A pictorial view of structural design

4014 Graphic Computer Terminal Application Note PET 4014-B
Interactive stress analysis

When offshore drilling operators need a new drilling platform, they have more concerns in mind than just where to build it. They have to know how their platform's design will withstand stress. All kinds of stress. Seismic, tidal, wind, wave and temperature caused stress.

A platform has to withstand 100-foot waves, but it also has to withstand small, seemingly insignificant wind and water waves which set up vibration frequencies. Those frequencies can be even more destructive than the 100-foot wave. Because, if a platform design responds to those wave frequencies with corresponding internal frequencies, the structure can be vibrated to pieces.

It is this reason that oil companies need to know the internal stress patterns they are building into their platform geometry.

So, when it comes time to build offshore platforms, oil companies often take their platform building plans to a service corporation for stress analysis. Or the oil company tells the service corporation the operating requirements for the platform and leaves the designing of the platform to that corporation. In searching out stress patterns within a designed platform, the helping hand of a Tektronix 19-inch Graphic Computer Terminal connected to a mainframe computer is able to pinpoint stress points quickly and efficiently. Whether the corporation uses time-sharing or its own on-the-job-computer, the hardware with their own specially-created software puts the data to work.

Coordinating elements

When the time comes to analyze a structure, an internal mesh generator breaks up the 3-D plan into a mesh of "finite elements" or coordinates. For convenience the user can manually create the mesh by typing in the dimensions, or by using the cursor on the 4014, or by using a 4954 Graphics Tablet. This mesh can be of any density, depending on the complexity of the structure.

Then, each "finite element" is assigned known digital values of stress according to mathematical formulas of stress laws. These formulas are based on a simplified version of the structure, reduced to convenient geometric shapes such as triangles, cubes, pyramids, or hexagons. Typically, this digital assignment is accomplished by typing up to 2000 computer cards for each job, and then inputting them in a batch mode. However, in the near future, interactive programming will enable a user to simply type the digital assignments via the terminal giving him faster and more efficient results.

Once the digital values are input, the graphics begin. At the touch of a terminal key, the computer converts digital values into geometry plots, creating a mathematical model of the platform. These plots clearly show "hot spots" or high and low stress points which weaken a structure. The stresses in the structure are then mapped out on iso-stress plots.

But that's only the start. Then the math model is subjected to computer-simulated external forces to see just how the platform will withstand operational conditions. These hypothetical forces can be wind or wave frequencies, or even the frequency which could be set up by a drill, or compressor. All to look for responsive frequencies within the platform design. These tests, too, are transformed into iso-stress contour maps, to show the entire picture on the screen of the Tektronix Terminal (with hard copies on command).

The graphic touch

This type of system is a new tool designed for the oil industry; it introduces graphics as a feasible means of analysis and checking for errors. In the past, graphics was limited to hand-drawn iso-stress maps, but this dot-to-dot method was time consuming, so it was seldom used. Plotter reproductions of hand-created iso-stress maps are possible by transporting the data to and from the plotter site in another city, but that also takes time.

Therefore, more often than not, structural analysis has been based solely on digital readout. The data came to the analyst in the form of 4,000 to 5,000 cards, each one representing a single "finite element" of the mesh, and a printout several inches deep. Interpreting the stress pattern took hours of tedious shuffling through printout. Mistakes in programming or stress assignments were easily overlooked in all that paper. Finally, beset by a number nightmare, the analyst was expected to make an educated guess of the stress patterns.

It all added up to a hefty job turnaround of three to four weeks, an undesirable factor to the oil industry. Since every job delay is extremely expensive, when the oil company comes up with the stress problem, they want the answer right now.

Now 4014 graphics by Tektronix has transformed that three to four weeks to three to four days. Mistakes show up clearly as geometric anomalies, and total stress patterns
are as easy to find as locating a mountain on a topographic map. Easy and fast. But also more accurate, because an educated guess cannot compare with an actual picture of the stress. Thus, computer graphics becomes one of the easiest, fastest, and most accurate tools for the oil industry.

Construction geometry of structure.

Enlarged construction geometry of structure.

Contour stress map of single structure element.

Agia Offshore Platform, designed, fabricated, and erected by Nippon Steel Corporation for Japex Offshore Ltd.
Example of equipment configuration for stress analysis

4014-1 Graphic Computer Terminal
4922 Dual Flexible Disc Memory
4631 Hard Copy Unit
4954 Graphic Tablet
Modem
Host Computer
4014-1 Graphic Computer Terminal
4631 Hard Copy Unit

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