MECHANICAL ENGINEERING NEWS

COADE®

For the Power, Petrochemical and Related Industries

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BULLETIN POLICY

The **COADE** Mechanical Engineering News Bulletin is published on a quarterly basis from the **COADE** offices in Houston, Texas. The Bulletin is intended to provide information about software applications and development for Mechanical Engineers serving the power, petrochemical and related industries. Additionally the Bulletin will serve as the official notification vehicle for software errors discovered in those Mechanical Programs offered by **COADE**.

PC HARDWARE FOR THE ENGINEERING USER (PART 6)

This issue of PC Hardware will concentrate on the system memory and its subsequent usage by application programs. Due to the number of support calls related to memory usage, it is felt that some additional explanation is necessary. In addition, a major hardware deficiency has been discovered which could affect many PCs throughout the world.

The hardware deficiency causes software to lock up the computer when certain mathematical anomalies occur, such as zero divides or underflows. The problem has been narrowed down to the LSI chip set which incorporates control for; the system timer, the DMA channels, and CPU/CoProcessor communication. The problem is that the LSI set manufactured by Zymos is not handling the CPU - CoProcessor communication properly, and hanging the machine. The chip in question is the "Zymos Poach" set, it is a square chip about the size of the CPU. Users with this particular chip set should contact their hardware vendor for a software fix or a new chip set.

The first system memory consideration is the amount of memory actually installed in the computer. For **COADE** programs to operate, this value must be 640 Kbtyes. (Additional "extended" memory may benefit other software products, however, **COADE** programs do not access "extended" memory at this time.) When the system is booted (started), the Disk Operating System (DOS) is loaded into memory. This operation will reduce the memory available to applications programs to some value less than 640 Kbytes. Here is the crux of the problem! Recent versions of DOS have tripled in size and can consume over 80 Kbytes of memory if not configured properly.

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3) *A hardware cache is the only system that can improve performance in ALL situations.*

4) *Software caches are likely to degrade the performance of sequential writes, provide big advantages for reading files that fit entirely into the cache, and degrade performance for larger files.* Most files created by **COADE** products are large, sequential files. As stated in point 1 above, it is unlikely that the data files would fit entirely in the cache.

5) *Caching of disk writes is not as important as caching for disk reads.*

6) *The effects of caching on file sorting are substantial.* None of the **COADE** data files undergo sorting.

7) *Using the DOS buffers is beneficial without caching, and has less affect with caching.* The number of buffers is important and seems to be optimum between 10 and 20. More than 20 buffers seems to degrade system performance. Recall that each buffer requires 512 bytes of memory, and too many will prevent **CAESAR II** from loading.

8) *RAM disks are the best way to avoid disk access.* This is an expensive solution, since the RAM disk must be large enough to hold both the program and its data files.

9) *The gain from caching on the PC is less than on mainframes. This is because the speed difference between the PC CPU and hard disk is not as drastic as it is on the mainframe.*

The following conclusions can be drawn from this article. First, unless a RAM disk or a hardware caching system are employed, there will not be a noticeable speed improvement in running engineering software. Second, with the amount of RAM a software caching system requires, most engineering products will be unable to load or function properly.

PIPE STRESS SEMINARS

The **COADE** sponsored Pipe Stress Seminars are being well received throughout the U.S., Canada, and Europe. Seminars are offered both as general courses open to all, and as courses tailored to meet specific client goals. The next course open to the public is scheduled for May 3-5 in Seattle. Users with questions on course schedules or contents should contact **COADE Engineering** for additional information.

BURIED PIPE ANALYSIS

Modeling a buried piping system is an involved process which takes considerable care to obtain accurate results. Before attempting to model the system in an analysis program, some preliminary thought must be given to the local soil conditions and the overall piping dimensions. The analysis will attempt to approximate a "beam on elastic foundation" with a standard three dimensional beam element with applied springs at the end node points. The accuracy of this approximation will depend on the values used for the spring stiffnesses and the number of nodes, i.e. how refined the model is.

The following generalities can be made on this modeling technique:

1) Include 200 to 300 feet of the buried pipe in the model.

2) Nodes should not be spaced more than twenty diameters apart for pipes greater than 12 inches in diameter. Node spacing should not exceed thirty diameters for pipe sizes under 12 inches.

3) For each node in the system, compute the projected area of the piping which will be supported by the node. This area will be 1/2 the length of each pipe framing into the node, times the appropriate pipe diameter.

4) Select the subgrade modulus of elasticity for the type of soil surrounding the piping system. The following table is taken from: Joseph E. Bowles, "Foundation Analysis and Design", 3rd Edition, 1982.

Soil Type	Subgrade Modulus (kips/cu.ft.)		
loose sand	30	-	100
medium dense sand	60	-	500
dense sand	400	-	800
clay and dense sand	200	-	500
silty and dense sand	250	-	700
clay, Qu < 4 ksf	75	-	150
clay, Qu < 800 ksf	150	-	300
clay, Qu > 1600 ksf		>	300

Where Qu is the unconfined compressive strength of the soil.

5) Multiply the effective area for each node by the subgrade modulus to get an effective restraint stiffness for that node.

6) Insert translational restraints, normal to the pipe axis, into the piping model with the computed stiffness at each buried node.

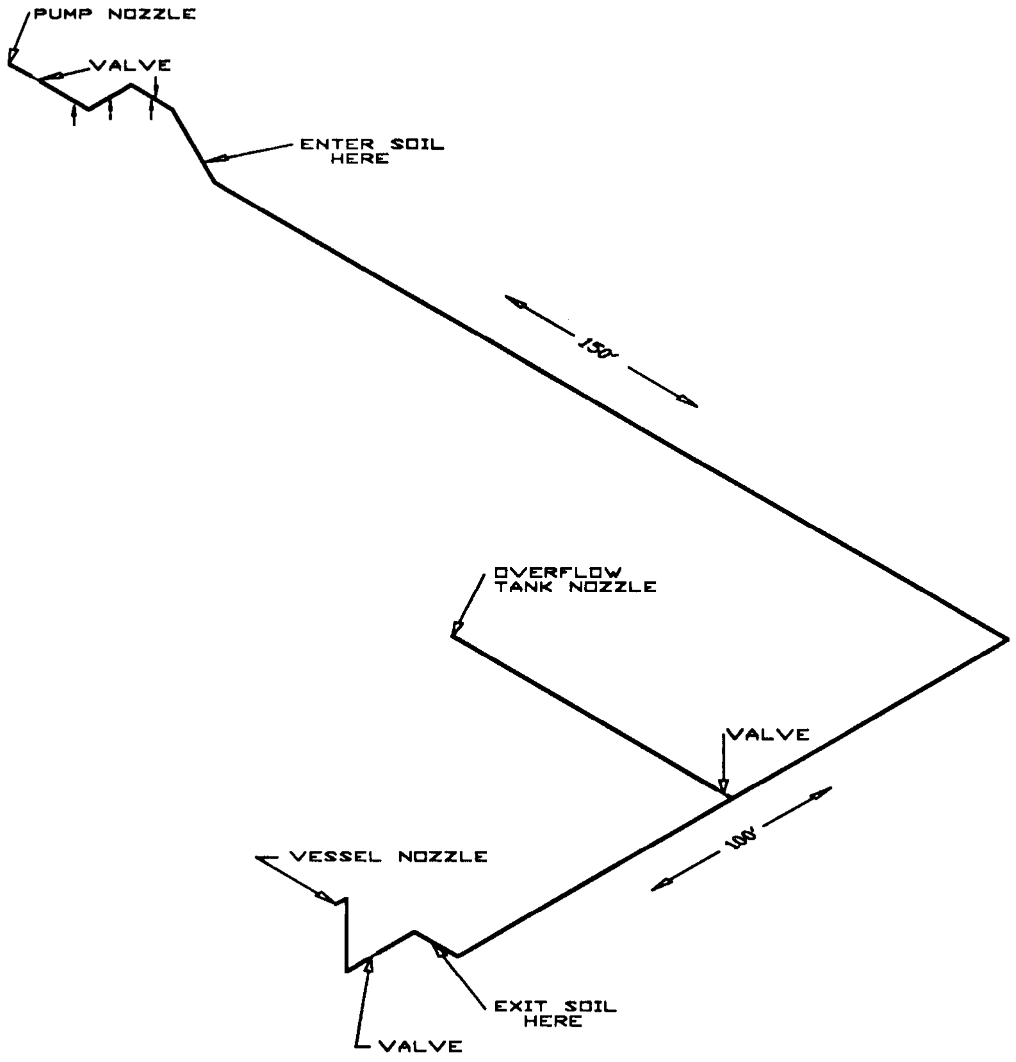
7) Set the density of the pipe to zero. The weight of buried pipe is uniformly supported along its length. Weight loads in buried pipe do not cause deflections, and so do not cause stresses or forces.

8) Often axial stops in the form of large flanges or concrete anchors must be designed to resist the thermal expansion of buried pipe. In these cases, it is recommended that the axial stiffness used be 25% of the transverse stiffness.

9) Use the **CAESAR II** "INCLUDE" capability as often as possible to reduce the amount of repetitive modeling. A word of caution is in order relating to the auxiliary field limits of the spreadsheets. Do not specify allowable stresses, or uniform loads on the model to be included. This data will be duplicated forward by **CAESAR II** from the main job. Respecification will be redundant and limit the ultimate size of the model.

The following example attempts to illustrate these points.

The system shown below is used to connect a pump to a vessel. The majority of the piping is buried, with a small branch to a buried overflow tank: The piping is 16 inch, standard wall, low carbon steel pipe. Assume dense sand soil conditions with a subgrade modulus of 600 kips per cubic foot. This system is shown sketched in the figure below:



Since the buried portion of the system consists of lengths in multiples of 50 feet, a small 50 foot model will be constructed, with applied nodal stiffnesses, to simplify the input process. This small model will consist of six nodes, connecting five, ten foot lengths of pipe.

The applied nodal stiffnesses are computed as follows:

Equivalent area: (10/2 + 10/2) * (16/12) = 13.33 sq.ft.
Stiffness : 600 k/cuft * 13.33 sq.ft. = 8000 k/ft
8000 k/ft * 1000 lb/kip (1 ft / 12 in) = 6.667E5 lb/in

Axial Stiffness: 6.667E5 * .25 = 1.6667E5 lb/in

The small model, used as the "include" file is named BINCLD. Once the input for this model is complete, the error checker is run to insure we will not be duplicating errors in the main job.

The main model is entered under the job name "BPIPE", and starts at node 10. Node 10 is the pump nozzle and will be modeled as an anchor. The first spreadsheet is filled out in typical fashion, specifying, the deltas, diameter & thickness, temperature, pressure, allowable stress, and restraint information. The fluid density used is 0.8 times the specific gravity of water. This value can be entered in the fluid density field as .8SG. **CAESAR II** will convert this entry to the appropriate weight density.

The second element in the model is a 150 pound class, flanged, gate valve. The **CAESAR II** generic valve & flange data base can be used to obtain the data for this element by striking "V". The next several elements proceed away from the pump station and finally start into the soil.

The pipe enters the soil at node 100. X and Z restraints will be placed at 100, with the computed stiffness of (2/10) * 6.667E5 psi. (Note, the 0.2 factor is necessary because only 2 feet of pipe acts with node 100, instead of the ten feet used to compute the stiffness value.)

From 100 to 110, the pipe continues on the 45 degree slope to a bend where it levels off. **Note, at node 100, the pipe and fluid densities should be set to zero.** Since we will place a node (109) at the bend near point, we will use the above 0.2 factor for the stiffnesses at both 109 and 110. From 110 to 120 is a 2 foot straight section, to get out of the bend. At this point, the **CAESAR II** "INCLUDE" capability can be used to simplify the input.

The next 150 foot section of pipe can be modeled by "including" the "BINCLD" job three times. While on the 110 - 120 spreadsheet, strike the "K" to obtain the auxiliary menu. From this menu, select option 5, INCLUDE PIPING FILES. This will present a screen where the piping jobs to be included into the current job can be described. Usage instructions are displayed next to the data entry box. For this job, it is advisable to try the include of BINCLD once, to make sure the modeling technique is correct.

Therefore, we will start with only a single line in the data entry box; BINCLD,N,0,119. This line indicates that the job to be included is BINCLD, it is only to be read when needed, the rotation angle about the "Y" axis is zero, and the node increment is 119. The rotation angle may be incorrect, so we should plot the model to verify this include. The node increment of 119 will be added to all the nodes in BINCLD, resulting in the nodes 120 thru 125 being added to the model. Note that 120 will match with the node 120 on the current spreadsheet, and connect the models properly. Again, it is important to plot the model to verify all of these assumptions. If anything is amiss, corrections should be made to the rotation angle or the node increment, and the "include" checked via the plot again.

Once we are satisfied with the plot, return to the "INCLUDE" screen and include the job BINCLD two more times. The data entry box should contain the following data:

```
BINCLD, N, 0, 119
BINCLD, N, 0, 124
BINCLD, N, 0, 129
```

Again, a plot is in order to verify that the model is as we think it is. Once we are satisfied with the plot, return to the "INCLUDE" screen and change the "READNOW" variable from "N" to "Y". This will cause the spreadsheets of the BINCLD job to be appended to our current job. **This is a permanent include, and can not be undone. Make sure of your data before doing this.**

A few corrections are necessary at this point. The stiffnesses at node 120 must be reduced, since only six feet of pipe, instead of ten, acts with this node. The length of 134 - 135 must be reduced to six feet, and the stiffnesses at 134 reduced by a factor of (8/10).

The element from 135 to 140 is a bend, where (6/10) of the computed stiffnesses are applied to the node at 140. The element from 140 to 150 is a 2 foot run to exit the bend. At this point, we can use the "INCLUDE" capability again to build the 100 foot section which runs in the "Z" direction. The data entry box should contain the following data:

```
BINCLD, N, -90, 149
BINCLD, N, -90, 154
```

A plot of the model should be used to insure everything is as expected. Then, return to the INCLUDE screen and change the READNOW variable from "N" to "Y". Several corrections are in order. First, the stiffnesses at 150 should only be (6/10) of the computed values. Then, the length of the element from 159 to 160 must be changed to 6 feet. The stiffnesses at node 160 must be added, using (6/10) of the computed values. Finally, the stiffness directions for the "X" and "Z" restraints must be switched.

Any complex system with repetitive piping can be modeled in this manner.

DYNAMICS - DAMPED HARMONIC MOTION

In a vibrating structure excited by a periodic external force, resonance occurs when the frequency of the periodic excitation, w, matches one of the natural frequencies of the structure, w_n. In a mathematically idealized vibrational system, a resonant condition without damping will cause vibrational displacements to grow without bound. In real structures, some amount of damping is always present. If the damping is not sufficient to amply dissipate energy , however, vibrational displacements due to a resonant condition in a damped system may still be large enough to cause failure even though the displacements remain finite.

Analysis of forced periodic vibrations (harmonic analysis), at a frequency near or equal to one of the system natural frequencies, must account for system damping to achieve realistic calculation results. Damping can be incorporated into a harmonic analysis by the use of an equivalent damped frequency, w_{eq}.

Consider a damped, single degree of freedom system with a natural frequency w_n, undergoing forced harmonic vibration at an excitation frequency w:

$$F(t) = F_o \sin wt$$

The classical equation for the steady state displacement, x(t), is:

$$x(t) = \frac{F_o}{k} \quad \frac{\sin(wt - \phi)}{\left\{ \left[1 - (w/w_n)^2 \right]^2 + \left[2\,R\,(w/w_n) \right]^2 \right\}^{1/2}}$$

R = Damping ratio C/C_c
ϕ = Phase angle

The term F_0/k is the displacement that the system would experience for a static force F_0 and a system stiffness k. The term

$$\frac{1}{\left\{ \left[1 - (w/w_n)^2 \right]^2 + \left[2\,R\,(w/w_n) \right]^2 \right\}^{1/2}}$$

is the amplification factor, A, which relates the static displacement F_0/k to the harmonic excitation displacement for a given excitation frequency w, a given system natural frequency w_n, and a given damping factor R. At resonance, $w = w_n$ and

$$w/w_n = 1$$

and

$$A = \frac{1}{2R}$$

The **CAESAR II** stress analysis program provides harmonic analysis capability for undamped systems. Analysis of a damped system for a resonant condition where $w = w_n$ must use an equivalent frequency, w_{eq}, to account for the effect of damping. The equivalent frequency is developed as follows:

For an undamped system, R = 0 and

$$A = \frac{1}{\left\{ \left[1 - (w/w_n)^2 \right]^2 + 0 \right\}^{1/2}}$$

For a damped system at resonance,

$$A = \frac{1}{2R}$$

Equating the two equations, letting $w = w_{eq}$, and noting that

$$\left\{ \left[1 - (w_{eq}/w_n)^2 \right]^2 \right\}^{1/2} = \pm \left[1 - (w_{eq}/w_n)^2 \right]$$

the equivalent frequency w_{eq} is

$$w_{eq} = w_n \left[(1 \pm 2R) \right]^{1/2}$$

This equation is used to calculate the equivalent frequency, w_{eq}, to use in the **CAESAR II** harmonic analysis of the undamped structure to predict the response of the same structure in a resonant condition with a damping factor of R. The equation will give two values of w_{eq}. W_{eq1} will represent an equivalent frequency slightly less than the resonant frequency w_n, and w_{eq2} will represent an equivalent frequency slightly greater than the resonant frequency w_n. Either of these equivalent frequencies may be used for the excitation frequency in the **CAESAR II** harmonic analysis of a system.

Selection of the value for the damping factor is critical to a harmonic analysis. Too much damping will yield very low displacements and stresses, whereas, too little damping will yield unrealistic displacements and stresses.

CAESAR II SPECIFICATIONS

Class 2

Structural Preprocess, C2S: The internal editor in the structural preprocessor (activated with the EDIT keyword) has a limit of 78 characters per line. Users exceeding this limit experience the loss of the following data line. This character limit will be manually enforced in subsequent versions.

PROVESSEL STATUS

In November of 1988, Version 2.0B of **PROVESSEL** was released. In March of 1989, Version 2.1 was released. These two releases offer the additional capabilities of: user controlled units systems, user attribute control, internal accounting, angle and channel stiffeners, an improved Help facility, and support for the DOS environment. Additional input items have been incorporated at the request of several users.