM algorithm.

Class UML diagram



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References

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