

APPLICABILITY OF THE PREDICTIVE FORMULAE FOR SUPENDED SEDIMENT CONCENTRATION ON FULL-SCALE RIPPLED BED AND SHEET FLOW

Ravindra Jayaratne¹ & Tomoya Shibayama²

E-mail: ¹r.jayaratne@uel.ac.uk, ²shibayama@waseda.jp

1. INTRODUCTION

□ **Purpose:** To investigate the applicability and performance of *Suspended Sediment Concentration Models of Jayaratne & Shibayama (2007)* using full-scale rippled bed and sheet flow laboratory data in *SANTOSS* database.

□ **Methodology:** *Dimensional Analysis & Best-Fit Technique (Regression analysis)* are the main methods used to revise the previous sets of theoretical models of Jayaratne & Shibayama (2007).

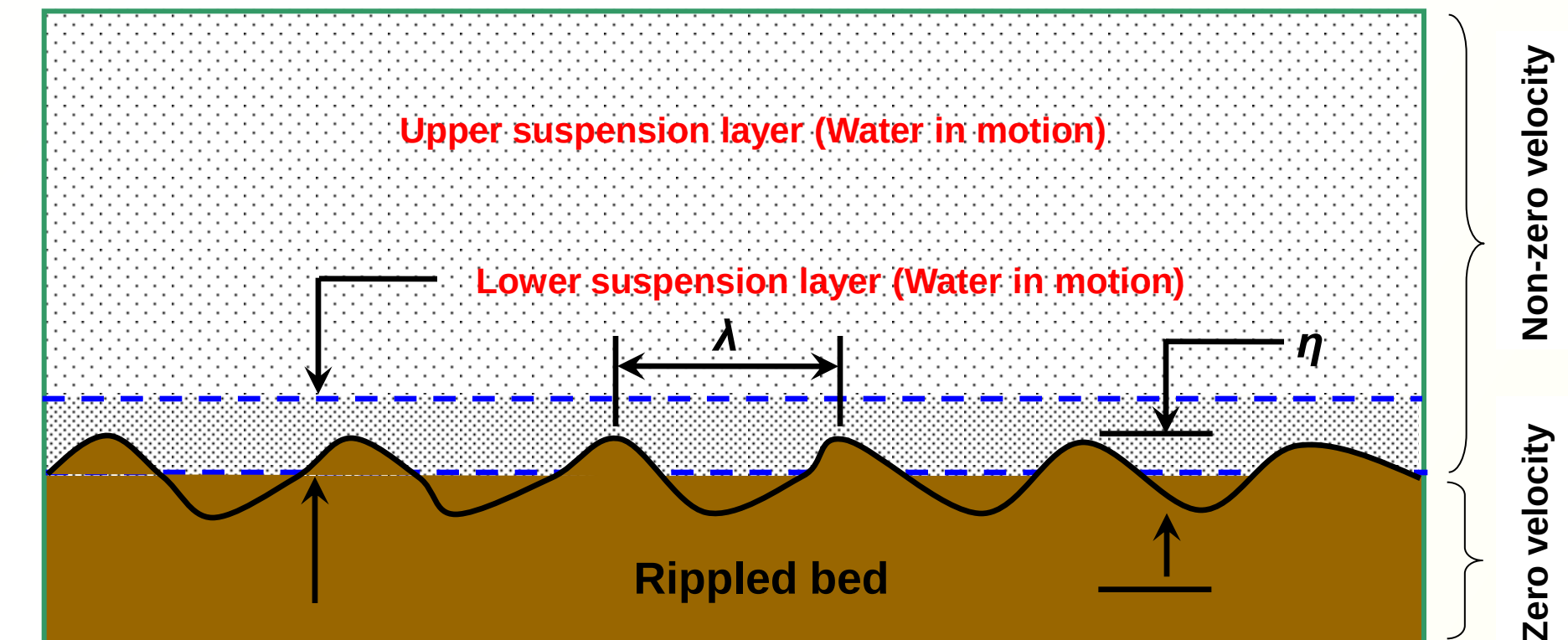
□ **Innovative Points:** Two suspension layers (Lower & Upper) were identified over rippled beds, therefore two separate theoretical models were proposed whereas four suspension layers (Pick-up layer, Upper sheet flow layer, Transition layer & Suspension layer) were identified over sheet flow and models were proposed for upper sheet flow and suspension layers due to the availability of measured data.

3. REVISED MODELS

FULL SCALE RIPPLED-BED (75 DATA SETS)		
	Lower Suspension Layer	Upper Suspension Layer
Reference concentration	$c_r = \frac{k_1 \psi v}{\sqrt{(s-1)gd} (\eta/2)}$	
Diffusion coefficient	$\varepsilon_r = k_2 u_{wc} A_b \left(\frac{w_s}{u_{wc}} \right)^2 \left(\frac{\eta}{d} \right)^{0.1} \left(\frac{\lambda}{d} \right)^{0.25} d^{*1.5}$	$M_r = k_3 \left(\frac{\eta}{d} \right)^{0.1} \left(\frac{\lambda}{d} \right)^{0.25} d^{*1.5}$
Sediment concentration profile	$c(z) = c_r \exp \left\{ \frac{-w_s (z-r)}{\varepsilon_r} \right\}$	$c(z) = c_r \left(\frac{z_0}{z} \right)^{M_r}$

FULL SCALE SHEET-FLOW (80 DATA SETS)		
	Upper Sheet-Flow Layer	Suspension Layer
Reference concentration	$c_s = \frac{k_4 \theta v}{\sqrt{(s-1)gd} d}$	
Diffusion coefficient	$M_s = \left(\frac{w_s}{U_{*wc}} \right)^{k_5}$	
Sediment concentration profile	$c(z) = c_s \exp \left\{ \frac{-(z-k_6 d)}{5M_s d} \right\}$	$c(z) = c_s \left(\frac{25d}{z} \right)^{M_s}$

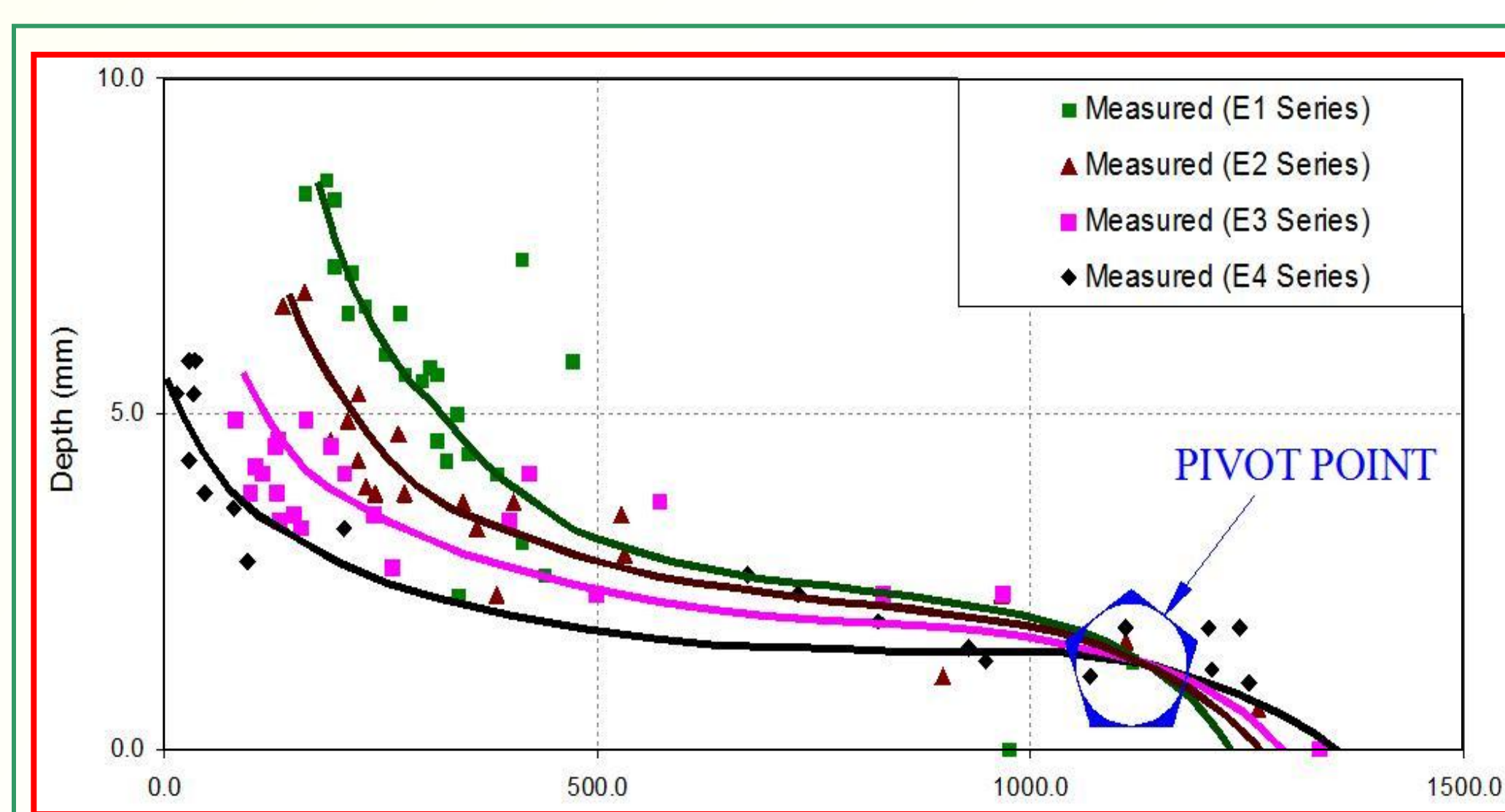
RIPPLED-BED REGIME



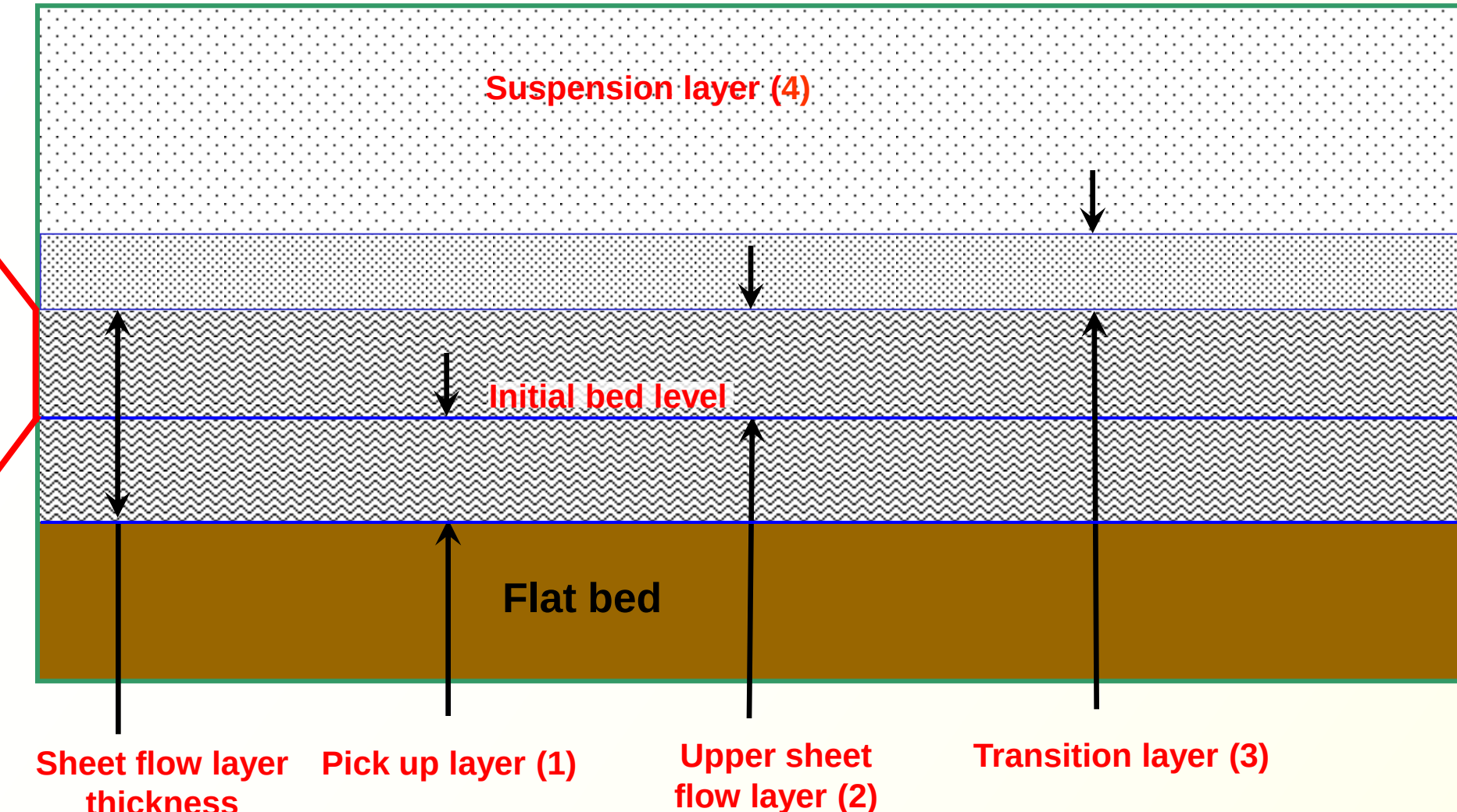
where

c_r = reference concentration over rippled bed
 c_s = reference concentration over sheet flow
 ε_r = diffusion coefficient over lower suspension layer of rippled bed
 M_r = diffusion coefficient over upper suspension layer of rippled bed
 M_s = diffusion coefficient over sheet flow
 $c(z)$ = concentration profile over rippled bed/sheet flow
 z = water depth measured from the bed
 r = reference level for lower suspension layer in rippled bed
 z_0 = reference level for upper suspension layer in rippled bed
 ψ = mobility number
 θ = Shields Parameter
 d = average grain diameter

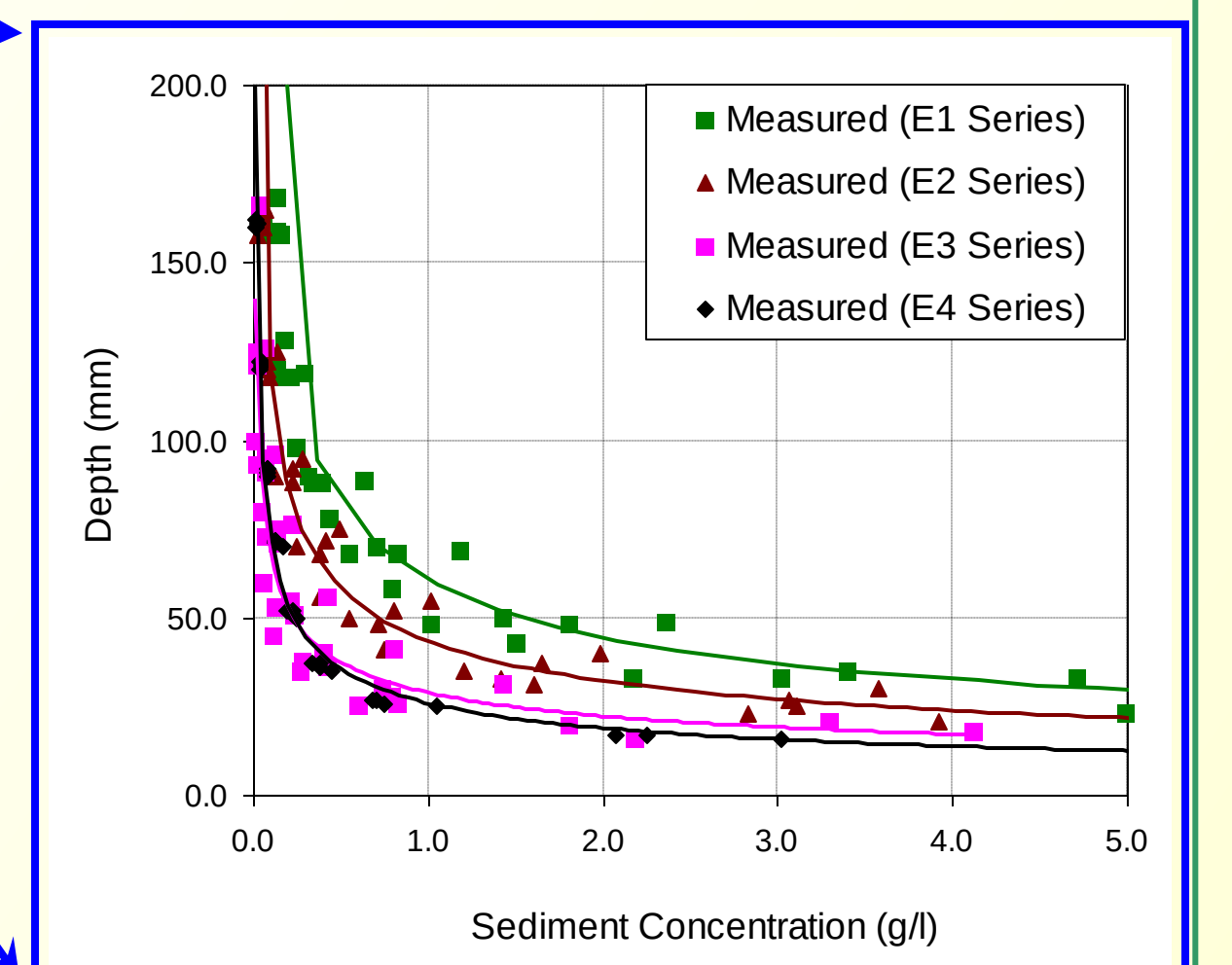
u_{wc} = maximum combined wave-current shear velocity
 w_s = settling velocity
 A_b = orbital amplitude of fluid just above the boundary layer
 k_1, k_2, k_3 = numerical constants based on maximum near-bed fluid velocity and coherent vortex structure
 k_4, k_5, k_6 = numerical constants based on magnitudes of imposed wave and net-current
 d^* = non-dimensional parameter related to average grain diameter
 s = specific gravity of sand
 η = ripple height
 λ = ripple length



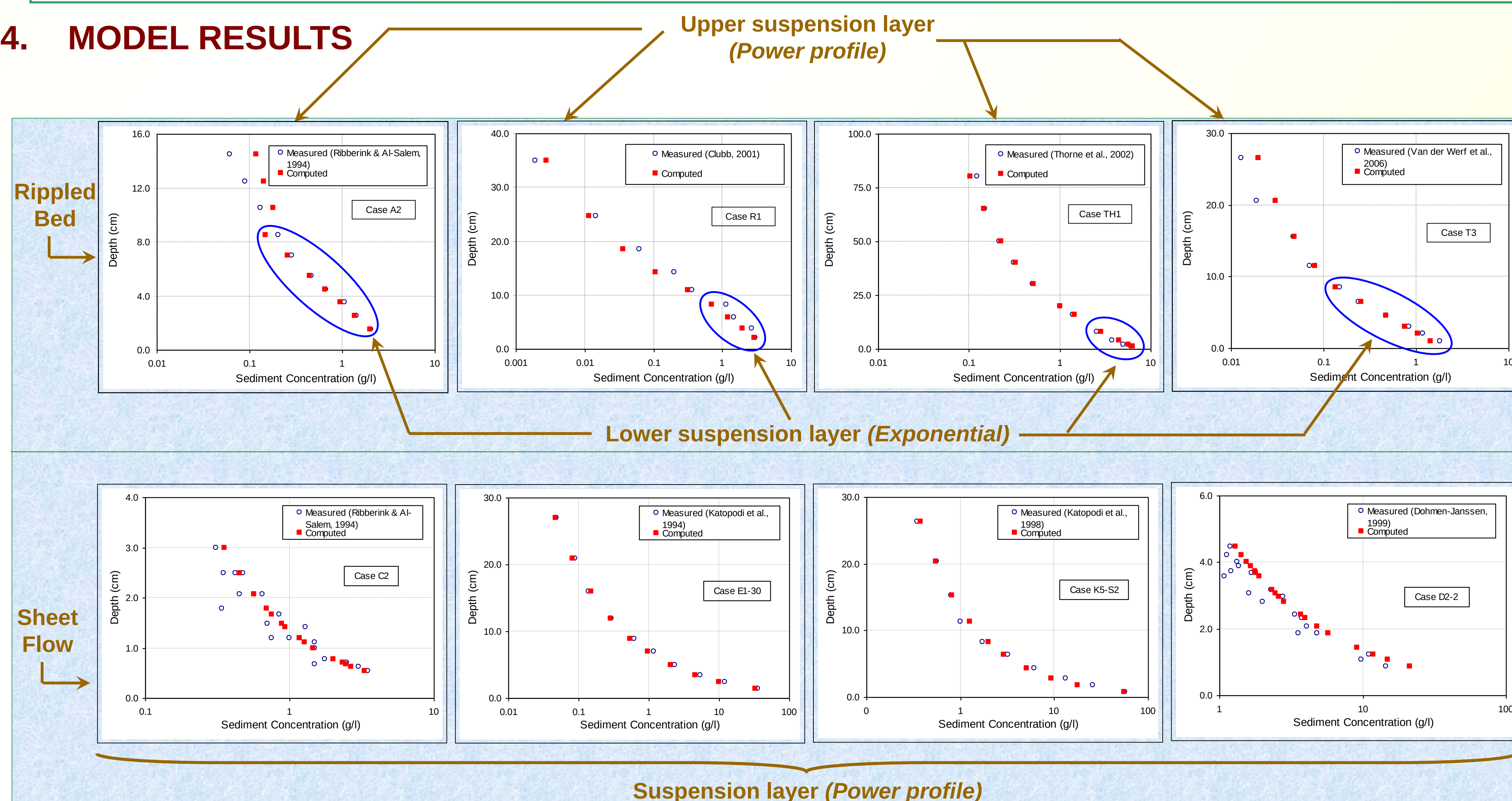
SHEET-FLOW REGIME



From the measured experimental data of Katopodi et al. (1994)



4. MODEL RESULTS



5. DISCUSSION

□ In **rippled bed regime**, time-averaged concentration profile over **lower suspension layer** shows an **exponential** form of behaviour with depth whereas it is over **upper suspension layer** shows a **power relationship**. The numerical coefficients (k_1, k_2, k_3) in revised predicted formulae depends on the maximum near-bed fluid velocity and coherent vortex structure.

□ Similarly, in **sheet flow regime** the time-averaged concentration profile over **upper sheet flow layer** shows an **exponential** form of behaviour with depth, and conversely it is over **suspension layer** shows a **power relationship**. The numerical coefficients (k_4, k_5, k_6) in revised predicted formulae depends on the magnitudes of imposed wave and net-current.

6. CONCLUSIONS

□ There is a **close match** between **sediment concentration predicted** by the revised rippled bed and sheet flow models and the measured data.

□ From the measured data of Katopodi et al. (1994), in sheet flow regime, when the wave period remains constant, different combination of wave and net-current conditions acting on a particular sand form a **Single Pivot Point** on the curves of measured time-averaged concentration profiles.