Available online at www.elixirpublishers.com (Elixir International Journal)

Civil Engineering

Elixir Civil Engg. 95 (2016) 40993-40997

ISSN: 2229-712X

Selection of Canal Alignment and Fixing the Canal Cross-Section by Using GIS Techniques and BIM Tools

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ARTICLE INFO

Article history:

Received: 18 April 2016;
Received in revised form: 9 June 2016;
Accepted: 14 June 2016;

Keywords

spatial analysis,
Data sets,
GIS- Geographical Information System,
BIM- Building Information Modeling Tools,
Cross-section.

ABSTRACT

GIS assist in specific planning and decision making processes in irrigation through the input, spatial analysis & output of relevant information. The real strength of GIS is its ability to integrate information. This integration power makes the scope of GIS almost infinite. The unique integration capability of GIS allows disparate data sets to be brought together to create a complete picture of a situation. GIS technology illustrates relationships, patterns & connections that are not necessarily obvious in any one data set but are amazingly apparent once the data set are integrated. The GIS based systems helps in selection & fixing of the various canal alignments in a command area. Building Information Modeling(BIM) tools is an intelligent model based process which is very helpful for planning & designing purpose. The cross-section of the canal has been fixed along the final selected alignment by using BIM tools. The aim of this study is to present the applications of GIS techniques along with BIM tools for fixing of the canal alignment and also designing a canal cross-section in Somnala Minor Irrigation Scheme of Gosikhurd Indira Sagar Project.

Introduction

In a command area three canal alignments are compared & the final alignment is selected, Depeweg et al. (2003) have given the procedure for selection of final alignment based on the GIS tools. The procedure for the canal design along the final alignment is also illustrated by using ILWIS.3 software with the help of Visual Basic(VB).

In the paper final alignment has been decided among the three selected alignments by using TIN surface model developed in civil 3D and the cross-section of the canal along the final alignment is fixed by using BIM tools, an attempt has been made for the same in this paper. For the case study " Somnala Minor Irrigation Scheme" of Gosikhurd Indira Sagar Project has been selected.

The application of GIS techniques is used for fixing the canal alignment and the canal cross-section has been fixed by using BIM tools. In this paper the discharge calculation is done as per AI/DC (Area Irrigated/ Day Cusecs) method, for which the canal alignment is divided into three reaches from chainage (0 to 810m, 810m to 1750m & 1750m to 2758m) respectively. The canal is designed by using Mannings formula for all the three reaches for which a programming is made in MS Excel. The L- section & cross-section of the canal alignment is marked by using BIM tools & the earthwork calculation is also done by using BIM tools.

Design Steps

1. Selection of final alignment.
2. Discharge calculation as per AI/DC method.
3. Canal design as per Mannings formula.
4. Marking L-Section & Cross-Section of the canal alignment.
5. Earthwork calculation.

Methodology

Input methods & programs

For the study, a part of Gosikhurd Indira Sagar Project situated situated near Bhandara District of Maharashtra State has been taken. A part of the project named " Somnala Minor Irrigation Scheme" has been considered as an illustrative example to explain the concept of GIS & BIM tools for fixing the canal L-Section & Cross-Section.

1. Selection of the Final Alignment:-

For the study three canal alignments are chosen in the study area, one alignment is existing and other two are proposed in Somnala Minor Irrigation Scheme. These alignments are studied by using GIS techniques & BIM tools. The final alignment is selected which is alignment No proposed I.

The procedure for selection of final alignment has been described by the Authours (2015)

2. Discharge calculation as per AI/DC Method:-

The total command area of proposed I is about 282.86 hectares. The alignment is divided into three reaches from chainage(0 to 810m, 810 to1750m & 1750m to 2758m) respectively. Around 16 outlets are coming in the command area and the discharge calculations are done as per AI/DC method.

In this method AI/DC=5, this formula is used for calculating discharge at canal outlets.

Where,

AI = area irrigated

DC = day cusecs

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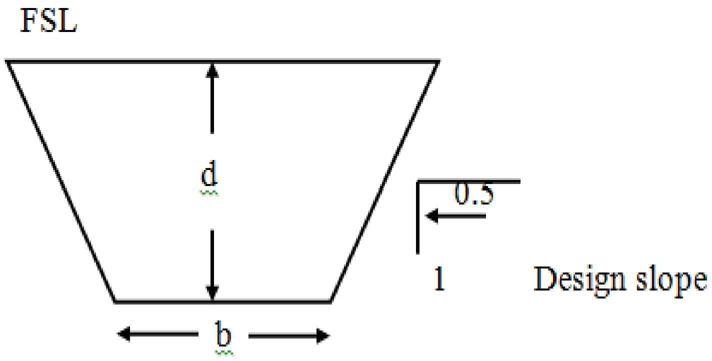
Table 1.Calculated Discharge

Sr. No.	Reach	Chainage	Discharge (m3/s)
1	I	0 to 810	0.58
2	II	810 to 1750	0.54
3	III	1750 to 2758	0.45

Table No 2.Canal Design As Per Manings Formula

Sr. No.	Cana reach in rd	Discharge for design	Required descharg (capacity factor =1.2)	Gradient=s	Side slope for design=n	Side slope for construction	N=rugosity constant	Bed width = b	Fsd = d	B/d ratio	Area	Perimeter	Hydraulic mean depth	R^(2/3)	Velocity	Calculated discharge	Free board	Total depth
1	RD 0 to 810	0.58	0.70	2500	1:0.5	1:2	0.035	2.50	1.30	1.92	4.095	5.407	0.757	0.831	0.475	1.944	0.60	1.9
2	RD 810 to 1750	0.54	0.65	2500	1:0.5	1:2	0.035	2.20	1.20	1.83	3.360	4.883	0.688	0.779	0.445	1.496	0.60	1.80
3	RD 1750 to 2758	0.45	0.54	2500	1:0.5	1:2	0.035	2.10	1.11	1.89	2.947	4.582	0.643	0.745	0.426	1.255	0.60	1.71

Design of canal section : Proposed I :
Reach I : From chainage (0 to 810m)



The thumb rule of this method is 1 outlet is to be provided for approximately 20 hectare area. The detailes are shown in figure 1 and final calculations are given in Table 1
Assume water loss as 15% for reach I, II & III respectively.

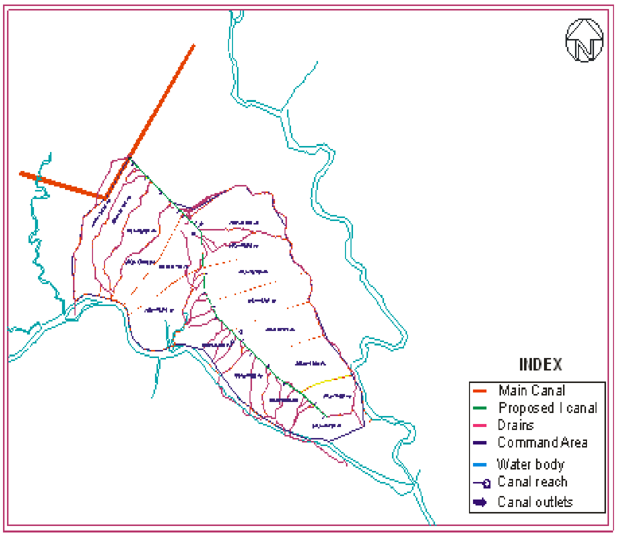


Fig 1. Discharge calculation as per ai/dc method.

3. Design of Canal Cross Section:-

The canal is designed by using Mannings formula for all the three reaches from chainage (0 to 810m , 810m to 1750m & 1750m to 2758m) respectively. The other design data are taken from Government of Maharashtra Circulars mentioned in the references. The designing and calculations are done in MS Excel program as shown in Table No. 2.

Table No. 3

Sr.no.	Parameters		Value
1	Discharge for Design		0.58 cumecs
2	Capacity factor		1.20
3	Gradient = s		1:2500
4	Side slope for design = n		0.5 : 1
5	Side slope for construction		2:1
6	N		0.035
7	Bed width		2.50m
8	FSD = D		1.30m
9	B/D ratio		1.92
10	Area	(b+nd) d	4.095m
11	Perimeter	$B+2d(n^2+1)^{0.5}$	5.407m
12	Hydraulic mean Depth	R= A/P	0.757m
13	R 2/3 =		0.831
14	Velocity	$R^{2/3}$ x $S^{1/2}$/N	0.475m/s
15	Calculated Discharge		1.944 cumecs
16	Free Board		0.60m
17	Check = Calculated Q > Progressive effective Q = 1.944 cumecs > 0.70 cumecs		

Reach II : From chainage (810 to 1750m)

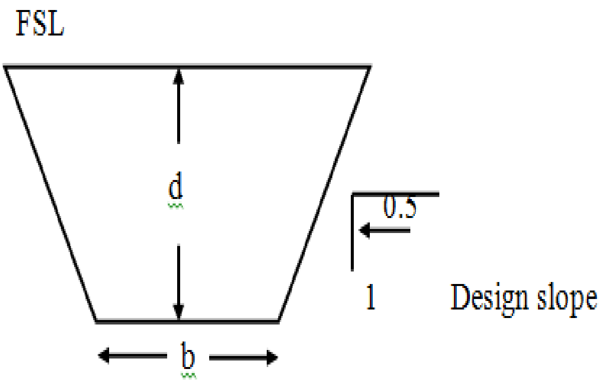


Table No. 4

Sr.no.	Parameters		Value
1	Discharge for Design		0.54 cumecs
2	Capacity factor		1.20
3	Gradient = s		1:2500
4	Side slope for design = n		0.5 : 1
5	Side slope for construction		2:1
6	N		0.035
7	Bed width		2.20m
8	FSD = D		1.20m
9	B/D ratio		1.83
10	Area	(b+nd) d	3.360m
11	Perimeter	$B+2d(n^2+1)^{0.5}$	4.883m
12	Hydraulic mean Depth	R= A/P	0.688m
13	R 2/3 =		0.779
14	Velocity	$R^{2/3}$ x $S^{1/2}$/N	0.445m/s
15	Calculated Discharge		1.496 cumecs
16	Free Board		0.60m
17	Check = Calculated Q > Progressive effective Q = 1.496 cumecs > 0.65 cumecs		

Reach III . From chainage (1750 to 2758m) .

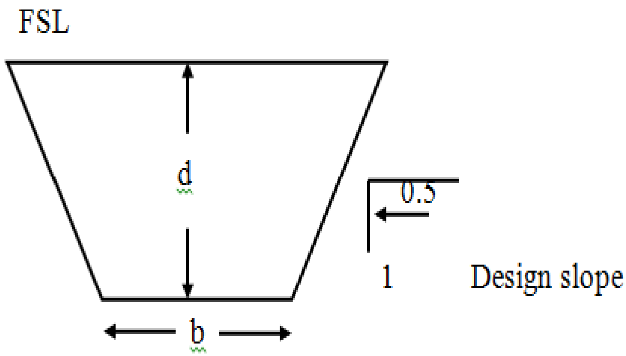


Table No. 5

Sr. no.	Parameters		Value
1	Discharge for Design		0. 45 cumecs
2	Capacity factor		1.20
3	Gradient = s		1:2500
4	Side slope for design = n		0.5 : 1
5	Side slope for construction		2:1
6	N		0.035
7	Bed width		2.10m
8	FSD = D		1.11m
9	B/D ratio		1.89
10	Area	(b+nd) d	2.947m
11	Perimeter	$B+2d(n^2+1)^{0.5}$	4.582m
12	Hydraulic mean Depth	R= A/P	0.643m
13	R 2/3 =		0.745
14	Velocity	$R^{2/3}$ x $S^{1/2}$/N	0.426m/s
15	Calculated Discharge		1.255 cumecs
16	Free Board		0.60m
17	Check = Calculated Q > Progressive effective Q = 1.255 cumecs > 0.54 cumecs		

4. Marking L- Section & Canal Cross-Section

The L section of canal alignment is design by using civil 3D software which is shown in the following figure

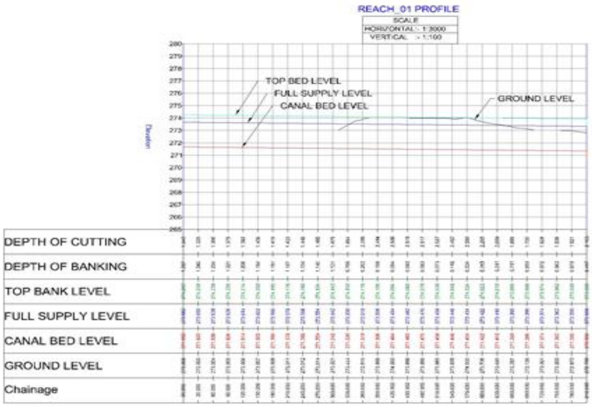


Fig 2. L-Section of Reach I.

Fig 3. L-Section of Reach II.

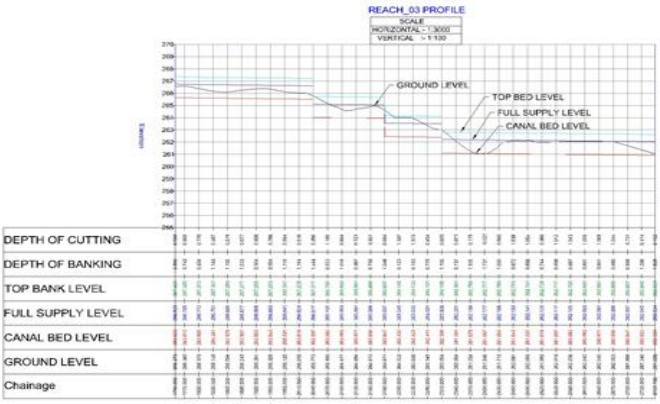


Fig 4. L-Section of Reach III.

The Cross Section of the Canal Alignment is designed by using civil 3D Software and the Interval of 10m Respectively, some specimen cross section are shown in the following figures-

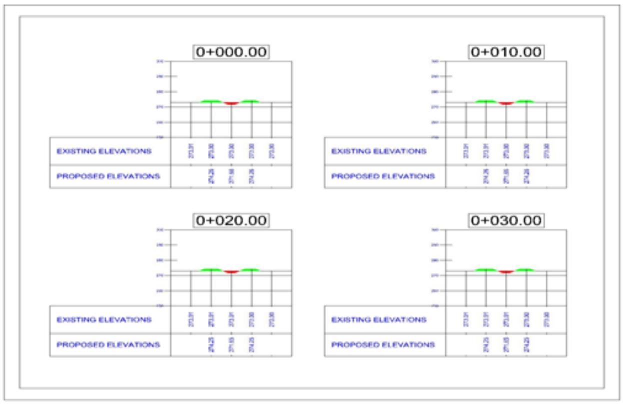


Fig 5.Cross-sections of the Proposal I Canal Alignment at the interval of 10m.

Fig 6. Cross-sections of the Proposal I Canal Alignment at the interval of 10m.

5. Earthwork calculations:-

A volume report is generated by Civil 3D software in MS Excel format which shows in detail about the calculated quantity of cutting area, filling area, cumulative cut, cumulative fill, net volume & total volume. Some specimen calculation are shown in the table below –

Table No. 6

Station	Cut Area (Sq.m.)	Cut Volume (Cu.m.)	Fill Area (Sq.m.)	Fill Volume (Cu.m.)	Cum. Cut Vol. (Cu.m.)	Cum. Fill Vol. (Cu.m.)	Cum. Net Vol. (Cu.m.)
0	15.19	0	6.15	0	0	0	0
10	15.22	152.07	6.12	61.33	152.07	61.33	90.73
20	15.26	152.41	6.08	61.01	304.48	122.34	182.14
30	15.29	152.74	6.06	60.7	457.22	183.04	274.19
40	15.32	153.05	6.03	60.42	610.27	243.46	366.81
50	15.35	153.34	6	60.15	763.61	303.61	460.01
60	15.38	153.64	5.97	59.87	917.26	363.48	553.78
70	15.41	153.96	5.94	59.58	1071.22	423.06	648.16
2680	11.04	113.64	0.11	0.53	36985.1	9988.94	26996.2
2690	10.3	106.71	0.46	2.82	37091.8	9991.76	27100.1
2700	9.57	99.37	0.88	6.68	37191.2	9998.44	27192.7
2710	8.85	92.11	1.35	11.11	37283.3	10009.6	27273.7
2720	8.16	85.05	1.87	16.07	37368.3	10025.6	27342.7
2730	7.49	78.25	2.45	21.58	37446.6	10047.2	27399.4
2740	6.85	71.69	3.07	27.59	37518.3	10074.8	27443.5
2750	6.23	65.39	3.75	34.11	37583.7	10108.9	27474.8
2757.7	5.77	46.21	4.3	31.01	37629.9	10139.9	27490

Conclusion

- With the use of Arc GIS software & BIM tools it is possible to select canal alignment, fix the canal L-section & cross-section more favorably and economically.
- The Civil 3D software provides flexibility in fixing the canal bed level, top bank level, full supply level until the desired condition is achieved.
- By using Civil 3D software the longitudinal section of canal can be generated in very short time.
- The accuracy in generating L-section of canal alignment in civil 3D is more.
- The Civil 3D also generates volume report which provides the calculated quantity of cutting and filling, therefore time is saved in the calculation of cutting and filling quantities.

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