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STILLING BASIN FOR PIPE OUTLET

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الماء هو عصب الحياة والمحافظة عليه باتت ضرورة من ضروريات استمرار الحياة على وجه الأرض مما حدا بالحكومات الى التوسع فى بناء منشات التحكم فى المياه مثل القناطر والهدارات وغيرها مساهمة منها فى تحقيق أفضل استفادة من المياه العذبة ، بالإضافة الى انتشار الكبارى وغيرها من المنشآت المدنية، ومن أهم المشاكل الناتجة عن ذلك زيادة مشكلة النحر نتيجة لزيادة طاقة المياه حول دعامات هذه المنشآت والتى قد تتسبب فى انهيار هذه المنشآت مما حدا بالعلماء للتفكير فى إنشاء مشتتات لهذه الطاقة من شأنها التقليل من ظاهرة النحر حول دعامات المنشآت البحرية والبحث يتناول هذا الموضوع باستخدام جهاز مشتت للطاقة وهو STILLING BASIN وقد حقق هذا الجهاز أقل معدلات للنحر بالمقارنة بالأجهزة الأخرى المشتتة للطاقة ٠

ABSTRACT

The cost of protection works at circular pipe outlets can be reduced using a suitable appurtenance to dissipate the excess energy in an efficient manor within a shorter length of the stilling basin. Some of the energy dissipators used for pipe outlets are the USBR type VI stilling basin, hydraulic jump type stilling basin and Garde's stilling basin. The stilling developed in these tests is an impact-type energy dissipator, contained in a relatively small box-like structure, which requires no tail water for successful performance. The model used in this test has a pipe outlet (5cm in diameter), Froude number varied from 1.5 to 3.7, with different type of bed material. The results demonstrate that the location of end sill at ten times a pipe diameter from pipe outlet gives minimum scour hole depth. Also, the results show that the decrease of median grain size by 75% will cause the scour hole to be deeper by 65%.

I. INTRODUCTION

There is an essential need to construct hydraulic structures along any waterway. Hydraulic structures are frequently of immense size, requiring the control of large volumes of water under high pressure. The energies at the base of the structures are often tremendous whether the discharge is through outlet conduits or over spillways. Dissipating the energy of the flow passing downstream the hydraulic structure or over a spillway is important in hydraulic engineering to reduce the scour downstream of the structure. Some means of expending the energy of the high velocity flow is required to prevent scour of the river bed, minimize erosion and prevent undermining of the structure itself. This may be accomplished by constructing an energy dissipator at the base of the structure, in order to dissipate the excessive energy and establish safe flow conditions in the outlet channel. Although hundreds of stilling basins and energy dissipation devices has been designed in conjunction with spillways, outlet woks and canal structures, it is often necessary to make model studies of individual structures to ensure that these will operate as anticipated. The reason for these repetitive tests is that a factor of uncertainty exists regarding the overall performance characteristics of energy dissipators.

2. EXPERIMENTAL SETUP

Experimental studies were conducted in the 8.6m length-tilting flume in the Hydraulic Laboratory of the Faculty of Engineering, Cairo University, Giza, Egypt. Three different types of sand were used as bed material with different grain size distribution. Type I was a graded sand with median grain size D50=0.2mm and with standard deviation σg=3.33. Type II was also a graded sand with median grain size D50=0.3mm and with standard deviation σg=2.0. And type III was also graded sand with median grain size D50=0.4mm and with standard deviation σg=1.7.

Nine groups of runs were carried out for testing the model. At end sill location, type of sand and the tail water depth were kept approximately constant, while the Froude number was increased from 1.5, 2.0, 2.6, 3.0, and 3.7. The bed surface profiles, before and during each experiment, the maximum scour depth during each experiment with respect to time and the final bed profile along the working section of the flume were measured in each run.

Running time for each model was kept as 4hrs. As shown in figure(1), the new stilling basin consists of:

Impact wall without notch.
Splitter block wedge shape with vertex angle 150° and width equal 0.7Dpipe.
Intermediate sill with height equals to pipe diameter and its location is at 3 Dpipe.
Rounded end sill with height equals to pipe diameter.

3. EXPERIMENTAL PROCEDURE

The experimental procedure is be summarized as follows:

The erodible bed on the downstream end of the stilling basin model was leveled to the top of the end sill.

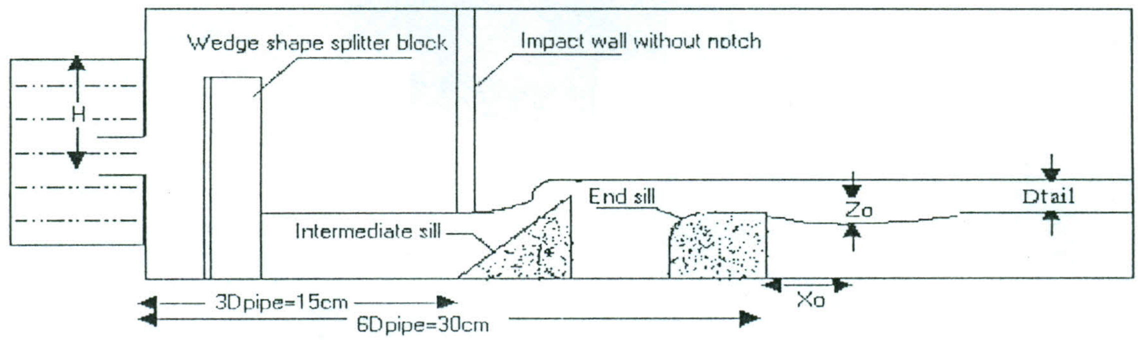
The gate valve inlet was opened to allow the discharge to pass slowly to reduce the disturbances on the erodible bed. Initially, the tail gate was kept completely closed and the flume was filled with water somewhat up to the level corresponding to the normal depth. At this stage, the inlet discharge was gradually increased to the desired flow corresponding to the required Froude number.

The tailgate was adjusted to give a constant down stream water depth and to measure the head above and down the stilling basin model.

To study the history of the profile the bed profile was monitored at different time intervals (5min, 10min, 15min, 30min, 60min, and 120min).

After the scour reaches its steady state, the flow to the flume was stopped and the water inside the flume was drained out slowly without causing any disturbance to the scour pattern. The shape of bed profile was determined.

During and after each run, photographs were taken for the equilibrium profiles and for different runs.



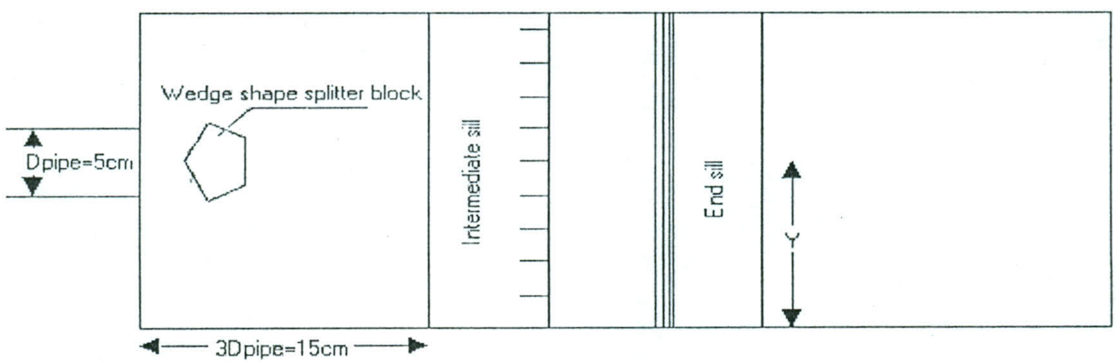


Fig. 1. The new stilling basin.

4. PRESENTATION AND ANALYSIS OF RESULTS

Several variables affect the bed profile of the experimental study. In the following analysis each variable was considered separately and its effect on the bed profile is demonstrated. In order to perform the analysis, different parameters were measured during the experiment and these parameters are given below and illustrated in figure (1). These parameters are:

- Inlet Froude number (Fr).
- The scour hole depth (z).
- The diameter of pipe (Dpipe).
- The maximum scour hole depth (Zo).
- Head above orifice (H).
- The inlet velocity (Vpipe).
- The length of hole (L).
- Median grain size (D50).
- The flow discharge (Q).
- Longitudinal distance from the end sill (x).

- The cross-distance from the right to left (Y).
- The depth of water downstream (Dtail).
- The distance of the maximum scour hole depth (Xo).
- Median standard deviation of bed material (σg).

Bed surface was represented by curve connecting the points of bed level measured along the centerline and side of the flume. To explain and understand the relation between the different variables measured experimentally and their effect on each other, the obtained data have been studied and plotted using dimensionless parameters and then technical comments and analysis were introduced.

The variable were put in dimensionless forms as follows: relative scour depth (z/Zo), relative distance (x/Zo), Froude number (Fr), the scour index (2Zo/Xo), the relative stilling basin length (Lsill/Dpipe) and the specific maximum scour hole depth ($Zo*D50/H^2$) was added to these dimensionless terms.

Figure (2) shows the approximate relation for all bed material types and end sill location. This chart can be used to give an approximate estimate on of the scour hole geometric features. It is clear that the maximum scour hole depth occurs at distance about fifth of the maximum scour hole depth, and it shows also the length of hole about tenth of the maximum scour hole depth.

Figure (3) shows the general relation between the relative stilling basin length (Lsill/Dpipe) and specific maximum scour hole depth ($Zo*D50/H^2$). It is clear that by increasing the location of end sill for same bed material, the median grain size will be decreased to the stilling basin ratio equals to about ten. This chart can be used for design the stilling basin length and define the median grain size which can be used downstream. The limitation of this chart and its equation is the Froude number more than 1.0.

Figure (4) shows the general relation between the Froude number and the specific volume (Vol*D50*Lsill/H^5). It is clear that from this chart by knowing the stilling basin length, median grain size and the Froude number, the volume cut downstream due to this Froude number could be obtained.

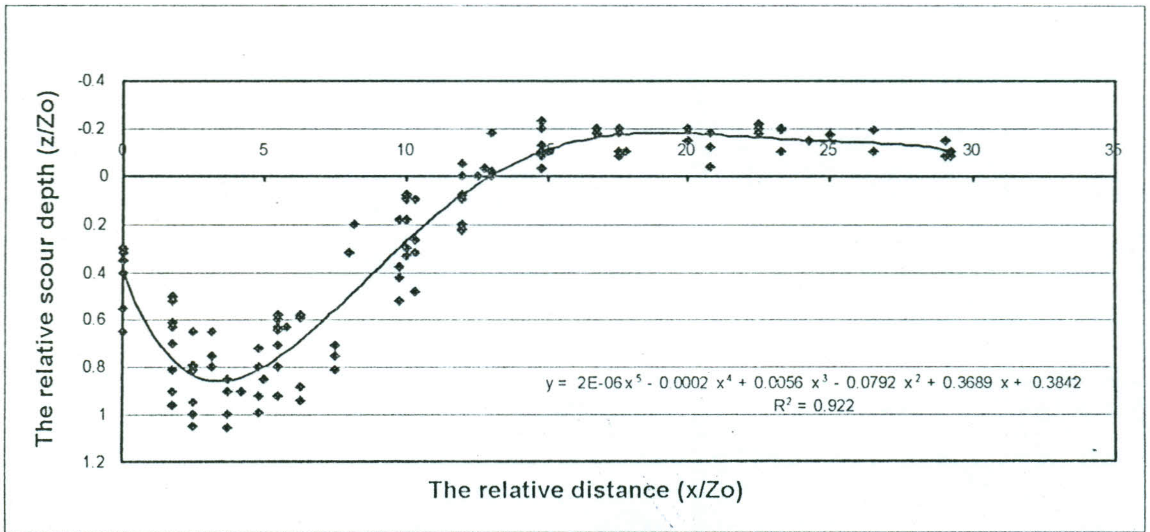


Fig. 2. The relation between the relative scour depth and the relative distance.

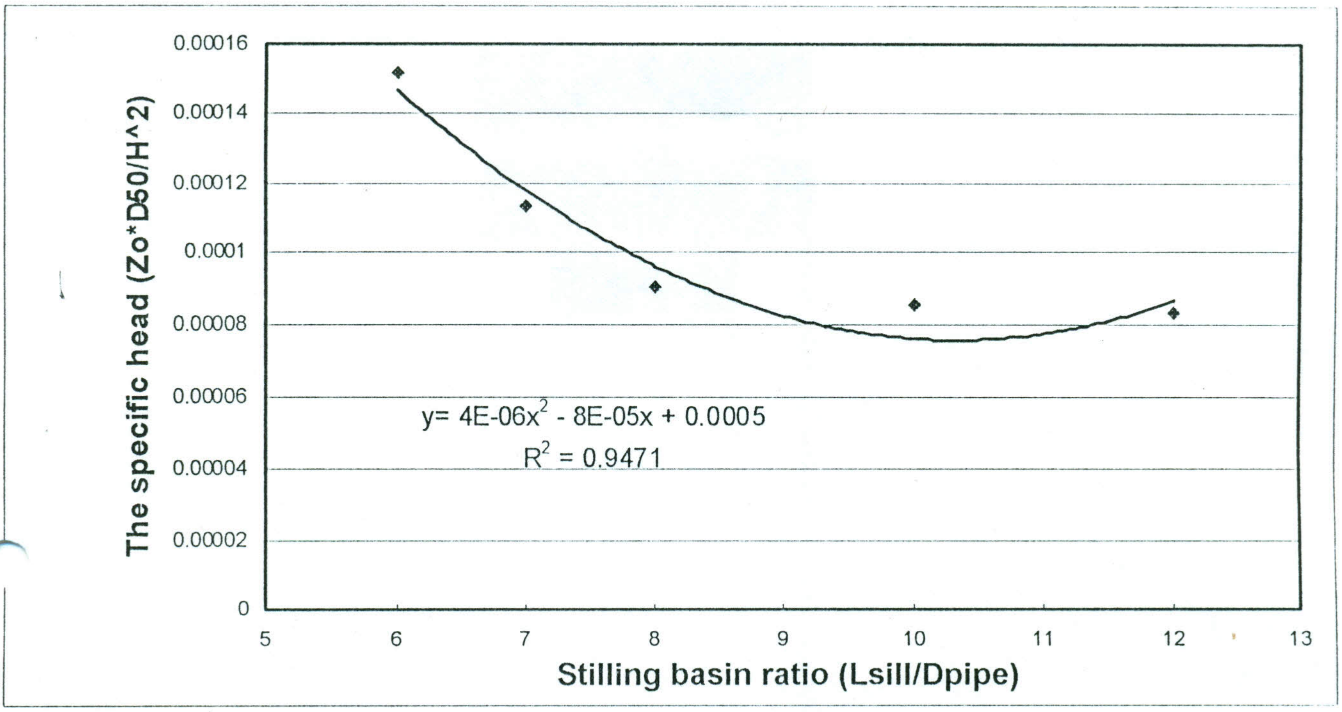


Fig. 3. The relation between specific maximum scour hole depth and the relative stilling basin length.

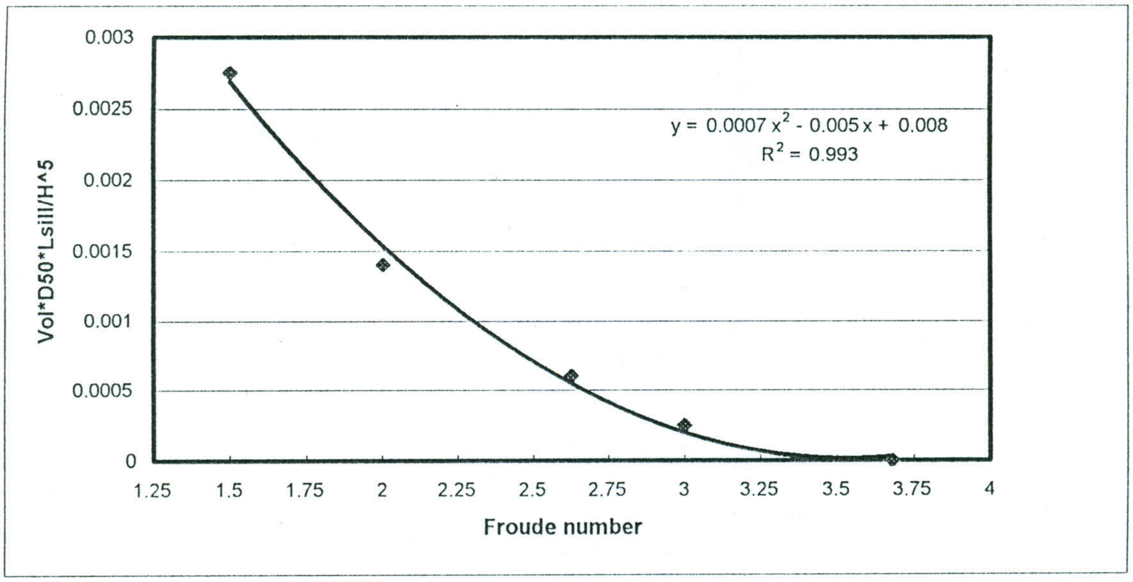


Fig. 4. The relation between specific volume and Froude number.

5. CONCLUSIONS

1. The triangular intermediate sill with height equal to the pipe diameter is better (reduce scour-index) compared to intermediate sill with height equal to half pipe diameter.
2. An increasing in Froude number by 80% will cause the hole to be deeper by approximately 75% and will cause the scour to extend further by 65%.

3. The decrease of median grain size by 75% will cause the scour hole to be deeper by approximately 65% and will cause the scour to extend further by 40%.
4. An increase in length of stilling basin by 25% will cause the scour hole to be shallower by approximately 30% to a certain length equal to ten times of diameter and after that the effect of stilling basin length will be neglected.
5. Experimental runs indicated that the observed length of scour hole was about ten times the maximum scour hole depth.
6. Experimental runs indicated that the maximum scour hole depth occurs at 4.5 times maximum scour hole depth from the pipe outlet.

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