Pressure Gradients of Air and Water/Air Two-Phase Flow in a Stratified Bed

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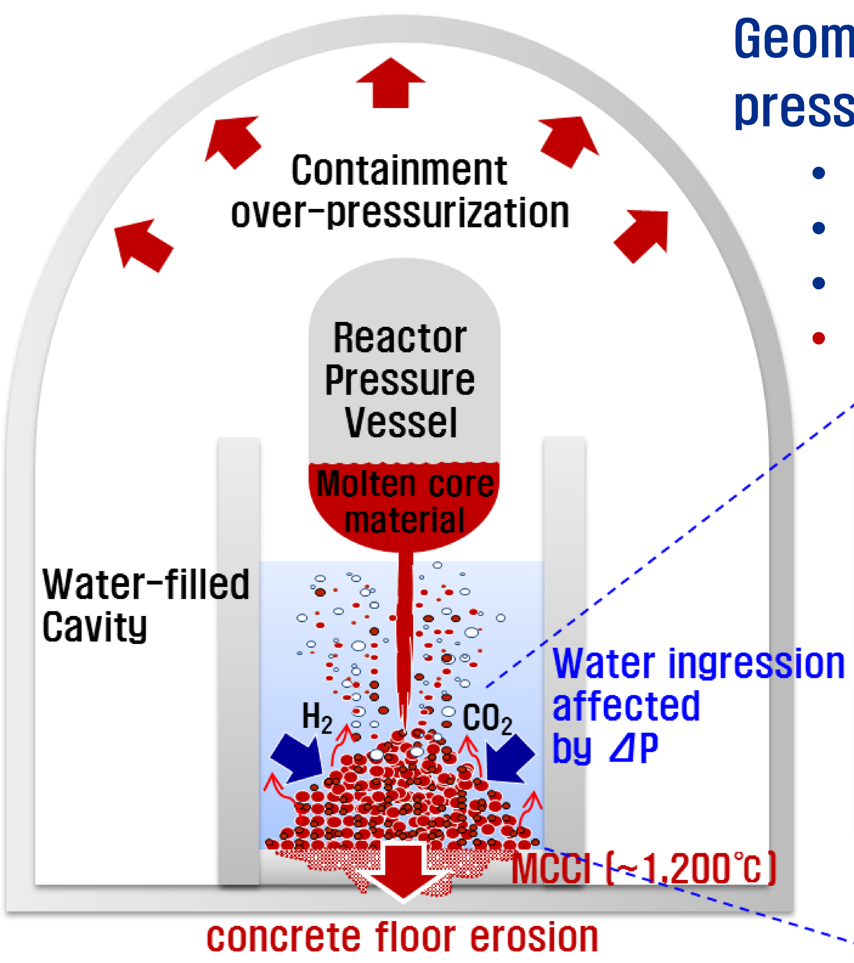
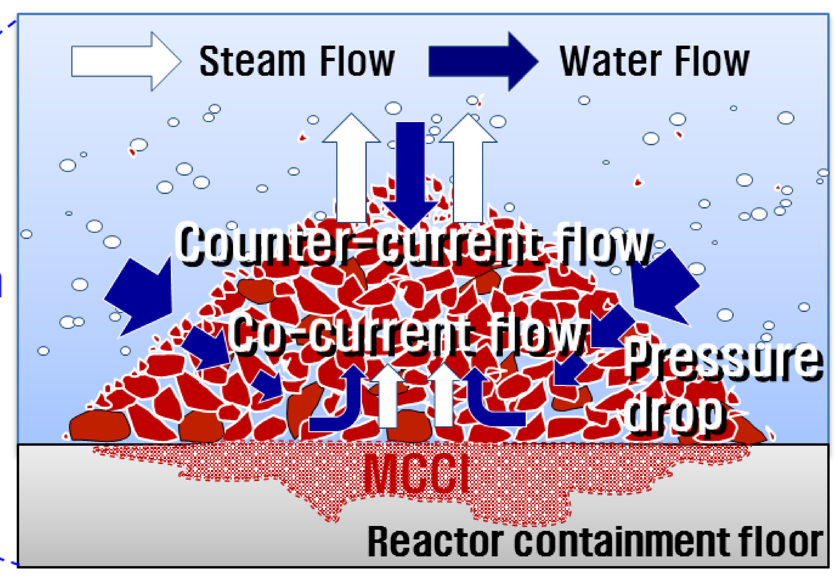
Introduction



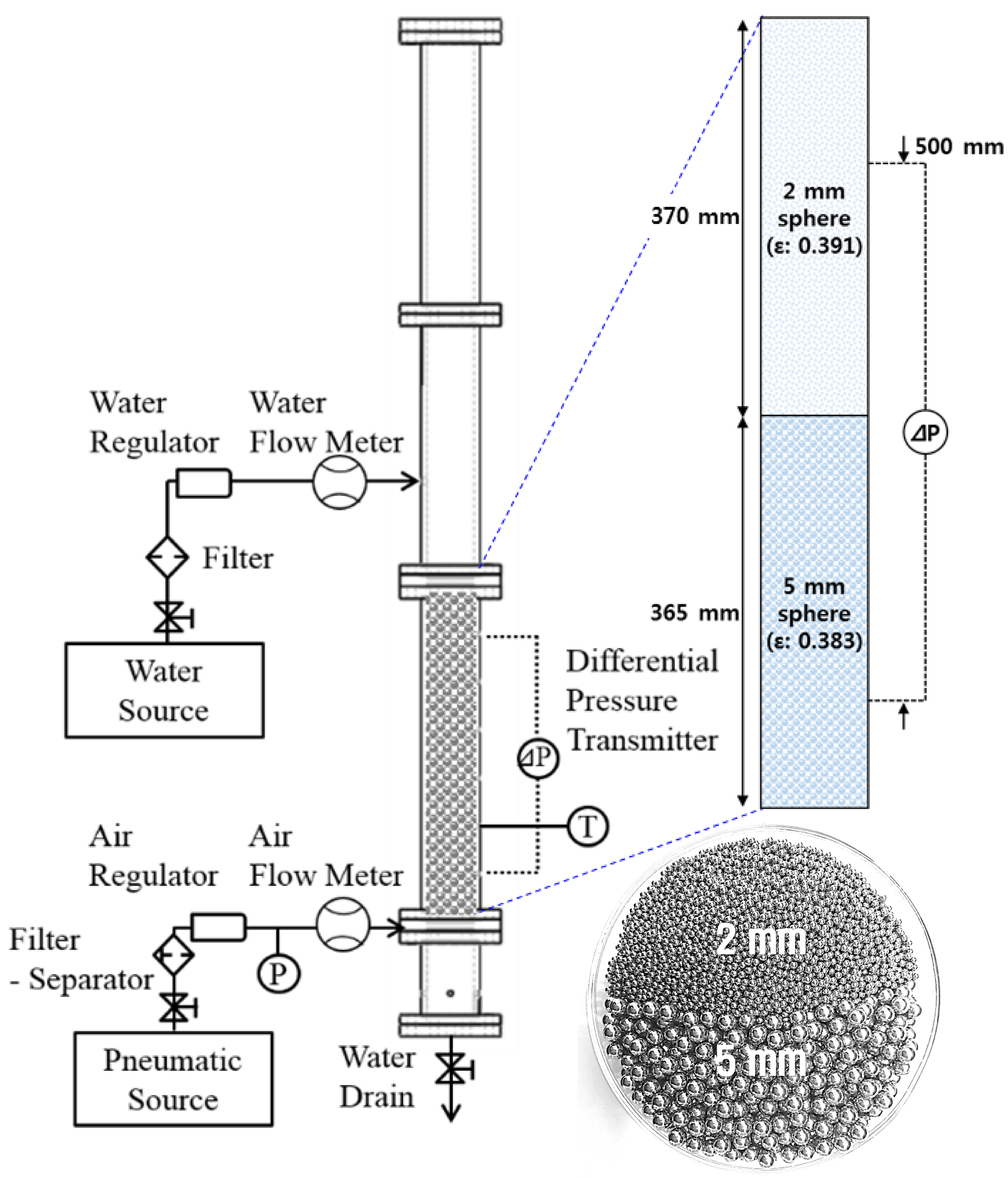
Geometric parameters affecting pressure drop mechanisms in a debris bed

- Porosity
- Particle morphology
- Particle size distribution
- Bed stratification



Experiments

PICASSO experimental facility & Test case



Exp. cases	Particle morphology	Particle size (mm)	Porosity (-)
PCS-SSB1	Sphere	2, 5 (mass 1 : 1)	0.387

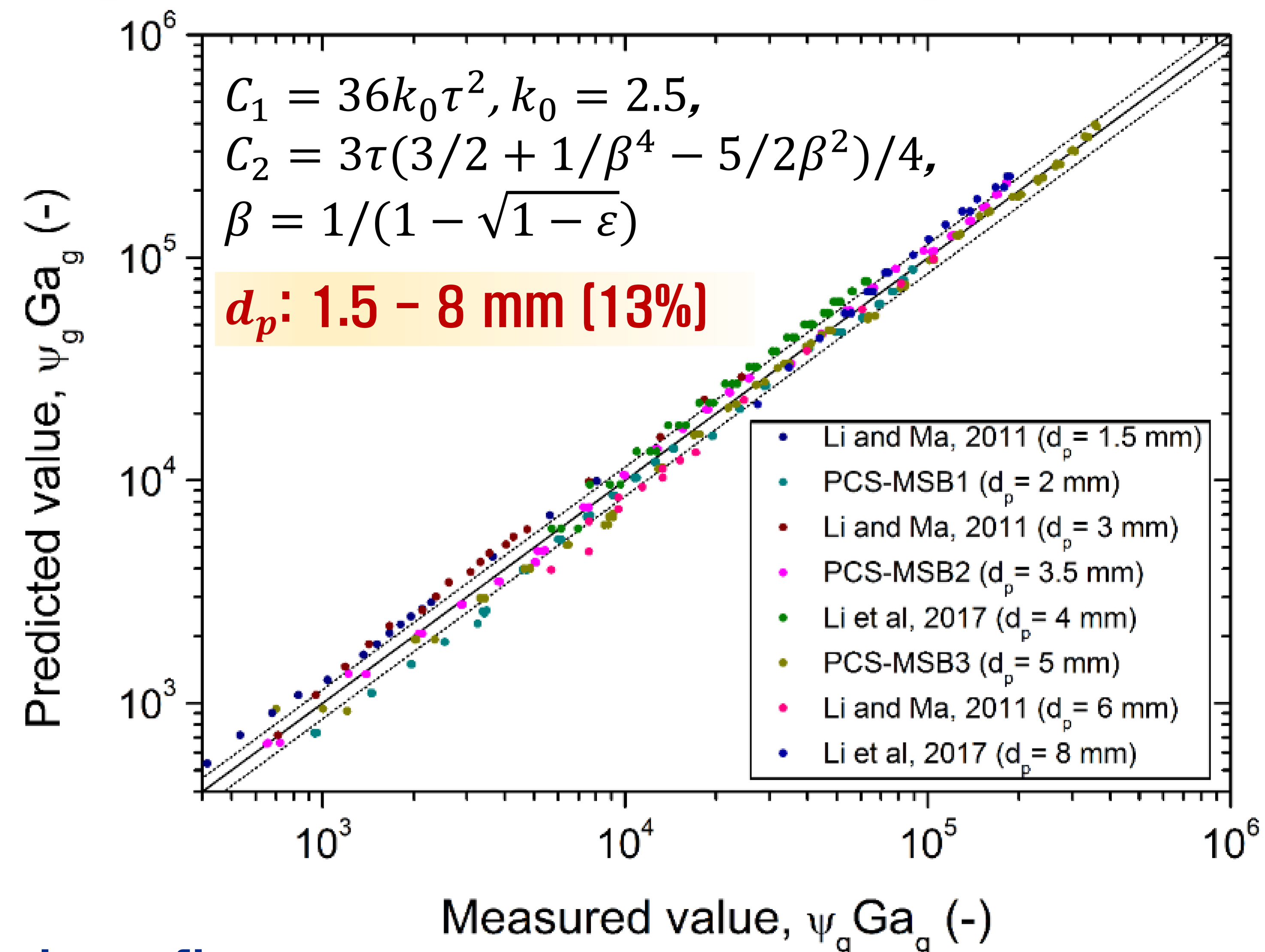
Proposed models through our previous studies

Single-phase flow

$$\frac{-dp/dz-\rho_i g}{\rho_i g}=\psi_i=C_1\frac{Re_p}{Ga_i}+C_2\frac{Re_p^2}{Ga_i}$$

$$Re_p=\frac{\rho_i V_{si} d_p}{\mu_i(1-\varepsilon)},\quad Ga_i=\left(\frac{\rho_i}{\mu_i}\right)^2 g\left(\frac{d_p\varepsilon}{(1-\varepsilon)}\right)^3,$$

$$\tau=\frac{L_t}{L}=\frac{1}{2}\left[1+\frac{1}{2}\sqrt{1-\varepsilon}+\frac{\sqrt{1-\varepsilon}}{1-\sqrt{1-\varepsilon}}\sqrt{\left(\frac{1}{\sqrt{1-\varepsilon}}-1\right)^2+\frac{1}{4}}\right]$$

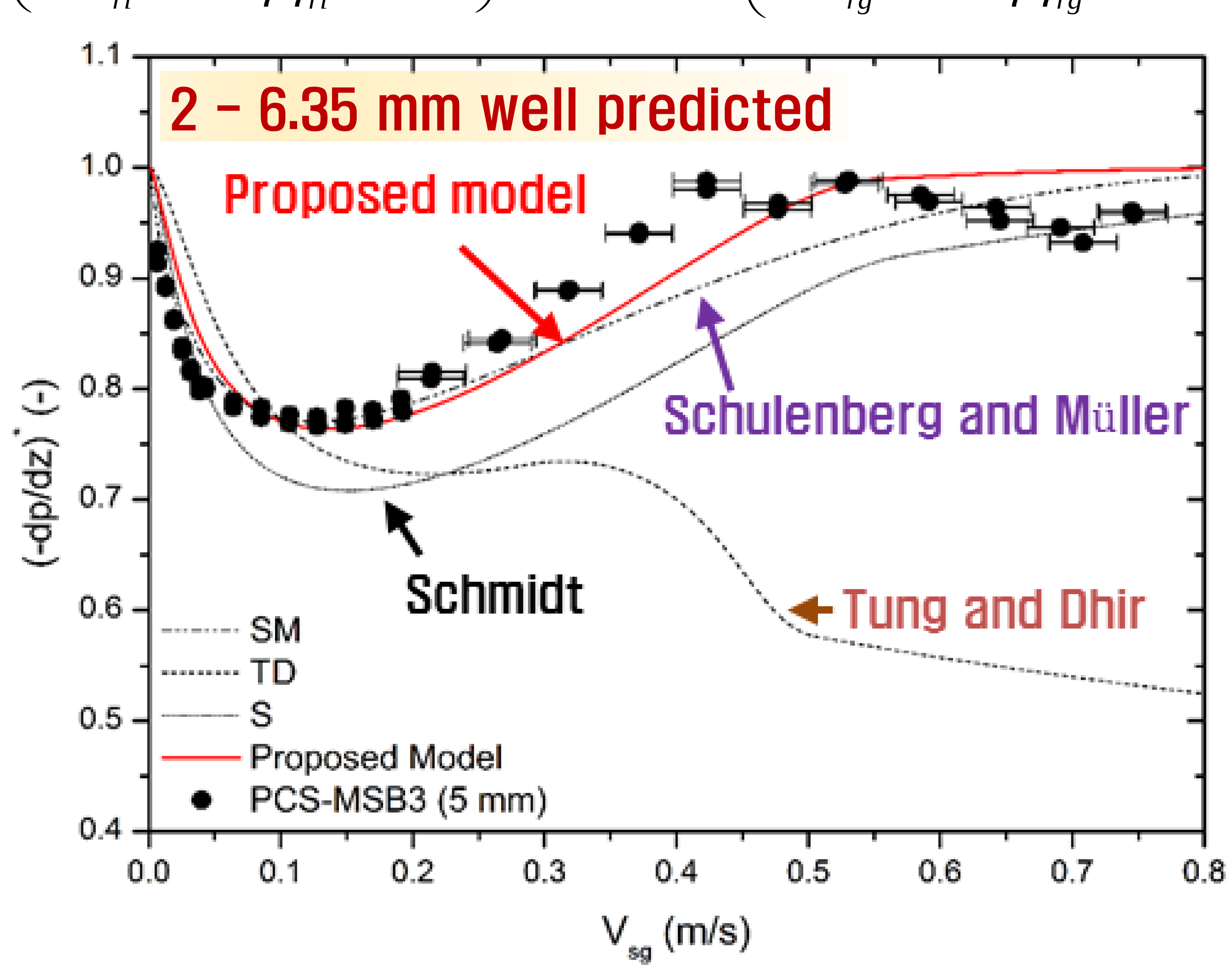


Two-phase flow

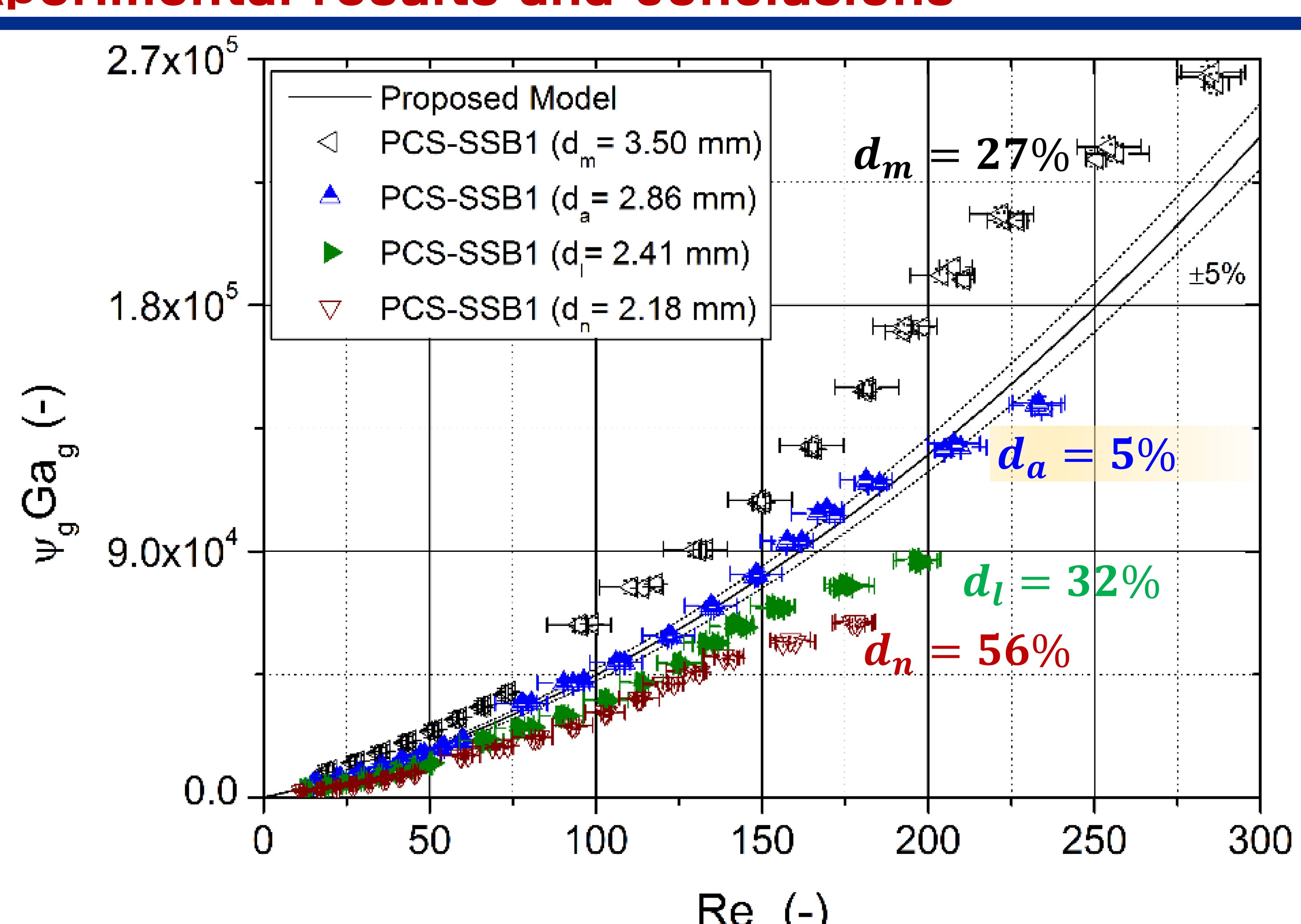
$$\left(-\frac{dp}{dz}\right)^*=\frac{-dp/dz}{(\rho_l-\rho_g)g}=\frac{\rho_l g}{(\rho_l-\rho_g)g}+\frac{F_{pl}^*}{s}-\frac{F_i^*}{s}=\frac{\rho_g g}{(\rho_l-\rho_g)g}+\frac{F_{pg}^*}{\alpha}+\frac{F_i^*}{\alpha}$$

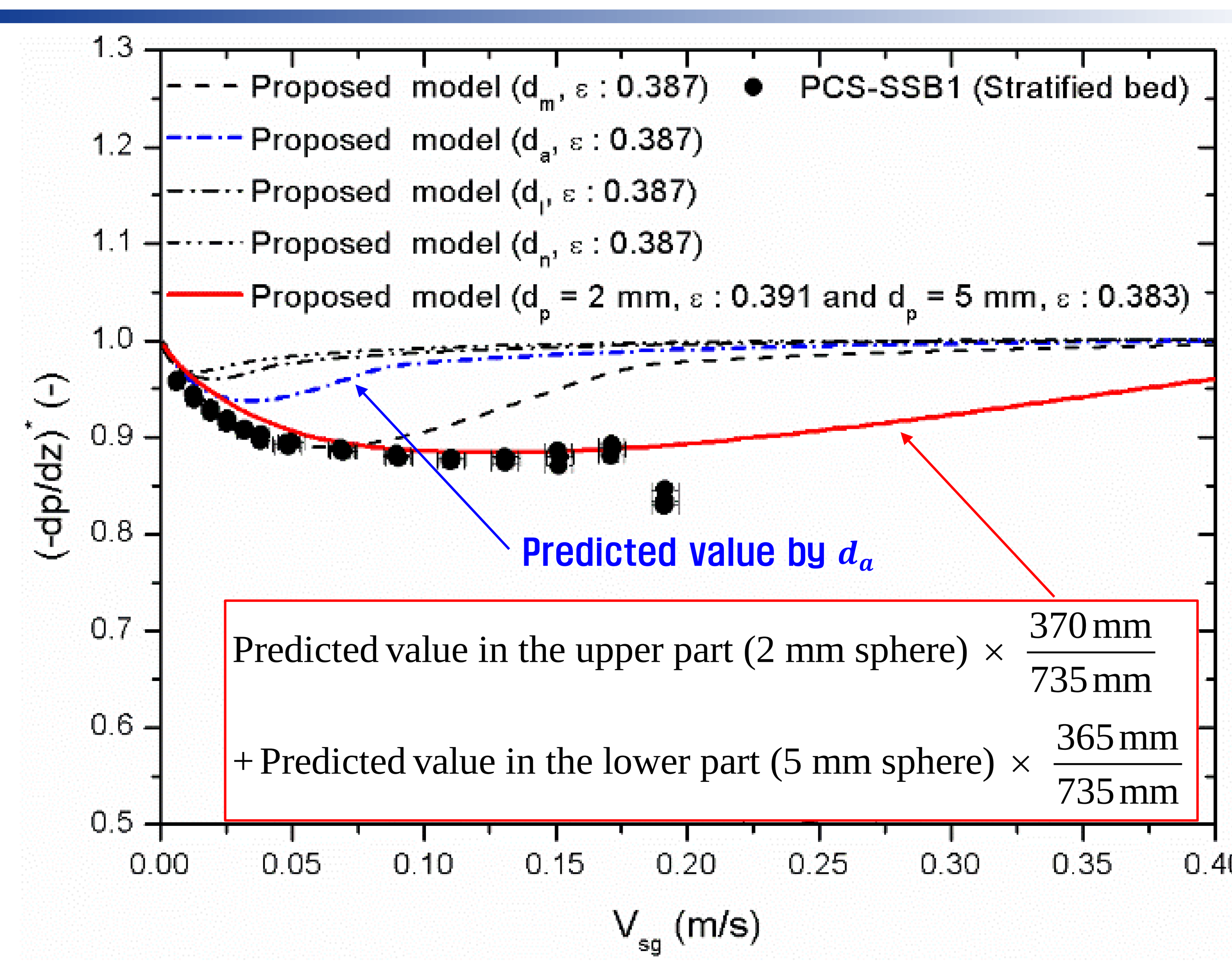
$$F^*=\frac{F}{\varepsilon(\rho_l-\rho_g)g},$$

$$F_{pl}=\varepsilon s\left(\frac{\mu_l}{KK_{rl}}V_{sl}+\frac{\rho_l}{\eta\eta_{rl}}V_{sl}|V_{sl}|\right),\quad F_{pg}=\varepsilon\alpha\left(\frac{\mu_g}{KK_{rg}}V_{sg}+\frac{\rho_g}{\eta\eta_{rg}}V_{sg}|V_{sg}|\right)$$



Experimental results and conclusions





[Air Flow]

- Proposed model predicts pressure gradients of air flow in a stratified bed within 5% with d_a.

[Water/Air Two-Phase Flow]

- Proposed model adopting d_a does not predict pressure gradients of water/air two-phase flow in contrast to air flow results.
- Proposed model predicts pressure gradients of water/air two-phase flow by means of averaging according to the bed height after calculating the upper (2 mm sphere, ε: 0.391) and lower (5 mm sphere , ε: 0.383) parts of the bed.

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