PIPEPREDICTOR.COM

AN INTERNET BASED USER ACCESSED PROGRAM FOR CALCULATING COMPLEX PIPELINES AND CATENARY RISERS IN DEEP AND ULTRA-DEEP WATER

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A.   SUMMARY

PipePredictor.com, an operating system and platform-independent computer program, is a novel ultra-precise non-approximative mathematical tool allowing pipeline engineers to accurately predict the geometry, stress and fatigue of any arrangement of offshore single or multiple pipelines installed from any floating construction or production facility in any water depth. Thanks to its uncompromising accuracy (664 bit number handling), PipePredictor.com will yield results departing substantially from those obtained through generally accepted finite element analysis programs, especially around the pipeline's TDP (Touch Down Point), with sizeable consequences as regards fatigue at TDP. Because of PipePredictor's inherently superior accuracy, users can avoid overdesign with unnecessary cost and underdesign with expensive failures.
PipePredictor.com's operational sequence is simple and straightforward:

1. An Internet subscriber posts his particular pipeline or catenary riser data and requirements in the web site's intuitive Internet browser forms

2.The very intensive calculation is conducted automatically and remotely from PipePredictor.com's powerful, continuously updated computers.

3. The subscriber automatically receives full graphical results by email, within 20 to 30 minutes of posting his data. The results consist of a complete graphical synthesis file not larger than a few hundreds of kB in the readily exploitable Excel format, showing both Static and Dynamic Analysis as well as a prediction for Accidental Flooding.

Pipeline engineers can request and analyze the very complex calculation from any email capable intermediate performance field terminal despite the large computational requirements. There is no need to install any program on an upgraded top of the line workstation, all operations are done remotely. The only requirements are access to email and a spreadsheet program to read the results.

B.   MATHEMATICAL ALGORITHM

B-1. Mathematical Model
Even a superficial analysis of the results obtained through competing software shows that the mathematics used in the software in question is necessarily approximate or even wrong. In particular the ground reaction to the pipeline especially at TDP is wrongly determined. Based upon this finding, the author of this paper endeavored to develop a new mathematical analysis of the so-called rigid pipeline catenary. He was able to represent the rigid catenary curve as the solution to a fourth degree non-linear differential equation. He believes this equation is new although he is not ready at this point to disclose t.

B-2. Solution to the mathematical problem
The above-mentioned fourth degree differential equation having no ready solution expressed as a mathematical function, it was necessary to devise a finite element method to solve it step by step in a computer environment. It soon appeared that whatever the operating system used, a serious limitation was the maximum number of digits allowed in most computer environments, according to the IEEE 754 specification.

The IEEE 754 specification deals with how to store and calculate floating-point numbers. Programs only store 15 significant digits in a number, and change digits after the fifteenth place to zeroes. IEEE is the Institute of Electrical and Electronics Engineers, an international body that, among other things, determines standards for computer software and hardware. The 754 specification is a very widely adopted specification that describes how floating-point numbers should be stored in a binary computer. It is popular because it allows floating-point numbers to be stored in a reasonable amount of space and calculations to occur relatively quickly. The 754 standard is used in the floating-point units and numeric data processors of nearly all of today's PC-based microprocessors that implement floating-point math, including the Intel, Motorola, Sun, and MIPS processors. The same limitation occurs with Apple and Unix computers.
To reach the expected accuracy of the rigid catenary curve, a precision of up to 200 digits (664 bits) was required.

A way to solve the limitation would have been to write the entire catenary program in the Java programming language, an option still pending. Java incorporates a package named BigInteger that presents no IEEE 754 limitation.

Another way was to circumvent the limitation by treating numbers as text, slicing the resulting string in as many 15 digits sections as required and rewriting all necessary mathematical functions so as to accommodate the series of numbers. The author of this paper chose to use the only already existing application, developed in Italy as a freeware open software by a team of professors from the University of Livourne and developed as a curiosity, no practical application having been found until it was applied to this problem. The application proved to work fine at the cost of course of a seriously reduced computational speed.

C. SOFTWARE APPLICATION

Once the mathematical problem was solved the next problem was how to devise the client interface between a user with a rigid catenary problem and the software. Typically software publishers make their programs available on a CD or downloadable from the Internet. The problem with such a support is that the program needs to be installed on the end-user's computer that will actually do the computation. Pipepredictor.com is a very power intensive program requiring a very powerful computer: even with the fastest PC to-date computation time takes close to 20 minutes. Another way would be to install the program on a powerful server and let the client-workstation utilize the server's resources to do the calculation in real time.

A safer and easier way was devised by the author:

End users will use as an interface a web page specially formulated for the purpose. End users input their data in an extensive form that incorporates all the necessary information. When they click a "Send" button, the ASCII data is sent as the body of an e-mail to Pipepredictor.com's e-mail address. Whenever one or several of Pipepredictor.com's PCs with the program installed check and receive their e-mail, the computer automatically opens the posted data e-mail from the end-user and transforms it into a spreadsheet page. The computing computer then automatically runs its internal program using the data it just received and after the time required to do the calculation prepares a spreadsheet summarizing all the results both as numbers and graphs. The spreadsheet is then automatically e-mailed back to the end-user.
To our knowledge there is no evidence of this method having been used formerly to trigger mathematical computations. Among the advantages are that there is no direct link between the client and the server, making it impossible to have direct access to the program and use it illegally, the computing station does not need to be online at all times, users can have very intensive calculations run on someone else's more powerful computer, the program can be continuously upgraded. Clients gain access to the service by first obtaining a password and then inputting it in their form. The software will check the password and deny service if it is incorrect.