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IMPROVING NAVIGATION CONDITIONS DOWNSTREAM LOCKS (CASE STUDY: NAVIGABLE REACH D.S. SARYAKOS LOCK)

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ABSTRACT

This research investigates the possibility of improving the navigation characteristics downstream (D.S.) locks by reducing the cross velocities. Several site visits were carried out to different navigable reaches where D.S. Saryakos Lock was chosen to be taken as a case study to investigate its navigation condition after constructing a new barrage. Different measurements, such as velocities, discharges and corresponding water levels, were undertaken D.S. the lock location. Based on the visits and measurements, a complete data picture was perceived to the study area. Consequently, a physical model was constructed in the Hydraulics Research Institute (HRI) to simulate the lock. The model was calibrated against field measurements that were carried out upstream and downstream the lock. An experimental test program was designed to examine the navigation conditions of the lock by varying the length of the guiding wall separating it from the main barrage under different discharges. Measurements were undertaken at the maximum, minimum and dominant discharges and were analyzed. Based on the results, it was found that the separating guide wall (SGW), with a length of one third of the total channel width, produced a reasonable velocity distribution along and across the channel. This wall length (30 m in this tested case) will lead to a better navigation conditions in the prototype.

هذا البحث يدرس كيفية تحسين الظروف الملاحيه بتقليل السرعات العرضيه خلف الأهوسه. حيث تم القيام بزيارات مختلفة لأماكن متعددة للممرات الملاحيه خلف الأهوسه وتم أختيار المنطقه الملاحيه خلف هويس سرياقوس كحالة دراسية وذلك لأختبار كفاءتها الملاحيه بعد إنشاء القنطرة الجديدة بجانبه. تم أخذ قياسات مختلفة مثل السرعات والتصرفات ومناسيب المياه المناظره عند الأماكن المحيطة بالهويس . وبناءاً على هذه القياسات تم وضع تصور كامل للمنطقه وتم عمل نموذج طبيعى لدراسة وتحليل المشكلة الناجمه من السرعات العرضيه التى تعوق حركة الملاحه حيث تم التأكد من صحة النموذج بعمل المعايرة اللازمة عند قطاعين أحداهما أعلى القنطرة والهويس والقطاع الآخر أسفل القنطرة والهويس . ثم تم وضع برنامج إختبارات معمليه لفحص الظروف الملاحيه بتغيير أطوال الحائط الفاصل بين القنطرة والهويس (دليل الهويس) كما أخذت قراءات عند التصرفات القصوى والصغرى والسائده وتم تحليل نتائج تلك القياسات . وبناءاً عليه تبين أن أفضل طول للحائط هو تقريباً ثلث عرض المجرى المائى وهو ٣٠ متر فى حالة هويس سرياقوس وهذا الطول أدى إلى الحصول على سرعات مناسبة فى الأتجاه الطولى والعرضى للمجرى المائى وهذا سيؤدى إلى تحسين الظروف الملاحيه فى الطبيعه.

***Keywords*:** Navigation Lock, Cross Velocities, Physical Model, Calibration, Separating Guide Wall.

1. INTRODUCTION

Navigation deficiencies are worldwide documented. Likewise, it is the case in Egypt where many navigable channels are facing different problems. Many investigations were conducted in the HRI. Among them, for example, are HRI (1989), (1998), (2000), and (2002).

This research was thus initiated in order to investigate the possibility of enhancing the navigation conditions D.S. lock locations by varying the guide wall length. Saryakos lock was chosen to be taken as a case study due to its significance importance to Egypt to investigate the navigation conditions under the new conditions after constructing a barrage beside it.

To accomplish this investigation, the study proceeded through phases. The executed phases are described in this paper under the following titles:

- site visits, field measurements and study area description
- data processing and analysis
- physical model construction
- physical model calibration
- measuring devices
- experimental test program and measurements
- experimental test results analysis
- conclusions and recommendations

2. SITE VISITS, FIELD MEASUREMENTS AND STUDY AREA DESCRIPTION

Visits were conducted to the different navigable reaches in Egypt where Saryakos lock was chosen to be taken as a case study due to its significance importance to Egypt. The chosen study area, Fig. (1), was thus visited several times to perceive a clear picture to the problems facing the lock.

On the other hand, field measurements were undertaken to compare their results with measurements that were carried out in September 2005. The following were carried out:

- a bathymetrical survey to cover a 3000 m along the canal (2000 and 1000 m downstream and upstream the regulator, respectively)
- velocity measurements at seven sections, Fig. (2).
    - Three cross sections (1), (2) and (3) are located 167 m, 78 m and 2 m
    - U.S. the barrage
    - Two cross sections (4) and (5) located 80 m and 160 m D.S. the barrage
    - One section along the center line of the navigation lock
    - One section along the D.S. of the SGW
- bed sampling that were exposed to a sieve analysis, the results are given on
- Figs. (3-a) and (3-b)
- surface current measurements.

The field measurements were undertaken using the following equipments:

- The bathymetrical survey was carried out using an echo sounder.
- The velocity measurements were undertaken using current meters.
- The bed sampling was executed using a bed sampler.
- The surface current measurements were carried out using standard floats with a 1.0 m draft.

Based on these visits and field measurements, the area was described as follows:

- A lock, of width 17 m, is located across Saryakos Canal.
- A regulator is located beside the lock. It has 10 gates of 5.0 m width (50 m width) in addition to pier width.
- The floor level is (+ 9.00).
- The sill's level is (+ 9.50).
- The maximum and minimum water levels, upstream the regulator, are (+ 15.40) and (+ 14.80), respectively.
- The maximum and minimum water levels, downstream the regulator, are (+ 14.50) and (+ 12.70), respectively.
- The maximum and minimum discharges, which pass through the canal, are 37.5 and 15.8 m3/day, respectively.
- The mean particle diameter was found to range between 0.25 and 0.3 mm and between 0.4 and 0.9 mm upstream and downstream the barrage respectively, Figs. (3-a) and (3-b).

3. DATA PROCESSING AND ANALYSIS

The field measurements were processed then were further analyzed. From the analysis, the following was determined:

- The velocities were 0.65 and 0.64 m/s at the upstream and downstream of the regulator, respectively.
- 50% of the discharge passes through one of the narrow vents which indicated the presence of a sump

The surveyed cross sections were compared to those taken in year 2005. From this comparison, clear was the following:

- A slight change occurred in the bed level at the upstream sections.
- The bed level at the downstream experienced no changes.
- A slight change occurred in the sump level.

The analyzed data was implemented in the construction and calibration of the physical model.

4. PHYSICAL MODEL CONSTRUCTION

The implemented physical model was constructed in the Hydraulics Research Institute (HRI). The model was constructed in two months, Photos (1) to (3). The model scale was chosen to be 1:40 to fit the laboratory area. The model simulated the lock and the neighboring new Saryakos barrage with ten gates, 5 m width each. An upstream reach of 400 m was modeled as well. Also a downstream reach of 800 m was simulated too.

5. PHYSICAL MODEL CALLIBRATION

The model was first calibrated. The model water surface slope was measured and compared to field data at the cross-sections given on Fig. (4). Also, the velocity distribution was measured at two cross sections. These measurements were compared to field measurements. This comparison showed the agreement of both measurements, Fig. (5).

6. MEASURING DEVICES IN THE MODEL

The following equipments were utilized to carry out the measurements in the model.

- An ultra sonic flow meter was installed on the feeding pipe, which supplies the water to
- the model in order to measure the flow entering the model. The device accuracy varies between ± 1 and ± 2 %.
- A current meter was used to measure the velocity values in both the longitudinal and
- transversal directions. The current meter has an accuracy of ± 0.5 %.
- The surface currents were detected using floats and dye. The surface currents were also
- detected by video cameras and an ordinary photo camera.

7. EXPERIMENTAL TEST PROGRAM AND MEASUREMENTS

A test program was planned. It was designed to test different SGW lengths (20, 30, 40 , 50, 60 m) under different canal conditions and different modes of operation. These modes are: winter flow condition (15.8 m^3/day); dominant flow conditions (24 m^3/day); and maximum flow condition (37.5 m^3/day).

Table (1) shows the test program that consisted of 10 runs. Velocity measurements were undertaken at the different locations as shown on fig. (2).

8. EXPERIMENTAL TEST RESULTS ANALYSIS

Measurements were analyzed and represented from which clear was:

- The longitudinal velocity distribution across the canal became more uniform when the separation guide wall (SGW) increased from 20 m to 30 m (one third the width of the total channel width which is 90 m in the case of Saryakos Lock) but it did not improve significantly when the length was increased to 60 m. This was observed in the case of testing the maximum discharge, Figures (6-a) to (6-f)
- The cross velocity value was decreased when the SGW length was increased from 20 m to 30 m (one third the width of the total channel width which is 90 m in the case of Saryakos Lock) but this value did not decrease when the length was further increased to 60 m, Figures (7-a) to (7-f), Table (2).

  Vortices were formed at the end of the guide wall in case of the presence of a SGW with a length of 20 m, Photos (4) and (5).
- No vortices were formed in case of implementing a 30 m long SGW (one third the width of the total channel width which is 90 m in the case of Saryakos Lock), Photos (6) and (7), Table (2).
- Vortices disappeared when the SGW was extended to be 50 or 60 m, Photos (8) to (13), Table (2). Using such lengths are very expensive due to the addition of an extra length to the SGW.

9. CONCLUSIONS AND RECOMMENDATIONS

The above investigation shows that extending the SGW more than 30 m (one third the width of the total channel width which is 90 m in the case of Saryakos Lock) will not affect the:

- longitudinal velocity distribution
- cross velocity distribution
- vortices formation

Therefore, implementing (one third the width of the total channel width which is 90 m in the case of Saryakos Lock) long SGW will:

- reduce the construction cost, Table (2)
- improve the navigation conditions

It is to be noted that this research is confined only to the tested case. Otherwise, it is **recommended to** investigate the optimum length of the SGW between locks and regulators according to the site conditions (discharges – dimensions – location - …. etc). This was not investigated during the research. This investigation necessitates a big fund to collect data to establish a general applicable length.

8. LIST OF REFERRENCES

[1] HRI, "Increasing Discharge of Saryakos Barrage", 1988.

[2] HRI, "Solving the Navigation Problems at the Entrance and Outlet of the Naga-Hamadi Lock", 1989.

[3] HRI, "Over-Coming the Navigation Problems in the Lock Area at Assuit Barrage Lock", 1993.

[4] HRI, "the best alignment of a new navigation lock at km 100 of El-Nubaria Canal", 1998.

[5] HRI, "Studying of Scour Problem Downstream Saryakos Regulator", 2000.

[6] HRI, "Testing the Design of Filling and Emptying System of the Lock and Making the Necessary Modifications to Reach the Optimal Usage of Naga-Hamadi Lock ", 2000

[7] HRI, "Hydraulic Studies on Saryakos Regulator", 2001,

[8] HRI, "Testing the Design of Filling and Emptying System of the Lock and Making the Necessary Modifications to Reach the Optimal Usage of Esna Lock" 2002.

[9] HRI, "Studying of Saryakos Inlet and Outlet" 2006.

Table 1. Test Program

Test No.	SGW Length (m)	Discharge (m^3/s)
1	20	183.1
2	20	433.4
3	30	183.1
4	30	433.4
5	40	183.1
6	40	433.4
7	50	183.1
8	50	433.4
9	60	183.1
10	60	433.4

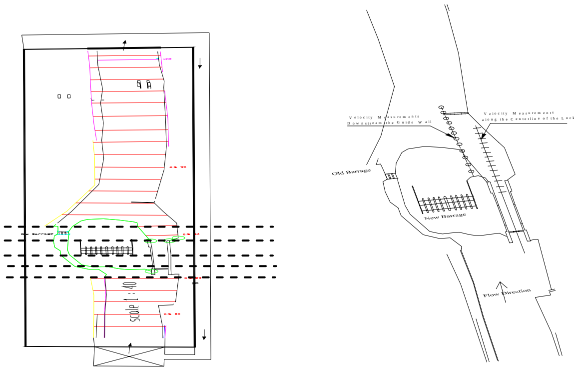


Figure 2. Velocity Measurement Locations

Table 2. The Obtained Results Showing the Effect of the SGW Lengths

Test No.	SGW Length (m)	Disch. (m^3/s)	Cross Flow	Vortex Form	Const. Cost
1	20	183.1			Low
2	20	433.4			Low
3	30	183.1	X	X	Low
4	30	433.4		X	Low
5	40	183.1	X	X	Reasonable
6	40	433.4		X	Reasonable
7	50	183.1	X	X	High
8	50	433.4		X	High
9	60	183.1	X	X	High
10	60	433.4		X	High

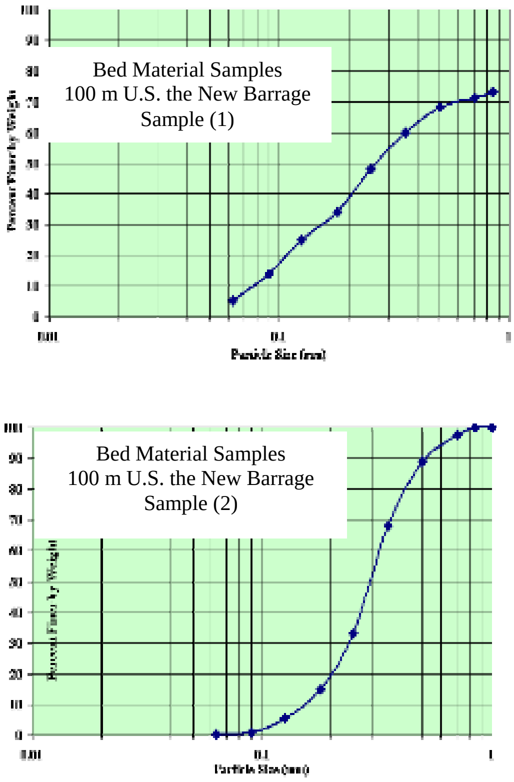


Figure 3.a. Sieve Analysis U.S. Barrage

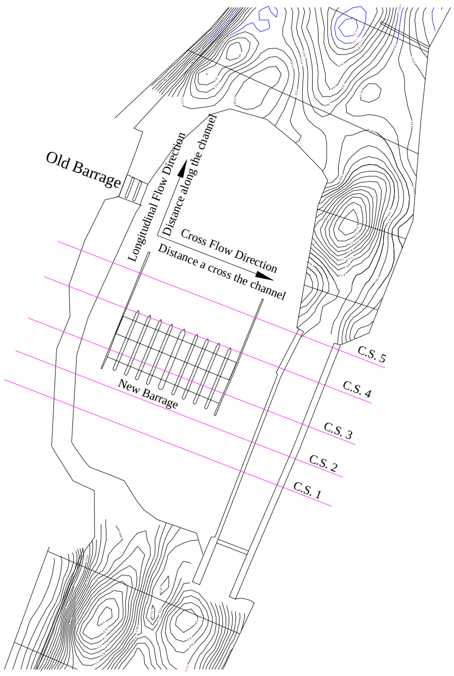
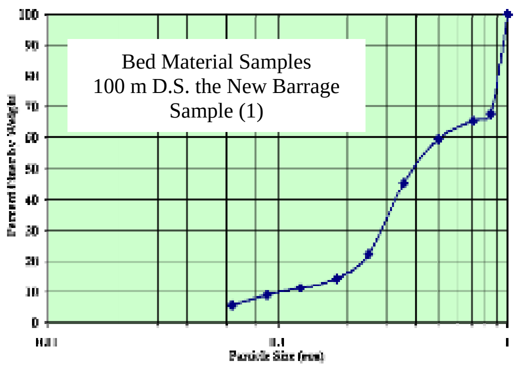


Figure 1 The Chosen Study Area



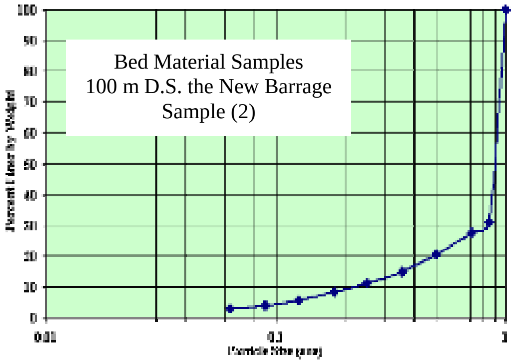


Figure 3.b. Sieve Analysis D.S. Barrage

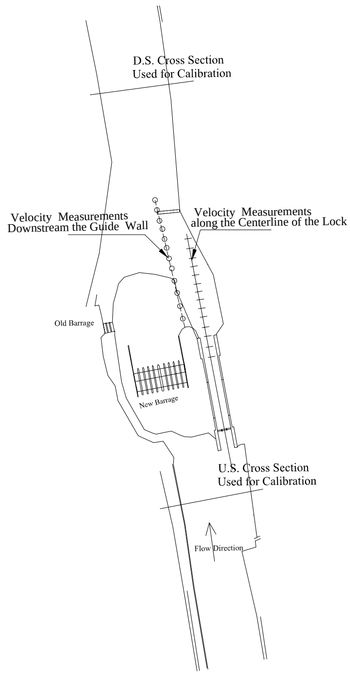


Figure 4. Cross-Sections U.S. and D.S. Saryakos Barrage used for the Model Calibration

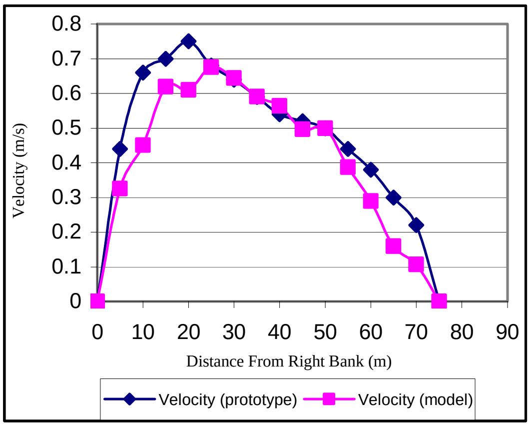


Figure 5. Prototype and Model Velocity Distribution D.S. the Lock (Calibration Process)

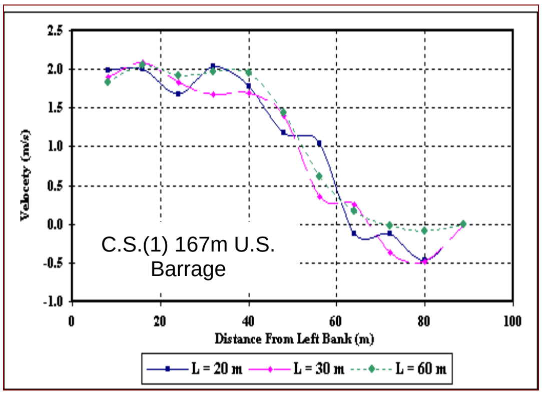


Figure 6-A. Longitudinal Velocity Distribution 167 m Upstream Barrage (Q_{max} = 433.4 m^3/s)

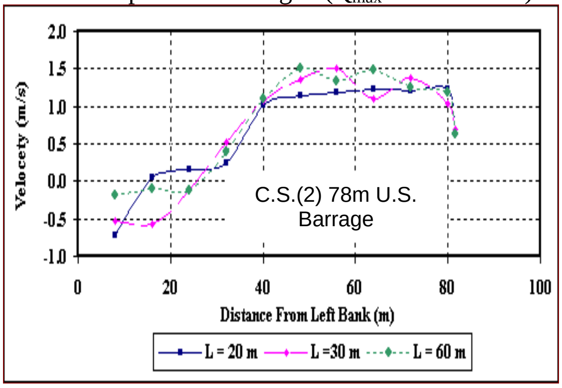


Figure 6- B. Longitudinal Velocity Distribution 78 m Upstream Barrage (Q_{max} = 433.4 m^3/s)

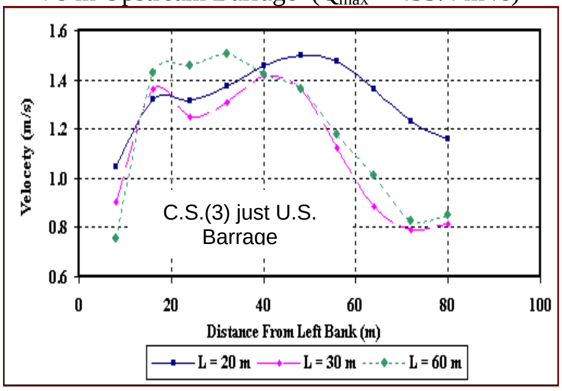


Figure 6- C. Longitudinal Velocity Distribution Directly Upstream Barrage (Q_{max} = 433.4 m^3/s)

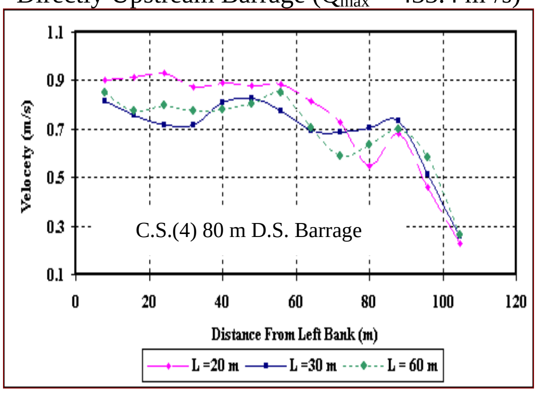


Figure 6-D. Longitudinal Velocity Distribution 80 m Downstream Barrage (Q_{max} = 433.4 m^3/s)

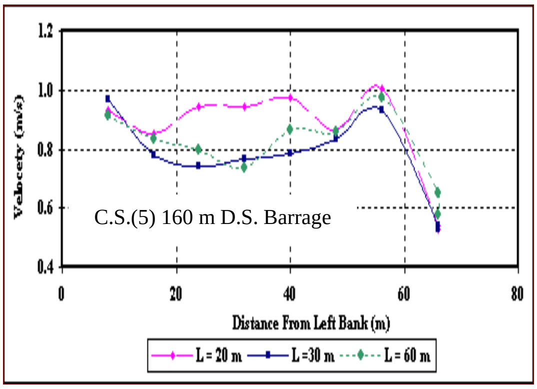


Figure 6-E. Longitudinal Velocity Distribution 160 m Downstream Barrage (Q_{max} = 433.4 m^3/s)

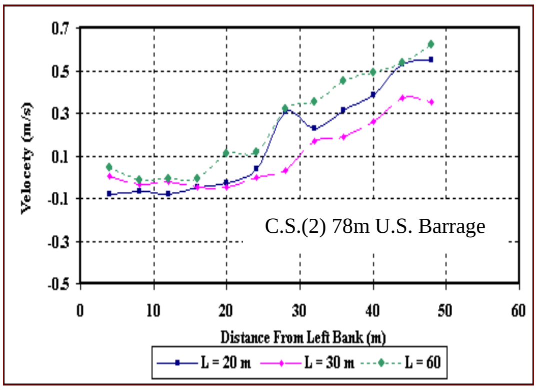


Figure 7-B. Cross Velocity Distribution 78 Upstream Barrage (Q = 433.4 m3/s)

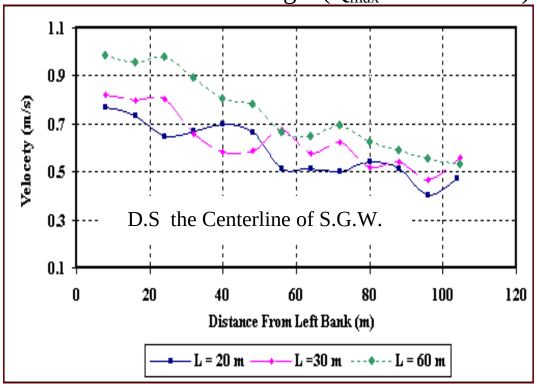


Figure 6- F. Longitudinal Velocity Distribution Downstream the Center Line of the Guide Wall

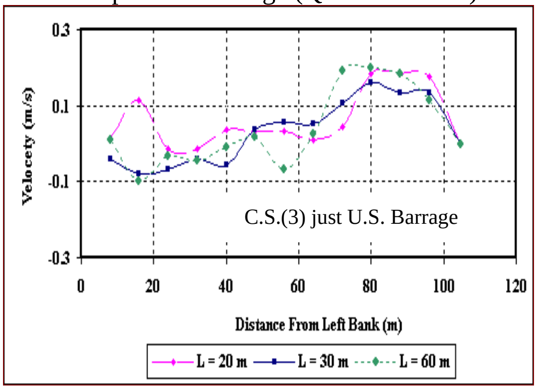


Figure 7-C. Cross Velocity Distribution Directly Upstream Barrage (Q = 433.4 m3/s)

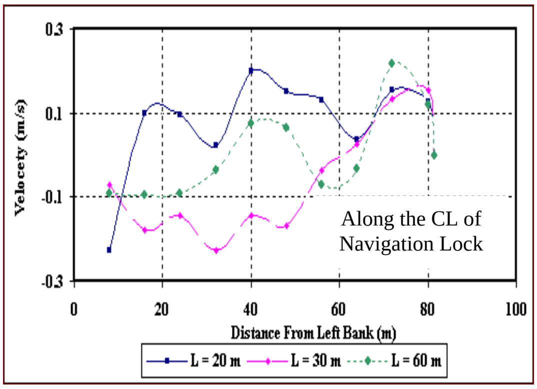


Figure 6-G. Longitudinal Velocity Distribution along the Center Line of the Navigation Lock

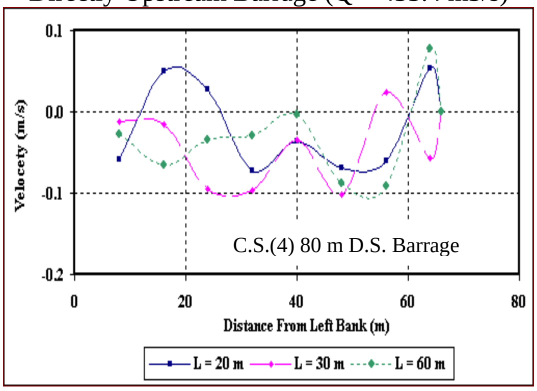


Figure 7-D. Cross Velocity Distribution 80 m Downstream Barrage (Q = 433.4 m3/s)

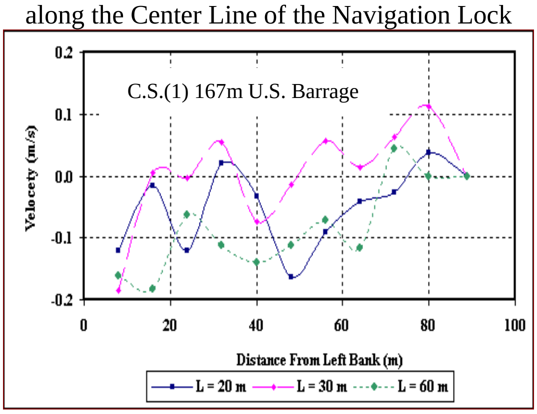


Figure 7-A. Cross Velocity Distribution 167 m Upstream Barrage (Q = 433.4 m3/s)

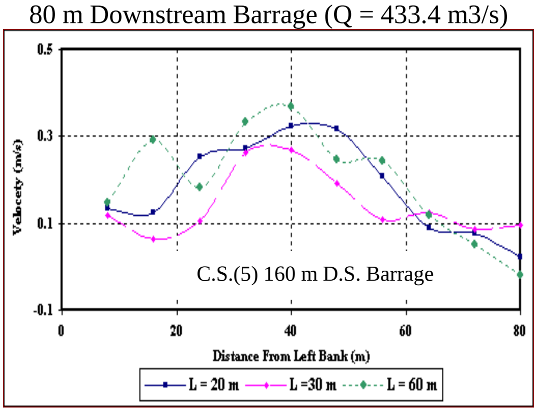


Figure7-E. Cross Velocity Distribution 160 m Downstream Barrage (Q = 433.4 m3/s)

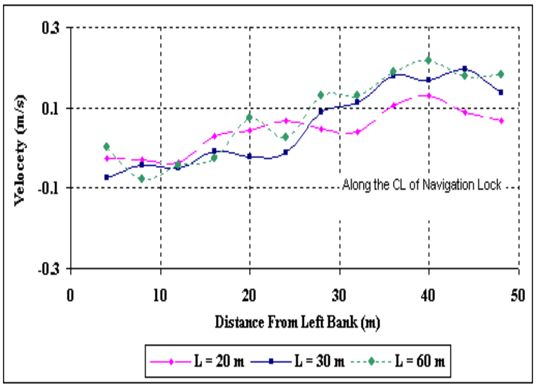


Figure 7-F. Cross Velocity Distribution Downstream the Center Line of the Guide Wall

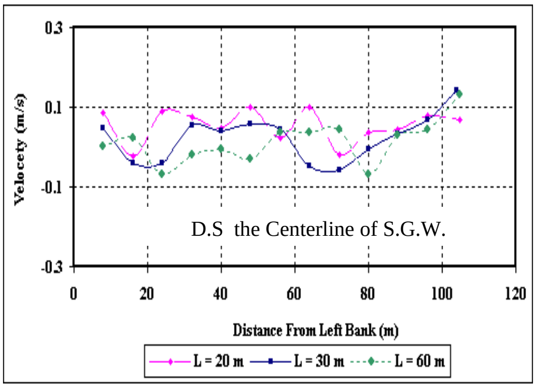


Figure 7-G. Cross Velocity Distribution along the Center Line of the Navigation Lock

Photo 1. Construction of the Model

Photo 2. The Model before Constructing New Barrage

Photo 3. The Model after Constructing New Barrage

Photo 4. Flow Currents D.S. Barrage using 20 m Long SGW (Q_{min})

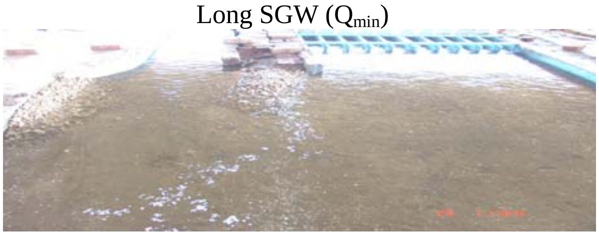


Photo 5. Flow Currents D.S. Barrage using 20 m Long SGW (Q_{max})

Photo 6. Flow Currents D.S. Barrage using 30 m Long SGW (Q_{min})

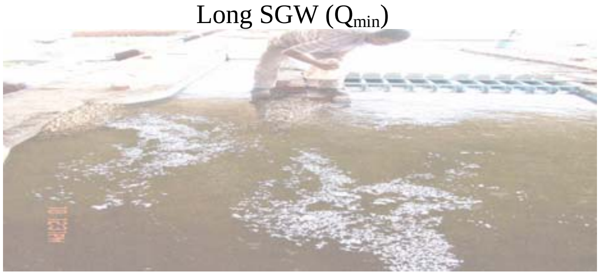


Photo 7. Flow Currents D.S. Barrage using 30 m Long SGW (Q_{max})

Photo 8. Flow Currents D.S. Barrage using 40 m Long SGW (Q_{min})

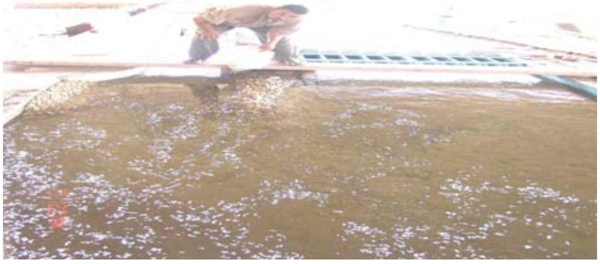


Photo 9. Flow Currents D.S. Barrage using 40 m Long SGW (Q_{max})

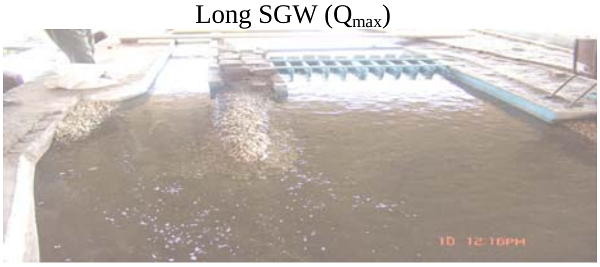


Photo 10. Flow Currents D.S. Barrage using 50 m Long SGW (Q_{min})

Photo 11. Flow Currents D.S. Barrage using 50 m Long SGW (Q_{max})

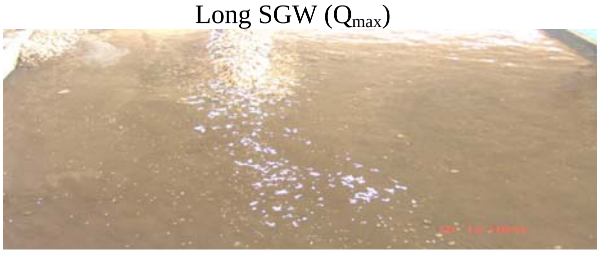


Photo 12. Flow Currents D.S. Barrage using 60 m Long SGW (Q_{min})

Photo 13. Flow Currents D.S. Barrage using 60 m Long SGW (Q_{max})