Local Scour by Offset and Propeller Jets

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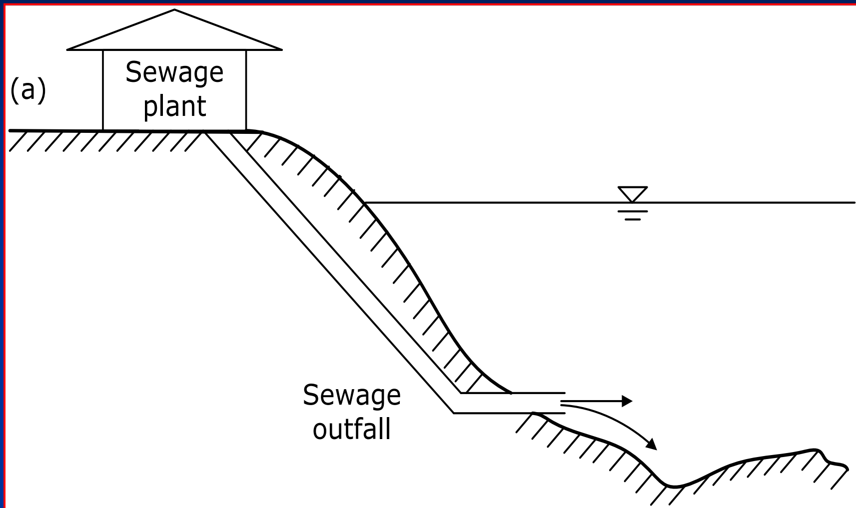
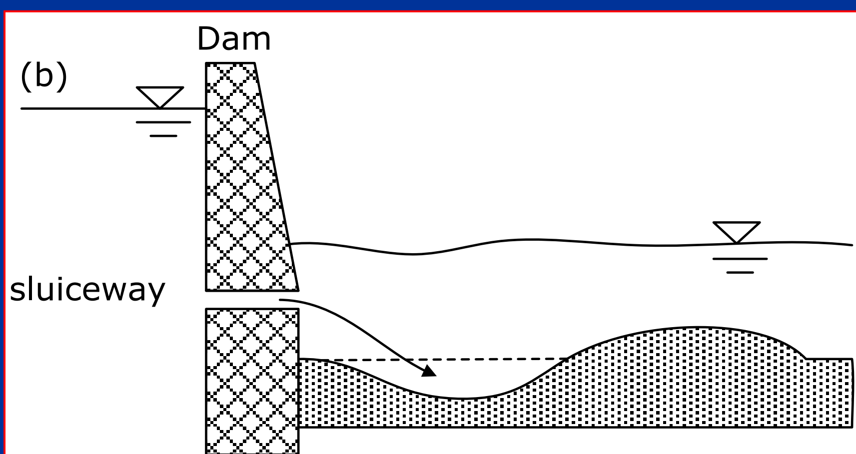
Outline

- Introduction
- Dimensional analysis
- Effect of densimetric Froude number on jet scour
- Effect of offset height on scour
- Initiation of scour
- Conclusions

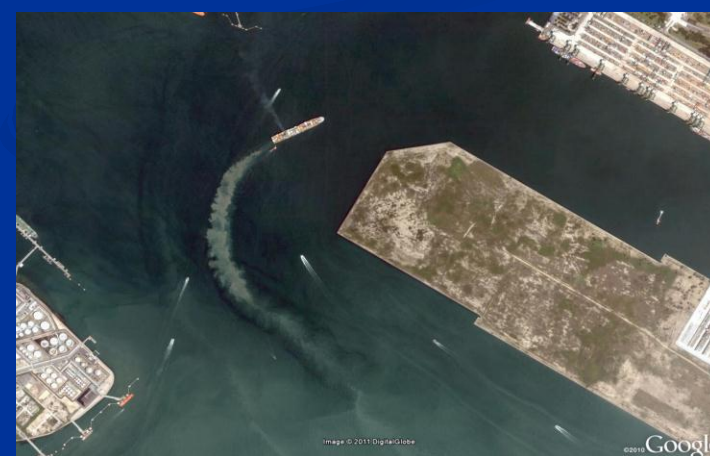
Introduction





Submerged horizontal jet

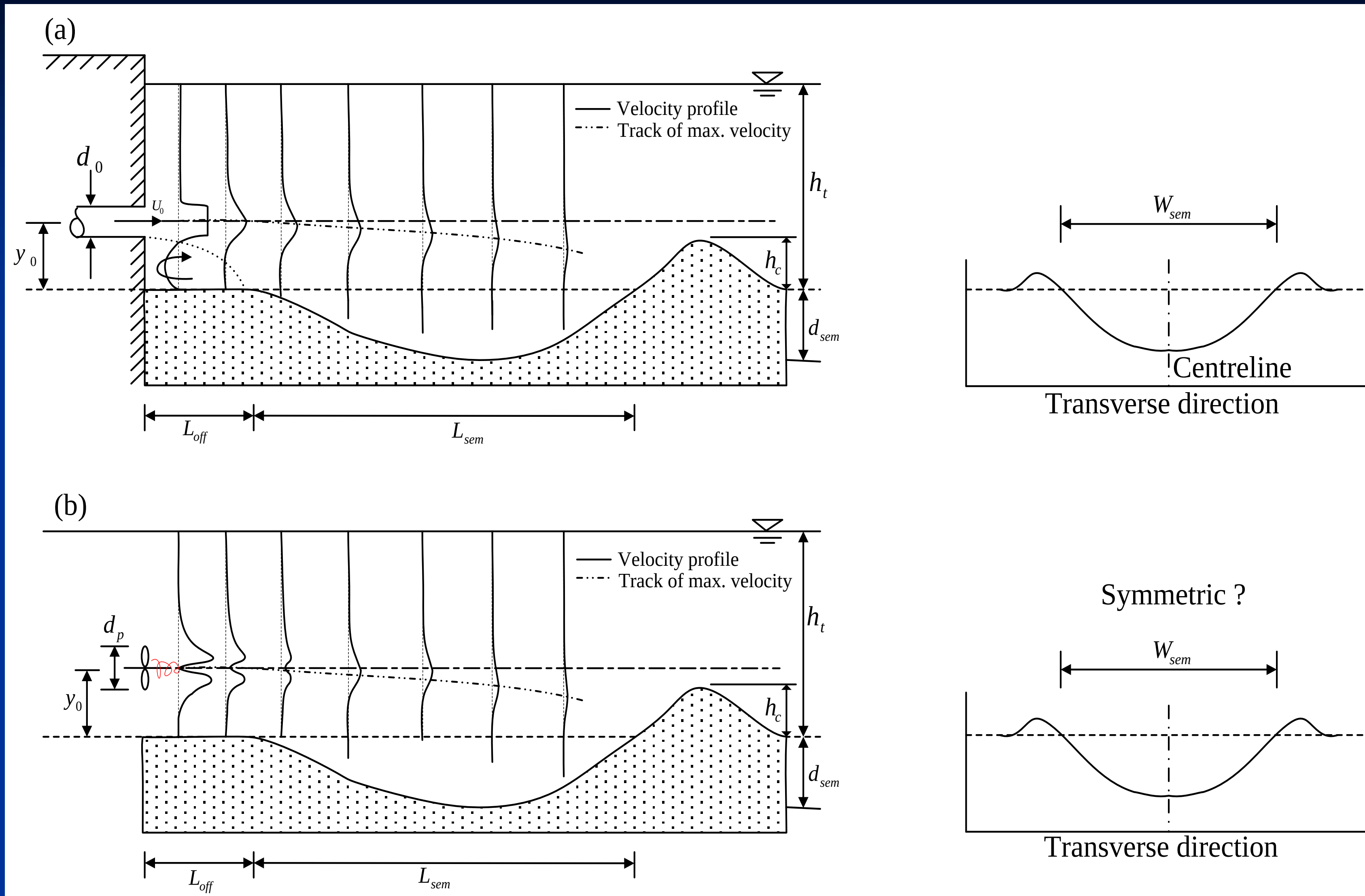
Ship-propeller jet



Propeller wash induced erosion

One Week Vessel Track at PPT (25 -31 May, 2011)

Source: Maritime Port Authority of Singapore, MPA



Scour by (a) offset jet; and (b) propeller jet

Objective

- To investigate the characteristics of a 3-D scour hole in non-cohesive sediment beds due to a submerged horizontal 3-dimensional offset and propeller jet

Dimensional Analysis

$$d_{sem}; L_{sem}; W_{sem} = f\left(U_o, d_o, d_{50}, y, \rho, g, \rho_s, \mu, h_t\right)$$

$$\frac{d_{sem}}{d_o} = f\left(\frac{U_o}{\sqrt{\frac{\Delta\rho}{\rho} g d_{50}}}, \frac{U_o d_o}{\nu}, \frac{y}{d_o}, \frac{h_t}{d_o}\right)$$

$$\mathbf{F}_o = U_o / \sqrt{(\Delta\rho/\rho) g d_{50}}$$

$$\mathbf{R}_{ej} = U_o d_o / \nu$$

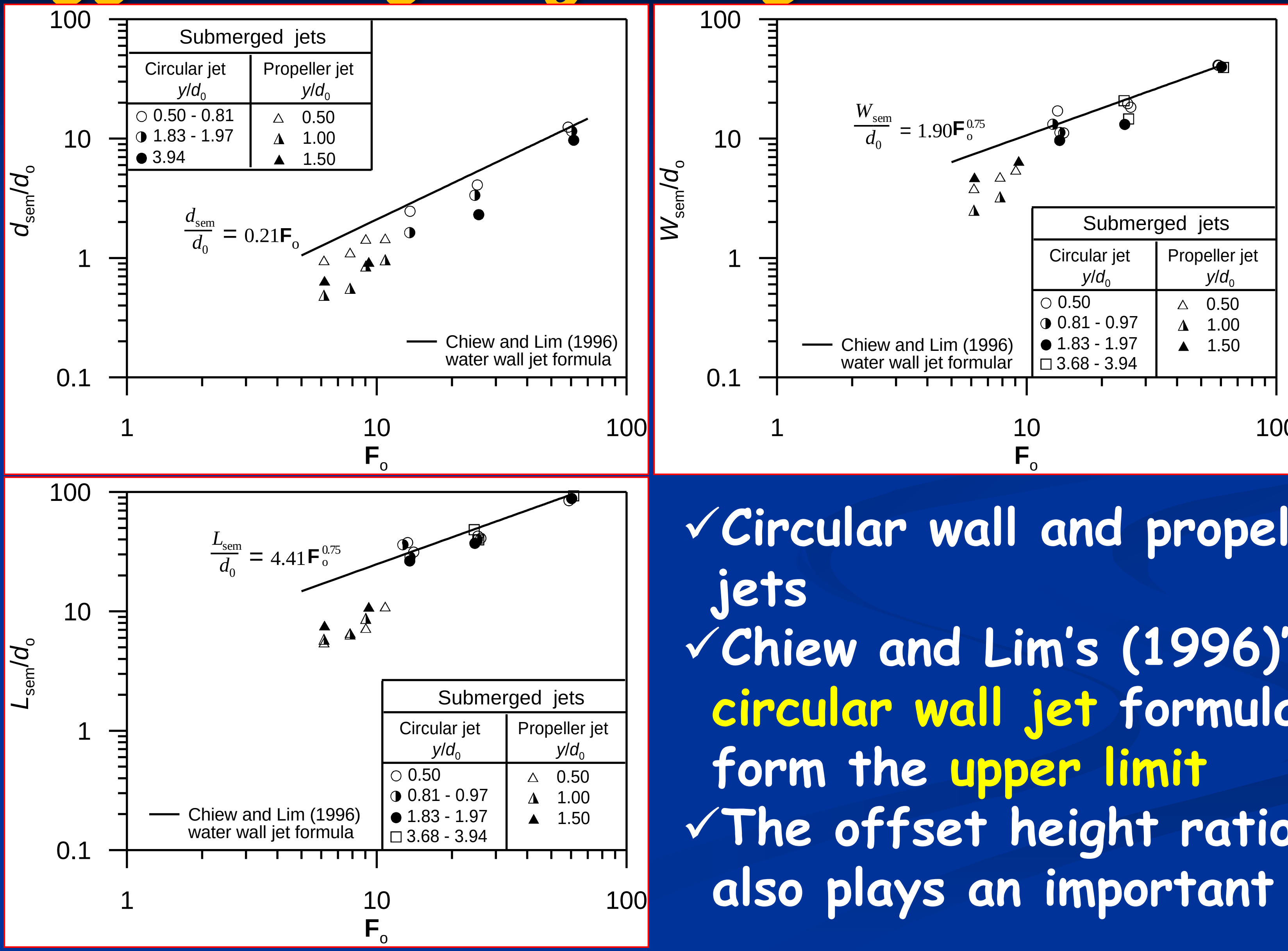
$$\frac{d_{sem}}{d_o} = f\left(\mathbf{F}_o, \frac{y}{d_o}\right)$$

$$\frac{d_{sem}}{d_o} = f\left(\mathbf{F}_o - \mathbf{F}_{oc}, \frac{y}{d_o}\right)$$

Range of data collected on scour cause by submerged 3D jets

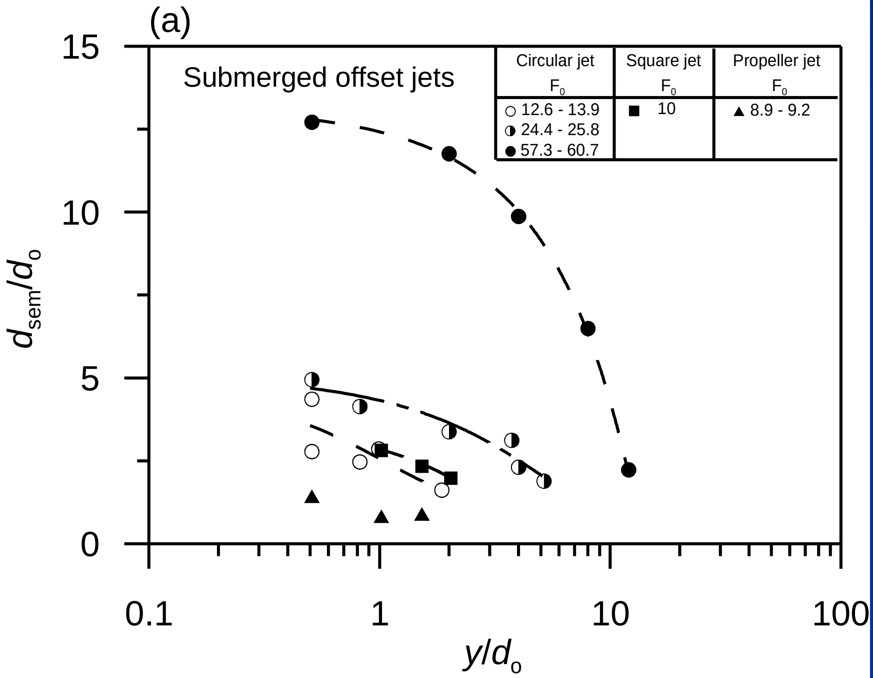
Investigators	y/d_o	F_o	d_{sem}/d_o	L_{sem}/d_o	W_{sem}/d_o	Remark
Hamill (1987)	1.14	5.55 - 7.73	0.91 – 1.00	—	6.89 – 20.98	**propeller jet**
Chiew and Lim (1996)	0.50 – 15.75	13.14 – 60.74	0.47 – 12.76	9.88 – 42.20	27.07 – 95.12	**circular jet**
Karki (2007)	1.00 – 2.00	10.00	2.03 – 2.87	11.28 – 12.85	28.02 – 29.65	**square jet**
Hong et al. (2012)	0.50 – 1.50	6.08 – 10.69	0.50 – 1.50	2.57 – 6.65	5.62 – 11.26	**propeller jet**

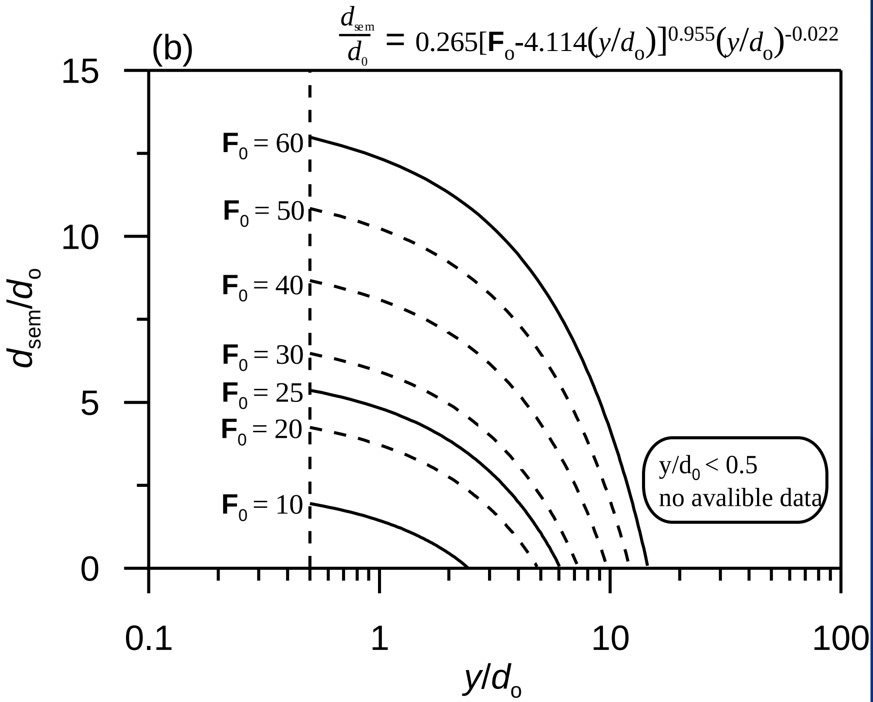
Effect of F_o on jet scour



- ✓Circular wall and propeller jets
- ✓Chiew and Lim's (1996)'s **circular wall jet** formulas form the **upper limit**
- ✓The offset height ratio also plays an important role

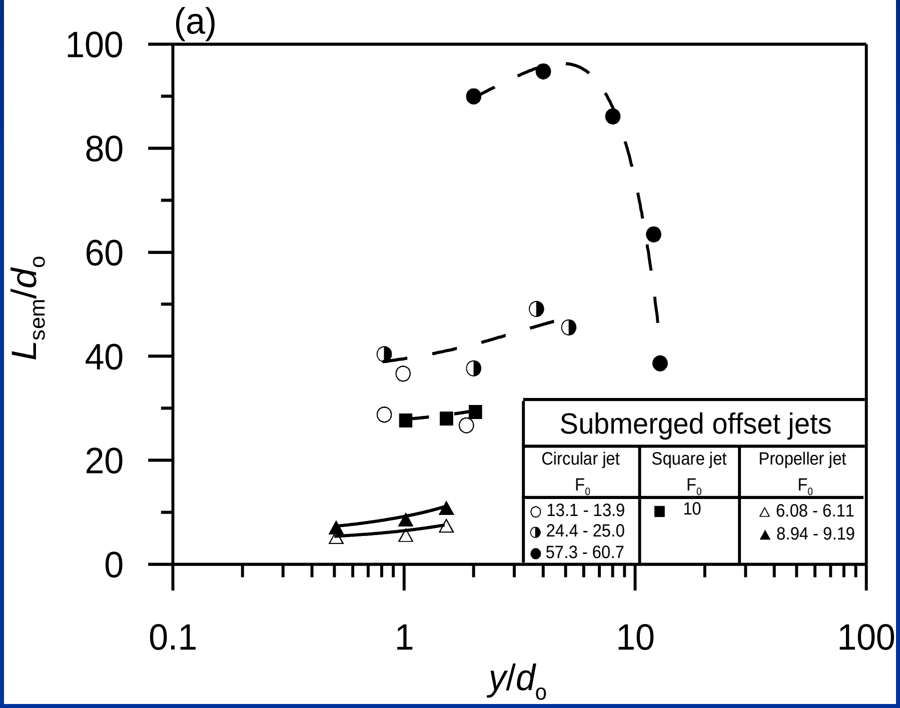
Effect of y/d$_o$ on scour depth

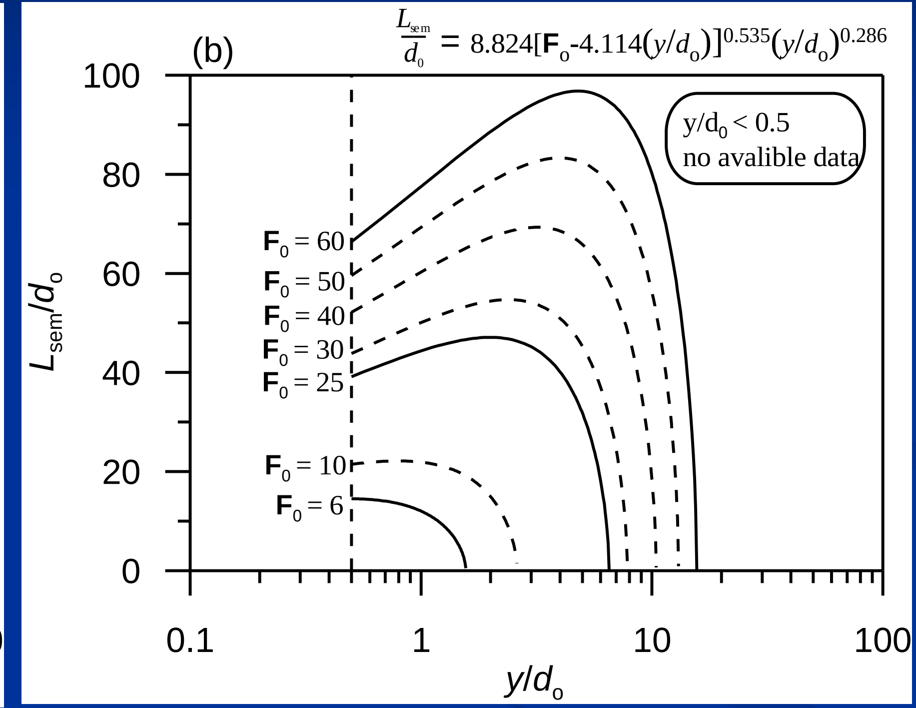




$$\frac{d_{sem}}{d_o} = 0.265\left(\mathbf{F}_o - (4.114\,\frac{y}{d_o})\right)^{0.955}\left(\frac{y}{d_o}\right)^{-0.022}, \quad \frac{y}{d_o} \geq 0.5$$

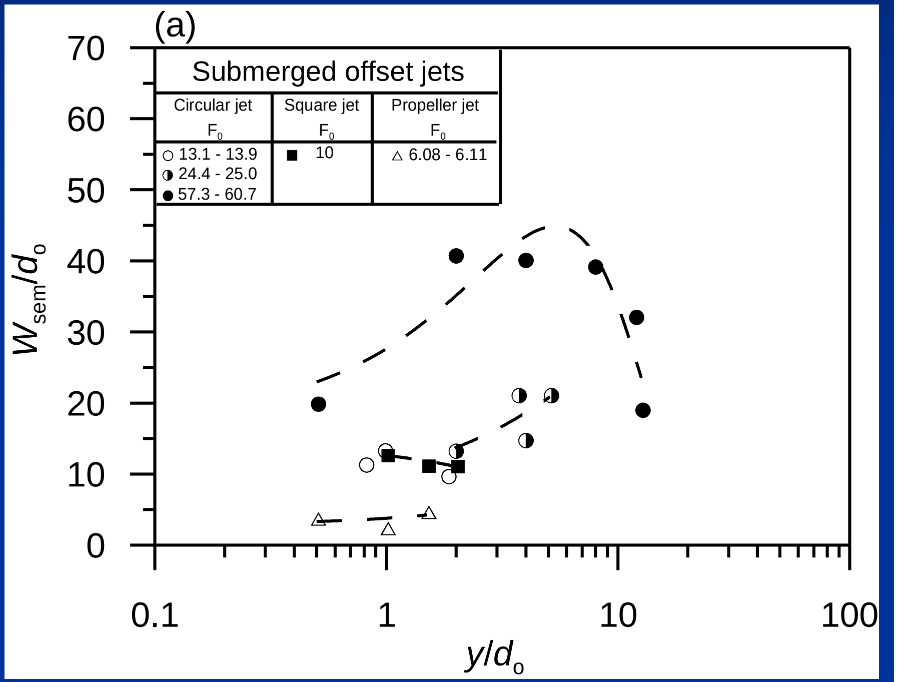
Effect of y/d_o on scour length

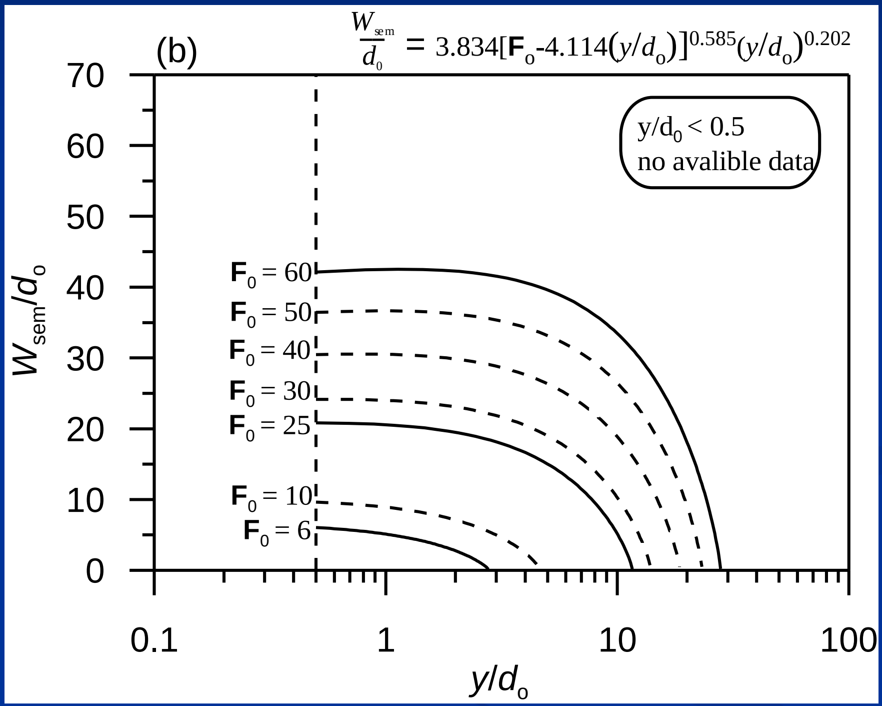




$$\frac{L_{sem}}{d_o} = 8.824\left(\mathbf{F}_o - (4.114\frac{y}{d_o})\right)^{0.535}\left(\frac{y}{d_o}\right)^{0.286}, \quad \frac{y}{d_o} \geq 0.5$$

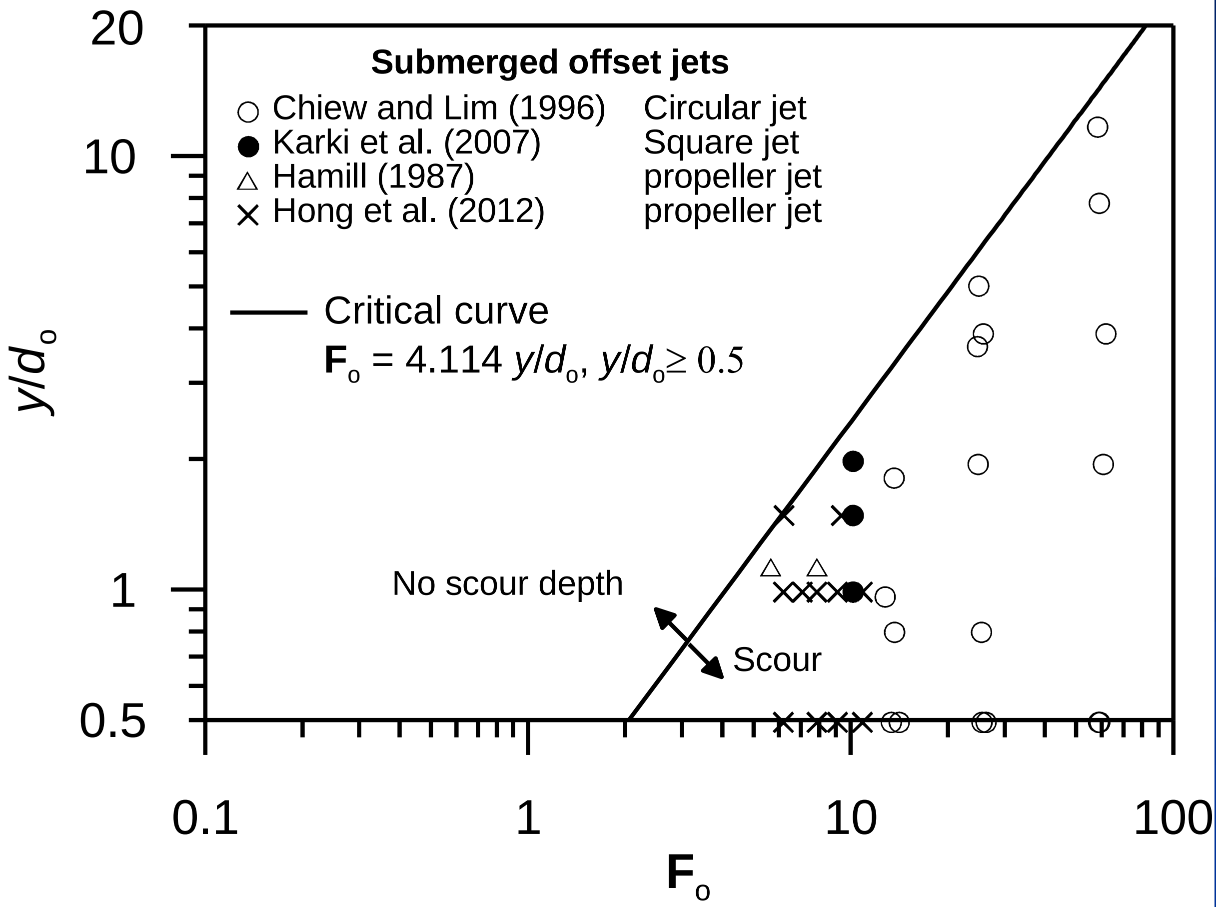
Effect of y/d_o on scour width





$$\frac{W_{sem}}{d_o} = 3.834\left(\mathbf{F}_o - (4.114\frac{y}{d_o})\right)^{0.585}\left(\frac{y}{d_o}\right)^{0.202}, \quad \frac{y}{d_o} \geq 0.5$$

Initiation of 3-D jet scour



$$\mathbf{F}_{oc} = 4.114\frac{y}{d_o}, \quad \frac{y}{d_o} \geq 0.5$$

Conclusions

1. The offset height ratio, y/d_o and densimetric Froude number, F_o affects both offset and propeller jets
2. The 3-D wall jet equations proposed by Chiew and Lim (1996) form the upper limits for scour induced by both types of jets

Conclusions

3. The variation between the scour length, width and offset height is non-linear
4. Eq. 11 (Fig. 9) in the paper may be used to determine the critical condition for the initiation of scour

$$\mathbf{F}_o = (4.114\frac{y}{d_o})$$

Questions & Comments