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Design and Fabrication of A trapezoidal Form for Precasting of Concrete Canal-lets

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Abstract**—** *Canalization system at Rawakeeb Research Station (RRS) experienced high water losses due to seepage. Based on maximum expected discharge at RRS of 200 m^3/s, a trapezoidal cross section form is designed then fabricated of local materials (angle bars, rectangular pipes, steel sheets, iron steel shaft, roller thrust bearings, steel wire and nuts) with the dimensions of 82 cm (width) x 2.5 m (height) x 82 cm (long) to precast concrete canal-lets of 1 m × 55 cm × 8 cm (length, width, thickness) as required for lining of RRS canal. Designed unit discharge and flow velocity were found to be 0.06 m^3/s, 0.5 m/s, precasted concrete canal-lets then cured for 14 days. The suggested trapezoidal form design can be adopted to produce trapezoidal precasted concrete canal-lets without distortions, precasted concrete canal-lets provided required water tightness. As a result the suggested precasting technique can be adopted.*

Keywords**— *Seepage, Canal Lining, Precasting Technique.***

I. INTRODUCTION

Life is tied to water as it is tied to air and food. Sudan occupies a region that is located in the middle part of the Nile Basin to the south of Egypt. The country is located within the Sudano- Sahelian region in north east Africa, with geographic coordinates of 4˚ and 22˚ N and 22˚ and 38° E. Sudan area was reduced from 2.500.000 km^2 to 1.882.000 km^2 following the independence of South Sudan in 2011. Most of Sudan area is located within arid and semi-arid regions. During the second half of the previous century, the arid and semi-arid regions of the country were subjected to different forms of land degradation. West of Omdurman particularly Rawakeeb Area, located within the arid region, experienced severe land degradation such as sand encroachment and deforestation in the past few decades, due to the influx of displaced people who entered the area fleeing from famine in Kordofan state and other parts of the country (Ahmed *etal.*, 2009[1]; Mahgoub, 2014[2]; El Gamri, 2004[3]). In many locations around the globe unlined irrigation canals are characterized by very high water losses. Out of these losses, seepage is the most significant one. Unlined canals lose a substantial part of the usable water through seepage so substantial amounts of water can be saved by improving water management at the farm (Ahmed *etal.*, 2008[4]; Uchdadiya *etal.*, 2014[5]; Ahmed, 2007[6]; Ahmed *etal.*, 2014[7]; Ahmed *etal.*, 2017[8]). Canalization system at Rawakeeb Research Station (RRS) has been suffering the problem of high water losses due to seepage (Ahmed, 2007[6]). Canal lining using precasting technique is anticipated to solve this problem for the following reasons: (a) Precasting has proved to be one of the best types of lining. (b) Availability of coarse aggregates and sand in the vicinity of RRS. (c) Availability of labor. The objective of this research is to design and fabricate a trapezoidal form to produce precasted concrete canal-lets that provided the required water tightness for lining of RRS canal. To achieve this goal, a trapezoidal section form was suggested considering many design aspects including; operation power, cross section and removing out of concrete canal-lets.

II. MATERIALS AND METHODS

2.1 DESIGN OF CANAL CROSS SECTION

The trapezoidal cross section was suggested considering many factors related to RRS conditions such as topography, soil type, operation power, and construction technique and form maintenance. A simple online flow calculator (Sturmfels, 2016[9]) based on Manning equation has used to calculate flow velocity and unit discharge out the following parameters:

a) With reference to Birch *et al* (1994[10]) and DWSRM/ENRDRI/NCR (2016[11]),canal top width was selected to be 0.41 m, canal bottom width was selected to be 0.25, canal depth was selected to be 0.47 m, and flow depth was selected to be 0.37 m.

b) Canal bed slope (S) was selected to be 0.001 m/m as suggested by Mashhadi, (1994[12]).

c) With reference to Zaidi, (1994[13]) the Manning's coefficient of roughness (n) was selected to be 0.016.

d) With reference to Michael, (1978[14]) the value of 0.1 m was selected for free board.

2.2 THE DESIGN OF CONCRETE CANAL-LET FORM

2.2.1 DESIGN AND FABRICATION OF INNER FORM

The original trapezoidal cross section was suggested by Birch *et al* (1994[10]), considering mentioned factors related to RRS, concrete canal-lets are to be precasted with the modified dimensions shown in Fig (1). The materials used to fabricate the inner form were:

1. Angle bars of 1¼″ (3.15 cm) side thickness.

2. Angle bars of 1½″(3.81 cm) side thickness.

4. Hot rolled (HR) of 3 × 6 cm rectangular pipes.

5. Cold rolled (CR) of 3 × 6 cm rectangular pipes.

6. Hot rolled (HR) of 5 × 2.5 cm rectangular pipes.

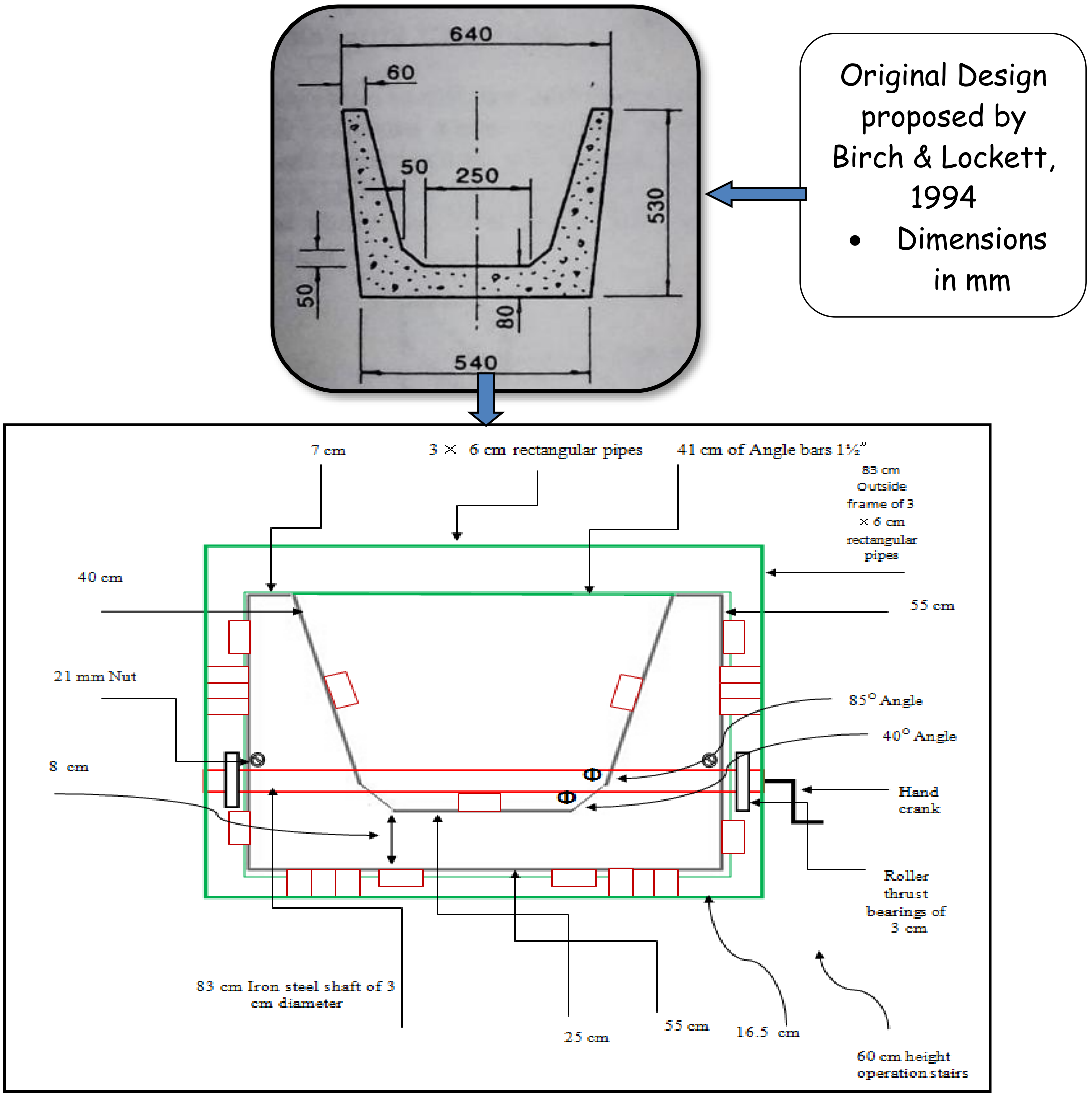

Fig.1: Proposed Design of Concrete Canal-Let Form

Plate (1) Fabricated inner steel form section

Plate (2) 21 mm Handling points

7. Cold rolled (CR) steel sheet of 1 mm thickness.

The trapezoidal section inner form was fabricated out of CR steel sheet of 1 mm thickness as shown in plate (1). Inner form was supported longitudinally from inside and outside with HR 3×6 cm rect. pipes welded internally and externally at each side. Four shaped angle bars of 3.15 cm were welded internally and externally to support the form transversally. Two 21 mm nuts were welded at the upper part of the form as handling points as shown in plate (2). Also, the inner form was supported with four HR 3×6 cm rect. pipes welded externally as sliding bars (two bars welded at back and one bar at each side) to facilitate up and down movements of it during operation. The bars were designed to be slided through four stand guides as shown in plate (3).

2.2.2 DESIGN AND FABRICATION OF MAIN FRAME

The main frame was fabricated of HR 3×6 cm rect. pipes with dimensions of 82 cm (width) x 2.5 m (height) x 82 cm (long). Three sides of the frame were provided with 3×6 cm rect. pipes welded externally to support the form longitudinally and to act as a guides for inner form sliding bars so as to ease handling of the inner form as shown in plate (4). The upper part of main frame was also provided with a hand cranking system as shown in plates (5) and (6). Hand cranking system (act at the same time as handling system for inner form) was fabricated of 3 cm Iron steel shaft, 3 cm Roller thrust bearings, 17 mm Screw pins and nuts, 21 mm Nuts, 5 mm Aluminum wires and 2 cm Steel hand crank.

2.2.3 PRECASTING OF CONCRETE CANAL-LETS

Precasting of concrete canal-lets had done following below steps:

1. Painting of inner form and sliding guides with burned car oil.
2. Preparing of fresh concrete mixture of 1:2:3 (cement: gravel: sand) to be added.
3. Compaction of concrete mixture inside inner form then after while, a gentle removing of inner form as shown in plate (7) and finally curing of concrete canal-lets for 14 days.

III. RESULTS AND DISCUSSIONS

Selected thickness of precasted canal-lets of 8 cm was found to be reasonable since Mashhadi, (1994[12]) reported that; in cases where foundation or subgrade conditions are unfavorable, or where high velocities are inevitable, thicknesses of 5.08 to 12.7 cm (2-5 in) have been used. No general rule can be stated for establishing the thickness of concrete lining which is not a structural number. For small canals such as RRS canal, un-reinforced concrete lining of 1½ inch thickness has been satisfactory.

Plate (3) Sliding bars of the inner form

Plate (4) Parts of main frame

Plate (5) Parts of hand cranking system

Plate (6) Cranking Mechanism

Plate (7) Removing out of inner form

In the Pakistan Command Water Management Project, concrete lining thickness of 3 inches with 1:2:4 volumetric mix (strength 3,000 ib/in^2) has been used for all canal section, discharge ranging from 6 to 600 cusecs. The obtained unit discharge of .06 m^3/s was found to be reasonable since the maximum discharge at RRS is expected to be about 200 m^3/s. The obtained flow velocity of 0.5 m/s was found to be as well as recommended by Kraatz, (1977[15]). 14 days of curing was found to be ideal as recommended by Mashhadi, (1994[12]) who stated that concrete cured for 14 days had a 28 day strength, as twice as that of concrete which was allowed to dry in open air. Many advantages were observed during precasting with the fabricated form:

1. The form can be operated manually easily.
2. Precasting (i.e. filling and smoothing of mixture) can be done easily and rapidly; no form accessories are needed.

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3. The precasted concrete slabs can be removed out of the form easily (i.e. no need for hummer blows), no technical maintenance is needed and the form can be stored anywhere under any storage conditions .
4. Curing of 14 days provided the required water tightness.

IV. CONCLUSION

It can be concluded that, the suggested trapezoidal section design fulfilled all the required criteria to adopt precasting technique. Furthermore, the precasted concrete canal-lets shown in plate (8) can be produced with the dimensions of 1 m × 55 cm × 8 cm (length, width, thickness) for lining of RRS canal, with the specifications which provided required water tightness.

Plate (8) Precasted concrete canal-let

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