International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 9, September- 2014

Hydraulic Transient Analysis of Kolar Water Pipeline using Bentley Hammer V8i – A Case Study

Sadanand
Research Scholar
MANIT,Bhopal; India

Dr.T. S. Desmukh
Professor
MANIT,Bhopal; India

***Abstract*- The case study belongs to hydraulic transient analysis with Bentley Hammer V8i software and validating the results with manual calculations. Kolar water pipeline has been taken for case study. For this the result obtained from the PHE department, Bhopal were used for comparison. The available results were for the transient analysis with the surge protection devices in position. However as no detail of the devices was available the analysis with surge protection devices was not possible in Bentley Hammer V8i. . Hence initially the transient analysis for the Kolar pipeline was done manually (using excel sheet) considering the location of air vessels for validation. These results were found to match with the PHE department results. Then manual analysis was done without surge protection devices. After this the transient analysis of the pipeline was performed using Bentley Hammer V8i without surge protection devices. The results so obtained matched fairly well with the manual results for the same case. Bentley hammer v8i used for analysis with condition without surge protection so that the location for surge protection can be found out.**

Keywords— Hydraulic transients, MOC, bentley hammer v8i, surge .

INTRODUCTION-

The hydraulic analysis in closed conduits is based on the steady state flow conditions. by applying some governing equations of conservation of mass and momentum and extracting a general equation for the elastic pipe for solution. That results into a method of solution called method of characteristics(wylie and streeter)[15]. Methods of characterstics(moc) is very popular method for studying transients and water hammer effects. Avoiding the effects of water hammer is big concerned in pipe technology. Design of pipe on the basis of elastic theory of pipes and finding the maximum and minimum pressure or wave oscillations(R.Wichowski)[14]. Methods of characterstics is related to finite difference method as the equation is discritized for different points. These points gives the analysis values of pressure, discharge and velocity. Transients of such systems are also depends upon the valave settings. variation in demands,sudden closure of valves and pumping system performances affects the unsteady flow .These all conditions effects the steady state nature of flow(T.Tezcan,U.Gokkus and G.Sinir)[16].

Solution by Methods Of Characterstics(MOC):

Water hammer equations for elastic pipes produces a 1-d partial equation and result of this one is found by Methods of characterstics. this is the mathematical modeling of the unsteady flow. To solve the momentum and conservation of mass equation moc is used (wylie and streeter)[15]. These equations are :

$$\frac{\partial V}{\partial t}+\frac{1}{\rho}\frac{\partial p}{\partial s}+g\frac{dz}{ds}+\frac{f}{2D}V|V|=0 \quad \text{……1.}$$

And

$$a^2\frac{\partial V}{\partial s}+\frac{1}{\rho}\frac{\partial p}{\partial t}=0 \quad \text{………2.}$$

Solution of the equations is:

C+ :

$$\frac{a}{gA}(Q_p-Q_{i-1})+(H_p-H_{i-1})+\frac{f\Delta x}{2gDA\text{^}2}Q_p|Q_{i-1}|=0 \quad \text{…………..3.}$$

C-:

$$\frac{a}{gA}(Q_p-Q_{i+1})-(H_p-H_{i+1})+\frac{f\Delta x}{2gDA\text{^}2}Q_p|Q_{i+1}|=0 \quad \text{………..4.}$$

In the solution of equations; here velocity terms are converted into discharge terms for our convenience(wylie and streeter)[15]. Equation 1 and 2 are the quasi hyperbolic equations and general method of solving is MOC in 3 and 4 equations.

For the solution there are many boundary solution is considered requiring like reservoirs, pumps ,pipeline branches, dead ends etc. but here we are using upstream reservoir boundary conditions and pump conditions for

compatible MOC equation(A.Bergant, A.R.Simpson, E. Sijamhodzic)[1].
The compatibility equation for c+ line Q_{i-1} has the known value at the upstream section and H_{i-1} also has the known value at upstream section but for finding Q_p at the starting upstream section H_p is equal to H_r. similarly for c- line Q_{i+1} is known and for H_p due to pump shut down considering initial value is equal to zero. this approach at the downstream section of pump outlet.

Problem statement and analysis: in the study of kolar water scheme at Bhopal, MP; has two pumping main one raw water main 7.2 km long and clear water pumping main 3.2 km long. Here the data for the hydraulic transients

Table-Data of Kolar supply scheme

SR.NO.	ITEMS	RAW WATER PUMPING MAIN	CLEAR WATER PUMPING MAIN
1.	Length of Pumping Main	7200m.	3200m.
2.	Material of Pipes	(1.)M.S. Pipes with cement mortor inlining and outcoating fro 0 to 3210m. (2.)PSC Pipes from 3210m.to 7200m.	M.S. Pipes with cement mortor inlining and outcoating.
3.	Internal Diameter of pipe line	1450mm. for Steel Pipes 1500mm. for PSC Pipes.	1450mm. Steel Pipe.
4.	Laying condition	Under Ground	Under Ground
5.	Maximum flow rate	7152 cum/hr.	6740 cum/hr.
6.	Pump Discharge Head	90.50m.	90m.
7.	Pressure wave velocity	1016m/s upto 3210m. and 904m/s for next 3990m. 7200m.	1016m/s.
8.	pump velocity	1000rpm.	980rpm.
9.	Pump type	Vertical Turbine Type	Horizontal

As per the general solution of the MOC firstly calculated the discharge term and then head term which is discussed earlier after calculating all the values which gives the analysis of the hydraulic transient for the case study.

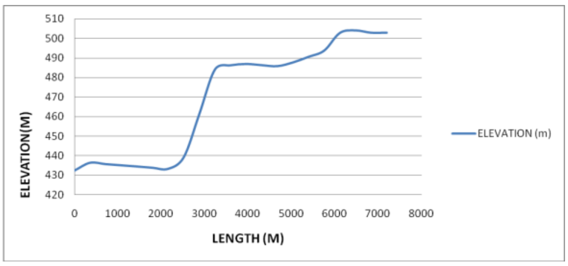

Fig.1. Profile for raw water pipeline

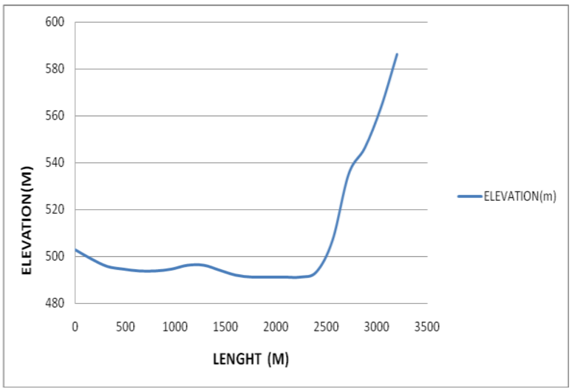

Fig.2. Profile for clean water pipeline.

In above shown figures, those are the general data used for elevation for the pipeline mains.

Analysis for pipeline mains with surge protection:

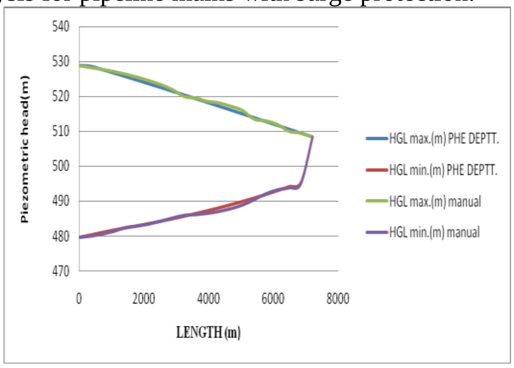

Fig.3. HGL vs length for raw water main with surge protection

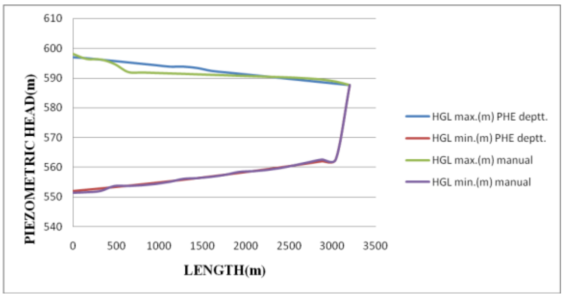

Fig.4. HGLvs. length clear water main with surge protection

In both the pipeline mains results are matched quite well. Following the same procedure for hydraulic transient analysis with manual calculations for without surge protection devices.

Benley Hammer V8i:

The transient analysis of the Kolar pipelines was done through Bentley Hammer V8i software keeping the same length of reaches as in case of manual solution. The given profile of th**e** Kolar pipeline was modeled in the software and all its parameter specified. Then the pumps were defined for both the pipelines. The analysis for raw water pipeline was done initially using pump shut down time as the period (2L/C) and then with the trial and error method we've determined the total run duration time. The results shown below is a comparison between manual calculation and Bentley V8i Hammer V8i software.

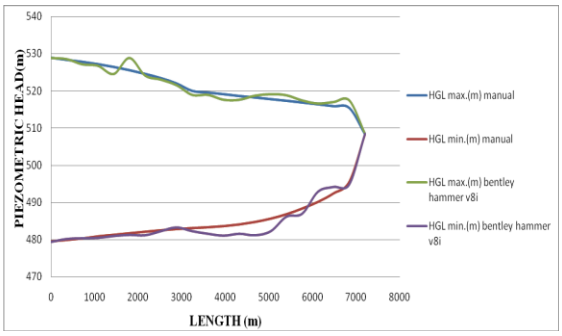

Fig.5. Comparison of manual and software results without surge protection raw water pipeline.

The study of the graph given above shows that the results obtained both through manual as well as software give quite comparable results. The nature of curve in maximum as well as minimum piezometric head condition is similar. In case of minimum HGL the deviation in two solutions is seen in the reach between 3000m. to 6150. (Approximate). This is because surges are expected in this reach and hence the software automatically introduces air pocket in this region. Similarly the introduction of air pocket in the maximum HGL is at 1250m (Approximate).

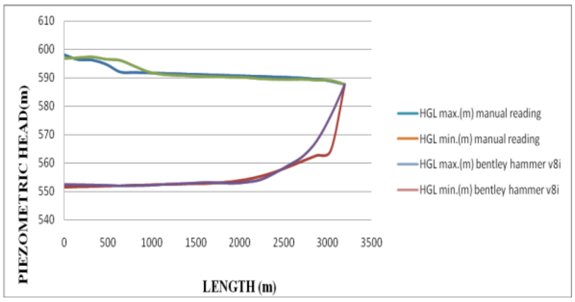

Fig.6. Comparison of manual and software results without surge protection in clean water pipeline

The study of the figures given above shows that the results obtained both through manual as well as software calculation are quite comparable. The nature of curves in maximum as well as minimum hydraulic grade line is similar. In case of minimum HGL the deviation between the two solutions is seen between 2750m. to 3060m. (Approximately). This is because surges are expected in this reach and hence the software automatically introduces air pocket in this region. Similarly the introduction of air pocket in the maximum HGL is in the initial reach upto 750m. (Approximately).

CONCLUSION:

The analysis of both the raw water and clean water mains revealed that hydraulic transients occur in the system. The abrupt changes in pressures due to these transients are liable to affect the performance and sustainability of the water supply scheme. The present work shows the feasibility of performing the transients analysis for a water supply pipeline using the Bentley Hammer V8i software. For this the solution obtained through the software has been validated through manual solution of transient analysis for Kolar Pipeline.

The locations are suggested for the surge protection devices are very critical as pipe rupture conditions are high. Due to air vapour pocket formation the problem of cavitation can take place and hazardous effects can be happened.

Bentley Hammer V8i software is very efficient and user defined for the study of this problem. A big advantage of the Bentley Hammer V8i software is that it can introduce the air vapour pocket itself in the model according to given condition and reduces the trial and iterative work for calculating the air vapour pressure in the system.

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