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Innovative Method of Finding Discharge, Velocity & Diameter Simultaneously in the Drinking Water Supply Distribution Network

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ABSTRACT: *TheEqualization is the word system design about quantification of factors desires of. It is on better stand to design any network system on safety by possible equilibriums. Somewhere it may be different but that also must be in proper conformance without causing any disturbance, in segment-wise by magnitude. Network analysis of the distribution network (from treated water storage tank to the city's population) of drinking water supply is always done to have this property of design ahead/critically in every loop of the pipe system of city. Hardy-cross method is the well-known name in this regard. This study has explained a typical estimation procedure to design the equalization. Not only the flow or discharge of pipe, the velocity & diameter of the pipe in a loop-section have also been found suitably determined by the way this study has shown. Entire determination has followed the goal of 'desirable' head-loss which is why the property has been so introduced to derive its inter-relation. In the procedure of formation of the estimation some most nearby physical phenomena have been imparted so as to make & bring the possible operation in relation with maintaining the desired property. This study has shown the inter-relation of the various factors used & found & their immense scopes of future working with the goal for which this study has been presented of.*

KEYWORDS: Water supply, Distribution network, Loop, Flow correction, Hardy-cross method, Darcy-Weisbach equation, Continuity equation, Head-loss criteria, Head Loss versus Pipe Diameter & Flow-velocity, Entire design, Iteration.

INTRODUCTION

Water supply project is the life-line of its place. Its proper planning, design & implementation should be done carefully. Water supply engineer or Infrastructure engineer should have the level of clear cognition at every stage of the scheme. Many a times, the renovation works are seen here & there due to capacity concern. This not only increases the budget, it also causes city-life congested additionally. Various design softwares have been in the market & getting applied on the factorial suitability. The Engineer must check the specification as well as the specifically applicable software going to be run on need. Otherwise it's not so tough to have the view of rhythm of life of the city under such. It's ultimately the very serious concern of whether the city shall run smoothly 24x7 under a selected design of distribution network on all through. Keeping this in vision, a procedural method is developed & discussed here in this study which shall be able to derive the corrected flow-values in a composite way of estimation.

In the Hardy-cross method, flow-correction is done on the assumed flows owing to the reason of the intensity of magnitude in the flow-values, even if corrected also. The aim is kept at finding the most possible minimum magnitude in the value of the correction of flow so that error in distribution of the flow becomes the possible lowest. This possible extent is called in this study as the 'desired' extent in choosing the 'stable' flow-correcting value/ mechanism. The goal of reaching at the stable state of flow-equalization has not been altered in this study. This study has shown a procedure of iterative kind, to some extent. This procedure has been guided by related limitation, physical property in maintaining the flow, application of their inter-dependency, suitable orientation/movement etc. - ultimately with little efforts the stabilized/the desired distribution in determining the corrected flow has become in estimation. As said in goals, there are the flow-variables such as velocity, pipe diameter, etc. involved in the procedure while finding the corrected flows. This has thereby a simultaneous outcome in each iteration of the variables so attached. It's again here required to be mentioned that this study's entire determination is to reach at the desired value of the head-loss only, around a loop in the pipe network.

GOALS OF THE STUDY

i. To determine the corrected pipe-flow about the consideration given to the head-loss, alongwith the simultaneous estimation of its related flow-variables such as velocity, diameter etc.

ii. To have stability & confirmation on the entire safety in the distribution network design.

iii. To configure out skeletal problems & give preventive measure with reasonable adjustments.

ASSUMPTION

i. Continuity of flow is applicable.

ii. The head-loss equation of the Darcy-Weisbach equation ($H_L=KQ^x$) is applicable; H_L, K, Q, x etc. are the flow-variables.

ii. Head-loss (H_L) is inversely proportional to the pipe diameter (D) –

(a) H_L less, more D, more energy lost is due to it

&,

(b) H_L more, less D – less energy lost occurs.

iii. Head-loss consideration in determining the flow-variables is given the prime guideline.

iv. The corrected-flow estimation is with respect to the desirability in the guiding value of H_L.

v. Head-loss (H_L) around a loop must be zero at critical value/equilibrium in the value of H_L.

vi. Discharge (Q) around a loop must be equal to the sub-flows.

vii. Iteration for a loop depends on the number of the pipe-line in the loop & may be forward or backward for each pipe in the loop.

METHODOLOGY

In this study, general physicality has been applied & the flow-variables have been corrected & found by equating the physicality with the general expression given by the Darcy-Weisbach equation. Here the variables are first of all expressed as functionary element & then its fundamental has been estimated. It's described as followed –

Writing the following functionary property as given in assumption of this study:

The Methodological Property:

Function of the head-loss, f(H), of a pipe in a loop is inversely proportional to the functionary element of the diameter of pipe, f(D)- more energy is used.

Or in reverse mode, the function of diametrical element, f(D), of a pipe of the loop increases with the decrease in the function of the head-loss, f(H).

The amount of the energy lost depends on whether f(H) is more or less than f(D).

Now the property is given by the following expression

f(H) = P1/f(D)

where, P1 = Proportional constant (it depends on various factors of pipe's flow-mechanics).

Or, f(D) = P1/f(H) ... (Eq.A)

By the continuity equation Q = VA ; V = velocity, A = Pipe's flow area

Equation of the continuity equation is expressed by the following functionary representation

f(Q) = f(V)f(A)

Or, f(A)=f(Q)/f(V) ... (Eq.B)

A = function of Pipe diameter = f(D)

Eq.(B) is hereby given in terms of the following flow-variables in functionary form as

f(D) = f(Q)/f(V)... (Eq.C)

Or, f(V)=f(Q)/f(D)

f(Q) = f(V)f(D)... (Eq.D)

The Eq.(A) & Eq.(D) represent the methodological aspect of this study.

Equating Eq.(A) & Eq.(D),

f(Q) = f(V) P1/f(H)... (Eq.E)

Or, f(H) = (P1)f(V)/f(Q) ... (Eq.F)

Or,

f(V)=f(Q)f(H)/P1 = P2 f(Q)f(H) ... (Eq.G)

Thereby, the methodology of this study has derived the flow-variables such as V, Q, H, A etc. in terms of the methodological equation of inter-relationship amongsts.

From the Eq.(G) of the various flow-variables the corrected ones may be determined with regards to property of equation by the provision of the judgementative variable.

After finding out the required variables of the flow of distribution network confirmation in the estimated values may be finalized using the following way -

The fundamental property of flow in pipe is given by the Darcy-Weisbach equation in terms of functionary form of the flow-variable(H=Head-loss) as f(H)= Kf(Q) ; where K is a functionary property of the Pipe dia (D) & Pipe length(L).

Or, H = K(Q^x) ...Eq(X)

From Eq.(A) to Eq.(G) the determination may be done by the suitable use of it.

Estimation procedure:

In this study, the flow variables are shown to have been determined simultaneously in one estimation method. It is not quite common to experience such determination where all the necessary variables could be estimated. This is the resulting outcome for the assumption so implemented. Here, two methods of estimation for the flow ddesign in the distribution network are given in the following as procedural sequences -

1st Method (Table 1) – Method of Simulatneous Iteration

I. For single pipe design

i. see the Table 1.

ii. Select the pipe loop & define the 1st set (q01) of the pipe-flows.

iii. Specify the P1 value(P01) of this 1st set of flow through the pipe.

iv. Assume Pipe dia & Length in col.(4) & determine V in col.(5).

v. Define the value of x for the pipe

vi. Determine the value of K using the equation $K=(1/470)(L/D^{4.87})$

vii. Determine the 1st set Head-loss(H01).

viii. In order to assess the range of H value 2nd set (H02) is required similarly but reasonably.

ix. Repet the procedure in the same way to determine the H03.

x. Compare & determine the H's.

xi. Final set depends on the value of H desired & increase in the no. of sets increases the precision level towards better & correct value of the flow-variables.

Xii. Although right on the 2nd set the desired H value (if it's H-based) may be fixed, but it's nonethelessly quite risky.

II. For single loop design

In designing the loop of a pipe network in one estimation the siimilar procedure as given in for **'single pipe design'** should be applied except on the following procedure of importance -

i. The three sets described in Table 1 or in the procedure of the **'single pipe design'** shall constitute ONE set for this case. In each such set, there shall be three H's simultaneously, each of which must be designed on the basis of the assumed values, either by Q-basis or H-basis, as a whole, of the entire ONE set of such variables.

ii. Repeat the same procedure of forming such ONE set as given in (i) here.

iii. Reminder should be on the chosen assumed values of the flow-variables.

Iii. The design shall be the correct one when the basis of the design must be correct & the correction given in the lowest bottom row of the Table1 is the correct one.

iv. 'Foreward-backward-foreward' mechanism may not be applied here in this design – Rather, here the Q-basis or the H-basis of design shall remove this optional mechanism as explained in col.(8).

2nd Method (Table 2) – Method of Simulatneous Evolution

i. This method is given & discussed here with regard to the consideration of the head-loss(H) shown in col.(7) of Table 2. It may also be derived with respect to the Q values as to be desired of – the defining equation is **f(H) = (P1)f(V)/f(Q)** which may also be expressed in terms of Q.

ii. In this method the pipes of a loop are not designed as whole entirely & simultaneously.

iii. The design procedure by this 2nd method consists of two significance -

a. The 1st step – here the value of the H is assumed/estimated in the way as shown in Table 1. It may also be from assuming the Q value based on the Q-based estimation as discussed earlier in this study.

b. After determining the H value (H001) by any possible way as discussed in (i) here, the defining stage of this method (the Table 2) starts.

iv. The flow-area(A001) of the Pipe, given in col.(4), is then estimated by the equation f(D)= P1/f(H); where P1 already been fixed by the way the 1st step has been made of.

v. Assume then the flow velocity (V001) given in the col.(5). This assumption should be after its permissible abidance.

vi. The discharge(corrected) is then estimated using the 'defining' equation f(Q) = P1f(V)/f(H) from the col.(1), here it's q001.

vii. Thereby this method has, in the way it's described here the flexibility in choosing the value of V resulting the simultaneous design of pipe dimension simultaneous to the corrected flow estimation.

In addition to the knowledges so gathered from the procedural discussion step-wise it is to be metioned here that there may be also another/multiple direction of estimation procedure found out using the Table 1 & Table 2 as just the correlative one or by making its opposite or by inter-mixing judiciously of the flow-variables so associated as discussed in this study's work/methodology.

CHECK:

Following outlets may be used on the results obtained from the Table 1 & Table 2 on behalf of getting confirmation over the determined results derived out using the methods of this study -

Equating Eq.(X) & Eq.(A), $(P1)f(V)/f(Q) = KQ^x$

It has the following solution –

$(P1)f(V)/f(Q) - KQ^x = 0$ ... (Eq.Y)

Or, $(P1)f(V)/f(Q) = KQ^x$

$(P1)f(V) = (KQ)Q^x$; assuming $f(Q) \sim Q$

$(P1)f(V) = KQ^{x+1}$

$Q^{x+1} = (P1)f(V)/K$

$f(V) = KQ^{x+1}/(P1)$

$f(V)/Q^{x+1} = K/P1$

...(Eq.Z)

Thereby the Eq.(Y) & Eq.(Z) be the two equations given here to be used for the confirmation.

Table.1: Distribution Design of Network for Drinking Water Supply

Sl.	Assumed Flow (Qa = q)	P1	Diameter, (D for A) (assume next best) & L	(V) = Qa/A (in each pipe of the loop)	Value of the factor x, K	f(H) = (P1)f(V)/f(Q) (check with H = KQ^x)	Remarks on corrected flows*
col.(1)	col.(2)	col.(3)	col.(4)	col.(5)	col.(6)	col.(7)	col.(8)
	q01	P01	D01 ~ A01, L01	V01=q01/A01 (Foreward)	x01,K01	H01	Selection of q01, q02, q03 depends on the desired 'H'; the corrected flows may be found by **backward movement** also & also in combination of both, foreward & then backward or foreward-backward-foreward & so on depending on desirability, of whether the Q or H basis indeed.
	q02	P02	D02 ~ A02, L02	V02=q02/A02 (Foreward)	x02,K02	H02	
	q03	P03	D03 ~ A03, L03	V03=q03/A03 (Foreward)	x03,K03	H03	
Correction	Sum = sum of applied flows					Sum = zero or else	

*check with contnuite equation Q=AV

Table.2: Distribution Design of Network for Drinking Water Supply

Sl.	Assumed Flow (Qa = q) =P1f(V)/f(H)	P1	Diameter, (D for A)‡ f(D)= P1/f(H)	Velocity† (V) = Qa/A	Head-loss# f(H) = (P1)f(V)/f(Q)	Remarks on corrected flows
col.(1)	col.(2)	col.(3)	col.(4)	col.(5)	col.(7)	col.(8)
The 1st step	It may be by any suitable way of formulation foreward and/or backward or else by the suitable applied column/value-driven philosophy in change of this present one (see Table1).					
Defining stage	q001	P001	D001~A001	V001 = q001/A001	**H001** (assumed) /determined/desired)	The design flow-variable(here it's H) may be selected suitably & designed its correction value.

#check with H = KQ^x
†check the permissible D & V.
‡individual pipe design beside flow-equalization by P1/H after the 1st step.

CONCLUSION (with future scope)

i. The applied physical methodology as given in the assumption of this study is almost happened to be forming into each water supply project. Here lies the realistic feature on the extraction of this study. And, the equilibrium of it (the assumption) with the Darcy-Weisbach equation (H_L= KQ^x) gives the various limiting guideline for the estimated quantity to have its obeyance/control. It's also truthful while it negotiates with the equation of continuity in the determination.

ii. The total head-loss around a loop of the pipe network has here been distributed as shown in the Table 2. It has the cross-check of the various variables while using it to find out diameter & velocity. Consequently the Table 2 also shows the balancing in the total quantification of the flow Q (as done in Table 1 for the head-loss), its proportionate distribution & the subsequent estimation, such as dia, velocity etc., for finding out the head-loss (along-with D, V etc.) for each pipe which got already checked for the head-loss criteria in its earlier stages – this entire procedure shows the balance & stability in the level of precision of the values determined.

iii. No. of pipes in a loop is a deciding factor in branching out or getting the no. of set of the variables.

iv. This study has advantages in various perspectives. First of all it (flow-correction) is estimated by the iteration method (Table1). It may also be estimated along with the determination (simultaneously) of the flow-variables such as diameter, velocity & the head-loss indeed (Table 2) after the head-loss criteria has been adjusted desirably or brought to zero as it's convenient in most of the network design. .

v. The several checks of confirmation in the derived estimation on the all across the tabulation procedure (Table1 & Table2) give the reliability of the estimation & methodology – there is a final check given in the Eq. (F) & Eq. (G) on the determined values of Q & V in order to get them checked & justified also.

vi. This study's feasibility may also be checked & realized by laboratory experimentation & its further enunciation applying various theoretical judgements.

vii. Future scope of this work lies in each & every description of determination in the subjective variable.

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