OPTIMIZATION OF IRRIGATION NETWORK

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Abstract— The paper describes the development of a computer model that involves the applications of numerical computation and programming to the problem of least cost design of water distribution network. C# represents an efficient search method for analyze, data develop algorithms and create applications. The language tools, built in math functions enables to explore multiple approaches faster than spreadsheets and traditional programming. This paper presents an example of pipe distribution network of upper manar project nanded district. Cost optimization is carried out by C# programming.
It has been observed that selected set of diameters of pipe satisfies the requirements of constraints.

Index Terms: Optimization, water distribution network, C# programming.

I. INTRODUCTION

Pipe networks are an essential part of world's infrastructure. The construction and operation of these networks are very costly as for gas, sewerage, irrigation and electricity and communication networks. A relatively small decrease in construction and component cost of these networks therefore leads to huge total saving. These can be considerably reduced through optimal design of networks. Optimization of pipe networks is a multidisciplinary task involving hydraulics, quality and reliability requirements Pipe network optimization is also a combinatorial optimization problem as the pipe diameters can only be selected from a discrete set of commercially available sizes. In spite of all the progress made the optimization of pipe networks fulfilling all these requirements seem to be out of reach at the present time. Most of the current investigations are, therefore restricted to considering the hydraulic and availability requirements, leading to the so-called optimal pipe sizing of the pipe networks.
Around 40% of the world´s food crops are produced by irrigated agriculture and remaining 60% comes from rainfed system. (The International Fund for Agricultural Development)Over the period 2050 worlds water will have to support the agricultural system that will feed and create livelihood for an additional 2.7 billion people. The ultimate goals in managing irrigation water are efficiency, equity and sustainability. Among the distribution systems, the pressurized system has been developed during the last decades with considerable advantages with respect to open canals. The transit losses in open canal system are generally of the order of 40-50%.In case of closed pipe system the transit losses would be much less than 10%, thus efficiency of water conductor system would be more than 90%.Therefore a greater surface may be irrigated with a fixed quantity of water. They overcome the topographic constraints and make it easier to establish water fees based on volume of water consumed because it is easy to measure the volume of water delivered.
Being computationally efficient, able in finding global design and capable in solving large problems are the marked aims in developing new models.
In general Optimization methods applied to design of pipe networks are classified as mathematical and natural inspired evolutionary methods Within last two decades, many researches have shifted the focus of water distribution network optimization from traditional optimization techniques based on linear and non-linear programming to the implementation of heuristics derived from nature (HDNs) namely; Genetic Algorithms (GAs),Simulated Annealing, the Shuffled Frog-Leaping Algorithm (SFLA) and Ant Colony Optimization (ACO).
Dragon, Savic and Walter (1997) developed computer model for least cost optimization problems for water distribution network system optimization. Aaron C. Zecchin Michael Leonrd (2006) presented two ant colony optimization algorithms to water distribution system optimization.

Fig 1 Irrigated area by region1990

II. METHODOLOGY

C# is a multi-paradigm programming language encompassing strong typing, imperative, declarative, functional, generic, object-oriented (class-based), and component-oriented programming discipline.

C# can be written with any text editor, like Windows Notepad, and then compiled with the C# Command line compiler, csc.exe, which comes with the .NET framework. However, most people prefer to use an IDE (Integrated Development Environment), and Microsoft offers several options for this. Their flagship is Visual Studio, which can be used to work on every possible aspect of the .NET framework. This product is very advanced, and comes in several editions.

Microsoft visual studio

Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop computer programs for Microsoft Windows, as well as web sites, web applications and web services.

Visual Studio supports different programming languages and allows the code editor and Debugger to support (to varying degrees) nearly any programming language, provided a language-specific service exists.

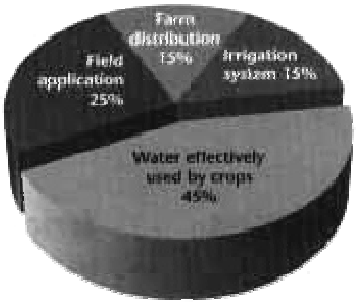

Fig.2.Irrigation losses: where the water goes

III. CASE STUDY

The example of case study is one of the off take from upper manar project tq.Loha, District Nanded. The upper manar medium project envisages an earthen dam of gross storage capacity of 107.986Mm³ across manar river just upstream of limboti village tq.Loha, dist Nanded in Maharashtra state. The CCA of the project is 8750 ha. The CCA of the off take is 218.55 ha.

Design considerations

Data required for pipe network such as total no. of links, Irrigable area at each outlet, discharge required at each outlet and length of pipe, available head in meters, is given in table I.

Problem Formulation

For least cost design of pipe distribution network objective function is formulated as equation (1). In C# programming diameter of each pipe is replaced by available discrete size diameters and network is checked for head constraint which gives us optimized diameter for each pipe.

$$\text{Total cost}=f(D1\ldots Dn)=\sum_{i=1}^{N} C(Di,Li) \quad \ldots\ldots\ldots(1)$$

where C (Di,Li)cost of pipe i with diameter Di and length Li and N = total number pipes in the system.The objective function is to be minimized under the following constraints :

$Haj \geq Hrj$……..(2)

$Di = Da$ ……(3)

Haj = Head available at jth node in meter which is ground elevation difference at two ends of pipe,Hrj = Head required at jth node in meter which is calculated by formula = (1.62*Q^1.852*D^-4.87*L) where Q = discharge required at ith outlet in m³/hr,diameter D in cm,length in m.Di = diameter of ith pipe in meter Da = commercial available diameter in meter.

TABLE I: DESIGN PARAMETERS

Sr.No	Pipe	Length m	Area ha	Discharge m³/hr	Avail.Head m
1	L1	376	4.78	11.87	1.85
2	L2	218	4.46	11.07	2.85
3	L3	97	4.45	11.06	2.45
4	L4	76	5.04	12.53	2.35
5	L5	142	6.89	17.13	2.65
6	L6	230	3.68	9.15	1.85
7	L7	56	4.39	10.91	0.35
8	SM1	190	8.08	21.23	2
9	SM2	412	33.71	88.58	1
10	L8	256	4.71	11.69	2.05
11	L9	86	5.60	13.92	0.35
12	L10	438	6.24	15.51	1.85
13	L11	309	5.41	13.44	0.65
14	L12	214	3.89	9.66	0.35
15	SM3	393	59.56	156.52	6
16	L13	446	5.97	14.83	3.85
17	L14	529	5.43	13.48	3.35
18	L15	393	5.68	14.10	0.35
19	L16	193	6.85	17.02	0.35
20	L17	148	4.04	10.02	0.35
21	L18	210	5.74	14.25	0.65
22	L19	208	5.83	14.47	0.65
23	SM4	168	11.56	30.39	2
24	L20	58	4.52	11.24	0.65
25	L21	58	3.73	9.28	0.65
26	SM5	325	19.82	52.09	4
27	L22	104	6.05	15.02	1.25
28	SM6	228	25.87	67.98	5.5
29	L23	103	4.97	12.36	2.55

30	L24	16	5.60	13.91	0.35
31	SM7	158	36.44	95.77	0.5
32	SM8	908	123.96	325.77	1.86
33	L25	408	5.85	14.54	5.25
34	L26	352	6.97	17.32	4.65
35	L27	140	4.90	12.17	1.55
36	L28	76	6.46	16.06	1.05
37	SM9	366	24.19	63.57	4
38	L29	168	6.45	16.02	1.85
39	L30	170	6.04	15.00	2.05
40	L31	322	7.30	18.35	4.05
41	SM10	62	44.07	115.81	1
42	L32	63	6.19	15.37	0.65
43	SM11	481	50.26	132.07	3.8
44	L33	472	6.70	16.65	1.15
45	L34	268	7.55	18.75	0.65
46	L35	28	6.54	16.25	0.65
47	SM12	112	71.13	186.93	1.06
48	L36	248	6.48	16.11	3.25
49	L37	64	5.60	13.90	1.05
50	SM13	157	12.08	31.75	3
51	L38	28	5.82	14.46	0.35
52	SM14	261	17.90	47.05	0.5
53	L39	22	5.56	13.80	0.35
54	SM15	116	23.46	61.65	1.36
55	M	36	218.55	590.08	1.25

TABLE II: Results Obtained C# Programming

RESULTS OBTAINED BY C	Length	Optimized Diameter	Rate of pipe	Cost of pipe
1	376	9	95.2	35795.2
2	218	7.5	68.3	14889.4
3	97	6.3	48.15	4670.55
4	76	6.3	48.15	3659.4
5	142	7.5	68.3	13518.4
6	230	7.5	68.3	15709
7	56	9	95.2	5331.2
8	190	9	95.2	18088
9	412	22.5	616	253792
10	256	9	95.2	24371.2
11	86	11	129.9	11171.4
12	438	11	129.9	56896.2
13	309	11	129.9	40139.1
14	214	11	129.9	27798.6
15	393	18	389.75	153171.75
16	446	9	95.2	42459.2
17	529	9	95.2	50360.8
18	393	14	217.3	85398.9
19	193	12.5	171.35	33070.55
20	148	11	129.9	19225.2
21	210	11	129.9	27279
22	208	11	129.9	27019.2
23	168	11	129.9	21823.2
24	58	7.5	68.3	3961.4
25	58	7.5	68.3	3961.4
26	325	12.5	171.35	55688.75
27	104	9	95.2	9900.8
28	228	12.5	171.35	39067.8
29	103	6.3	48.15	4959.45
30	16	7.5	68.3	1092.8
31	158	22.5	616	97328
32	908	40	2209.3	2006044
33	408	7.5	68.3	27866.4
34	352	9	95.2	33510.4
35	140	7.5	68.3	9562
36	76	9	95.2	7235.2
37	366	14	217.3	79531.8
38	168	9	95.2	15993.6

39	170	9	95.2	16184
40	322	9	95.2	30654.4
41	62	16	286.7	17775.4
42	63	9	95.2	5997.6
43	481	20	481.6	231649.6
44	472	12.5	171.35	80877.2
45	268	12.5	171.35	45921.8
46	28	7.5	68.3	1912.4
47	112	22.5	616	68992
48	248	9	95.2	23609.6
49	64	7.5	68.3	4371.2
50	157	11	129.9	20394.3
51	28	7.5	68.3	1912.4
52	261	18	389.75	101724.8
53	22	7.5	68.3	1502.6
54	116	14	217.3	25206.8
55	36	28	997.9	35924.4
			Total COST	=Rs.38,83,565.35

CONCLUSION

In this paper a programme is developed for optimization of irrigation network by using C# proggamming. Results obtained are validated with computer spreadsheet. It is observed that C# programming gives better results than spreadsheets. In C# there are very less chances of errors. This is time saving method. Once the programme is set for particular constraints same programme can be used for design of other networks. So if we have the details like length, discharge, head available, head required for a network C# gives the results in seconds.

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