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On the effect of cross sectional shape on incipient motion and deposition of sediments in fixed bed channels

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Abstract: The condition of incipient motion and deposition are of the essential issues for the study of sediment transport. This phenomenon is of great importance to hydraulic engineers for designing sewers, drainage, as well as other rigid boundary channels. This is a study carried out with the objectives of describing the effect of cross-sectional shape on incipient motion and deposition of particles in rigid boundary channels. In this research work, the experimental data given by Loveless (1992) and Mohammadi (2005) are used. On the basis of the critical velocity approach, a new incipient motion equation for a V-shaped bottom channel and incipient deposition of sediment particles equations for rigid boundary channels having circular, rectangular, and U-shaped cross sections are obtained. New equations were compared to the other incipient motion equations. The result shows that the cross-sectional shape is an important factor for defining the minimum velocity for no-deposit particles. This study also distinguishes incipient motion of particles from incipient deposition for particles. The results may be useful for designing fixed bed channels with a limited deposition condition.

Keywords: Incipient motion; Incipient deposition; Cross-sectional shape; Rigid boundary channel; Sediment particles; Critical velocity.

INTRODUCTION

The presence of sediments in water transport systems has a significant impact on their hydraulic behaviour and operation. An important factor in the design of these systems is the set of minimum flow conditions which is necessary to prevent problems which are caused by the deposition of sediment in rigid boundary channels. Deposition of sediments on the invert of rigid boundary channels, such as sewers and irrigation channels, is a common technical and economic problem. The criterion of incipient motion and incipient deposition best responds with the need of optimizing the conveyance characteristics by providing its maximum sediment carrying capacity with no sedimentation. By considering the economic and applicable aspects, one of the integral criteria in channel designing issues is the determining the cross-sectional shape of the channel. Incipient motion is one of the main parameters in sediment transport models in rigid boundary channels and these models were developed based on self-cleansing velocities. Butler et al. (1996a, b) proposed a suitable sediment transport model in sewers using the Novak and Nalluri (1984) incipient motion equation. The point at which sediment begins to deposit should be closely related to the condition under which sediment first begins to move. This condition is the threshold of movement or simply the threshold condition (Task Force Committee, 1966). Banasiak et al. (2005) focused on tests using sewer sediment in which strong biochemical reactions were observed during the deposit formation period. Ashley et al. (2004) give a list of various types of settling velocity apparatus used in recent years. The effect of cross-sectional shape has been also of interest of several researchers in this case. Ojo (1980) studied incipient motion of grouped particles on fixed beds as well as channel shape effects. In addition, models of sediment threshold and deposition must be detailed and preferably quantitative to be of use in understanding and predicting the nature of the problem. In order to construct and validate adequate predictive models, it is necessary to have information on: (1) variation and interaction of channel cross-sectional shape, water flow and sediment; (2) 2-D variation of channel geometry, sedimentary structures and sediment deposition threshold. This paper highlights the cross sectional shape effects on sediment threshold and deposition of particles.

INCIPIENT MOTION IN LOOSE BOUNDARY CHANNELS

The threshold condition of particles requires certain parameters to be considered, namely bed shear stress, critical velocity, cross sectional shape, fall velocity of individual particles, material size and boundary conditions. The following fundamental approaches may be applied for the particles threshold and sediment transport.

Critical velocity approach

The threshold condition depends on critical bed velocity or critical mean velocity. Shields (1936) criterion combined with Manning's $n = 0.04d^{1/6}$ (The Strickler equation) gives:

$$\frac{V_c}{\sqrt{gd(s-1)}} = a\left(\frac{d}{R}\right)^{1/6} , \quad (1)$$

where V_c is the critical velocity, d is the sediment particle size, g is the acceleration due to the gravity, s is the sediment relative density, R is the hydraulic radius and a is a constant coefficient. Neill (1968) proposed a design curve for the scour uniform sand as follows:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 1.58\left(\frac{d}{Y}\right)^{-0.10}, \quad (2)$$

in which Y is the flow depth.

Bogardi (1968) proposed the following relationship:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 1.70\left(\frac{d}{Y}\right)^{-0.095}.$$

(3)

Ackers and White (1973) proposed for particles bigger than 2.4 mm:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.96\log\left(\frac{Y}{d}\right) + 1.04 \cdot \quad (4)$$

Garde and Ranga Raju (1985) analyzed data of the incipient motion particles carried on rough surfaces and they suggest a following relationship:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.5\log\left(\frac{Y}{d}\right) + 1.63 \cdot \quad (5)$$

Critical shear stress approach

To define the threshold condition, the equilibrium of a layer of sediment particles resting on the bed under the frictional drag of flow is often adopted as an alternate approach. Shields (1936) was first to use the concept of friction velocity. Shields (1936) defined which physical parameters influenced sediment transport and gave a functional relationship as:

$$\tau_c^* = \frac{\tau_c}{\rho g(s-1)d} = F(\mathrm{Re}^*) = F\left(\frac{u_* d}{\nu}\right), \quad (6)$$

where τ_c^* is the average critical dimensionless shear stress, τ_c is the critical shear stress, ρ is the fluid density, Re^* is the particle Reynolds number, $u_* \left(= \sqrt{\tau_c/\rho}\right)$ is shear/friction velocity in the boundary and ν is the kinematic viscosity of fluid. Shields (1936) then defined a critical dimensionless shear stress as values of the shear stress for zero sediment discharge. In fully turbulent flows, the Shields equation may be written as (Mayerle, 1988):

$$\tau_c = 0.056\rho g(s-1)d\,. \quad (7)$$

Yalin (1992) suggested a different combination of dimensionless parameters initially proposed by Shields, whereby the shear velocity is eliminated and only parameters of the fluid and sediment are retained:

$$\frac{\tau_0}{\rho g(s-1)d} = F(D_{gr}) = F\left[\frac{(s-1)gd^3}{\nu^2}\right]^{1/3}, \quad (8)$$

where τ_0 is the mean bed shear stress and D_{gr} is the dimensionless grain size parameter.

INCIPIENT MOTION IN RIGID BOUNDARY CHANNELS

The determination of incipient motion is of important not only to study of sediment transport but also to the design of hydraulic structures. Most engineers use either critical shear stress or critical average velocity as a criterion for incipient motion computation.

Critical velocity approach

Craven (1953) studied the condition for the beginning of movement of particles in pipes flowing full. He concluded that for no permanent deposit in a pipe the designer ensure that:

$$\frac{Q}{D^2\sqrt{(s-1)gd}} \geq 2.5, \quad (9)$$

where Q is the flow discharge and D is the internal diameter of pipe channel. For a part full pipe flow, Eq. (9) can be rearranged as:

$$\frac{V_c}{\sqrt{gd(s-1)}} \geq 3.18\,. \quad (10)$$

Novak and Nalluri (1975) carried out experiments in free surface flumes with rectangular and circular cross sectional shape and proposed the following relationship:

$$\frac{V_c}{\sqrt{gd(s-1)}} = a\left(\frac{d}{R}\right)^b, \quad (11)$$

where a and b depend on the bed and whether there are single/touching particles. Novak and Nalluri (1984) proposed the following relationship for rectangular and circular cross section channels:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.50\left(\frac{d}{R}\right)^{-0.40}. \quad (12)$$

El-Zaemey (1991) conducted his experiments in a circular channel having a flat rigid bed utilizing several sizes of non-cohesive sediments and obtained the following equation:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.75\left(\frac{d}{R}\right)^{-0.34}. \quad (13)$$

Ab Ghani et al. (1999) carried out other sorts of experiments. The experiments were conducted to study the effects of sediment deposits' thickness on the incipient motion of particles in a rigid rectangular channel. The results showed that the deposits' thickness significantly affects the channel ability to erode the sediment deposits. The following equation was proposed:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 1.07\left(\frac{d}{R}\right)^{-0.23}. \quad (14)$$

Critical shear stress approach

Ippen and Verma (1953) investigated the motion of discrete particles along a fixed bed coated with uniform sand. Experiments were conducted in a rectangular flume. They presented a curve which was suggested to identify the effect of all variables involved in the incipient motion. To bring all points on their plot approximately to the Shields line, they suggested the following empirical relation:

$$\frac{1.5\tau_0}{\rho g (s-1)^{1/2} k_s} = \frac{11.6d}{\delta'} = F(\text{Re}^*) , \quad (15)$$

where δ' is the sublayer thickness and k_s is the overall Nikuradse's equivalent sand roughness.

Mohammadi (2005) carried out research in the field of incipient motion condition in rigid boundary channels, based on the critical shear stress approach. Sediment threshold experiments were conducted in two types of the V-shaped bottom channels. It was found that a simple relationship between two parameters as $\text{Re}^*\left(=\frac{u_* d}{\nu}\right)$ and the dimensionless critical shear stress, $\tau_c^*\left(=\frac{\tau_c}{\rho g (s-1) d}\right)$ best describes the phenomenon. The following equations were obtained for the V-shaped bottom channels:

$$\tau_c^* = 7 \times 10^{-5} \text{Re}_*^2 \ , \quad (16)$$

for sand size of d_{50} = 0,87 mm, R^2 = 0,99

$$\tau_c^* = 7 \times 10^{-7} \text{Re}_*^2 \ , \quad (17)$$

for gravel size of d_{50} = 7,72 mm, R^2 = 0,99

LOVELESS (1992) AND MOHAMMADI (2005) EXPERIMENTS ANALYSIS

Experiments

Loveless (1992) studied the subject of sediment transport in rigid boundary channels particularly at the point where the sediment is about to deposit. It was decided to concentrate on the specific case of the incipient deposition condition. The experiments were carried out in several channels with different cross section shapes. One series of tests were conducted in circular and rectangular channels. Two non-cohesive sand sizes were used to model the sediment having d_{50} sizes of 0.45 mm and 1.3 mm respectively and the specific gravity of the sand assumed to be 2.65. All the conduits in this series of tests were constructed in lengths of 900 mm making a total of 7.2 m overall and had cross-sectional areas of 60 cm^2. The other series of tests were conducted in which a U-shaped channel was 220 mm wide as shown in Fig. 1. It was constructed in 1.0 m lengths to a total length of 7.0 m. Besides the two sediments employed in the earlier experiments, angular non-cohesive granite chips having d_{50} size of 6 mm were also tested. The specific gravity of the granite was assumed to be 2.7. For sediment tests, first of all the gradient, flow and sediment discharges were set at values producing non-deposit flume traction flow with the conduit part full. Next the gradient was gradually reduced until local deposition began to occur. The flow was then increased to clear the settled deposit and this procedure was repeated several times. In this way, the incipient deposition condition could be clearly identified. Summary of the results for the experiments in rectangular, circular and U-shaped channels are tabulated in Tables 1 to 3 respectively.

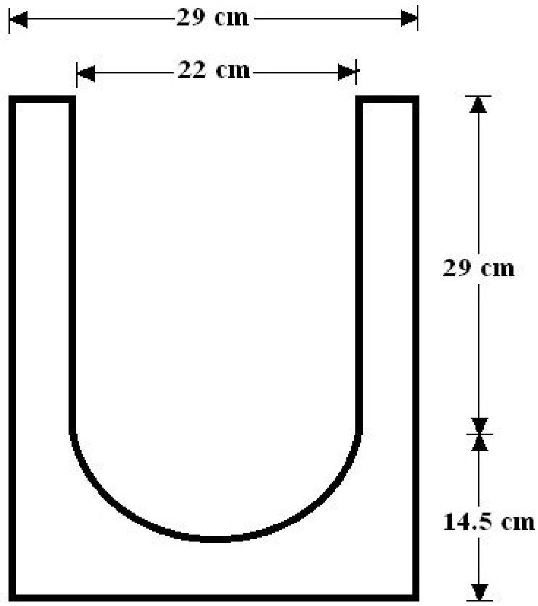

Fig. 1. Cross section of a U-shaped channel.

Table 1. Incipient deposition test results for a rectangular channel.

Test No.	Y (mm)	R (mm)	$Q\ (m^3/s) \times 10^{-3}$	S_0 (---)	V_c (m/s)	d_{50} (mm)
1	12	9.7	0.486	0.0116	0405	0.45
2	19	13.8	0.825	0.0083	0.434	0.45
3	20	14.3	0.825	0.0078	0.413	0.45
4	31	19.1	1.546	0.0056	0.499	0.45
5	28	14.5	0.761	0.0080	0.453	0.45
6	43	17.7	1.452	0.0071	0.563	0.45
7	74	21.3	2.751	0.0056	0.620	0.45
8	77	21.6	2.684	0.0048	0.581	0.45
9	36	16	0.793	0.0051	0.35	1.3
10	64	20	1.956	0.0051	0.52	1.3
11	76	21	2.330	0.0047	0.52	1.3
12	17	11	0.346	0.0084	0.35	1.3
13	18	11	0.346	0.0080	0.33	1.3
14	19	12	0.346	0.0074	0.31	1.3
15	20	12	0.346	0.0071	0.29	1.3
16	68	21	2.155	0.0053	0.54	1.3
17	69	21	2.155	0.0048	0.53	1.3
18	55	19	2.155	0.0086	0.66	1.3

Table 2. Incipient deposition test results for a circular channel

Test No.	Y (mm)	R (mm)	$Q\ (m^3/s) \times 10^{-3}$	S_0 (---)	V_c (m/s)	d_{50} (mm)
1	14.0	12.9	0.282	0.0148	0.453	0.45
2	20.7	16.2	0.561	0.0098	0.515	0.45
3	31.9	19.6	1.112	0.0075	0.559	0.45
4	37.1	20.7	1.546	0.0066	0.634	0.45
5	18	11	0.299	0.0094	0.339	1.3
6	40	21	1.383	0.0057	0.512	1.3
7	53	25	2.097	0.0048	0.546	1.3
8	37	20	1.384	0.0075	0.567	1.3

Table 3. Incipient deposition test results for a U-shaped channel.

Test No.	Y (mm)	R (mm)	$Q\ (m^3/s) \times 10^{-3}$	S_0 (---)	V_c (m/s)	d_{50} (mm)
1	66	37.5	9.005	0.0062	0.94	0.45
2	70.4	39.6	9.259	0.0050	0.89	0.45
3	69.6	39.2	11.160	0.0057	1.09	0.45
4	87.0	46.6	13.800	0.0043	0.99	0.45
5	43.1	26.0	3.912	0.0081	0.75	0.45
6	63.4	36.4	8.590	0.0077	0.95	0.45
7	50.6	30.0	5.012	0.0061	0.76	1.3
8	41.3	25.1	3.613	0.0062	0.73	1.3
9	48.9	29.1	4.894	0.0080	0.78	1.3
10	68.7	38.4	9.431	0.0059	0.95	1.3
11	86.5	46.3	12.750	0.0050	0.92	1.3
12	48.1	28.7	4.332	0.0056	0.71	6
13	63.9	36.6	6.692	0.0044	0.73	6
14	54.4	32.1	5.251	0.0051	0.72	6
15	68.3	38.6	7.875	0.0047	0.79	6
16	31.7	19.6	2.181	0.0066	0.65	6
17	42.6	25.7	3.237	0.0054	0.63	6
18	58.7	34.0	6.144	0.0047	0.76	6

Table 4. Incipient deposition test results for V-shaped bottom channel.

Test No.	Y (mm)	R (mm)	$Q\ (m^3/s) \times 10^{-3}$	S_0	V_c (m/s)	d_{50} (mm)
1	68.71	39.5	7.986	0.00032	0.39	0.87
2	55.18	28.8	5.022	0.00078	0.36	0.87
3	41.83	20.4	2.180	0.00173	0.27	0.87
4	77.75	46.1	13.118	0.00078	0.54	7.72
5	55.98	29.5	8.457	0.00173	0.59	7.72
6	43.71	21.4	3.334	0.00364	0.38	7.72
7	35.99	17.6	0.936	0.00840	0.16	7.72

Mohammadi (2005) carried out a research in the field of incipient motion in rigid boundary channels. Two types of channels with a V-shaped bottom cross section were examined. Firstly, the 300 mm wide CIS units, 13.5 m long, and a working cross section of 278 mm wide ×76 mm deep were tested. The second V-shaped bottom channel shaped was built by using PVC panels to make a 14.5 m long channel having 50 mm cross fall (see Fig. 2).

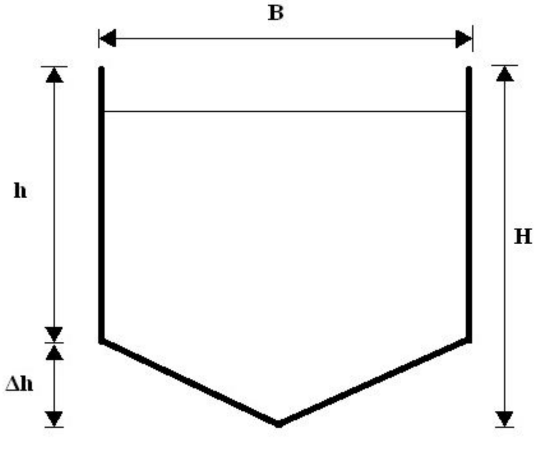

Fig. 2. Cross section of the V-shaped bottom channel.

In this research work, 22 tests were carried out for two particles sizes (d_{50} = 0.87 mm for sand, and d_{50} = 7,72 mm for road/concrete aggregate material). The particles were non-cohesive and their specific gravity was 2.65. Incipient motion of particles was investigated using a seven channel target bed slope. For each fixed bed slope, one flow discharge was set and uniform flow was established. For each discharge, the motion of particles was then studied visually and sometimes by manual measurements. When the threshold condition occurred, the critical flow discharge and bed slope were recorded. Summary of the results are tabulated in Table 4.

The Results Analysis

The following function used by Novak and Nalluri (1975, 1984), El-Zaemey (1991) and Ab Ghani et al. (1999) was utilized with the experimental data of Loveless (1992) and Mohammadi (2005).

$$\frac{V_c}{\sqrt{gd(s-1)}} = f\left(\frac{d}{R}\right) . \tag{18}$$

The right and left sides of Eq. (18) are computed and shown in Tables 5 to 8 based on the experimental data from Tables 1 to 4 respectively.

Utilizing data of Loveless (1992), the following incipient deposition equations are derived for the rectangular, circular and U-shaped cross section channels.

The incipient deposition equation for a rectangular channel is:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.48\left(\frac{d}{R}\right)^{-0.70} , R^2 = 0.85 . \tag{19}$$

The incipient deposition equation for a circular channel is:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.62\left(\frac{d}{R}\right)^{-0.64} , R^2 = 0.98 . \tag{20}$$

The incipient deposition equation for a U-shaped channel is:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.92\left(\frac{d}{R}\right)^{-0.55} , R^2 = 0.95 . \tag{21}$$

Utilizing data taken by Mohammadi (2005), the following incipient motion equation is derived for a V-shaped bottom channel:

$$\frac{V_c}{\sqrt{gd(s-1)}} = 0.68\left(\frac{d}{R}\right)^{-0.41} , R^2 = 0.91 . \tag{22}$$

The high values of R^2 for Eqs. (19), (20) and (21) show that the cross sectional shape affects the incipient deposition of particles and for Eq. (22) show that it affects the incipient motion of particles in rigid boundary channels.

Eqs. (19), (20), (21) and (22) are compared with the incipient motion equations in loose boundary channels namely, Shields (1936), Neill (1968), Bogardi (1968), Ackers and White (1973), Garde and Ranga Raju (1985) and with the incipient motion equations in rigid boundary channels namely, Novak and Nalluri (1984), El-Zaemey (1991) and Ab Ghani et al. (1999) in Figs. 3 to 6 respectively.

Table 5. Calculated amounts of d_{50}/R and $V_c\Big/\sqrt{gd(s-1)}$ from Table 1 for a rectangular channel.

Test No.	d_{50}/R	$V_c\Big/\sqrt{gd(s-1)}$
1	0.046	4.642
2	0.033	4.877
3	0.031	4.901
4	0.023	5.104
5	0.031	5.921
6	0.025	6.453
7	0.021	6.989
8	0.021	7.032
9	0.081	2.872
10	0.065	2.981
11	0.062	3.005
12	0.118	2.414
13	0.118	2.276
14	0.108	2.138
15	0.108	1.999
16	0.062	3.724
17	0.062	3.655
18	0.068	4.552

Table 6. Calculated amounts of d_{50}/R and $V_c\Big/\sqrt{gd(s-1)}$ from Table 2 for a circular channel.

Test No.	d_{50}/R	$V_c\Big/\sqrt{gd(s-1)}$
1	0.035	5.308
2	0.028	6.035
3	0.023	6.550
4	0.022	7.429
5	0.118	2.432
6	0.061	3.679
7	0.052	4.113
8	0.065	3.565

Table 7. Calculated amounts of d_{50}/R and $V_c\Big/\sqrt{gd(s-1)}$ from Table 3 for a U-shaped channel.

Test No.	d_{50}/R	$V_c\Big/\sqrt{gd(s-1)}$
1	0.0120	11.014
2	0.0113	10.428
3	0.0115	12.772
4	0.0096	11.600
5	0.0173	8.788
6	0.0124	11.132
7	0.0433	5.241
8	0.0518	5.035
9	0.0446	5.379
10	0.0338	6.551
11	0.0281	6.345
12	0.2090	2.278
13	0.1639	2.343
14	0.1869	2.311
15	0.1554	2.535
16	0.3061	2.086
17	0.2334	2.022
18	0.1764	2.439

Table 8. Calculated amounts of and from Table 4 for a V-shaped bottom channel.

Test No.	d_{50}/R	$V_c\Big/\sqrt{gd(s-1)}$
1	0.022	3.252
2	0.030	2.855
3	0.042	2.480
4	0.167	1.416
5	0.262	1.177
6	0.361	1.032
7	0.439	0.953

DISCUSSION

Figs. 3–5 show the incipient deposition curves obtained for the experimental data which are over the incipient motion curves. This result reveals that the critical velocity value of incipient deposition is more than that of incipient motion critical velocity at the same flow condition. This result denies the assumption that the incipient motion and incipient deposition are equal. It may be due to the type of experiments, because in case of incipient motion experiments, tests begin at low flow velocity and then by gradually increasing velocity reach the incipient motion condition, but in case of incipient deposition experiments, tests begin at high velocity and non-deposit condition, then by gradually decreasing velocity reach the incipient deposition condition. This is the main reason why Eqs. (19), (20) and (21) differ from Eqs. (12), (13) and (14).

Therefore, the incipient deposition design criterion is better than that of the incipient motion criterion for clean water channels that do not have deposited bed (e.g. water transport systems and surface water collecting channels). The quantities of incipient deposition velocity in rigid boundary channels for smaller amounts of *d/R* are greater than incipient motion velocity, whereas this differences decrease as the amount of *d/R* increases and it gets close to the incipient motion velocity. It may be concluded that for the fine particles, the incipient motion velocity and incipient deposition velocity are far from one another, but for coarse particles this difference is not very tangible. According to Tables 1–4, there are little differences in critical velocities for sediment particles of different sizes. Evidently, the incipient motion and deposition conditions depend upon the geometry of channel cross section. It may be noted that the parameters, hydraulic radius and channel bed slope, which are not constant in the experiments, play a key role in this case.

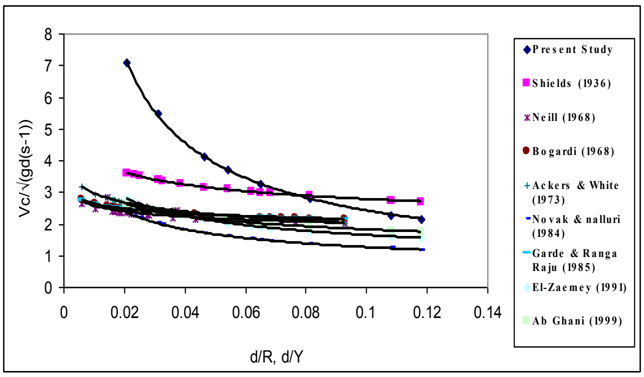

Fig. 3. A comparison of Eq. (19) with the incipient motion equations.

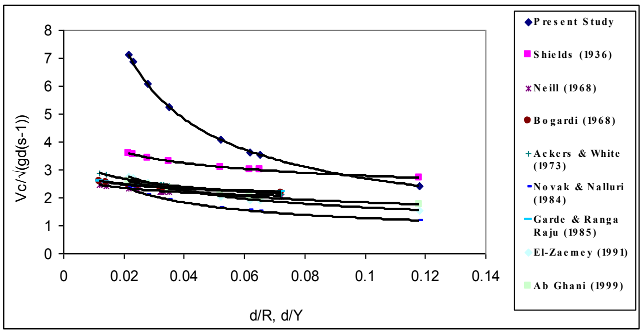

Fig. 4. A comparison of Eq. (20) with the incipient motion equations.

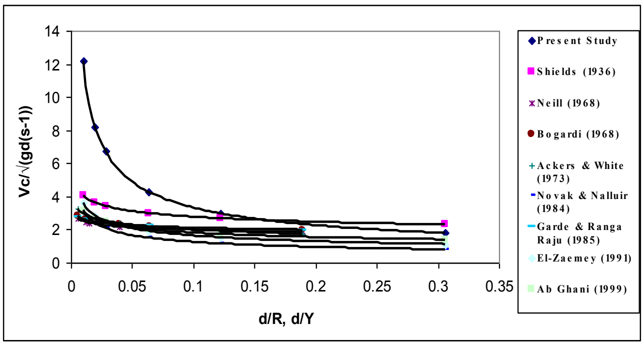

Fig. 5. A comparison of Eq. (21) with the incipient motion equations.

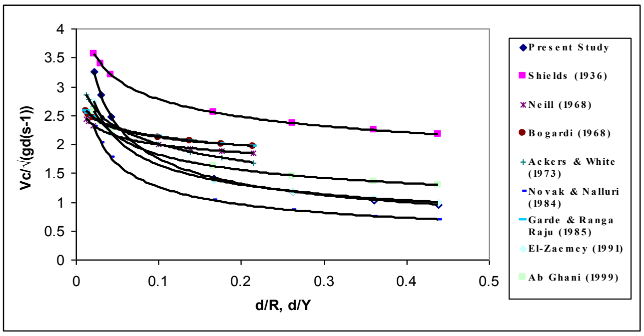

Fig. 6. A comparison Eq. (22) with the incipient motion equations.

According to Figs. 3–5, the closest amount of velocity to the incipient deposition is Shields (1936) incipient motion velocity which predicts more critical velocity than the other equations. Generally, incipient motion equations in loose boundary channels predict more critical velocity than incipient motion equations in rigid boundary channels. In comparison of the incipient motion equations in rigid boundary channels, the Ab Ghani et al. (1999) equation predicts the most and the Novak and Nalluri (1984) equation predicts least amount of critical velocity. The incipient motion curves in rigid boundary channels are below the incipient motion curves in loose boundary channels. Also the incipient motion equations in loose boundary channels for little amounts of *d/R* and *d/Y* anticipate more critical velocity.

Generally, the Shields (1936) equation expects the highest incipient motion critical velocity among the incipient motion models in loose and rigid boundary channels. In rectangular rigid boundary channels, Fig. 4 shows that the Shields (1936) equation for lower amounts of *d/Y* and *d/R* than 0.085 predicts lower critical velocity and for higher amounts of 0.085 anticipates higher critical velocity than Eq. (19). Fig. 5 shows that in U-shaped cross section rigid boundary channels, the Shields (1936) equation for quantities of *d/Y* and *d/R* lower than 0.16 expects a lower critical velocity and for higher quantities of 0.16 anticipates higher critical velocity than Eq. (21). As it is seen in Fig. 6, the closest equation to Eq. (22) is the El-Zaemey (1991) relationship. The El-Zaemey equation for the lower amounts of *d/R* than 0.25 predicts less critical velocity and for more amounts than 0.25 anticipates a higher critical velocity, but this difference is not very noticeable. The second closest equation is the Ab Ghani et al. (1999) equation. It gives lower critical velocity for amounts of *d/R* less than 0.08 and a higher critical velocity for the ones higher than 0.08. Through the analysis of incipient motion equations in V-shaped bottom rigid boundary channels, it is clear that the Novak and Nalluri (1984) equation predicts a lower critical velocity. As a result of the analysis through incipient motion in a V-shaped bottom rigid boundary channels, The Shields (1936) equation shows the highest and the Novak and Nalluri (1984) reveals a lowest critical velocity.

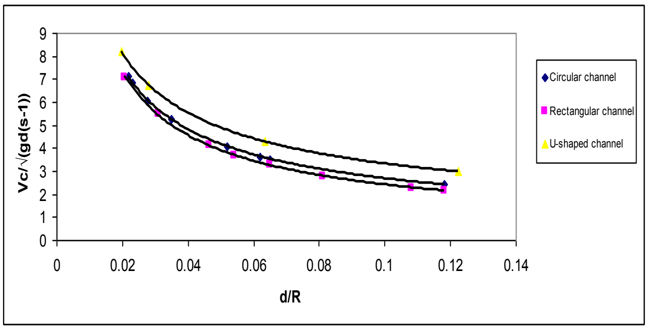

Fig. 7. Comparison of incipient deposition equations for different channel shapes.

CONCLUDING REMARKS

1. Eqs. (19), (20) and (21) are proposed for computing the incipient deposition critical velocity in circular, rectangular and U-shaped cross section rigid boundary channels respectively and Eq. (22) is suggested for computing the incipient motion critical velocity in a V-shaped bottom rigid boundary channel.
2. Evaluations of available incipient deposition and incipient motion criteria show the effect of cross sectional shape in this phenomenon and new equations with high values of R^2 show the significance of channel cross section.
3. Predominantly, the incipient motion equations in loose boundary channels expect more critical velocity than the incipient motion equations in rigid boundary channels.
4. When comparing the incipient motion equations in rigid boundary channels, the Ab Ghani et al. (1999) equation predicts the most and the Novak and Nalluri (1984) equation predicts the least value of critical velocity. The incipient motion equations in loose boundary channels for little values of *d/R* and *d/Y* anticipate high critical velocity.
5. The quantity of incipient deposition critical velocity is higher than the incipient motion critical velocity under the same flow condition. This difference is tangible in the case of fine sediment particles, however it is intangible with coarse sediment particles and it seems that the incipient deposition criteria is exactly appropriate with designing of rigid boundary channels.
6. Taking into account the incipient deposition equations, among the three sorts of circular, rectangular and U-shaped channels, the rectangular channel needs the least critical velocity and U-shaped cross section requires the most critical velocity at the same flow condition. This result explains the effect of cross-sectional shape on incipient deposition of sediment particles.

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