Research implications for future sustainable building drainage systems

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Two key areas of drainline research –

1. Waste media research –
   Influence of waste media on WC drainline performance

2. Drainline profile experimental research –
   Influence of drainline profiles on WCs drainline performance
1. **Waste media research** - Waste combinations in domestic installations

ASFlow Investigation drainline blockages in WA

Toilet paper by experience is a significant factor in drainline and fixture blockages in the field
Waste combinations – commercial installations

Blockages in commercial installations predominantly occur in women’s toilets
In all WC blockage cases, toilet paper has been identified as a key factor
Drainline research – solids test media

Internationally researchers have focused on solids test media to evaluate drainline transportation.

Varying types of solid test media used in standards test.

- Aus/DIN media
- Modified MaP media US (latex)
- MaP media US (uncased)
- ASME US Polypropylene balls
### Drainline research – Performance variation between types of solid test media

<table>
<thead>
<tr>
<th>Vol.</th>
<th>Media</th>
<th>MaP Uncased - Drainline Carry (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3L (0.8gal)</td>
<td>Uncased MaP</td>
<td>![Bar Chart]</td>
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<tr>
<td>4.8L (1.3gal)</td>
<td>Uncased MaP</td>
<td>![Bar Chart]</td>
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<tr>
<td>6L (1.6gal)</td>
<td>Uncased MaP</td>
<td>![Bar Chart]</td>
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<th>Vol.</th>
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<th>AUS/DIN - Drainline Carry (m)</th>
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<tr>
<td>3L (0.8gal)</td>
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<td>4.8L (1.3gal)</td>
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<td>6L (1.6gal)</td>
<td>Aus/DIN</td>
<td>![Bar Chart]</td>
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<thead>
<tr>
<th>Vol.</th>
<th>Media</th>
<th>MaP (Latex) - Drainline Carry (m)</th>
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<tbody>
<tr>
<td>3L (0.8gal)</td>
<td>MaP (Latex)</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td>4.8L (1.3gal)</td>
<td>MaP (Latex)</td>
<td>![Bar Chart]</td>
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<tr>
<td>6L (1.6gal)</td>
<td>MaP (Latex)</td>
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<tr>
<th>Vol.</th>
<th>Media</th>
<th>Polypropylene Balls - Drainline Carry (m)</th>
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<tbody>
<tr>
<td>3L (0.8gal)</td>
<td>Polypropylene Balls</td>
<td>![Bar Chart]</td>
</tr>
<tr>
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<td>Polypropylene Balls</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td>6L (1.6gal)</td>
<td>Polypropylene Balls</td>
<td>![Bar Chart]</td>
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Results show significant difference in drainline transportation between types of test media.
Typically women's use of WCs consume more toilet paper than male toilets - urination
Behavior of Solids and Paper during transportation testing

Typical Separation of Solids and Paper

Observation that generally solids accelerate away from paper
Toilet paper research – Initial research

Toilet paper was never identified as having a key impact on drainline transportation

Early studies indicated that toilet paper and paper type have an influence on WC drainline transportation and fixture performance
WC drainline transportation evaluation of 22 commercially available toilet paper brands

The ASFlow Committee conducted research into the performance of toilet paper and the identification of appropriate test media.
Comprehensive drainline testing conducted on 60m drainline testing rig
Results of our 2010 research produced significant results.
Toilet paper research – Results

Breakdown of 30 sheets of paper after a 4.5L full flush with 1 metre drainline carry
• PERC /ASFlow research collaboration
  - Sharing of research findings

• PERC Design of Experiment
  - The “Real World”: too variable to duplicate / characterize
  - Need to understand what’s really important
  - Build a perfect drainline

• The Test Apparatus
  - 4” clear PVC
  - 135 feet long (~41 M)
  - Slope adjustable – 1%, 2%
• **Test Procedure**
  - 40 test runs consisting of 100 flushes into the drainline
  - Each flush contained either solids (300, 200, 100 gm) and paper or only paper – no empty flushes to clear the line
  - Flush characteristics varied in each run by:
    - Flush volume (3.0, 4.8, 6.0L)
    - Flush rate (3.5 or 2.5 L/sec)
    - % trailing water (75% or 25%)
    - Drainline slope (1% or 2%)
    - Paper tensile strength (high or low)
  - Key measurement for analysis is the average number of flushes to clear the drainline (AFO - Average Flushes Out)
Ranking of test variables:

**Significant Variables**

Slope > **Paper** > Volume > % Trailing Water > Flush Rate

**Insignificant Variables**
PERC research – toilet paper test results

Graph showing average flushes to out with bars for 3L flush, 4.8L flush, and 6L flush.
PERC research – toilet paper test results

PERC performed further testing that proved a definite correlation between the wet tensile strength of toilet paper and drainline transportation.

Low Tensile Strength Paper

High Tensile Strength Paper

“The higher the Tensile Strength of the Paper the lower the drainline transportation.”
Toilet paper characteristics have the potential to drastically impact DLT distances
- Strong inverse correlation between wet tensile strength and DLT distances
- Caution: Potential demonstrated in the PERC DOE characterizes the extremes of toilet paper influence
- Easy test to determine relative wet tensile strength developed
- Possible low-cost solution to mitigate DLT related blockages
- **Inline with ASFlow findings**

**PERC paper wet tensile strength test**
- Secure a single sheet of toilet paper to a cup with a rubber band
- Soak in water for 60 sec
- Place washers (or similar) on to paper until it ruptures
- Number of washers gives a numeric value for wet tensile strength
2. Drainline profile experimental research

Influence of drainline profiles on WCs drainline performance
Drainline profile design – 100DN & 80DN pipe

Typical Australian WC drainline installation configurations use DN100 and DN80 pipe

In the search for improved WC drainline transportation alternative drainline profiles were explored
An alternate drainline was developed based on a combination of the cross-sectional air flow associated with DN100 pipe and the waste transportation characteristics associated with the DN80 pipe.
Experimental Drainline Testing – Comparison results

Transportation comparison of paper only, solids only & paper + media on DN100, DN80 & alt drainline at 4.5L using ave paper

Drainline transportation (m)
Experimental Drainline Testing – Comparison results

Transportation comparison of paper only, solids only & paper + media on DN100, DN80 & alt drainline at 3L using ave paper
Experimental drainline study – waste transportation performance

Better drainline carry results were achieved using good paper on the Alternate Pipe at 3L half flush – compared with 4.5L full flush using poor paper on DN80, DN100 and alternate drainline.
Experimental drainline test – solids media + paper transportation performance

Improved drainline transportation results were achieved using good paper + solids media in the alternate drainline profile with a 3L reduced flush – compared with poor, average and good paper + solid media on DN100 at 4.5L.
Simple variables – Paper media and drainline profiles have a significant impact on WC
drainline transportation.

As with PERC direction, research and Standards must consider appropriate test media in
future developments.
Thank you