





SUPERCRITICAL VORTEX INTAKES FOR URBAN STORMWATER MANAGEMENT

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HISTORICAL FLOODING EVENTS



ENGINEERING CHALLENGES

Hong Kong West Drainage Tunnel

- Steep hillslope watercourses
- Supercritical flow with velocities in the order of 10 m/s
- Adjacent to densely-populated residential area
- Land constraints
- Minimize public disruption
- Traffic & environmental impact

Characteristic	Maximum	Minimum
Design discharge (m ³ /s)	18.3	0.5
Channel slope (%)	77	1.5
Channel width (m)	7.0	0.7
Dropshaft height (m)	178	5





Steep hillslope watercourses

Adjacent to densely-populated residential area

STORMWATER FLOW AT INTAKES



INNOVATIVE SOLUTION: INTEGRATED BOTTOM RACK – VORTEX INTAKE SYSTEM





Bottom Rack Intake



Bottom Rack Chamber





Vortex Intake



(a) Warped invert spiral intake

(b) Flat invert spiral intake

(c) Tangential vortex intake





PERFORMANCE CRITERIA



Standing Wave Height



INTEGRATED BOTTOM RACK – VORTEX INTAKE SYSTEM PHYSICAL MODELLING



Final design of bottom rack and spiral vortex inlet with warped invert:

- Min. shock wave
- Max. air core area

Bottom rack intake for supercritical flow diversion (final design); observed flow at Q = 53.9 L/s.



Spiral vortex intake with warp invert for supercritical flow diversion

CFD SIMULATION



STABILITY OF SPIRAL VORTEX FLOW



Unstable Flow

Stable Flow

SUMMARY OF ACHIEVEMENT

- Unique integrated bottom-rack and spiral vortex intake design for supercritical flow diversion (Lee *et al* 2005);
- First use of the spiral vortex intake with warped invert in storm water management (Lee et al 2006);
- A new theory for design of tangential vortex intakes was developed (Yu and Lee 2009) and being adopted by the industry:
 - Design of the Thames Tideway Tunnel in London;
 - London Mogden Sewage Works;
 - Toronto Don River and Central Water Front; and
 - Singapore Deep Tunnel Sewer System.
- Proven post-operation performance of the HKWDT; and



• Significant long-term collaboration between academia, industry and Government.

PUBLIC ENGAGEMENT AND EDUCATION OUTREACH



Tunnel Breakthrough Ceremony in 2011



Commissioning Ceremony in 2012



Visit of Financial Secretary of Hong Kong in Aug 2017

PUBLIC ENGAGEMENT AND EDUCATION OUTREACH





Programme





Overseas Site Visits (e.g. MIT)







THANK YOU