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EXPERIMENTS OF GEOMETRIC SHAPE OF SEDIMENT TRAP RECTANGULAR AND VORTEX SETTLING DESILTING BASIN

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ABSTRACT: Modernising irrigation is a top priority in Indonesia, with managing irrigation water supply services effectively and efficiently, particularly in providing value to farmers. Sediment traps are an essential component of the head structure in irrigation. Vortex Settling Desilting Basins (VSDB) have inherent advantages over other types of sediment-removal desilting basins. The experiments were conducted under three different discharge scenarios, and three-dimensional flow velocities were measured. The streamlines and velocity vectors in the horizontal superimposed sections were drawn and analysed then for the incipient motion of sediment. This study presents the results of experimental research that was accomplished in a VSDB to observe the slope orifice chamber with 1:10, 1:5 and 1:2. The method used numerical methods with CFD simulations by Ansys R.21 2020 (student version) to approach geometric shapes then laboratory experiments with a model scale 1:40 prototype to an undistorted 3-D physical model. Comparing the magnitude of the velocity and streamlined path in horizontal sections with the occurrence of secondary in radial sections revealed that the flow in the vortex direction plays a higher role in the removal efficiency of the desilting basin. As a result, by comparing the performance of rectangular shapes with the same hydraulic parameters, the slope orifice chamber of 1:5 is more effective in case of deposition and removal than another slope chamber. Eleven times running, it settled 84.90% of the sediment fraction and left a sediment fraction of 12.10%, higher than the effectiveness of the performance of sediment traps with a rectangular shape.

Keywords: Deposition, Removal efficiency, Sediment removal, Undistorted 3-D physical model, Vortex

1. INTRODUCTION

Rapid land-use change during the last decades has resulted in a decrease in irrigation areas and an increase in urban/developed areas. Although water demand for irrigation areas tends to decrease as affected by land-use change, even the East Tarum canal and irrigation infrastructures are still in the same dimension [1]. Land use change on the main island of Indonesia is inevitably increased due to the demographic growth and regional development activity in the last two decades [2].

One of the primary constraints to sustainable agricultural production is a lack of irrigation water supplies. In recent years, developing alternative water sources and applying irrigation water-saving technologies are two key strategies to alleviate the scarcity of agricultural water resources [3], [4]. Nowadays, surface irrigation is the most extensively used irrigation method due to its long tradition and low energy consumption [5]. However, this method may pose more erosion and pollution risks than drip or semi-technique irrigation methods. The concentrated water flow in the canals may erode the soil and disperse the agrochemicals adsorbed to the sediments in the environment. Therefore, evaluating the transport process requires improved techniques to determine sediment concentration in irrigation canals' narrow, concentrated flow, especially if the bed and suspended loads are to be evaluated separately and similar improvements are required in flow velocity determinations [6].

While fresh sediment deposits are often close to fluid mud, older and deeper riverbed sediments tend to be consolidated, with the state of consolidation higher for deeper sediment. These vertical gradients complicate the modelling of sediment erosion, transport, and deposition [7].

A considerable effort is required to improve irrigation operations and modernise them. A desilting basin is a temporary sediment control structure to intercept sediment-laden runoff and retain the sediment. It aims to detain sediment-laden runoff from the disturbed area for sufficient time and allow most deposits to settle within the sediment trap [8]. Decreasing the flow velocity in the basin to ensure the sediment particle's remaining time is longer than the settling time is the primary design idea of settling basins. To address it, the weir as a head structure requires a sediment trap that can deposit non-cohesive type sediments and quickly remove out because the water required for irrigation is complicated to stop during the cropping pattern because farmers need it. This phenomenon results in the flow of water for irrigation required that is diverted through the weir, resulting in a decreased supply of irrigation water. Water flowing in the canal taking off from head works on such rivers also carries sediment load, the canal gets silted if it receives sediment load over its transporting capacity, and effective measures are not taken for its control [12].

Previous authors investigated the Vortex settling chamber; Cecen and Bayazit (1975), Curi et al. (1975), Ogihara and Sakaguchi (1984), Sanmuganathan (1985), Mashauri (1986), Paul et al. (1991), Athar (2000), Athar et al. (2002), Athar et al. (2005), Keshavarzi et al. (2006), Ansari (2008) and Ansari and Athar (2013). The Vortex settling chambers can also separate solids from their transporting fluids, such as treating sewage and industrial wastes. However, the development by the previous study is to deposit sediment in a power plant and electrical energy to avoid a larger diameter of non-cohesive sediment entering the turbine drive system. In irrigation, sediment gradation allowed and neglected to enter the irrigation canal is cohesive type sediment whose diameter is < 0.06 mm. It is challenging to deposit this type of sediment because it is suspension sediment that moves with the water flow [9], [10].

The Macan weir was designed in a narrow space in Subang Regency, West Java Province, Indonesia, as a case study for head structure in the weir for sediment traps. This weir services a technical irrigation area of 9,670 ha, where the current condition of the wet perimeter section area is reduced by ±35%, caused by sedimentation. The existing conventional plan will construct rectangular sediment traps located right side of the head structure [11].

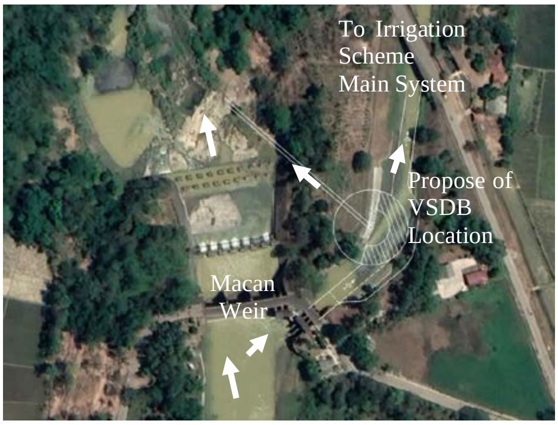

Fig. 1 Layout of Macan weir

The present research examines and develops the modern shape of sediment traps as a proposal to replace sediment traps with conventional geometric shapes in the future. This research aims to improve the vortex desilting basin sediment trap performances, settling non–cohesive sediment > 0.06 mm and removing sediment fraction as trapped settling basins. The slope orifice chamber of 1:5 is further effective in case of deposition and removal faster than the 1:10 and 1:2 slope chamber types.

2. RESEARCH SIGNIFICANCE

The shape of the sediment trap must meet the hydraulics rules and design criteria and be standardised. So that non–cohesive sediment is deposited, increasing removal efficiency to the maximum requires different characteristics and velocities. If hydraulically it can be fulfilled, then the aspect of operational costs is undoubtedly a consideration and research significance. This proposed geometric shape is recommended for a weir that does not yet have sediment traps and can only be built in a narrow space.

3. METHODS

3.1 Sediment Properties

3.1.1 Primary Data Extracted

This research started and was carried out by taking sediment properties obtained by primary data in 2019 and tested at the Laboratory of Engineering Geology, Padjajaran University in Bandung, to obtain sediment properties and physical properties. The sediment particle was tested by comparing the data around the study site, such as on the Cibeet and Ciasem rivers, and sediment properties in the Macan weir sediment trap were taken at upstream (3 samples) and downstream (3 samples) sampling points with laboratory test results at 20°C water temperatures [12]. Sediment transport involves the entrainment and movement of granular material by a shearing fluid flow. Although natural fluid flows are turbulent, experiments have shown that laminar flows can produce similar behaviour in sediment transport and morpho-dynamics.

3.1.2 Sediment's Laboratory Test

There are four key classifications of sedimentation processes, each characterised by different settling behaviour; describes these Type I: Discrete particle settling, Type II: Flocculant settling, Type III: Hindered or Zone settling and Type IV: Compression settling. Discrete particle settling occurs in dilute mixtures where there is no particle interaction, with discrete particles defined as particles whose size, shape and specific gravity do not change with time. The settling velocity of a single spherical particle undergoing discrete settling under laminar conditions [9]. An effective settling velocity is measured using a settling tube, which can be converted into an equivalent particle diameter. Parameters C_1 and C_2 are taken at values of 18 and 0.3 for fine-grained particles but somewhat higher values for natural particles, as discussed later. For particles that can be considered redundant, so the following equation is obtained:

$$V_s = \frac{\rho_s \ gD^2}{18\,\mu + \sqrt{0.3\,\rho_s\,\rho g D^3}} \tag{1}$$

Where V_s deposition velocity, g acceleration gravity, D spheres particles diameter, ρ_s sediment density, ρ water density, μ viscosity. Before the results of the sediment deposition rates are obtained, this settling tube is carried out as shown in Figures. 2 - 4 as follows:

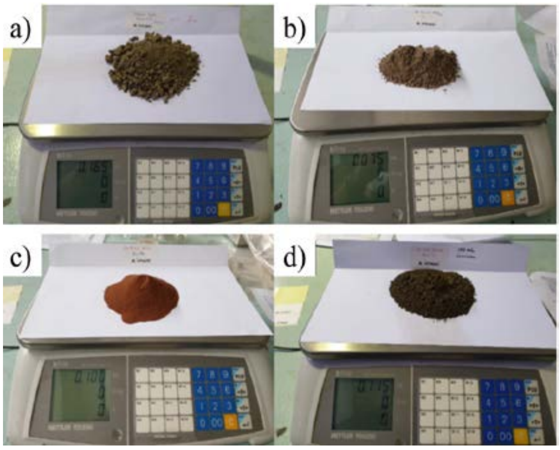

Fig. 2 Equivalent weighing of test sediment samples a) Ex. Field Sediments, b) Passed sieve #400 Ex. Stone Crusher, c) Passed sieve #400 Ex. Coal, and d) passed sieve #400 Ex. Brick in the Fluid Laboratory ITB (2022)

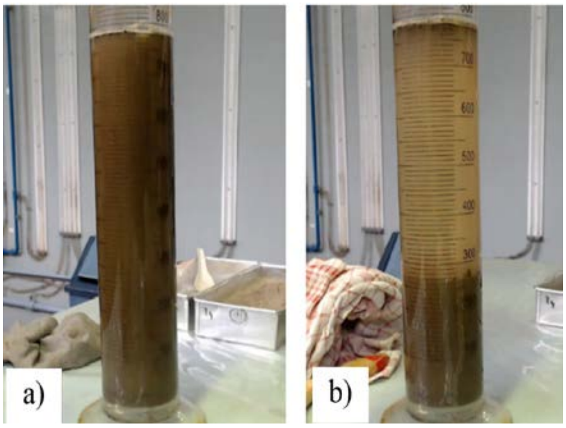

Fig. 3 Field sample testing (Prototype), a) initial deposition, b) sediments deposition

Referring to Eq.1, the analysis results are calculated using four (4) formulas and calibrated by laboratory tests with four (4) samples. As a result, the deposition rates result in 0.735 cm/s as tested in previous studies [12].

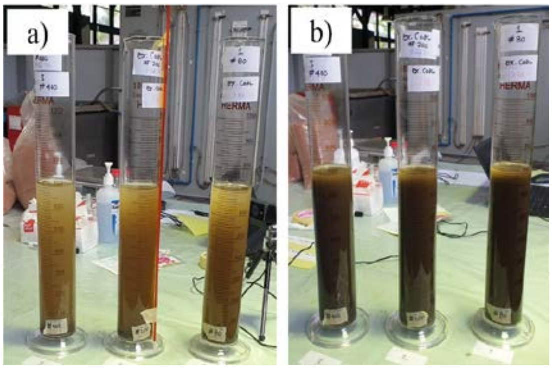

Fig. 4 Deposition rate test Ex. Brick's sample passed sieves #80, #200, and #400. a) initial deposition, b) sediments deposition

3.2 Numerical Analysis by Computational Fluid Dynamic (CFD)

In recent years, the growing availability of computational sources and progress in the accuracy of numerical methods has helped researchers to solve fluid mechanics. CFD complements testing and experimentation, reducing the efforts and costs required for experimental procedures and data acquisition [13]. A numerical approach is used in Ansys R.21 2020 CFD to analyse the flow behaviours. This simulation will be carried out by modelling three fluid phases, namely air, water, and sediment or mud so that the sediment's flow characteristics can be obtained against time (transient). Because in this simulation, several fluids have different phases (air, water, and mud), multiphase modelling must be used. For flows with a clear separation between one phase and another, the Volume of Fluid (VoF) model is used. This model is also relatively simple and efficient compared to eulerian or mixture [14].

3.3 Dimensional Analysis

Dimensional analysis is formulating fluid mechanics problems in the case of non-dimensional variables and parameters. Physical problems are described by relations, which are determined by quantities having a particular dimension—length, time, mass, force, temperature, etc. These relations must be so structured that dependent and independent quantities are combined so as to yield dimensionally correct formulas [15]. Dimensional analysis can sometimes provide a complete set of dimensionless products constructed from the pertinent process variables. Similitude by dimensional analysis requires that the dimensionless products have the same value in the prototype as in the model; the similarities tested in this study are geometric, kinematic and dynamic [16].

3.4 Experiment Set-up in Laboratory

Physical model tests are performed to investigate the hydraulic behaviour of the entire sediment trap or each component. Physical model tests often solve fluid mechanics and hydraulics problems to discover the hydraulic behaviour that not obtained in numerical models with CFD. This physical model test is intended to test or check the performance of sediment traps in the efficiency of deposition and desilting that have been previously tested in numerical analysis with CFD.

3.4.1 Accessories of the Experimental Set-up

Simple ADV performance interface, enabling fast data collection by a data logger by a computer. Laboratory test used 2 units Micro ADV 16 MHz down and side-looking, 1 unit Probe Propeller Current Meter H33 with data logger and 8 units Camera Highspeed DSLR.

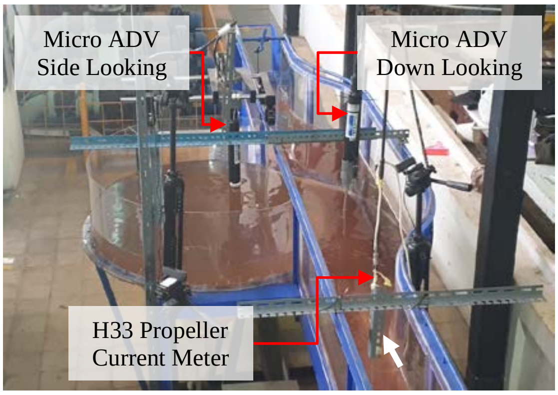

Fig. 5 View of undistorted 3-D Lab physical model

3.4.2 Laboratory test and experimental procedures

A 3-D test of this physical model was carried out in the hydraulics laboratory of the Faculty of Civil and Environmental Engineering Institut Teknologi Bandung (ITB). An undistorted scale of 1:40 with the 3-dimension physical model was conducted from February to May 2022 (see Fig. 5). The slope at the bottom of the chamber used is the slope orifice chamber with 1:10, 1:5 and 1:2 which, as a scenario and comparison of the slope of the chamber which is the most optimal performance (see Figures 6-8)**.**

The sediment removal efficiency of the vortex settling/desilting basin was measured by systematically varying the inlet discharge, underflow removal discharge, sediment size, underflow outlet orifice diameter, and canal width. The sediment trap efficiency is defined as the ratio of deposited sediment to the total sediment inflow for a given period within the sediment trap economic operation [17].

The determination of the scale model in the analysis of the relationship between scales prototype to model, considering space in a laboratory, accuracy, facilities/accessories, and visual view of the undistorted physical model with a scale of 1:40.

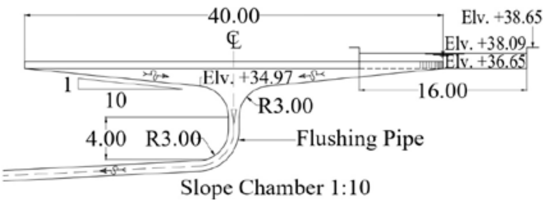

Fig. 6 Section of Slope Chamber 1:10

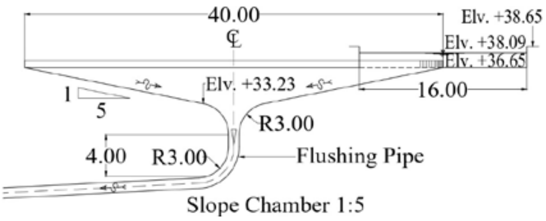

Fig. 7 Section of Slope Chamber 1:5

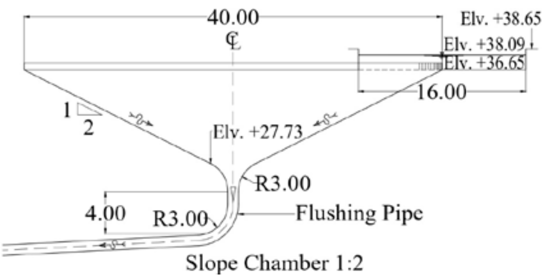

Fig. 8 Section of Slope Chamber 1:2.

3.5. Limitations

In this study, the authors limited several variables so that the focus of the study became clear and not pseudo; here are the limitations of the research: a). Laboratory 3D Physical Model, Undistorted Scale 1: 40; b). Inlet Irrigation Main Canal length at Model: 5.5 m equal to Prototype 220 m and static with 0.2 m in model equal to 8.00 m at prototype; c). A circular cylindrical type of vortex settling basin having a diameter at model 1.00 m equal to 40 m at prototype was used for experimentation in the present study; d). Sediment to be deposited cohesionless type > 0.06 mm, and <0.06 mm neglected and allowable enter the main system; e). Water depth has variations based on Q 50%, 100% and 120% by NFR; f). The underflow outlet orifice static diameter is 0.025 m, equal to a diameter of 1.00m, and: g). Suspended sediment concentration in the Vortex settling basin varied from 11,200 ppm to 190,000 ppm by weight.

4. RESULTS AND DISCUSSIONS

Decreasing the flow velocity in the basin to ensure the sediment particle's remaining time is longer than the settling time is the primary design idea of the settling basin. To reach the standard, procedures are widening the basin width and lowering the basin bottom. However, different combinations of length, width, and depth may attain the same deposition efficiency. The economic design of the settling basin with specific efficiency is the focus of this study.

4.1 Rectangular Shape Sediment Trap Results

The performance of a sediment trap is expressed in how effectively it is depositing and quickly removing the sediment fraction. As a comparison, in 2018, there was an undistorted 3-D of the physical model of the rectangular shape of sediment traps in the Hydraulics Laboratory of PUSSAIR Bandung (see Fig. 9).

Fig. 9 Undistorted physical model test scaling 1:20 for conventional rectangular sediment trap

In such irrigation systems, sediment in canal structures has technical and economic implications in developing and utilising water resources; hence, its control is essential. With a similar location and parameters, due to the Macan main canal's alignment in the irrigation system's direction, if it is built on a space with curved alignment is not optimal in terms of performance. The alignment of sediment traps on the curved line leaves significant sedimentary fractions in the inner curve and under the sluice, see Fig. 9.

The results of physical modelling on conventional sediment trap forms with a model scale of 1:20 are not optimal, the deposition efficiency is measured at 69.12%, and this deposited sedimentary fraction can only be removed by 53.33%. In the Design Criteria (KP-02, 2015) as a standardised issued by the Ministry of Public Works and Housing, sediments deposited in diameter > 0.06 mm, for diameters < 0.06 mm are allowed to be neglected and then moved in the irrigation system with operational routine and periodic maintenance conditions extracting [18].

4.2 Simulation for Approach Geometric Shape by CFD

In all, 22 runs were conducted for sediment removal efficiency of vortex settling/desilting basin by varying slope chamber of underflow outlet, whereas 44 runs were conducted for this study.

Here are the inputs used in boundary conditions: Mass-flow-Inlet: a). In the inlet section, it is defined as a mass flow inlet either for water or mud. b). Wall: On walls, it is defined as a wall with a no-slip condition representing the friction between the fluid and the wall. c). Surface: At the top of the domain, the effects of wall friction are removed to represent atmospheric air, and d). Outlet: The outlet section is a pressure outlet representing the flow's "exit" [14]. Computational Fluid Dynamics (CFD) is the art of transforming fluid dynamics set equations in the form of integrals and derivatives into discrete algebraic forms, which a computer can solve to obtain the values of the flow field at a particular discrete point or time [19]. As for the regulatory equations in fluid dynamics: the continuity equation, the momentum equation and the energy equation [13],[14]. Here are the equations used in CFDs, continuity equation of integral forms:

$$\frac{\partial}{\partial t}\iiint_V \rho dV + \iint_A \rho\vec{V}\cdot d\vec{A} = 0 \qquad (2)$$

The continuity equation of the differential form:

$$\frac{\partial\rho}{\partial t}+\rho\vec{\nabla}\cdot\vec{V}=0 \qquad (3)$$

The equation of momentum in the direction of the x-axis:

$$\frac{\partial(\rho u)}{\partial t}+\vec{\nabla}\cdot\left(\rho u\vec{V}\right)=-\frac{\partial p}{\partial x}+\frac{\partial\tau_{xx}}{\partial x}+\frac{\partial\tau_{yx}}{\partial y}+\frac{\partial\tau_{zx}}{\partial z}+\rho f_x \qquad (4)$$

The equation of momentum in the direction of the y-axis:

$$\frac{\partial(\rho v)}{\partial t}+\vec{\nabla}\cdot\left(\rho v\vec{V}\right)=-\frac{\partial p}{\partial y}+\frac{\partial\tau_{xy}}{\partial x}+\frac{\partial\tau_{yy}}{\partial y}+\frac{\partial\tau_{zy}}{\partial z}+\rho f_y \qquad (5)$$

The equation of momentum in the direction of the z-axis:

$$\frac{\partial(\rho w)}{\partial t}+\vec{\nabla}\cdot\left(\rho w\vec{V}\right)=-\frac{\partial p}{\partial z}+\frac{\partial\tau_{xz}}{\partial x}+\frac{\partial\tau_{yz}}{\partial y}+\frac{\partial\tau_{zz}}{\partial z}+\rho f_z \qquad (6)$$

The energy equation is written in the form of internal energy:

$$\frac{\partial}{\partial t}\left[\rho\left(e+\frac{V^2}{2}\right)\right]+\vec{\nabla}\cdot\left[\rho\left(e+\frac{V^2}{2}\right)\vec{V}\right]=\rho\dot{q}-\frac{\partial(\rho p)}{\partial x}-\frac{\partial(vp)}{\partial y}-\frac{\partial(wp)}{\partial z}+\rho\vec{f}\cdot\vec{V} \qquad (7)$$

Where ρ is Liquid density (kg m^{-3}), A is a mass area, $\vec{V}$ is Velocity vector (m s^{-1}) or velocity fluid parcel, e for internal energy, three velocity components are u, v, w, $\vec{\nabla}$ vector, f any vector function. The solution of a partial differential analytical equation results in a continuously closed-form dependent variable expression across domains. In contrast, the solution of numerical equations can only give values to discrete points in the domain, also called grid points.

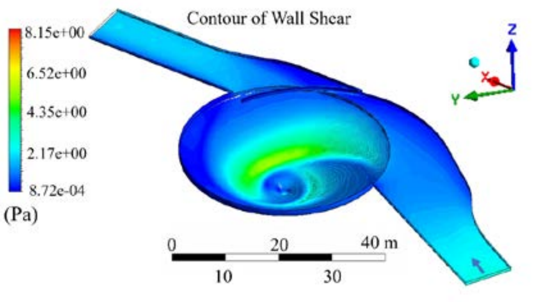

Fig. 10 Wall shear contour in valve-way closed condition (slope chamber 1:5)

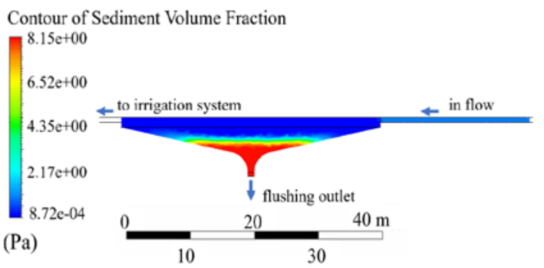

Fig. 11 Sediment volume fraction longitudinal section view in settling time (slope chamber 1:5)

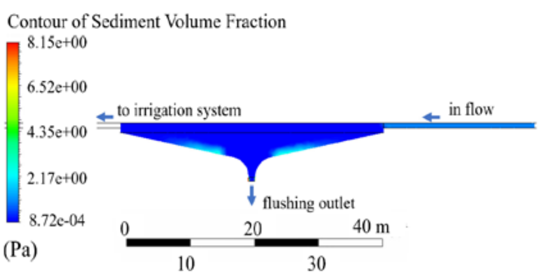

Fig. 12 Sediment volume fraction longitudinal section view in desilting time (slope chamber 1:5)

As shown in Fig.10, the wall shear contour on the free vortex flow along the forced vortex flow side of the chamber is relatively high and states that sediment is well deposited. Applying Eq. 2-7 to CFDs, it is obtained the fraction of sediment volume deposited from sediment transport within the continuous flow in seven days of flow amounting to 82.11%.

As shown in Fig. 12, the longitudinal section of this sediment trap has left a fraction of sediment deposited present by the predominance of red. Leaving approximately 30.69% in cyan colour cannot be remove-out due to the position of the sediment in the transition of the free vortex flow to the forced vortex. In addition, the rheological process of sedimentary sediments also exerts an influence on the classification of this type of sediment 82.11% as settled; as shown in Figures 11 - 12, a total of 69.31% of the sediment fraction can be flushed.

4.3 Result Laboratory Undistorted 3-D Physical Model Test

The following equation calculates the deposition efficiency value:

$$T_{ef}=\frac{V_{in}-V_{out}}{V_{in}}\times 100 \qquad (8)$$

Where T_{ef} is trap efficiency (%), V_{in} is the volume of sediment entering the sediment trap, V_{out} is a volume of sediment as removed at the outlet. To calculate the efficiency of removing/desilting, use the following equation:

$$\eta_0=\frac{\text{Ws Removed}+\text{Ws Settled}}{\text{Total Ws Feeding}}\times 100 \qquad (9)$$

Where η_0 is removal efficiency (%), Ws removed is the volume of a sediment chamber, and Ws Settled as sediment deposited. Ws feeding the total sediment transport rates [20].

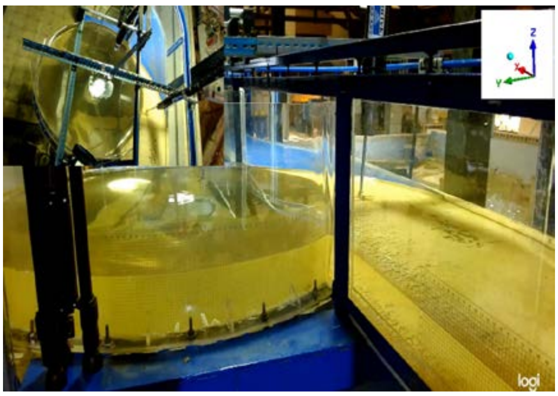

Fig. 13 Deposition time condition in 3.25 of 12 hours running

As shown in Figures 13-14, 11 runs were conducted for this study and feeding the sediment through a sediment feeder to determine the deposition volume, and removal efficiency refers to Eq.8 and Eq.9. The maximum performance result for chamber 1:5, with the effectiveness, deposited 84.90% > 80% of these sediment fractions, 87.90% were removed within 0.3 hours and left a sediment fraction of 12.10%.

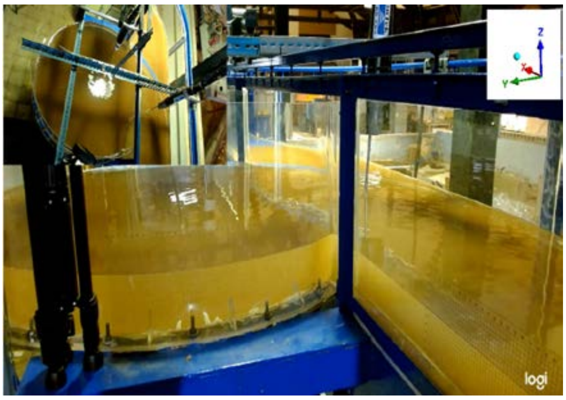

Fig. 14 Measurement and observation of sediment fraction in 8.25 of 12 hours running

The deposition conditions yielded the maximum, with flow conditions Q = 0.53 lps, V= 8.18 cms, water level height 8.23 cm in flume and Froude Number 0.8. The operation gate requires a gate regulator to maintain and implement this parameter.

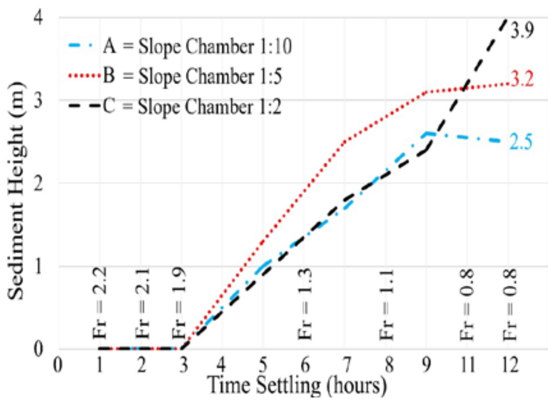

Fig. 15 Raising curve of sediment fraction in 12 hours running in case of settling time

Similarities analysis results, the kinematic similarity of 3 hours of continuous flow in the model is equal to 1 day in the prototype. As a result of the sediment's fraction volume plot, it seems that the more sloping the slope chamber, the faster the process of raising sediment increases. However, in the results of observations on this deposition process, the Froude (Fr) number and flow velocity influence the transition of the supercritical flow Fr > 1 to the subcritical flow where the number Fr < 1. Then a steady flow with a Froude number ranging from 0.7 – 1 is more effective at depositing sediment in the settling basin. Fig. 15 shown that the sloping chamber rapidly deposits sediment inflow running at 5 to 9 hours, this is due to the function of the chamber height as Figures 7-9 show that the height of the chamber base from the chamber surface exerts an influence due to the high characteristic of the flow.

5. CONCLUSION

Present research for steady, vortex, and open channel flows over smooth, rough, and movable beds, independent and based on Reynolds (Re) and Froude (Fr) numbers.

By comparing two different geometric shapes of sediment traps with hydraulic parameters such as discharge and the exact characteristics of sediments to deposition and removal, the running results showed an increase in the number of volumes settling from 69.12% to 84.90%. Meanwhile, for the removal cases, the sediment fraction of 53.33% increases to 87.90% from the deposited can be removed.

Unlike classical rectangular sediment trap shape, needs for higher inlet velocity to maintain higher hydraulic and removal efficiencies. Therefore, an increase in the incoming velocity generates a powerful centrifugal forced vortex causing a better formation of the central air core with a smaller flushing ring diameter, which results in higher hydraulic and extraction efficiencies of the basin.

In this research, by computation of turbulence components, a new approach was developed to observe the critical and effective basin regions in sediment extraction processes. The following conclusions are based on the above-described laboratory experiment under well-defined and ideal conditions of the impact of an axisymmetric laminar vortex ring on the chamber orifice. Most importantly, the height of the chamber here corresponds to the size of the vortex core.

For future research, it is optimising the geometric shape of the chamber to be optimum based on the diameter ratio chamber orifice's effect.

6. ACKNOWLEDGMENTS

This study aims to develop a 3-D rectangular sediment trap to a vortex desilting/settling basin shape. The authors would like to thank the Ministry of Public Works and Housing for their assistance regarding the data collection required for this paper. Furthermore, the authors would also like to express gratitude to this research, the Water Resources Engineering Research Group of the Faculty of Civil and Environmental Engineering Institut Teknologi Bandung, for supporting this publication.

7. REFERENCES

[1] Kusuma M. S. B., and Kuntoro A. A., Preparedness Effort Toward Climate Change Adaptation in Upper Citarum River Basin, West Java, Indonesia. Soc. Manag. Syst. Internet J, 2011.

[2] Kusuma M. S. B., Hutasoit L. M., Kombaita B., Syafila M., and Setiadi T., Strategi Pengelolaan Terpadu Penyelesaian Permasalahan DAS Citarum. Forum Guru Besar ITB, Bandung, pp. 1–25, 2018.

[3] Kusuma M.S.B., Rahayu R.A., Anom., and Cahyono M., Development Study of Turbulent *k-ε* Model for Recirculation Flow III: Two Dimension Recirculation Flow in a Reservoir, ITB Journal of Engineering Science, Vol. 41, Issue 1, 2008, pp.1-16.

[4] Kusuma M. S. B., Setiawati T., and Farid M., Experimental Model of Dam Break Flow Around Several Blockages Configurations. International. Journal.of GEOMATE, Vol. 16, No. 58, 2019, pp. 26 – 32.

[5] Kuntoro A.A., Putro A W, Kusuma M S B., and Natasaputra S., The effect of land use change to maximum and minimum discharge in Cikapundung river basin, AIP Conference Proceedings, Vol. 1903, Issue 1, 2017, 100011.

[6] Shen Y., Puig-Bargués J., Li M., Xiao Y., Li Q., and Li Y., Physical, Chemical and Biological Emitter Clogging Behaviors In Drip Irrigation Systems Using High-Sediment Loaded Water. Agric. Water Manag., Vol. 270, p. 107738, 2022.

[7] Lepesqueur J., Hostache R., Martínez-Carreras N., Montargès-Pelletier E., and Hissler C., Sediment Transport Modelling in Riverine Environments: On The Importance of Grain-Size Distribution, Sediment Density, and Suspended Sediment Concentrations at The Upstream Boundary. Hydrol. Earth Syst. Sci, Vol. 23, No. 9, 2019, pp. 3901–3915.

[8] Ali A., Mynett A. E., and Azam M. H., Sediment Dynamics in the Meghna Estuary, Bangladesh: A Model Study. J. Water. Port Coast. Ocean Eng, Vol. 133, No. 4, 2007, pp. 255–263.

[9] Chapokpour J., Turbulent Flow Measurement in Vortex Settling Basin. Iran Journal Energy Environment (IJEE)., Vol. 2, No. 4, 2011, pp. 382 – 389.

[10] Ansari M. A., and Athar A., Design Parameters of Vortex Settling Basin. Proc. Inst Civil Eng. - Water Manag, Vol. 166, No. 5, 2013, pp. 262–271.

[11] Isnaeni M., Kusuma M. S. B., and Nugroho J., Rheological Relationship to Sediment Deposition Rate in Macan Weir Sediment Traps. International Journal of GEOMATE, Vol. 21, No. 87, 2021, pp.128-136.

[12] Isnaeni M., Kusuma M. S. B., and Nugroho J., Rheological Relationship to Sediment Deposition Rate in Macan Weir Sediment Traps. International Journal of GEOMATE, Vol. 21, No. 87, 2021, pp.128-136.

[13] Ramirez R., Avila E., Lopez L., Bula L., and Forero J. D., CFD characterisation and optimisation of the cavitation phenomenon in dredging centrifugal pumps. Alexandria. Eng. J, Vol. 59, No. 1, 2020, pp. 291–309.

[14] Mohammad M. E., Al-Ansari N., Knutsson S., and Laue J., A Computational Fluid Dynamics Simulation Model of Sediment Deposition in a Storage Reservoir Subject To Water Withdrawal. Water, Vol. 12, No. 4, 2020, pp. 959 – 969.

[15] Lee C. H., Low Y. M., and Chiew Y. M., Multi-Dimensional Rheology-Based Two-Phase Model for Sediment Transport and Applications to Sheet Flow and Pipeline Scour. Phys. Fluids, Vol. 28, No. 5, P. 053305, 2016.

[16] Huang C. C., Lai J. S., Lee F. Z., and Tan Y. C., Physical Model-Based Investigation of Reservoir Sedimentation Processes. Water, Vol. 10, No. 4, 2018, pp. 352 – 367.

[17] Shahi S., and Kuru E., Experimental Investigation of The Settling Velocity Of Spherical Particles In Power-Law Fluids Using Particle Image Shadowgraph Technique. Int. Journal. Miner. Process, Vol. 153, 2016, pp. 60 – 65.

[18] Ministry of Public Works and Housing DGWR KP-02., Design Criteria, Vol.2, Kriteria Perencanaan KP-02 Bangunan Utama, pp.16-133, 2015.

[19] Magdalena I., Hariz A.A.A., Farid M., Kusuma M.S.B., Numerical studies using staggered finite volume for dam break flow with an obstacle through different geometries, Results in Applied Mathematics, Vol.12, 2021, 100193

[20] Chemeda B., and Dinka M. O., Evaluation of Sediment Trapping Efficiency of A Settling Basin at Finchaa Sugar Estate, Ethiopia. Phys. Chem. Earth Parts ABC, Vol. 117, P. 102869, 2020.