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CONSIDERATION ON THE SEDIMENTATION PROCESS IN A SETTLING BASIN

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The paper presents the results of the study of the sediments deposition process in a settling basin by using a k-ε turbulence model. The results obtained are than compared with the results obtained by using 1 and 2 D mathematical models and field measurements. In the first step, the settling basin is designed based on the formulae recommended by classical approach. The transition zone at the entrance of settling basin is then adjusted to satisfy more uniform flow at the beginning of the active zone. The flow velocity variation and bed shear stress distribution over the cross section area are furthermore analyzed and questions suggesting further development of mathematical models are identified.

For the second step, a schematized settling basin is then modelled in three-dimensional laterally confined model for the purpose of dealing with turbulences that potentially bring more sediment to the side and to the end of settling basin. Finally, recommendations for the design of settling basin are given by analyzing the results obtained by both mathematical and empirical methods. By comparison of the results obtained and field measurements made in Indonesia, useful design recommendations are derived.

KEY WORDS: Sediment, Settling, Transport, Modelling.

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Príspevok obsahuje výsledky štúdia sedimentačného procesu v usadzovacej nádrži s využitím modelu turbulencie k-ε. Takto získané výsledky sú porovnané s tými, ktoré boli získané pomocou jedno- a dvojdimenzionálneho modelu a s terénnymi meraniami. Najskôr bol sedimentačný bazén navrhnutý pomocou klasických vzorcov. Prechodová zóna a vstup do usadzovacieho bazénu bol potom upravený tak, aby zabezpečil relatívne homogénne prúdenie na začiatku aktívnej zóny. Boli analyzované zmeny rýchlosti prúdenia a rozdelenie trecích napätí na dne v priečnych rezoch koryta a boli identifikované problémy, ktoré by umožnili ďalší vývoj matematických modelov tohto javu.

V ďalšom kroku bol modelovaný schematizovaný usadzovací bazén ako trojrozmerný, na oboch stranách ohraničený model, aby sa dalo manipulovať s turbulenciou, ktorá by mohla potenciálne dopraviť viac sedimentov na strany a na koniec sedimentačnej nádrže. Nakoniec uvádzame odporúčania pre návrh sedimentačných nádrží, vychádzajúc z výsledkov využitia matematických aj emprických metód. Porovnaním týchto výsledkov s výsledkami terénnych meraní v Indonézii boli navrhnuté užitočné odporúčania.

KĽÚČOVÉ SLOVÁ: sediment, sedimentácia, transport, modelovanie.

1. Background

One of the most difficult problems related to the design of water diversion is the reduction of the amount of sediments entering in the conveyance systems. While, in the case of irrigation systems a certain amount of suspended sediment may be beneficial on porous and well-drained soil, the same water may be totally unsuitable if the soil is heavy and the climate dry. In the case of hydropower plants a process of abrasion of tunnel linings, penstocks and turbines will take place if the water contains other than wash load. Sediments accumulated in the front of the water intakes may produce partial or complete shutdown of the power production facilities. Associated extensive economic and investment losses for the project and all dependent downstream installation may occur. Consequently, a correct design and operation of the settling basin provided at the intake is of great importance and one of the main challenges of the designer is to keep the amount of sediment entering the diversion system to a minimum by maintaining the sediment transport and stability of the stream to remove the sediment diverted from the system.

Settling Basins are used to remove objectionable sediment of a specified size and quantity and are typically designed based on ideal settling theory, with a factor to account for turbulence. The advantage of this approach is that it is simple to use, and will often yield a reasonable approximation to actual sediment removal efficiency. However, ideal settling theory does not quantify turbulence, and various empirical and analytical methods have previously been proposed to estimate settling basin performance.

Settling basin is generally accomplished by reducing the velocity to the lowest permissible magnitude for the longest possible period. An expansion transition by widening the approach channel and lowering its floor are possible to reduce the flow velocity and make it possible for sediment to settle out of suspension due to gravity. However, the movement of sediment in vertical direction is not only due to gravity alone, but also under the combined action of gravity and vertical component of turbulence. Effective design of settling basin therefore depends upon an analysis of the effect of turbulence on deposition.

The description of the deposition profiles in settling basin is studied by applying Delft-3D k-ε turbulence model.

This paper reports that the result for sedimentation process in the settling basin obtained by Delft-3D k-ε turbulence model fits the field measurement rather better than that computed using 1D, Quasi-2D and 2DH mathematical models. The recommendation for the design of settling basins then can be derived according to Delft-3D simulation results.

Implementation of transition zone by widening its width has successfully achieved the desired removal efficiency. The comparison indicates that when basins are modified using 1 : 4 gradual expansion transition, the head losses can be minimized and the optimum bed shear stress can be provided at the entrance of the settling basin. Maintaining this angle, the deposition of suspended sediment transport in the basin is preserved without re-suspension if the settling basin is expanded ranging from 1.75 up to 2.00 wider than the length of transition. Consequently, the length of settling basin compared to the one without transition can then be reduced up to 50% and leading to more economic design consideration.

2. Modelling considerations

In this study, sediment transport phenomenon in settling basin is studied using mathematical model Delft-3D three-dimensional hydrostatic, free surface flow solver. The system of equations consists of the continuity equation, the horizontal momentum equation, and the transport equation for conservative constituents. The equations are formulated in orthogonal curvilinear coordinates.

Model with a rectangular grid are considered as a simplified form of a curvilinear grid. The vertical momentum equation is reduced to the hydrostatic pressure relation as vertical accelerations are assumed to be small compared to gravitational acceleration and are not taken into account.

The mathematical model Delft-3D solves the Navier-Stokes equations for an incompressible fluid, under the shallow water and the Boussinesq assumptions. In the vertical momentum equation the vertical accelerations are neglected, which leads to the hydrostatic pressure equation. In three-dimensional models the vertical velocities are computed from the continuity equation. In the vertical direction, Delft-3D offers the σ coordinate system (σ-grid), therefore the hydrodynamic equations described in this section are valid for the σ coordinate system.

Two mathematical models were set up for predicting sedimentation processes in two different settling basins. The first model is a simple straight single chamber settling basin in which the low flow velocity required for settlement of suspended sediment is created by gradually increasing the flow depth towards downstream direction. The second model is the development of the first model, which is oversized cross section formed not only by lowering its floor, but also by widening its width. Both models are three-dimensional mathematical models with laterally restricted flow and are simulated with the aid of the Delft-3D software package.

To validate the results of the modelling, comparison with field data from Karangtalun settling basin in Central Java, Indonesia was performed. The results are also compared with design data obtained by application of classical design methods for settling basins. The most significant characteristics of this settling basin are presented in Tab. 1.

T a b l e 1. Karangtalun Settling Basin – main data.
T a b u ľ k a 1. Usadzovacia nádrž Karangtalun – hlavné údaje.

Nr.	General input data	Notation	Value
1	Design discharge	Q	16 [$m^3\ s^{-1}$]
2	Width of approach channel	b	12.5 [m]
3	Slope of approach channel	S	15[cm/km]
4	Slope of settling basin	Sb	4.8 [m/km]
5	Equivalent Nikuradse roughness	K_s	0.004 [m]
6	Length of settling basin	L	500 [m]
7	Channel roughness coefficient	K	75
8	Water temperature	Te	20 °C
9	Particle size need to be removed	D_s	100 [μm]
10	Bed material size	D_{50}	120 [μm]
		D_{90}	150 [μm]
11	Sediment concentration	c	400 [ppm]
12	Desired removal efficiency	E	90%

A short description of the modelling considerations is given below.

Model 1 – Simple settling basin

The first model analysed was based on the geometry of the Karangtalun settling basin in Central Java, Indonesia, Fig. 1. An important parameter of the design is the active deposition length. This length of the basin is expected to be sufficient for deposition of the undesired sediment sizes within the basis of flushing after 10 days of operation. Using the formula of *Camp* and *Dobbins* (1946), the required basin length to deposit the particle sizes of 100 μm or more, is found to be 460 m. As given in Tab. 1, the actual length of the settling basin is 500 m. The discrepancy of about 10% between the measured and the calculated settling length is considered acceptable to compensate the excessive turbulence in approach flow.

Setting up the model included a number of steps shortly presented subsequently:

- The horizontal grid is generated with 480 grid cells in the longitudinal direction (M-direction) and 10 grid cells in the transverse direction (N-direction), Fig. 2.
- The selection for simulation time step is based on numerical scheme stability criterion i.e., the Courant number, which is dependent on the grid size of the model and on the flow depths. The selected time step used to provide an accurate and stable numerical computation in both the hydrodynamic and the morphology simulation process is taken as 0.025 minutes or 1.5 seconds.
- Sediments and temperature are taken into account as constituents that might influence the hydrodynamic simulation. The uniform values of 0.4 kg m^{-3} of inflow sediment concentration is introduced at the upstream transport boundary conditions. Due to unavailability of data about the inflowing water temperature variation in the real settling basin, a constant water temperature of 20 ^{o}C is selected for all simulations.

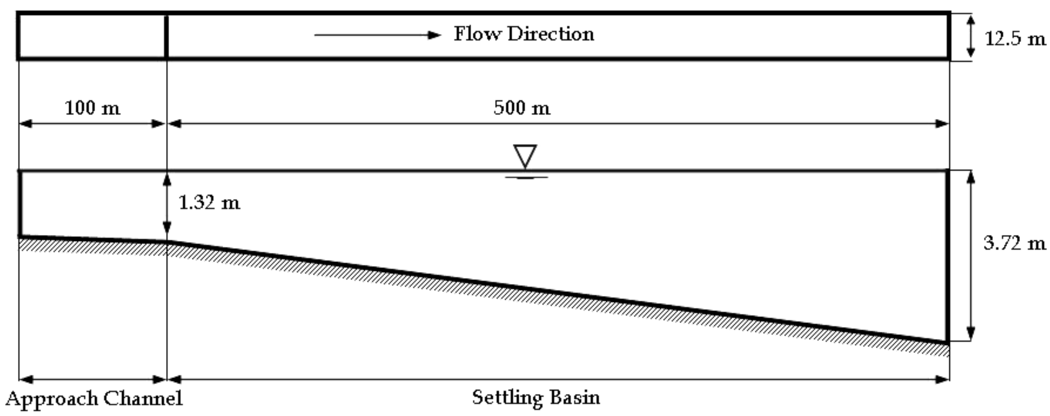

Fig. 1. Geometry of the first model.
Obr. 1. Geometria prvého modelu.

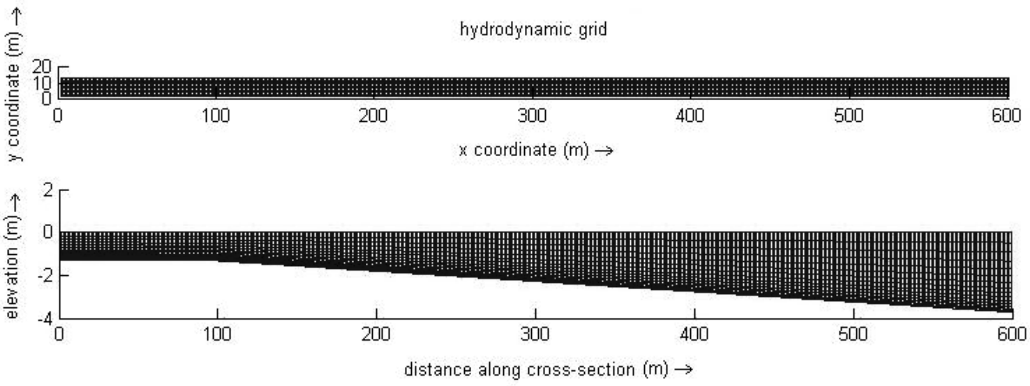

Fig. 2. Horizontal and vertical grid of the first model.
Obr. 2. Horizontálna a vertikálna sieť prvého modelu.

Boundary condition
– Upstream boundary condition:

$$\frac{\partial Q}{\partial t} = 0;$$

– Downstream boundary condition:

$$\frac{\partial h}{\partial t} = 0.$$

The equivalent Nikuradse roughness as determined experimentally is 0.133 mm. This condition can be introduced in the model by simply selecting partial slip condition with the value of 0.133 mm in the roughness input file.

The selection of the observation points and cross-sections to monitor the computational results are specified in the model. Both of them are used to monitor the time-dependent behaviour of the velocities and sediment concentration along the longitudinal section. Observation points are located at cell centre, Fig. 3, i.e. at water level points while the locations of each cross section measured form upstream boundary.

The most significant computation parameters used in the simulation for the first model are given in Tab. 2. The tests, simulates a classic suspended sediment transport problem. The water with the discharge of 16 m^3 s^{-1} carries a constant sediment concentration of 0.4 kg m^{-3}. Since the basin is lined with concrete, there is no additional sediment coming from the bed. Therefore, the initial sediment layer thickness at bed is set as zero.

T a b l e 2. Computation parameters used for the first model.
T a b u ľ k a 2. Výpočtové parametre použité pre prvý model.

Nr.	Computational parameters	Value
1	Length of computational cells in longitudinal direction	600 [m]
2	Width of computational cells in transverse direction	12.5 [m]
3	Computational time step	0.025 [min]
4	Number of layers	15
5	Discharge	16 [m^3 s^{-1}]
6	Initial sediment concentration	0.4 [kg m^{-3}]
7	Water temperature	20 °C
8	Courant number in longitudinal direction	4
9	Courant number in transverse direction	7
10	Bed roughness length	0.000133[m]
11	Undesired sediment particle size	100 [μm]
12	Horizontal Eddy viscosity coefficient	0.1 [m^2 s^{-1}]
13	Horizontal Eddy diffusivity coefficient	0.1 [m^2 s^{-1}]
14	Turbulence model	k-ε
15	Type of velocity profile	Logarithmic
16	Morphological time scale factor	5

Model 2 – Oversized settling basin

In the case of the second model the channel is expanded into the basin by widening its width and lowering its floor through an expansion transition, Fig. 4. The transition zone has to be designed such a way to provide a uniform flow at the beginning of the settling basin so that the deposition of undesired particle size will occur in the basin uniformly without re-suspension. Furthermore, if head is available, then sluicing a basin clear of deposited material is possible. Usually the sluiced sediments are then returned to the river from which the irrigation water supplies were taken.

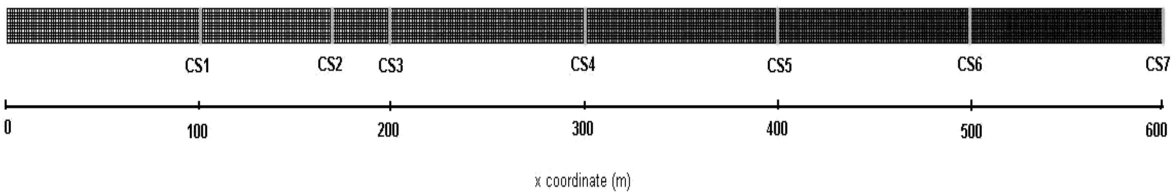

Fig. 3. Selected cross section of the first model.
Obr. 3. Vybrané priečne rezy prvého modelu.

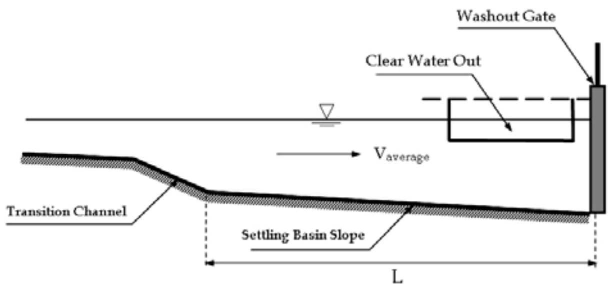

Fig. 4. Longitudinal profile of the second model.
Obr. 4. Pozdĺžny profil druhého modelu.

Considering the cost of the long and straight prismatic portion of the basin as the criterion, the first model is developed for its best width, depth and length. The problem which still requires explicit consideration is that of energy loss when the expansion is abrupt, and this problem is expected to be tractable by methods similar to those in the study of pipe flow. In order to ensure the low flow velocity throughout the settling basin, the floor of transition zone is gradually lowered, Fig. 5. Expecting that there is no separation of the flow and the losses are to be very small, the divergent angle of the side wall can be designed as V : H is equal to 1 : 4.

To compare the result with the one obtained in the first case the same *Camp* and *Dobbins* (1946) formula was used. According to their formula, if the width is increased as 20%, the required settling length to achieve the removal efficiency of 90% is found to be at least 280 m.

In order to describe the flow field in the basin, two characteristic zones are distinguished: a deceleration zone where a mixing layer and a reversed flow layer in case of low separation can be possibly formed, and a relaxation zone where mixing layer will change to a new boundary layer. The channel is gradually expanded with the transition length of 5 m and the ratio between vertical and horizontal of 1 : 4. The settling basin itself has a geometry of respectively 15 m and 280 m in width and length. As the control of flow, the gate is installed at the downstream end of the basin. The slope of the basin is designed as 4.8 m/km or 1.344 m fall in 280 m, in which this magnitude is sufficient to satisfy the required flow velocity for flushing process. Physical schematization of the model is presented in Fig. 6.

The same approach for setting up the model as described in the previous case was used. The grid that represents the second model will be better generated by using the help of land boundary layer. Boundary layer is a text file containing the coordinates that represent the position of each point in both X and Y directions. The output of this step will be a horizontal grid with 236 grid cells in the longitudinal direction (M-direction) and 10 grid cells in the transverse direction (N-direction). The vertical grid is created by selecting 15 numbers of layers. The plots of hydrodynamic grid both in horizontal and vertical directions are shown in Fig. 7.

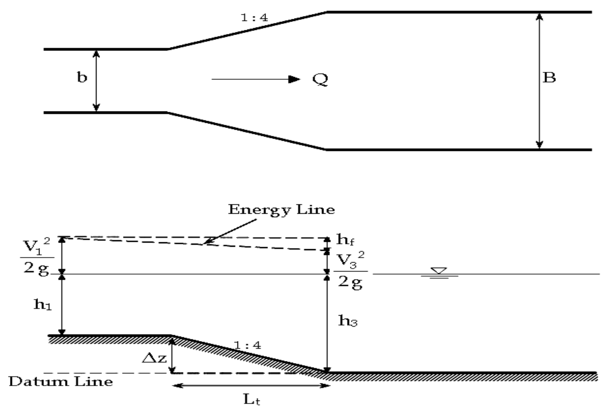

Fig. 5. Design of transition.
Obr. 5. Návrh prechodovej časti.

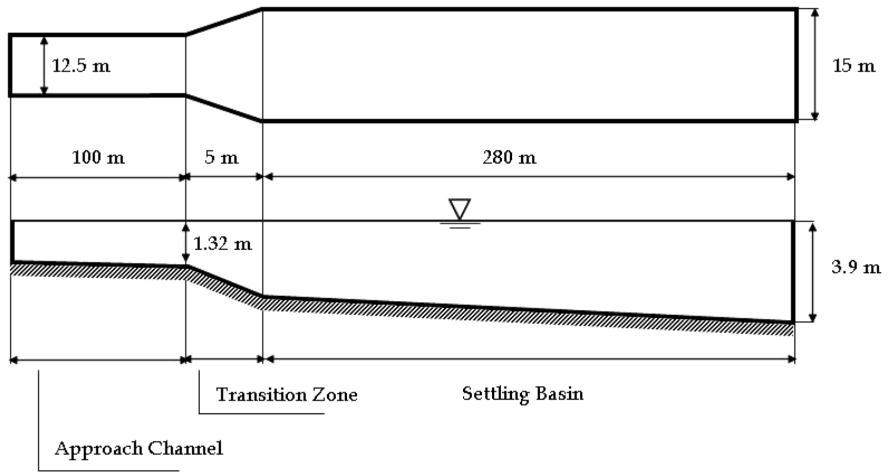

Fig. 6. Geometry of the second model.
Obr. 6. Geometria druhého modelu.

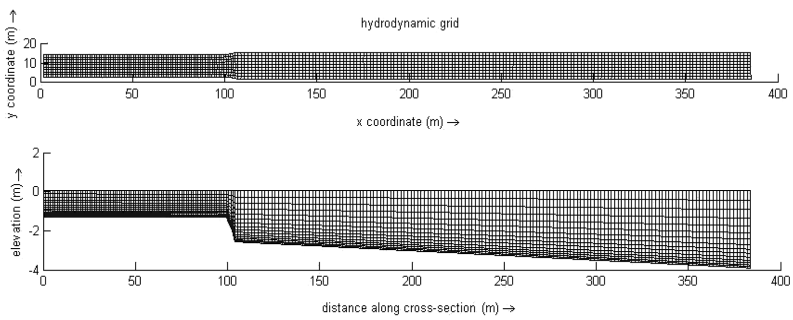

Fig. 7. Horizontal and vertical grid of the second model.
Obr. 7. Horizontálna a vertikálna sieť druhého modelu.

The information of boundary condition used in the first model is again applied in this case. A constant discharge of 16 $m^3 s^{-1}$ is used as a boundary in the upstream part. The hydrodynamic forcing is prescribed as time-series and the distribution of velocity over the depth is selected using logarithmic distribution function. The initial sediment concentration and water temperature are both set as 0.4 kg m^{-3} and 20 ^{o}C. All the sediment should fall to the bottom and accumulate in the time taken for a single particle to fall from the water surface to the bed. It should be noted that there is no additional sediment coming from the bed since the basin is lined with concrete, and this situation can be satisfied by setting the initial sediment layer thickness at the bed as a zero value.

In order to monitor the computational results of the second model, some observation points and cross-sections are added. The locations of the cross-section applied in this model are presented as following:

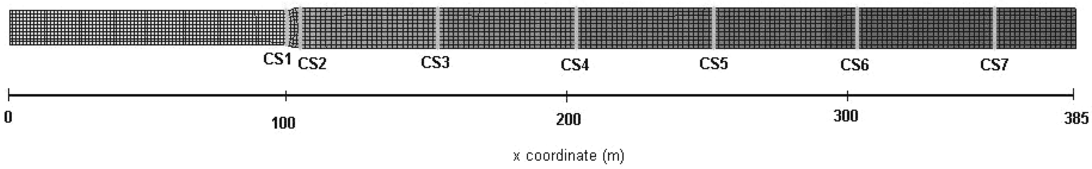

Fig. 8. Selected cross section of the second model.
Obr. 8. Vybrané priečne rezy druhého modelu.

Some of the most important computational parameters relevant to the simulation of the second model are summarized as following:

T a b l e 3. Computation parameters used for the second model.
T a b u ľ k a 3. Výpočtové parametre použité pre prvý model.

Nr.	Computational parameters	Value
1	Length of computational cells in longitudinal direction	385 [m]
2	Width of computational cells in transverse direction before transition	12.5 [m]
3	Width of computational cells in transverse direction after transition	15.0 [m]
4	Computational time step	0.025 [min]
5	Number of layers	15
6	Discharge	16 [m^3 s^{-1}]
7	Initial sediment concentration	0.4 [kg m^{-3}]
8	Water temperature	20°C
9	Courant Number in longitudinal direction	4
10	Courant number in transverse direction	6
11	Bed roughness length	0.000133[m]
12	Wall roughness length	0.000133[m]
13	Undesired sediment particle size	100 µm
14	Horizontal Eddy viscosity coefficient	0.1 [m^2 s^{-1}]
15	Horizontal Eddy diffusivity coeffcient	0.1 [m^2 s^{-1}]
16	Turbulence model	k-ε
17	Type of velocity profile	Logarithmic
18	Morphological time scale factor	5

3. Results and conclusions

This paper gives only the main results of the study. All simulations were executed using uniform sand sediment with the particle size of 100 µm and the discharge of 16 m^3 s^{-1}. For verification of the Delft-3D k-ε turbulence model, the results obtained from other available mathematical models (1D and 2D) and field data are used.

3.1. Model validation

In order to validate the k-ε turbulence model in Delft-3D, the results are compared with other results that had been tested in 1D and 2D mathematical models and with the data obtained from field measurements of the Karangtalun settling basin in Central Java, Indonesia. These measurements were carried out by Hydraulics Research Wallingford (1987).

The simulation in 1D mathematical model was carried out using the depth-integrated model developed by *Galappatti* (1983). For 2D model the results of simulation in quasi 2D model by *Saliharjo* (1991) and 2D depth-averaged model from Delft-3D are also compared. The results are then plotted together with the field data of deposition along the settling basin and the comparison is made based on the measurement or simulation corresponds to flushing time after 10 days operation.

Comparison of the measured and the computed deposition profiles in the longitudinal and in the transversal directions of the Karangtalun settling basin in Central Java, Indonesia are presented in Fig. 9.

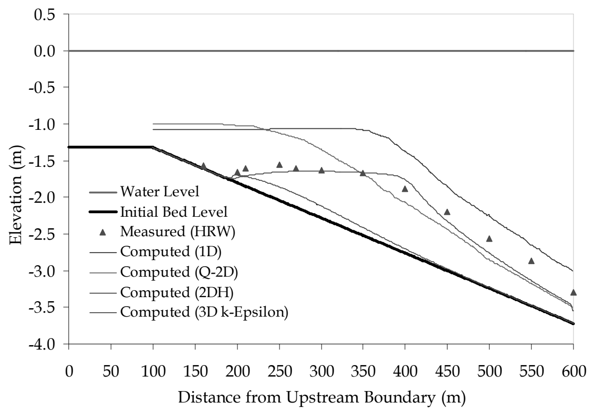

Fig. 9. Measured and computed longitudinal deposition after 10 Days.
Obr. 9. Merané a vypočítané pozdĺžne depozície po 10 dňoch.

It can be concluded that the results obtained using 1D was improved by the Quasi-2D model. However, both results show deviations towards the sedimentation process compared with the field data, especially the deposition pattern in the upstream part. The deposition profiles computed using Delft-3D k-ε turbulence model approximates field data rather better than that computed using 1D and 2D. The reason for this is that most three-dimensional phenomena for sediment transport is automatically resolved by the flow solver applied in Delft-3D model therefore requiring very few additional expressions and a minimum calibration.

3.2 Settling length and removal efficiency

It is quite obvious that the available empirical formulae for the design of a single chamber-settling basin is still the most popular in common practice. However, comparisons among the results obtained by classical designs have been worked out for the same discharge and incoming sediment concentration, Fig. 10. The comparison indicates that the designs calculated using the classical methods are not satisfactory, if the restriction is made based on the condition in which the flushing process is done for every 10 days.

The figure indicates that the recommended settling length by all available classical methods gives lower removal efficiency. Also, for the same basin and the same transport conditions, the classical methods were found to give different results. It is believed that overall performance of settling basin is impaired by turbulence, affecting the fine sediment and also re-entraining particles that have settled. The difficulties arise through the fact that the independence between sediment and the flow characteristics can not be completely introduced by analytical approach.

A further analysis of the efficiency of settling basins has been conducted for the second model by selecting different ratios between the width of the channel and the width of the settling basin, b/B. Five models with various widths of the transition zone were tested, each alternative satisfying the criterion highlight by USBR to avoid the separation of the flow. It is observed from simulation results presented in Fig. 11, that the dimension of transition in which the ratio B/b is less than 1.2 potentially creates re-suspension of the settled sediment in the beginning of settling basin if the flushing process every 10 days is applied. The consequence of the design within this range is that the particle is picked up from the bed, hindering the settling velocity and furthermore decreasing the basin efficiency

In this study, sediment transport phenomenon in settling basin is studied using mathematical model Delft-3D three-dimensional hydrostatic, free surface flow solver. The system of equations consists of the continuity equation, the horizontal momentum equation, and the transport equation for conservative constituents. The equations are formulated in orthogonal curvilinear coordinates.

Model with a rectangular grid are considered as a simplified form of a curvilinear grid. The vertical momentum equation is reduced to the hydrostatic pressure relation as vertical accelerations are assumed to be small compared to gravitational acceleration and are not taken into account.

The calculated settling length obtained by Delft-3D k-ε turbulence model is then compared with the classical design methods available in the literature such as *Camp* and *Dobbins* (1946), *Mosonyi* (1965), *Vanoni* (1975), *Sarikaya* (1977), *Sumer* (1977), and *Garde* et al. (1990), Fig. 12. All these methods essentially determine the length for a pre-determined flow condition, i.e., the reduced mean velocity in the basin. But the same mean velocity can be realized by widening and lowering the basin floor through an expansion transition. Each pair of width and depth needs a certain length of the basin to achieve the desired removal efficiency.

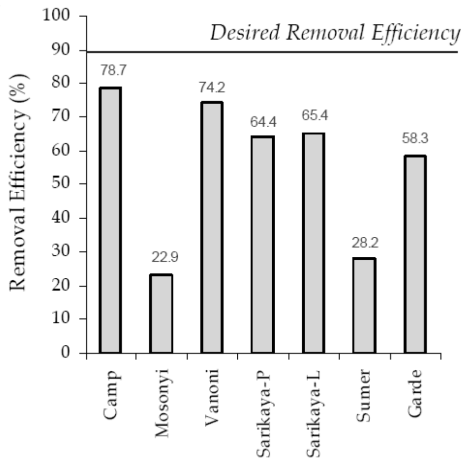

Fig. 10. Computed removal efficiency.
Obr. 10. Modelovaná efektívnosť odnosu.

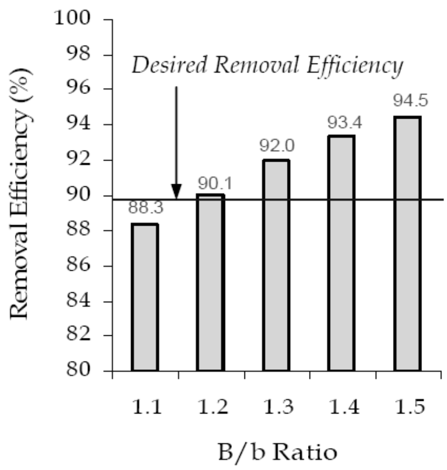

Fig. 11. Calculated removal efficiency.
Obr. 11. Vypočítaná efektívnosť odnosu.

4. Final remarks

The difference between the results of the classical methods is due to the fact that the two-dimensional mathematical model is superior to one-dimensional model in analyzing the turbulent flow. Finally, five designs of settling basin with the same discharge and same angle of divergent wall, but different length of transition zone and basin width were analyzed. The main criterion for the selection of the best design can be derived based on the turbulence energy and on the deposition profile in settling basin without re-suspension of the deposited sediment. Based on these parameters, and on the accepted condition of the flushing for every 10 days, the best design may be obtained with the ratio of the basin width and transition length ranging between 1.75 and 2.00. This range has been also confirmed as the optimum range of bed shear stress acting at the downstream end of transition zone without flow separation.

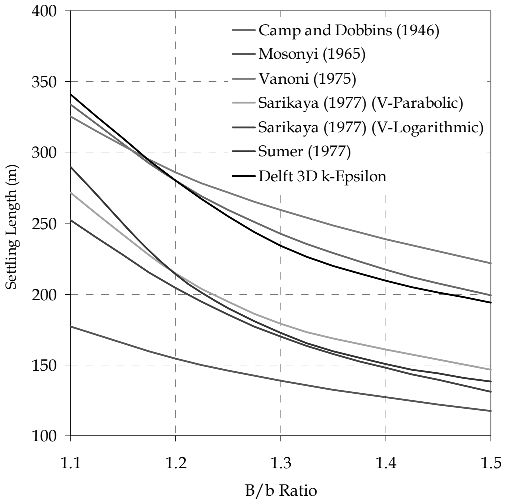

Fig. 12. Comparison of the calculated settling lengths.
Obr. 12. Porovnanie vypočítaných usadzovacích dĺžok.

Although reasonable results of deposition profile and good agreement with the literature is achieved in flow velocity computations, there are some uncertainties about the simulation results, and the numerical approach is limited by several factors. For example, for the basin with B/b ratio 1.5 when the bed evolution is predicted in the area in which the flow velocity is very much reduced at the end of transition zone, the Delft-3D k-ε turbulence model shows bottom undulations on the transition floor. It seems more likely that they are caused by some form of numerical instability or feedback that is particular to the use of δ coordinate system in the k-ε turbulence model. It is believed that the computed bed profile does reach stable solution when the vertical layers is increased by more than 15 layers and the simulations are run for a longer morphological time.

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List of symbols

B – width of the stilling basin [m],
c – sediment concentration [ppm],
D_{50} – bed material size [μm],
D_s – particle size to be removed [μm],
D_{90} – bed material size [μm],
E – desired removal efficiency,
H – water depth [m],
K – channel roughness coefficient,
K_s – equivalent Nikuradze roughness [m],
S – longitudinal slope of the approach channel [m/km],
Sb – slope of the settling basin [m/km],
T – time,
Te – water temperature [^{o}C],
Q – discharge [$m^3\ s^{-1}$],
μ – dynamic viscosity [$m^2\ s^{-1}$],
ν – fluid kinematic viscosity [$m^2\ s^{-1}$].

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PROCES SEDIMENTÁCIE
V USADZOVACEJ NÁDRŽI

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Rozdiely medzi výsledkami, získanými klasickými metódami sú dôsledkom skutočnosti, že dvojdimenzionálny matematický model je nadradený jednodimenzionálnemu modelu turbulentného prúdenia. Bolo analyzovaných päť rozdielnych návrhov usadzovacích nádrží s rovnakými prietokmi a s rovnakým uhlom divergenčnej steny, ale s rozdielnymi dĺžkami prechodovej oblasti a šírok nádrže. Hlavné kritérium pre výber najlepšieho návrhu môže byť získané z informácií o energii turbulencie a z profilu depozitov usadzovacej nádrže bez resuspenzie usadeniny. Vychádzajúc z týchto parametrov a z prijatých podmienok pre výplach realizovaný každých 10 dní, najlepší návrh má pomer šírky bazéna a prechodovej dĺžky v rozmedzí 1,5 až 2,0. Tento pomer bol tiež potvrdený ako optimálny rozsah pre šmykové napätia na stenách koryta na konci tranzitnej zóny, bez separácie prúdenia.

Napriek dobrým výsledkom pri určovaní depozičných profilov a zhode výsledkov výpočtu rýchlostí s výsledkami uvedenými v literatúre existujú nejasnosti vo výsledkoch simulácií, pretože existuje niekoľko faktorov, limitujúcich numerický prístup. Napríklad pre nádrž s pomerom B/b = 1,5, pri prognóze tvarovania dna v zóne silnej redukcie rýchlostí (koniec tranzitnej zóny), model turbulencie Delft-3D k-ε predpovedá vlnový povrch na dne nádrže v prechodovej oblasti. Zdá sa, že tento jav je spôsobený skôr numerickou nestabilitou alebo spätnou väzbou, ktorá je viazaná na použitie súradnice σ v modeli turbulencie k-ε. Panuje presvedčenie, že vypočítaný profil dna je stabilný, keď vertikálna vrstva je vyššia ako 15 (simulovaných) vrstiev a simulácia beží dlhšie.

Zoznam symbolov

B – šírka ukľudňovacieho bazénu [m],
c – koncentrácia sedimentu [ppm],
D_{50} – veľkosť materiálu dna [μm],
D_s – veľkosť častíc, ktoré majú byť odtransportované [μm],
D_{90} – veľkosť materiálu dna [μm],
E – požadovaná účinnost odnosu,
H – hĺbka vody [m],
K – súčiniteľ drsnosti kanála,
K_s – ekvivalentná Nikuradzeho drsnosť [m],
S – pozdĺžny sklon prívodného kanála [m/km],
Sb – sklon usadzovacieho bazéna [m/km],
T – čas,
Te – teplota vody [^{o}C],
Q – prietok [$m^3 s^{-1}$],
μ – dynamická viskozita [$m^2 s^{-1}$],
ν – kinematická viskozita suspenzie [$m^2 s^{-1}$].