Enhancing Tsunami-Borne Debris Velocity Estimation for Improved Risk Assessment

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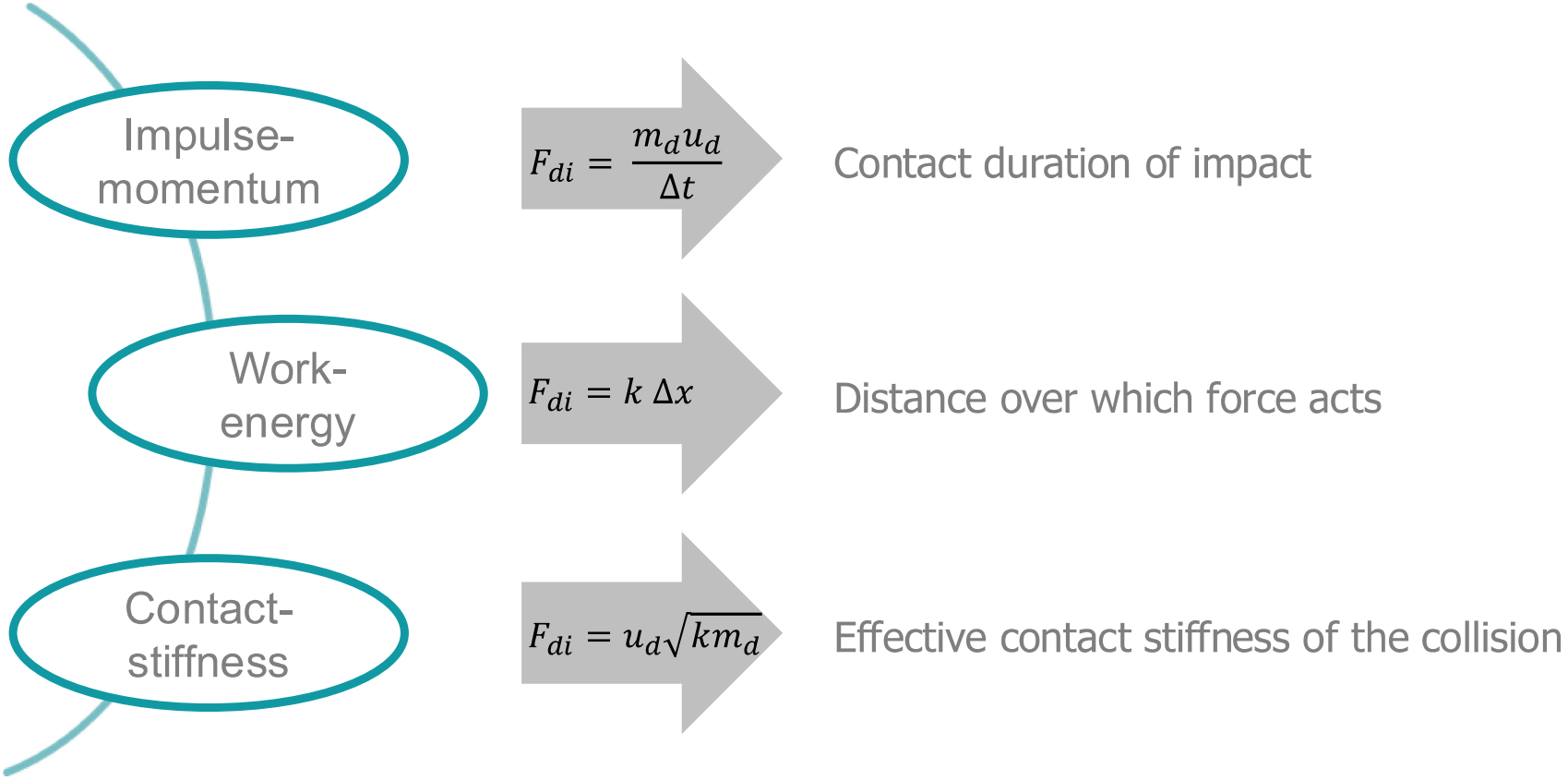
Tsunami Damage

Talcahuano Harbour – Chile Tsunami

Kisenuma – Japan Tsunami

Approaches For Estimating Debris Impact Force



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What are the challenges?

Contact-stiffness	$F_{di} = \boldsymbol{u_d}\sqrt{k\,(m_d + C\,m_f)}$ (Haehnel and Daly)	$F_{di} = 1.3\,\boldsymbol{u_d}\sqrt{k\,m_d(1 + c)}$ (FEMA P-646)
Impulse-momentum	$F_{di} = \frac{\pi}{2}\frac{\boldsymbol{u_d}\,m_d}{\Delta t}$ (Haehnel and Daly) $F_{di} = \frac{\pi}{2}\frac{\boldsymbol{u_d}\,m_d\,C_l\,C_O\,C_D\,C_B\,R_{max}}{\Delta t}$ (ASCE 7)	$F_{di} = C_{add}C_u\,C_{sh}C_{DD}C_{ss}\,\frac{\pi}{2}\frac{\boldsymbol{u_d}\,m_d}{\Delta t}$ (Shafiei et al) $F_{di} = \boldsymbol{u_d}\,m_d\,C_D\,C_B\,C_{Str}$ (FEMA P-55)
Work-energy	$F_{di} = \frac{m_d\,\boldsymbol{u_d}^2}{S}$ (Haehnel and Daly)	
Other Approaches	$\frac{F_{di}}{\gamma_d D^2 L} = 1.6\,C_M\left(\frac{\boldsymbol{u_d}}{\sqrt{g_n D}}\right)^{1.2}\left(\frac{\sigma}{\gamma_d L}\right)^{0.4}$ (Matsutomi)	$\frac{F_{di}}{g\,m_d} = S\,C_M\left(\frac{\boldsymbol{u_d}}{\sqrt{g\sqrt{D\,L}}}\right)^{2.5}$ (Ikeno et al)

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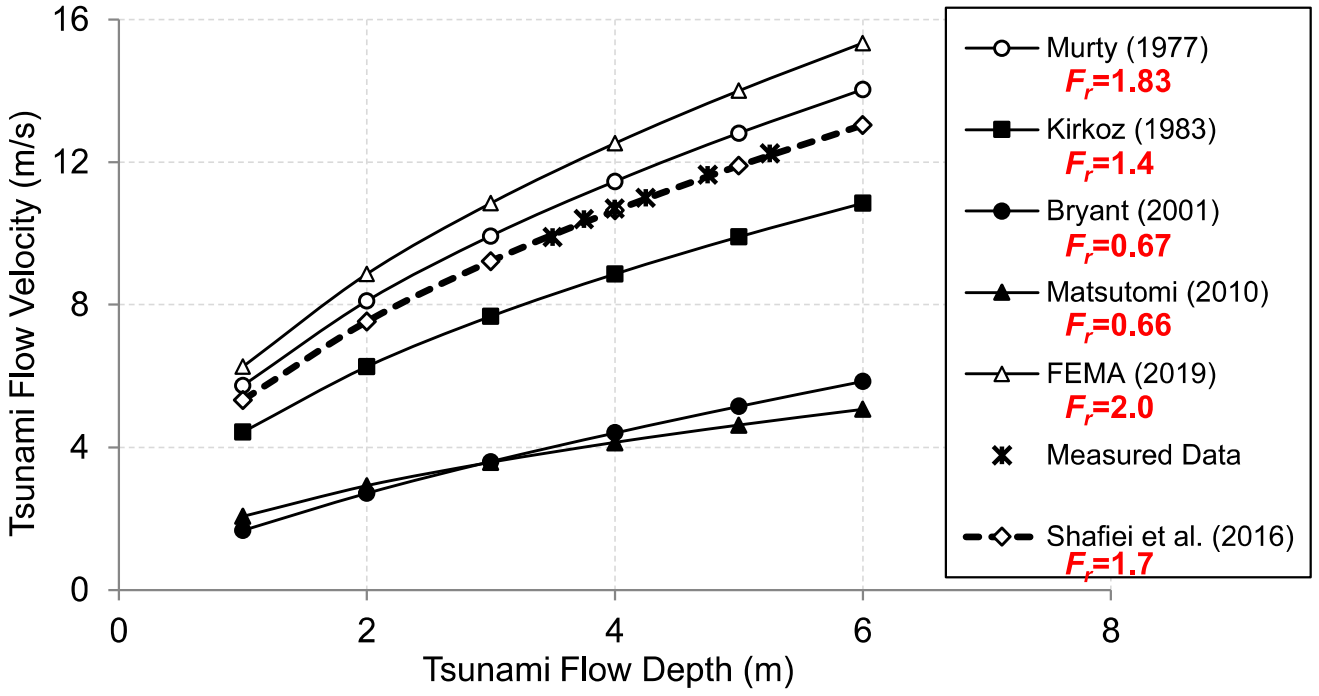
Tsunami Flow & Froude Number



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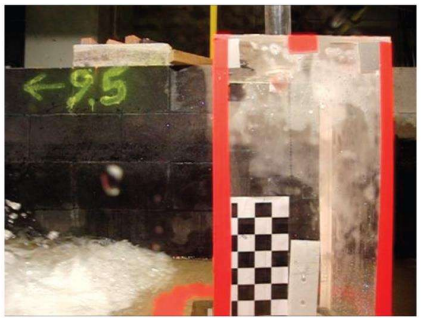
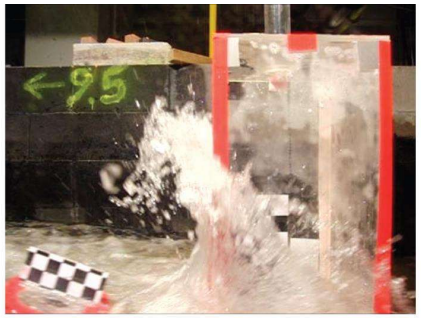
Debris Motion

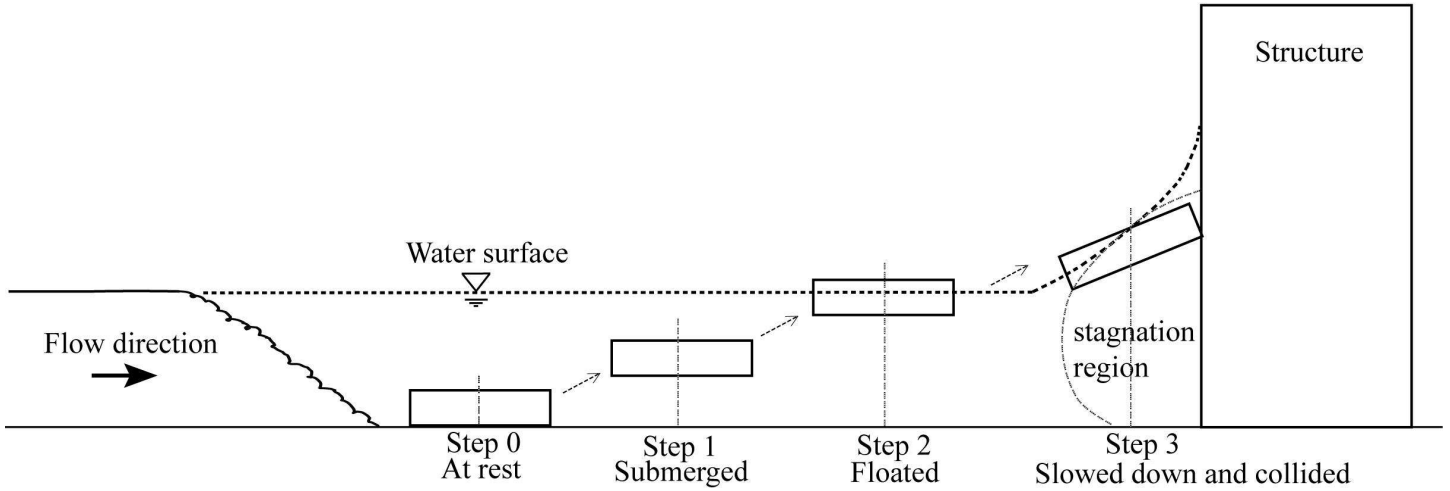


Steps 0 and 1

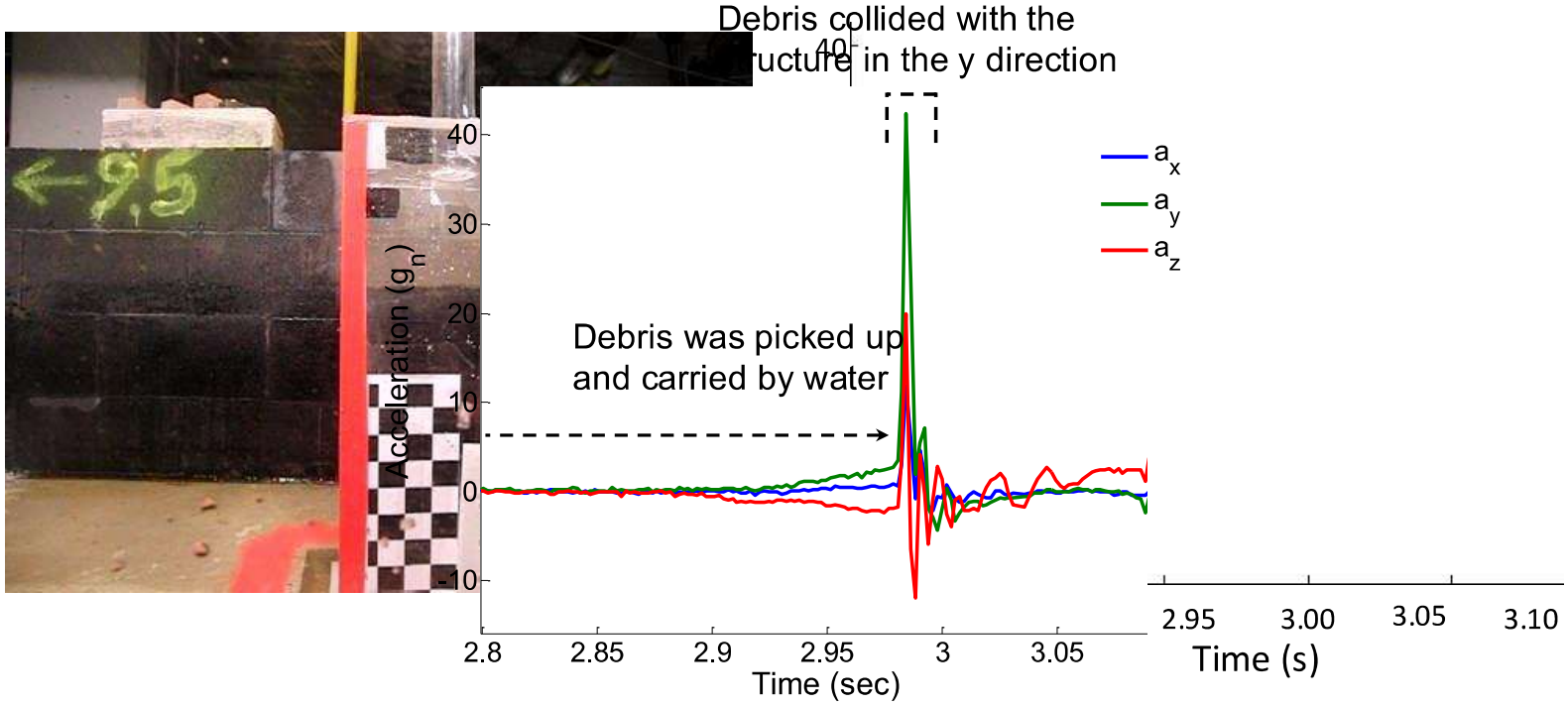


Step 2

Step 3



Data Collection Using The Smart Debris Device



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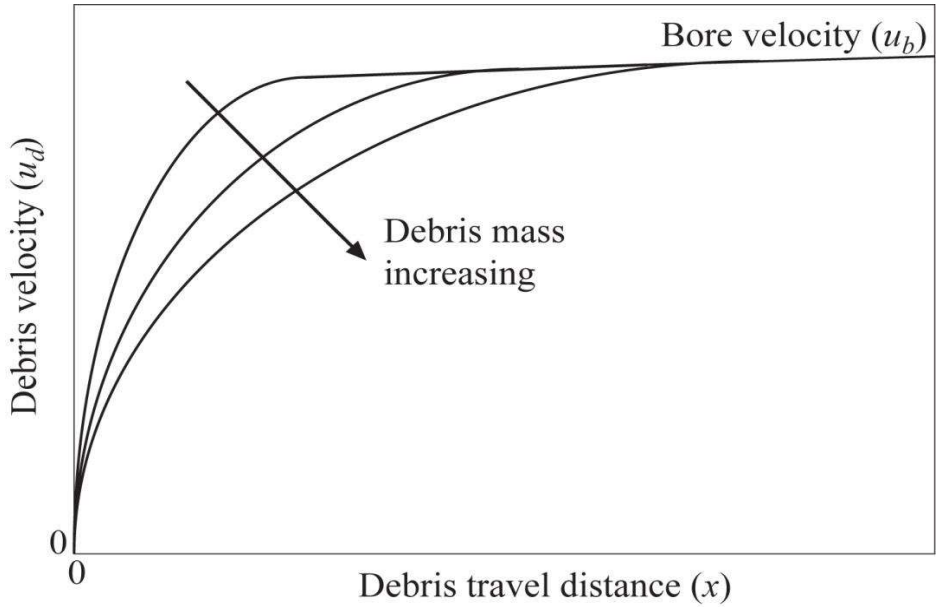
Theoretical Debris Velocity

$$m_d\ddot{x} = 0.5C_d\rho_w(u_b - \dot{x})^2 A_d$$

$$\begin{cases} \dot{x}(0) = 0 \\ x(0) = 0 \end{cases}$$

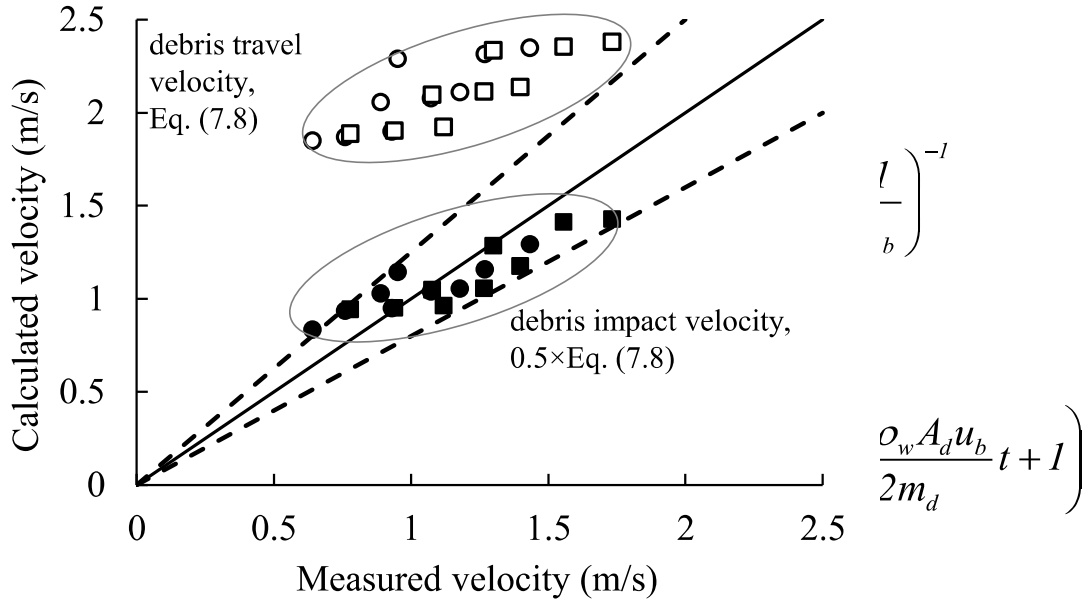


Schematic diagram of debris motion and the effect of debris mass on it

Debris Velocity

Debris m

Debris tra

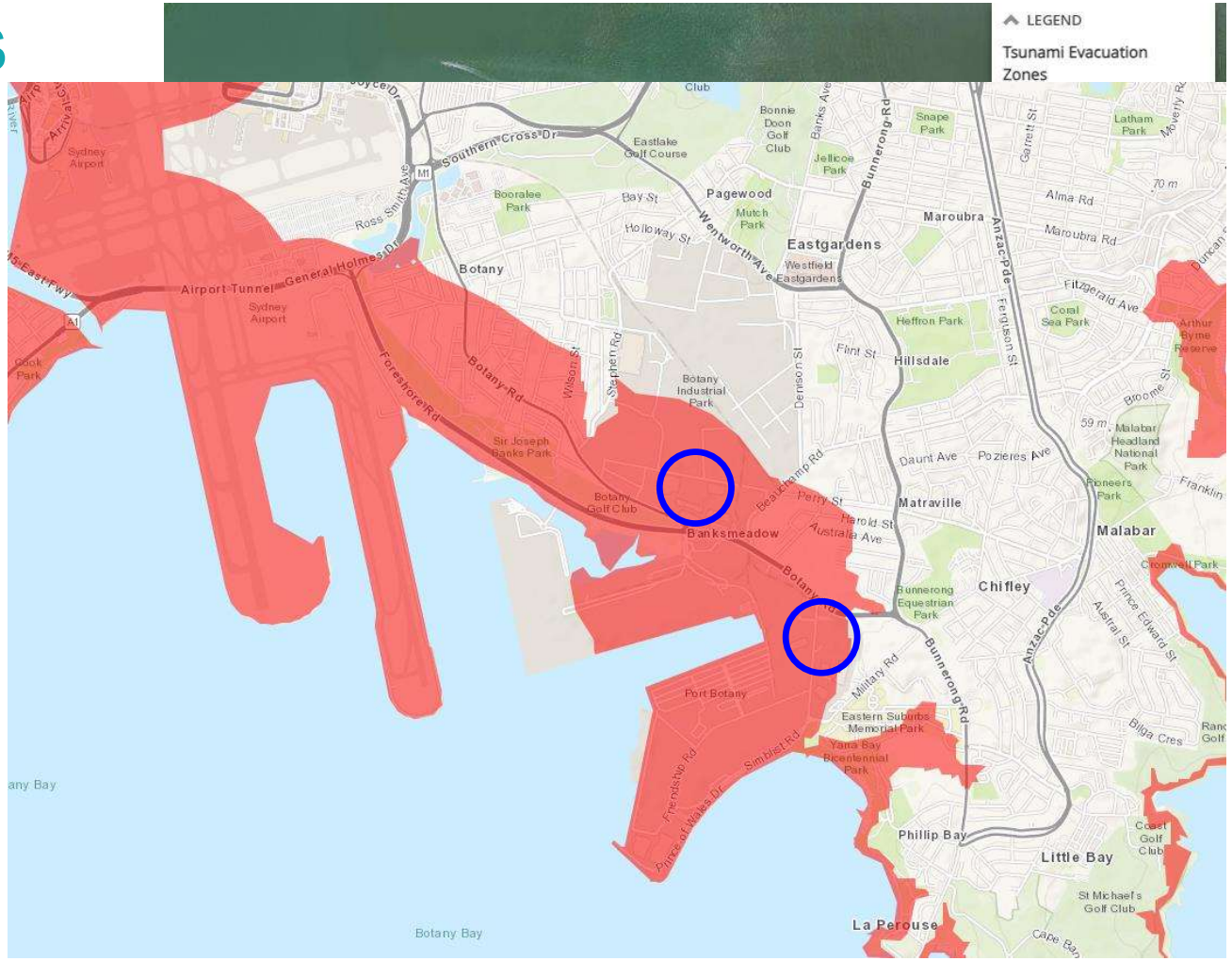


$$\left(\frac{l}{b}\right)^{-1}$$

$$\frac{\rho_w A_d u_b}{2m_d} t + 1$$

Case Studies

Australia



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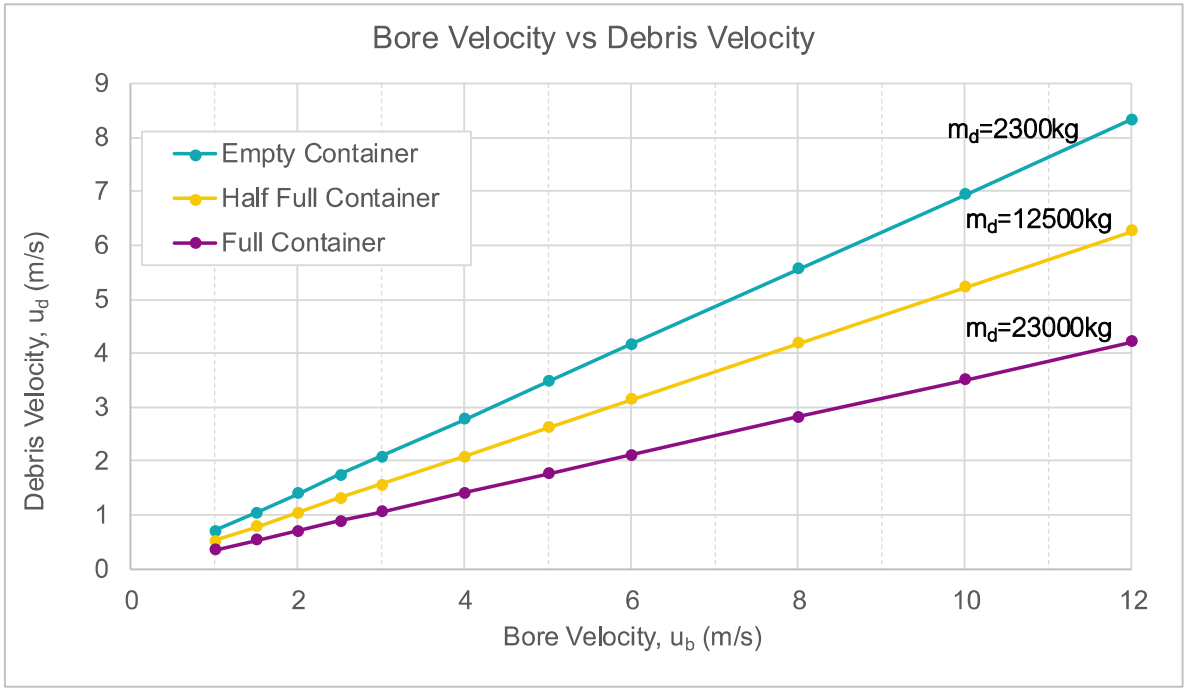
Debris Velocity vs Bore Velocity

Debris velocity (u_d) vs bore velocity (u_b) for various debris masses (m_d) travelling over **x=1000m**



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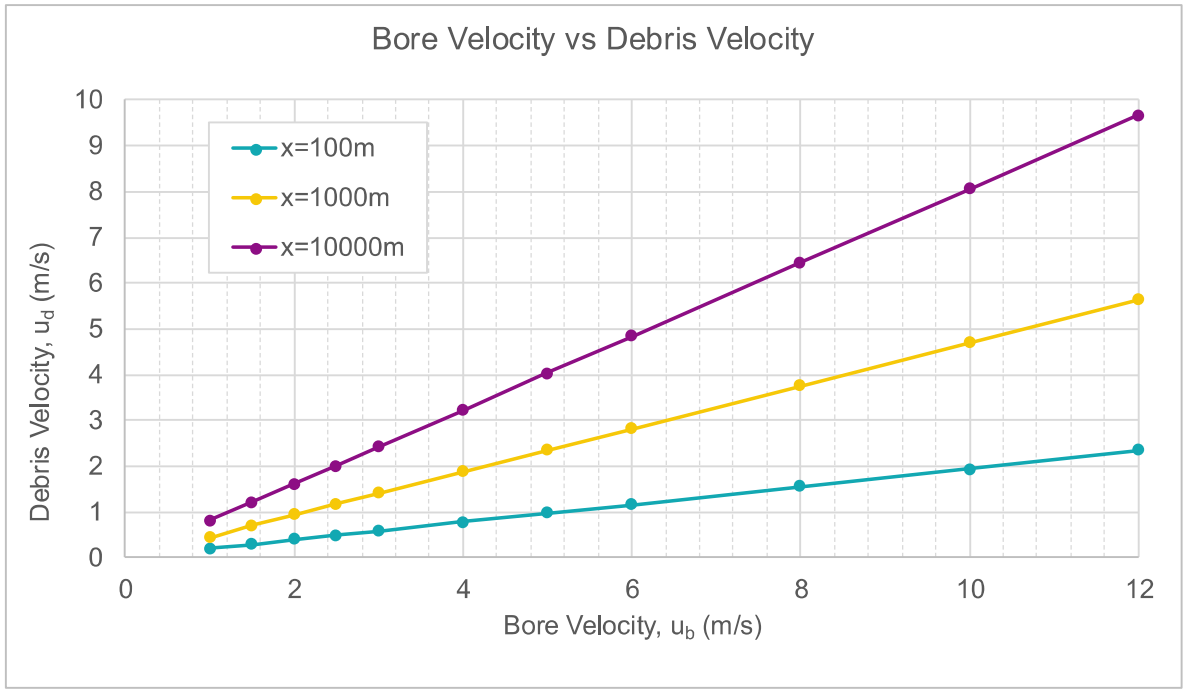
Debris Velocity vs Bore Velocity

Debris velocity (u_d) vs bore velocity (u_b) for m_d=10,000kg travelling over various distances (x)



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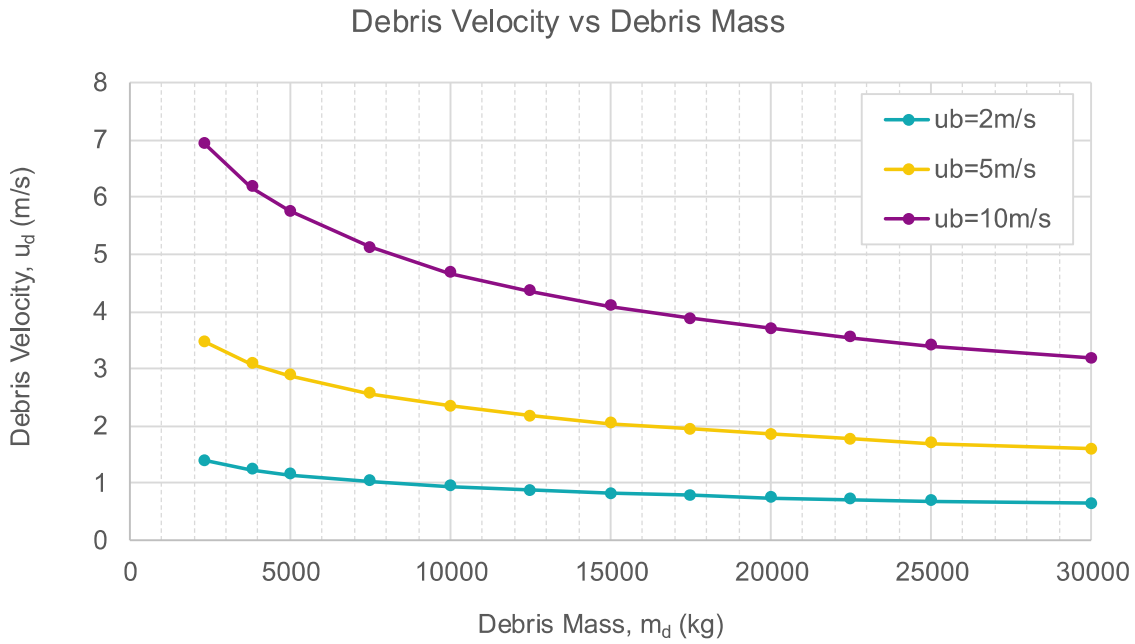
Debris Velocity vs Debris Mass

Utilising a range of weights of 20 ft standard containers the travel distance of 1000m with bore velocity of 2m/s and 5m/s



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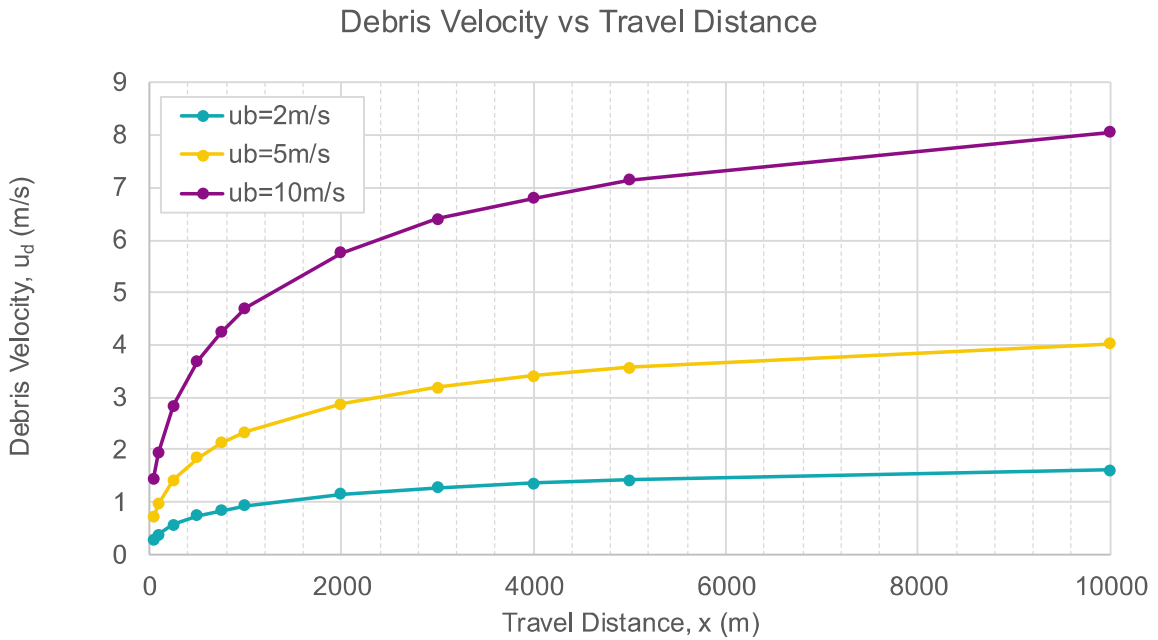
Debris Velocity vs Debris Travel Distance

Utilising a standard 10000kg containers with bore velocity of 2m/s and 5m/s



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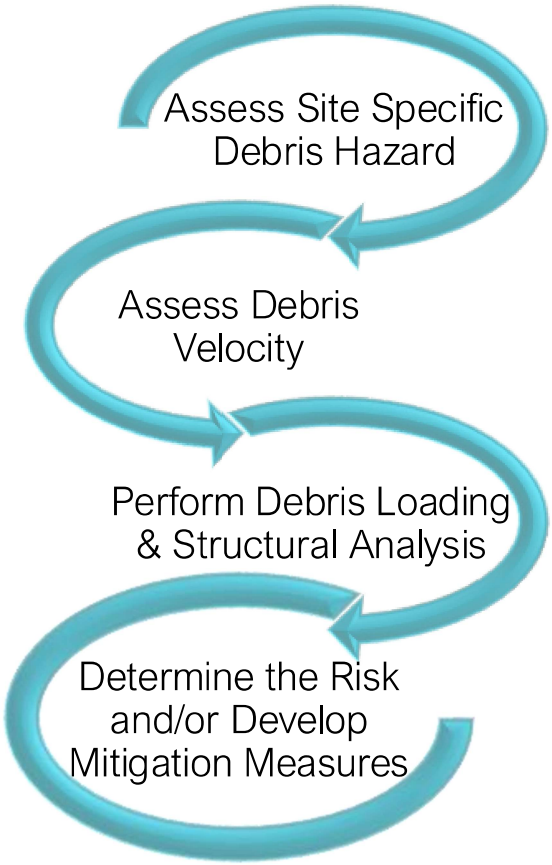

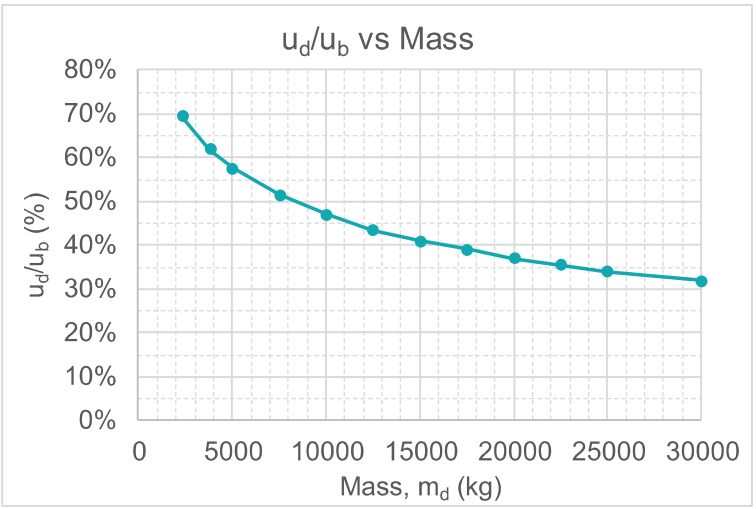

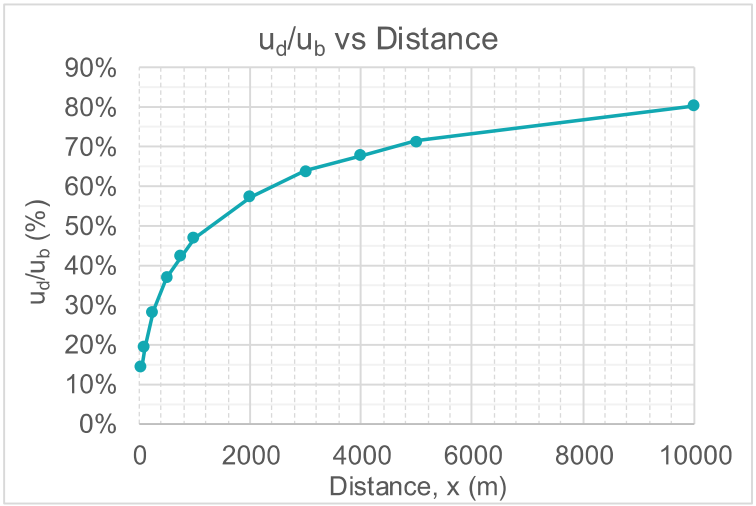

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Thank You!

Debris Velocity