Siphonic Roof Drainage

Saturday, September 21, 2013
2:15 – 5:15 p.m.

Addendum 1 - 9/30/13
Peter A. Kraut, P.E.

- B.S. Architectural Engineering Technology
  - Wentworth Institute of Technology, Boston
- Professional Engineer, Mechanical
  - Arizona, California, Colorado, Connecticut, Georgia, Hawaii, Indiana, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Texas, Virginia, Washington, Wisconsin
- 20 years experience designing plumbing systems
- South Coast Engineering Group, Inc., 2001
Outline

- Codes and Approvals
- Roof Slopes and Catchment Areas
- Structural Coordination
- Building Coordination
- Configuration
- Preliminary Pipe Sizing
Codes and Approvals
Codes and Approvals

- Proposal
- Coordination
  - five (5) feet outside of the building footprint
    - Manhole, Civil POC
  - *Rerouting requires re-engineering*
  - *Simultaneous modeling*
  - *Construction related changes*
Codes and Approvals

- National standards
  - ANSI / ASME A112.6.9 Siphonic Roof Drains
  - ASPE Technical Standard 45 Siphonic Roof Drainage Systems

- Model Codes
  - Alternate Engineered System
  - Certification
Codes and Approvals

- Not specifically listed in any model plumbing code
- Alternate engineered system.
  - Acceptance by the authorities having jurisdiction is not guaranteed
  - and if it is rejected …
Codes and Approvals

† Draft a Letter to the Code Official
  • Basic Concepts
  • History
    • Finland 1970
    • Boston Massachusetts 2001
  • Experience
  • Nearby Installations
The flow of rainwater under pressure is governed by the Darcy-Weisbach equation:

\[ h_f = f \left( \frac{L}{D} \right) \frac{V^2}{2g} \]

Where:
- \( h_f \) = pressure loss due to friction in feet
- \( f \) = friction factor
- \( L \) = length of pipe in feet
- \( D \) = diameter of pipe in feet
- \( V \) = velocity in feet per second
- \( g \) = gravitational constant; 32 feet/second²
Codes and Approvals

- Overflow Drains are Required
- If a roof drain system is designed to the 100 year storm, what is the likelihood that it will experience a greater rainfall intensity in the 100 year lifetime of the building?

<table>
<thead>
<tr>
<th>Storm Period (years)</th>
<th>Lifetime of Building (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>92</td>
</tr>
<tr>
<td>25</td>
<td>63</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>100</td>
<td>22</td>
</tr>
<tr>
<td>500</td>
<td>5</td>
</tr>
<tr>
<td>1000</td>
<td>2</td>
</tr>
</tbody>
</table>
Codes and Approvals

- Request approval of the *concept*
- Indicate what will be provided
  - Calculations
  - Plans
  - Dimensions
  - Construction administration
- Final approval after plans are submitted
Roof Slopes and Catchment Areas
2010 Uniform Plumbing Code

1101.11.1 Primary Roof Drainage. Roof areas of a building shall be drained by roof drains or gutters. The location and sizing of drains and gutters shall be coordinated with the structural design and pitch of the roof. Unless otherwise required by the Authority Having Jurisdiction, roof drains, gutters, vertical conductors or leaders, and horizontal storm drains for primary drainage shall be sized based on a storm of 60 minutes duration and 100 year return period. Refer to Table D 1.0 (in Appendix D) for 100 year, 60 minute storms at various locations.
Roof Slopes

- 2009 International Building Code
  1507.13.1 Slope. Thermoplastic single-ply membrane roofs shall have a design slope of a minimum of one-fourth unit vertical in 12 units horizontal (2-percent slope).

- Surface Slope
  - Surfaces sloped less than ¼” per foot (2%) may not have adequate surface flow
  - Slope is dependent on material roughness
Roof Slopes

- 2010 Uniform Plumbing Code
  
  **1105.3 Strainers for Flat Decks.** Roof drain strainers for use on sun decks, parking decks, and similar areas that are normally serviced and maintained, shall be permitted to be of the flat surface type. Such roof drain strainers shall be level with the deck and shall have an available inlet area of not less than two (2) times the area of the conductor or leader to which the drain is connected.

- Rule of Thumb: Use eight (8) or more times the area when placing over a siphonic drain.
Roof Slopes

- Load Rating ASME Standard A112.6.3M
- **6.1 Loading Classifications:** Grates and top rims shall be designed to meet the following loading classifications.
  - **6.1.1 – Light Duty** All grates having safe live load under 2000 lb.
  - **6.1.2 – Medium Duty** All grates having safe live load between 2000 lb. and 4999 lb.
  - **6.1.3 – Heavy Duty** All grates having safe live load between 5000 lb. and 7499 lb.
  - **6.1.4 – Extra Heavy Duty** All grates having safe live load between 7500 lb. and 10,000 lb.
  - **6.1.5 – Special Duty** Grates having safe live load over 10,000 lb. shall be considered special and treated accordingly.
Rainfall Rates

- Rainfall Rates
- City of Los Angeles = 2” per hour
- Los Angeles County = 3” per hour
- City of Santa Ana = 4” per hour
- The following charts are for conceptual information only!
- Check Local Codes
Side Walls

- 2010 Uniform Plumbing Code
  1106.4 Side Walls Draining onto a Roof. Where vertical walls project above a roof so as to permit storm water to drain to the roof area below, the adjacent roof area shall be permitted to be computed ... as follows:
Side Walls

- For one (1) wall – add fifty (50) percent of the wall area to the roof area figures.
- For two (2) adjacent walls – add thirty-five (35) percent of the total wall areas.
- Two (2) walls opposite of same height – add no additional area.
- Two (2) walls opposite of differing heights – add fifty (50) percent of wall area above top of lower wall.
- Walls on three (3) sides – add fifty (50) percent of area of the inner wall below the top of the lowest wall, plus allowance for area of wall above top of lowest wall, per (2) and (4) above.
- Walls on four (4) sides – no allowance for wall areas below top of lowest wall – add for areas above the top of the lowest wall per (1), (2), (4) and (5) above.
Side Walls

Area = Roof Area + 0.50 A

Area = Roof Area + 0.35 A + 0.35 D + 0.50 C

Area = Roof Area + 0.50 C

Area = Roof Area + 0.50 C + 0.50 D + (0.35 C + 0.35E) + 0.50F

Area = Roof Area + 0.60 D + (0.35 C + 0.35E) + 0.60F
Structural Coordination
Depth of Water

- Remember conventional flow:

\[ Q = \pi D \sqrt{gh_c^3} \]

- where

\[ h_c = \frac{2}{3} h \]
## Depth of Water

- Using conventional drains and the maximum flow rate allowed by code:

<table>
<thead>
<tr>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2”</td>
</tr>
<tr>
<td>3”</td>
</tr>
<tr>
<td>4”</td>
</tr>
<tr>
<td>5”</td>
</tr>
<tr>
<td>6”</td>
</tr>
<tr>
<td>8”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum flow rate</th>
<th>Depth of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 gpm</td>
<td>1.1”</td>
</tr>
<tr>
<td>67 gpm</td>
<td>1.7”</td>
</tr>
<tr>
<td>144 gpm</td>
<td>2.4”</td>
</tr>
<tr>
<td>261 gpm</td>
<td>3.1”</td>
</tr>
<tr>
<td>424 gpm</td>
<td>3.7”</td>
</tr>
<tr>
<td>913 gpm</td>
<td>5.2”</td>
</tr>
</tbody>
</table>
### Depth of Water

- Using one manufacturer’s siphonic roof drain and the same flow rates (except 4”):

<table>
<thead>
<tr>
<th>Size</th>
<th>Maximum flow rate</th>
<th>Depth of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>23 gpm = 0.05 cfs</td>
<td>n/a</td>
</tr>
<tr>
<td>2”</td>
<td>67 gpm = 0.15 cfs</td>
<td>0.8”</td>
</tr>
<tr>
<td>2”</td>
<td>144 gpm = 0.32 cfs</td>
<td>1.4”</td>
</tr>
<tr>
<td>2 ½”</td>
<td>261 gpm = 0.58 cfs</td>
<td>2.0”</td>
</tr>
<tr>
<td>3”</td>
<td>424 gpm = 0.94 cfs</td>
<td>2.6”</td>
</tr>
<tr>
<td>4”</td>
<td>765 gpm = 1.7 cfs</td>
<td>3.5”</td>
</tr>
</tbody>
</table>
Depth of Water

- Placing drains in a sump allows the water level to rise without ponding.
- With 50 foot drain spacing and ¼” per foot slope, a 2” deep rise will cover over 800 square feet and weigh up to 4500 pounds.
- A 2’ x 4’ x 2” deep sump, when full, weighs about 85 pounds.
- Sumps eliminate weight on the structure.
Depth of Water

Assuming 50 foot spacing between drains and 2% slope = 538 gallons = 4493 pounds

With a 48" x 24" x 2" deep sump = 10 gallons = 83 pounds
Building Coordination
Discharge

2010 Uniform Plumbing Code

1101.1 Where Required. Roofs, paved areas, yards, courts, and courtyards, vent shafts, light wells, or similar areas having rainwater, shall be drained into a separate storm sewer system, or into a combined sewer system where a separate storm sewer system is not available, or to some other place of disposal satisfactory to the Authority Having Jurisdiction. In the case of one- and two-family dwellings, storm water shall be permitted to be discharged on flat areas, such as streets or lawns, so long as the storm water shall flow away from the building and away from adjoining property, and shall not create a nuisance.
Discharge

- Increase to a conventional size for 10 pipe diameters (1% slope) to break the siphon
- Discharging into a vented manhole is best
- Daylighting pipes may be acceptable
  - Check velocities
- Alternatively, increase to conventional size in the vertical
  - Vent if necessary
Discharge

- If the city storm drain becomes blocked, your system could back-up.
- If the city storm drain surcharges, your 30’ siphon could turn into a 130’ siphon creating negative pressures far greater than your system can handle.
Expansion

Given the length of many siphonic systems, expansion must be considered

PVC Pipe has significant expansion and contraction

<table>
<thead>
<tr>
<th>PVC – Thermal Expansion and Contraction</th>
<th>Change in Length (inches) versus change in Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Length (inches)</td>
<td>Change in Degree Fahrenheit</td>
</tr>
<tr>
<td>40°F</td>
<td>50°F</td>
</tr>
<tr>
<td>60°F</td>
<td>70°F</td>
</tr>
<tr>
<td>80°F</td>
<td>90°F</td>
</tr>
<tr>
<td>100°F</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length (feet)</th>
<th>40°F</th>
<th>50°F</th>
<th>60°F</th>
<th>70°F</th>
<th>80°F</th>
<th>90°F</th>
<th>100°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.278</td>
<td>0.348</td>
<td>0.418</td>
<td>0.487</td>
<td>0.557</td>
<td>0.626</td>
<td>0.696</td>
</tr>
<tr>
<td>40</td>
<td>0.557</td>
<td>0.696</td>
<td>0.835</td>
<td>0.974</td>
<td>1.114</td>
<td>1.235</td>
<td>1.392</td>
</tr>
<tr>
<td>60</td>
<td>0.835</td>
<td>1.044</td>
<td>1.253</td>
<td>1.462</td>
<td>1.670</td>
<td>1.879</td>
<td>2.088</td>
</tr>
<tr>
<td>80</td>
<td>1.134</td>
<td>1.392</td>
<td>1.670</td>
<td>1.949</td>
<td>2.227</td>
<td>2.506</td>
<td>2.784</td>
</tr>
<tr>
<td>100</td>
<td>1.392</td>
<td>1.740</td>
<td>2.088</td>
<td>2.436</td>
<td>2.784</td>
<td>3.132</td>
<td>3.480</td>
</tr>
</tbody>
</table>
Configuration
Tailpiece
Tailpiece

- To ensure priming, tailpieces should be at least 24” long
- Tailpieces must turn horizontal before connecting to a collector pipe
- Connections to the collector should be made on the side
Wyes

- Fitting used in the calculations must match fittings used in the drawings and in the installed condition.
- DWV fittings are required
- Wyes are required
Reducer Placement

- When available, use eccentric reducers
  - In horizontal piping
    - placed with the flat side UP
  - No air pocket to delay priming
- Concentric reducers may be used
Reducer Placement

Horizontal Pipes
Reducer Placement

- Decrease pipe size at the top of risers
  - placed with the flat side on the inside
  - Alternatively, offset the pipe
- Increasing the pipe size in the vertical will almost always break the siphon
- Use this technique in tall buildings where the available head is much more than you need.
Reducer Placement

Top of Downpipe

ACCEPTABLE

NOT PERMITTED

TYPICAL UNLESS NOTED OTHERWISE
Elbows

- Fitting used in the calculations must match fittings used in the drawings and in the installed condition.
- Do not use short radius fittings
- Use DWV fittings
- Long radius bends permitted
- Use two (2) eighth bends (45°)
Elbows

Top of Downpipe
Elbows

Bottom of tailpieces and Downpipe
Preliminary Pipe Sizing
Preliminary Pipe Sizing

- Early suggestions include size at 1/8” per foot slope and cut the pipe size in half
  - 8” pipe becomes 4” pipe
  - Good for ballpark estimates
  - Difficult to balance
- Instead, try the constant friction method
Preliminary Pipe Sizing

- Step 1. Determine the tributary area of each drain
- Example
  - RD1 = 5000 sf
  - RD2 = 5000 sf
  - RD3 = 3000 sf
  - RD4 = 5000 sf
  - RD5 = 300 sf
Preliminary Pipe Sizing

- Step 2. Apply rainfall intensity and convert to gallons per minute

- $Q = 0.0104 \times R \times A$

where:
- $Q =$ Flow Rate (gallons per minute)
- $R =$ Rainfall intensity (inches/hour)
- $A =$ Area (square feet)
- $0.0104 =$ Conversion factor gpm/sq. ft./inch/hr.
Preliminary Pipe Sizing

Example

- Rainfall Intensity = 4 inches per hour
- \[ RD1 = 0.0104 \times 4''/hr \times 5000 \text{ sf} = 208 \text{ gpm} \]
- \[ RD2 = 0.0104 \times 4''/hr \times 5000 \text{ sf} = 208 \text{ gpm} \]
- \[ RD3 = 0.0104 \times 4''/hr \times 3000 \text{ sf} = 125 \text{ gpm} \]
- \[ RD4 = 0.0104 \times 4''/hr \times 5000 \text{ sf} = 208 \text{ gpm} \]
- \[ RD5 = 0.0104 \times 4''/hr \times 300 \text{ sf} = 12.5 \text{ gpm} \]
Preliminary Pipe Sizing

- Step 3. Convert to cubic feet per second

- \[ V = \frac{Q}{448.8} \]

where:

- \( V \) = Volumetric Flow Rate (cubic feet per second)
- \( Q \) = Flow Rate (gallons per minute)
- 448.8 = Conversion factor cfs/gpm
Preliminary Pipe Sizing

Example

- RD1 = 208 gpm / 448.8 = 0.46 cfs
- RD2 = 208 gpm / 448.8 = 0.46 cfs
- RD3 = 125 gpm / 448.8 = 0.28 cfs
- RD4 = 208 gpm / 448.8 = 0.46 cfs
- RD5 = 12.5 gpm / 448.8 = 0.028 cfs
Preliminary Pipe Sizing

- **Step 4.** Select a drain using manufacturer’s data
- Generally the smallest drain without exceeding the maximum flow

**USE SPECIFIC MANUFACTURER’S INFORMATION**

<table>
<thead>
<tr>
<th>Drain</th>
<th>Resistance coefficient $k$</th>
<th>Maximum flow $cfs$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; gutter</td>
<td>0.65</td>
<td>0.40</td>
</tr>
<tr>
<td>2&quot;</td>
<td>0.13</td>
<td>0.50</td>
</tr>
<tr>
<td>2½&quot;</td>
<td>0.13</td>
<td>0.60</td>
</tr>
<tr>
<td>3&quot;</td>
<td>0.16</td>
<td>1.40</td>
</tr>
<tr>
<td>4&quot;</td>
<td>0.23</td>
<td>1.70</td>
</tr>
</tbody>
</table>
Preliminary Pipe Sizing

- Step 5. Calculate disposable head
  - Subtract – vent elevation from drain elevation

- Example:
  - Roof elevation = 452’
  - Discharge elevation = 420’
    - Vented manhole cover elevation = 422’
  - Disposable head = 452’ – 422’ = 30’
Preliminary Pipe Sizing

- **Step 6. Calculate system length**
  - Add horizontal and vertical pipe lengths
  - Add 10% for fittings

- **Example:**
  - System length (Assumes 10% for fittings)
    - RD1 = 220' + 22' = 242'
    - RD2 = 120' + 12' = 132'
    - RD3 = 210' + 21' = 231'
    - RD4 = 140' + 14' = 154'
    - RD5 = 40' + 4' = 44'
Step 7. Divide disposable head by system, length and multiply by 100

Example:
- RD1 = 30’ / 242’ x 100 = 12.4 ft/100ft
- RD2 = 30’ / 132’ x 100 = 22.7 ft/100ft
- RD3 = 30’ / 231’ x 100 = 13.0 ft/100ft
- RD4 = 30’ / 154’ x 100 = 19.5 ft/100ft
- RD5 = 30’ / 44’ x 100 = 68.1 ft/100ft
Step 8. Convert ft/100ft to psi/100ft

Example:
- RD1 = 12.4 ft/100ft x 0.433 = 5.37 psi/100ft
- RD2 = 22.7 ft/100ft x 0.433 = 9.83 psi/100ft
- RD3 = 13.0 ft/100ft x 0.433 = 5.63 psi/100ft
- RD4 = 19.5 ft/100ft x 0.433 = 8.44 psi/100ft
- RD5 = 68.1 ft/100ft x 0.433 = 29.5 psi/100ft
RD1

- Draw a line at 5.37 psi per 100 feet
- Draw a line at 208 gallons per minute
- The intersection is just under 3"
- Use 3” pipe
RD2

- Draw a line at 9.83 psi per 100 feet
- Draw a line at 208 gallons per minute
- The intersection is between 2” and 3”
- Use 2” pipe, but increase to 3” after the tailpiece
RD3

- Draw a line at 5.63 psi per 100 feet
- Draw a line at 125 gallons per minute
- The intersection is just under 2”
- Use 2” pipe
 RD4

- Draw a line at 8.44 psi per 100 feet
- Draw a line at 208 gallons per minute
- The intersection is between 2” and 3”
- Use 2” pipe, but increase to 3” after the tailpiece
RD5

- Draw a line at 14.8 psi per 100 feet
- Draw a line at 29.5 gallons per minute
- The intersection is between ½” and ¾”
- Using 1½” pipe, the velocity is only 2 feet per minute ...
- **NO SIPHON**
Preliminary Pipe Sizing

- For combined pipe segments, use the lowest friction and the combined flow rate.
RD1+RD2

- Draw a line at 5.37 psi per 100 feet
- Draw a line at 416 gallons per minute
- The intersection is just under 4”
- Use 3” pipe, but increase to 4” before the next bend
RD3+RD4

- Draw a line at 5.63 psi per 100 feet
- Draw a line at 333 gallons per minute
- The intersection is between 3” and 4”
- Use 3” pipe, but increase to 4” after the next bend
Downpipe

- Draw a line at 5.37 psi per 100 feet
- Draw a line at 749 gallons per minute
- The intersection is between 4” and 6”
- Use 6” pipe at the junction, but decrease to 4” after the drop
Downpipe

- Check to make sure that velocities in horizontal pipe are 3 feet per second or greater
- Check to make sure that velocities in vertical pipe are 7.2 feet per second or greater
Questions
BREAK

Be back in 15 minutes!
Outline

- Review
- Parameters
- Balancing
- Drawing Standards
- Construction Administration
Review
<table>
<thead>
<tr>
<th>Segment</th>
<th>Flow Rate (CFS)</th>
<th>Drain Size</th>
<th>Beginning pipe size</th>
<th>Ending pipe size</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD-1</td>
<td>0.46</td>
<td>2”</td>
<td>3”</td>
<td>3”</td>
</tr>
<tr>
<td>RD-2</td>
<td>0.46</td>
<td>2”</td>
<td>2”</td>
<td>3”</td>
</tr>
<tr>
<td>RD-1 to RD-2</td>
<td>0.92</td>
<td>n/a</td>
<td>3”</td>
<td>4”</td>
</tr>
<tr>
<td>RD-3</td>
<td>0.28</td>
<td>2”</td>
<td>2”</td>
<td>2”</td>
</tr>
<tr>
<td>RD-4</td>
<td>0.46</td>
<td>2”</td>
<td>2”</td>
<td>3”</td>
</tr>
<tr>
<td>RD3 to RD-4</td>
<td>0.74</td>
<td>n/a</td>
<td>3”</td>
<td>4”</td>
</tr>
<tr>
<td>Downpipe</td>
<td>1.66</td>
<td>n/a</td>
<td>6”</td>
<td>4”</td>
</tr>
<tr>
<td>RD-5</td>
<td>0.028</td>
<td>2” conv.</td>
<td>2”</td>
<td>3”</td>
</tr>
</tbody>
</table>
Parameters
Parameters

- Velocities in horizontal pipe must be 3 feet per second or greater
  - If not, the pipe sizes must be made smaller
- Velocities of 3 to 25 feet per second or greater are normal
- Do not exceed maximum velocity for pipe material
  - Copper = 8 feet per second
- Slower speeds will break the siphon
Parameters

- Velocities in Vertical pipe must be 7.2 feet per second or greater
  - Varies with pipe size
  - Smaller pipes need less
  - Larger pipes need more
- Slower speeds will break the siphon
Parameters

- Negative pressures should be greater than (negative) -25’ to avoid cavitation
  - Check the top of the riser first
- Cavitation will reduce the energy in the siphon
Parameters

- 0’ to 3.0’ of residual head is required
  - Additional capacity
  - Installation flexibility
- Less than 0’ of residual head indicates that the system will not carry the 100 year storm
- More than 3.0’ of residual head yields larger than necessary pipe sizes and can lead to imbalance at lower flow rates
Parameters

- A balanced system requires:
  - Imbalance $\leq 1.5$ feet of head
  - Imbalance $\leq 10\%$ of the building height

- An unbalanced system will result in one drain running dry before the others
  - This will break the siphon and greatly reduce the carrying capacity
  - Like drinking out of a straw with a hole in it
Balancing
Balancing

- With a good first guess, dimension your sketch
- Starting with the discharge, enter your system into the calculation software
- Check for a valid configuration
Balancing

- Enter pipe and fittings one at a time until the entire system is accurately reflected in the software.
- 6x4 reducer is not entered
Balancing

- Most software will give an indication of a valid configuration
- In this case, a green bar appears at the top
Balancing

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Calculation</th>
<th>Imbalance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction (ft)</td>
<td>0.019</td>
<td></td>
</tr>
<tr>
<td>Pressure In (ft)</td>
<td>-8.208</td>
<td></td>
</tr>
<tr>
<td>Pressure Out (ft)</td>
<td>-8.581</td>
<td></td>
</tr>
<tr>
<td>Velocity In (ft/s)</td>
<td>5.411</td>
<td></td>
</tr>
<tr>
<td>Friction Energy Lost (ft)</td>
<td>0.373</td>
<td></td>
</tr>
<tr>
<td>Flow Rate (cfs)</td>
<td>0.278</td>
<td></td>
</tr>
<tr>
<td>Total Energy In (ft)</td>
<td>12.93 = -8.208(P) + 0.455(V) + -7.314(Fr) + 28(H)</td>
<td></td>
</tr>
<tr>
<td>Total Energy Out (ft)</td>
<td>12.93 = -8.581(P) + 0.455(V) + -6.941(Fr) + 28(H)</td>
<td></td>
</tr>
<tr>
<td>Total Friction Lost (ft)</td>
<td>-7.314(Friction) = 15.05(Total Friction lost) - 22.37(Friction Lost From Discharge)</td>
<td></td>
</tr>
<tr>
<td>Velocity Head Out (ft)</td>
<td>0.455</td>
<td></td>
</tr>
<tr>
<td>Velocity Head In (ft)</td>
<td>0.455</td>
<td></td>
</tr>
<tr>
<td>Energy Lost At Roof (ft)</td>
<td>15.052</td>
<td></td>
</tr>
<tr>
<td>Reynolds Number</td>
<td>98,852.638</td>
<td></td>
</tr>
</tbody>
</table>
Balancing

- 0.1’ to 3.0’ of residual head
- Imbalance ≤ 1.5 feet of head
- Imbalance ≤ 10% of the building height
- Negative pressures greater than -25’
- Velocities in horizontal pipe ≥ 3 fps
- Velocities in vertical pipe ≥ 7.2 fps
Balancing

- To increase friction, make the segments with the smaller pipe longer and the segments with the larger pipe shorter.
- To decrease friction, make the segments with the smaller pipe shorter and the segments with the larger pipe longer.
Balancing

- With the parameters in mind, adjust the system so that each drain has a similar residual head.
- Balance the system by repositioning reducers.
  - Vertical pipe sizes may be reduced
  - Vertical pipe sizes may NOT be increased
  - Horizontal pipe sizes may NOT be reduced
  - Horizontal pipe sizes may be increased
Balancing
Balancing
Balancing

- A balanced system requires:
  - Residual Head $\geq 0$ feet of head
  - Residual Head $< 3$ feet of head
  - Imbalance $\leq 1.5$ feet of head
  - Imbalance $\leq 10\%$ of the building height
Drawing Standards

4" PIPE UP TO DRAIN
4" SIPHONIC ROO DRAIN
UV-107

5'-0"

7'-0"

2'-4"

8"

10x10x4 WYE

10x8 ECCENTRIC REDUCER
Pipe Bracing

- Lateral Bracing Required:
  - At each tailpiece
  - At branch take-offs
  - At each change in direction
  - At 30 foot intervals
Pipe Bracing

- Longitudinal Bracing Required
Construction Administration

- Any changes must be submitted, reviewed and recalculated
- Revised drawings must be issued if balance or residual head do not meet parameters indicated earlier
- Engineering Fees …
Construction Administration

- The branch that runs straight through the wye has the greater pressure drop
- Check that installed conditions match the plans
Field Observation is essential

Check that no drains have been moved or added

Check that downpipes have not been moved or reconfigured
  - Offsets to avoid miscellaneous steel
Construction Administration

- Check pipe material
- Check tailpiece connection
Construction Administration

- Check pipe sizes
- Check lengths between reducers
  - Pipes up to 4”Ø shall be ± 4”
  - Pipes 5”Ø and larger shall be ± 8”
- Use building columns for reference
Construction Administration

- Check drain attachment to structure
- Check for unobstructed waterway
- Check for a secure baffle
Check leaf strainer
Check for debris
Even a small amount of debris can change the performance of a system
Construction Administration

- Check lateral and longitudinal bracing
  - Spacing
  - Attachment to structure
Questions