

Mechanical Engineering News

FOR THE POWER,
PROCESS AND
RELATED INDUSTRIES

The COADE Mechanical Engineering News Bulletin is published twice a year 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, process and related industries. Additionally, the Bulletin serves as the official notification vehicle for software errors discovered in those Mechanical Engineering programs offered by COADE.

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CAESAR II Version 4.40 Released

CAESAR II Version 4.40 is a major release, incorporating many enhancements, in addition to the usual plethora of piping code updates. The major enhancements made to **CAESAR II** for the 4.40 release are listed in the table below.

- A large number of updates have been made to the 3D input graphics, as well as partial implementation in the static output processor (including the "Element Viewer").
- An alpha-numeric node label option has been added to the piping input module
- Expanded Static Load case options: (1) added load components H, CS, HP, and WW (hanger loads, cold spring, hydro pressure, and weight filled with water, respectively), (2) added HYDRO stress type, (3) added option to set snubber and hanger status for each load case, (4) provided ability to scale friction factor for each load case.
- Added automatic generation of a hydrotest load case (WW+HP, HYD stress type, and spring hangers locked), triggered by the presence of a non-zero HP.
- The B31.11 piping code (for slurry piping) has been added.

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- Updated the spring hanger design algorithm to provide the option to iterate the “Operating for Hanger Travel” load case to include the stiffness of the selected hanger.
- Added new configuration options for ambient temperature, default friction coefficient (if non-zero, automatically applied to new translational restraints), liberal stress allowable, stress stiffening, and Bourdon settings, as well as B31.3 handling of B16.9 welding tee & sweepolet SIFs.
- Spring Hanger manufacturers have been added, Pipe Supports USA and Quality Pipe Supports.
- Added the ability to define the flexibility factor on bends.
- Included piping and structural files now support long file names, may be located in any directory path, and the number of included structural files has been expanded from 10 to 20.
- Results of the Hanger Design Cases are now optionally viewable in the Static Output Processor (set status to “KEEP” in the Load Case Options).
- Added the ability to filter static Restraint reports by CNODE status.
- Updated API-661 to 4th Edition.

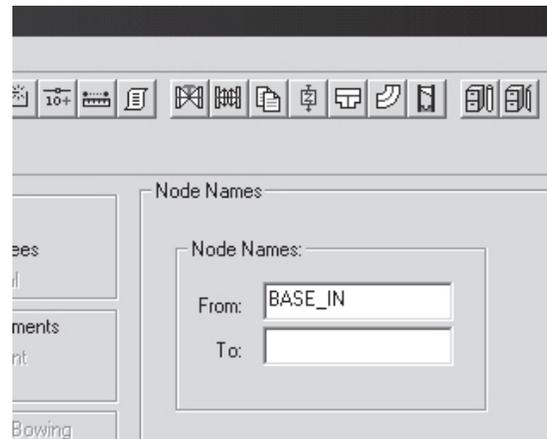
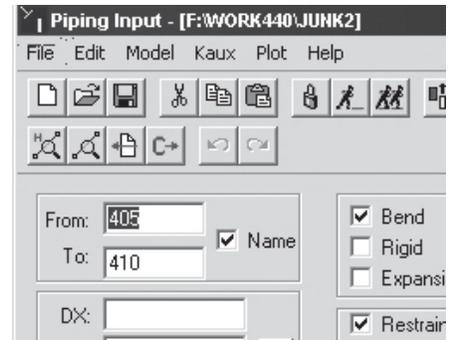
In addition to these enhancements, a number of **Technical Changes** have been made. **Technical Changes** are changes necessitated by either Code changes or implementation changes on our part that may cause the software to generate results different from prior versions. The list of these **Technical Changes** can be found with the “*distribution letter*”, and in Chapter 1 of the *User’s Guide*. Users are urged to review this list before using Version 4.40.

This article will elaborate on a number of the enhancements made for Version 4.40. Additional articles will detail some of the more involved topics.

Node Labels:

Node Labels are an optional alternative to node numbers. These labels can be used to identify or tag important points in the piping model. Note however, that **CAESAR II** still requires the use of “node numbers” to uniquely define node points. The node labels are optional user defined descriptions.

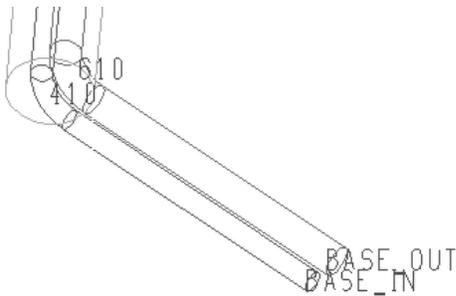
Node Labels can be specified by checking the “Name” check box (next to the “From” / “To” fields) on the piping input spreadsheet, as shown in the figure below. When activated, this check box displays the “Node Names” Auxiliary dialog, also shown in the figure below.



In the “Node Names” Auxiliary dialog, you can define a label for each node, up to ten characters in length. (This length limit is dictated by the space available in the output reports.) Use of node names is as follows:

- If defined, node names are used in graphics displays instead of node numbers.
- If defined, node names are used in all text based reports, instead of node numbers.
- In “80 column reports”, only the first six characters of the node name will be used.
- In “132 column reports”, all ten characters of the node name will be used.

An example graphics image and output report showing the use of these node labels are shown below.



With Version 4.40, two new basic load components have been defined. “H” represents spring hanger preloads, and “CS” represents cold spring. Now, a load case that in pre-4.40 looked like:

$$W + T1 + P1 + F1$$

may in 4.40 and later versions look like:

$$W + T1 + P1 + F1 + H + CS$$

The advantage here is that “F1”, “H”, and “CS” can be used independently.

3D Graphics Improvements:

Quite a lot of work went into the 3D (HOOPS) graphics for Version 4.40. If you have never used this graphics option, you really owe it to yourself to explore this capability. (Some of these 4.40 graphics improvements were released in 4.30 builds, as soon as they were operational.)

Two of the major additions to the 3D graphics are the display of displacement and force vectors. This display puts all defined displacements (or forces) in a scrollable list box. The list can be scrolled vertically to review the data for all nodes, and horizontally to review the data for all vectors. Additionally, this list box can be moved around the graphics window, to minimize its effect on the viewable pipe region. An example of this displacement display is shown in the figure below.

Static Output Processing

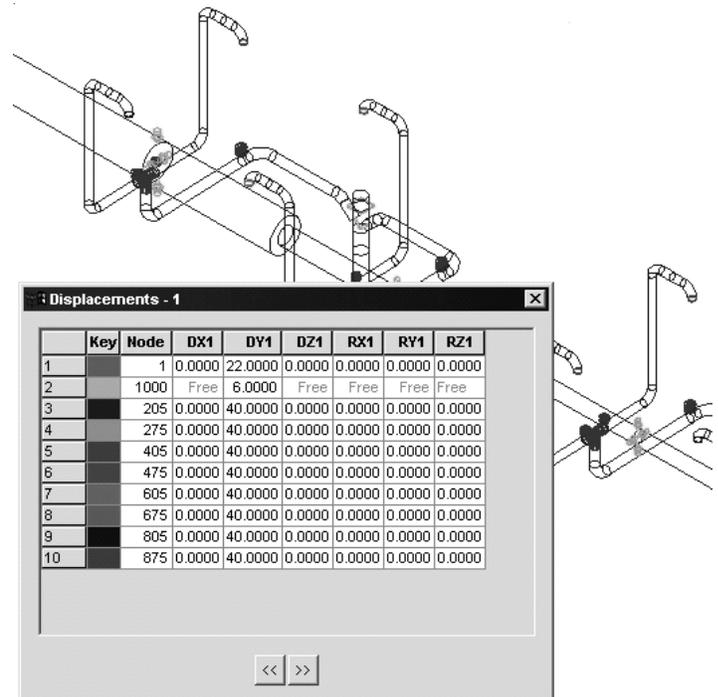
RESTRAINT REPORT, Loads on Restraints
CASE 1 (OPE) W+T1+P1+F1

NODE	Forces (lb.)		
	FX	FY	FZ
465	0.	0.	1533.
top exit	-1.	2780.	-1137.
BASE_OUT	25.	-898.	752.
615	-20.	0.	0.
615	0.	0.	-1235.
615	0.	-8569.	0.

Load Case Components “H” and “CS”:

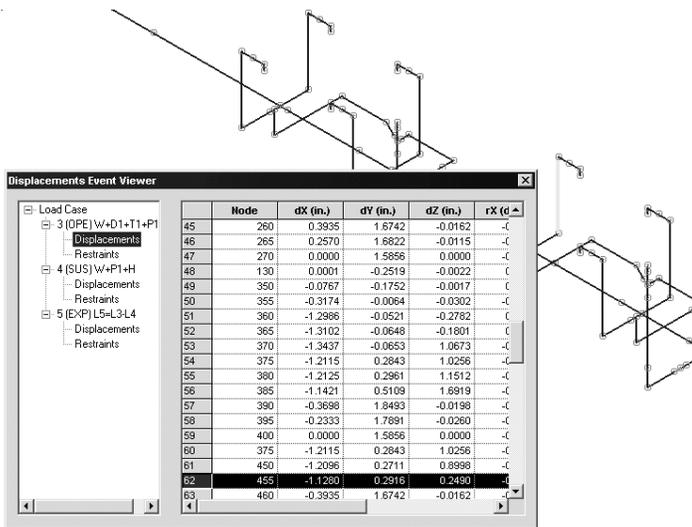
Version 4.40 provides a number of new capabilities for constructing static load cases. One change made here was to “break out” implied loads from the “F1” vector. Recall that in the input processor, concentrated loads (forces and/or moments) can be applied to node points. These loads can be grouped into different vectors (F1 through F9) as necessary, perhaps to correspond to temperature vectors T1 through T9. Defining F1 in the input means it can be incorporated into a load case.

What was not obvious (but explained in the documentation) is the fact that spring hanger preloads and cold spring loads were also loads included in the “F1” vector. So, you couldn’t separately address “F1”, hanger loads “H”, or “cold spring”, without making specific adjustments to the input (you would move the applied forces to “F2”, define colds spring using the “T2” method, and leave hanger preloads in “F1”). This is not obvious, and a little bit of work.



Note in this display the color key at the left. These colors are correlated to appropriate node points on the model graphic, to assist in locating the displaced point, even if node numbers are not displayed. The display of applied forces works identically to the display of displacements.

These same 3D graphics have begun their migration into the static output processor in Version 4.40. In the figure below, the new “**Element Viewer**” is shown. This new viewer allows the selection of various data types (displacements, forces, or stresses), for the various load cases.



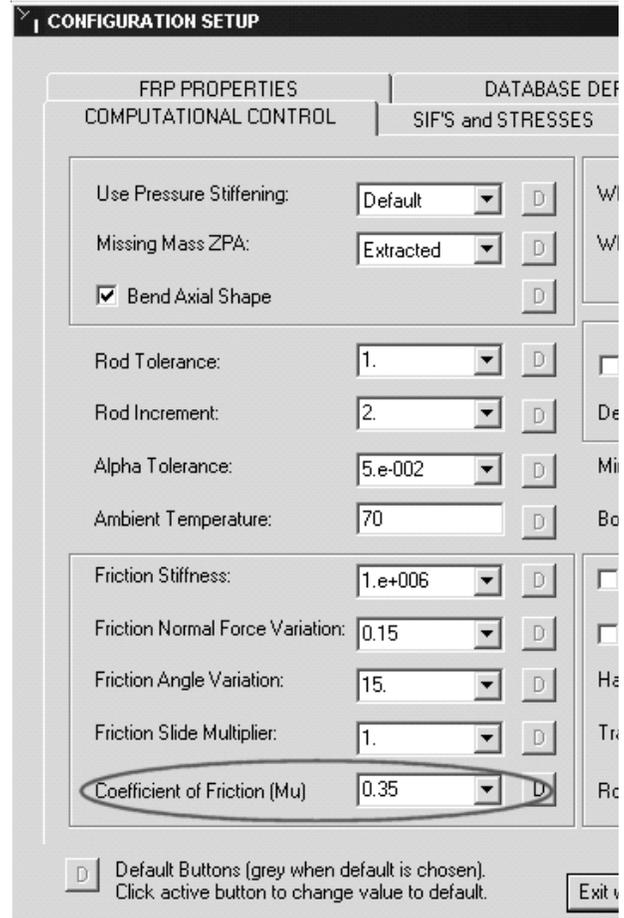
Note that the highlighted element in the Viewer Window corresponds to the highlighted element on the model graphic. Clicking on a different element in the Viewer Window highlights the corresponding element in the graphic. Likewise, clicking on a different element in the graphic, highlights the corresponding element entry in the Viewer Window.

Configuration Directive for Friction Coefficient and Load Case Friction Multiplier

Friction is a concept that cannot be quantified with 100% accuracy. The value of the friction coefficient changes over time, as the system ages and is exposed to the environment. Prior to Version 4.40, there was no easy way to specify or alter the value of this friction coefficient on every restraint. Version 4.40 provides two new capabilities that address modeling and evaluating friction effects.

The first new friction capability is specification of a default value of the friction coefficient in the configuration file. (Recall that each data directory can have its own configuration file, so this default friction value only affects jobs where the configuration file has been

modified appropriately.) By specifying a non-zero value for the friction coefficient, as shown in the figure below, all newly defined translational restraints (X, +X, -X, Y, +Y, -Y, Z, +Z, -Z, Guide, and Limit) automatically attain this friction coefficient. Existing (translational) restraints in existing jobs are not affected by this configuration setting.



As usual, the job can now be analyzed, which will include frictional effects on all (newly defined) translational restraints for all load cases. But what if it was necessary to analyze a particular load case without friction, or what if it was necessary to consider a 20% increase in the friction coefficient. In Versions prior to 4.40, these evaluations would mean returning to input and altering the model.

Now with Version 4.40, both of these situations can be addressed at the “load case level”, without altering the existing input. For example, assume a standard set of load cases as shown in the figure below.

Load Case Name	Output Status	Output Type	Comb Method	Snubbers Active?	Hanger Stiffness	Friction Multiplier
1 W(HGR)	Discard	Disp/Force/Stress		<input type="checkbox"/>	Rigid	1.0000
2 W+D1+T1+P1(HGR)	Discard	Disp/Force/Stress		<input type="checkbox"/>	Ignore	1.0000
3 W+D1+T1+P1+H(OPE)	Keep	Disp/Force/Stress		<input type="checkbox"/>	As Design	1.0000
4 W+P1+H(SUS)	Keep	Disp/Force/Stress		<input type="checkbox"/>	As Design	1.0000
5 L3-L4(EXP)	Keep	Disp/Force/Stress	Algebraic	<input type="checkbox"/>		

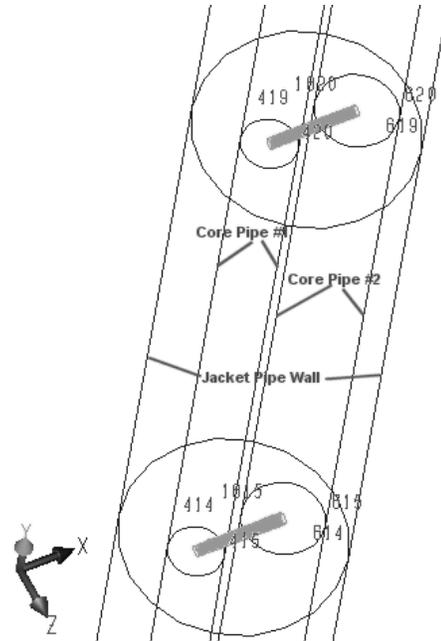
As expected, all basic load cases (1 through 4) are analyzed with the friction coefficient of 0.35 (on the appropriate restraints). To consider the Operating case without friction, and again with a 20% increase in friction, we now can simply add two more load cases, and change the “**Friction Multiplier**”, in the right most column of the “**Load Case Options**” tab. These modifications are shown in the figure below.

Load Case Name	Output Status	Output Type	Comb Method	Snubbers Active?	Hanger Stiffness	Friction Multiplier
1 W(HGR)	Discard	Disp/Force/Stress		<input type="checkbox"/>	Rigid	1.0000
2 W+D1+T1+P1(HGR)	Discard	Disp/Force/Stress		<input type="checkbox"/>	Ignore	1.0000
3 W+D1+T1+P1+H(OPE)	Keep	Disp/Force/Stress		<input type="checkbox"/>	As Design	1.0000
4 W+P1+H(SUS)	Keep	Disp/Force/Stress		<input type="checkbox"/>	As Design	1.0000
5 W+D1+T1+P1+H(OPE)	Keep	Disp/Force/Stress		<input type="checkbox"/>	As Design	0.0000
6 W+D1+T1+P1+H(OPE)	Keep	Disp/Force/Stress		<input type="checkbox"/>	As Design	1.2000
7 L3-L4(EXP)	Keep	Disp/Force/Stress	Algebraic	<input type="checkbox"/>		

In this figure, cases 5 and 6 are alternate operating cases using different frictional effects. Using this load case setup, a single run can evaluate friction effects considering a low value, the expected value, and a high value of the friction coefficient. The **CAESAR II** summary reports can then be used against these load cases to draw conclusions and make decisions.

Static Restraint Report CNODE Filter

The CNODE is a very powerful modeling construct in **CAESAR II**. Essentially, a CNODE is “*an association of degrees of freedom*”. CNODES are most often used to define “internal restraints”, or put another way, how one part of the model is connected to another part. An excellent example of this use is the restraint setup used to connect an internal core pipe to an external jacket, such as in a riser. A portion of such a model is shown in the figure below.



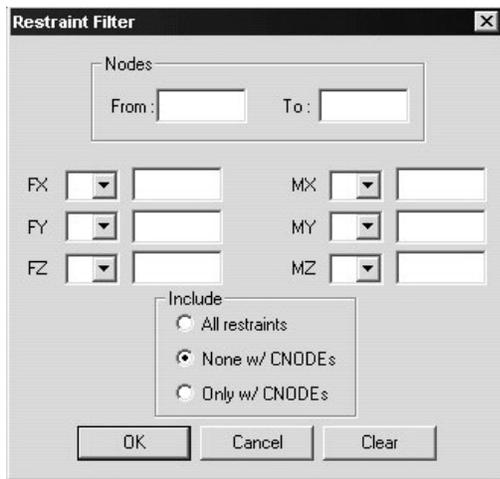
This model consists of a 4 inch core pipe (nodes in 4xx series), a 6 inch core pipe (nodes in 6xx series), and an 18 inch jacket pipe (nodes in 18xx series). Each of these pipes is labeled in the figure above. The core pipes are positioned/connected to the jacket pipe using the “dummy rigid elements” and CNODEs. For example, node 415 is restrained to node 414 in the “X” and “Z” directions using a CNODE. The dummy (shown as a solid bar in the figure above) spans from 414 to 1815, with 1815 a jacket node. Similarly, node 615 is restrained to node 614 in the “X” and “Z” directions using a CNODE.

This modeling setup means that as node 1815 moves in “X” and “Z”, nodes 414 / 615 move in an identical manner. Thus the core and jacket pipes move together in the horizontal plane (at these locations) but they are independent in the vertical (Y) direction. This is great, until it is necessary to review the output restraint report for “external loads”. In this situation, the loads at the CNODE restraints are not desired as these are internal loads. Prior to Version 4.40, the restraint report for this model would have contained all of the restrained nodes, as shown in the figure below.

CASE 2 (OCC) WAV1		DATE: JUN 7, 2002						
-----Forces (lb.)-----			-----Moments (ft. lb.)-----					
NODE	FX	FY	FZ	MX	MY	MZ	TYPE	
BASE_I	18.	-182.	199.	-366.	-99.	-106.	Rigid ANC	
415	-4.	0.	0.	0.	0.	0.	Rigid X	
415	0.	0.	-238.	0.	0.	0.	Rigid Z	
415	0.	357.	0.	0.	0.	0.	Rigid Y	
420	-14.	0.	0.	0.	0.	0.	Rigid X	
420	0.	0.	62.	0.	0.	0.	Rigid Z	
425	2.	0.	0.	0.	0.	0.	Rigid X	
425	0.	0.	-20.	0.	0.	0.	Rigid Z	
430	-2.	0.	0.	0.	0.	0.	Rigid X	
430	0.	0.	0.	0.	0.	0.	Rigid Z	
435	-2.	0.	0.	0.	0.	0.	Rigid X	
435	0.	0.	-7.	0.	0.	0.	Rigid Z	
440	-1.	0.	0.	0.	0.	0.	Rigid X	
440	0.	0.	-2.	0.	0.	0.	Rigid Z	
445	0.	0.	0.	0.	0.	0.	Rigid X	
445	0.	0.	-1.	0.	0.	0.	Rigid Z	
450	0.	0.	0.	0.	0.	0.	Rigid X	
450	0.	0.	4.	0.	0.	0.	Rigid Z	
455	1.	0.	0.	0.	0.	0.	Rigid X	
455	0.	0.	-14.	0.	0.	0.	Rigid Z	
460	-5.	0.	0.	0.	0.	0.	Rigid X	
460	0.	0.	54.	0.	0.	0.	Rigid Z	
465	-13.	0.	0.	0.	0.	0.	Rigid X	
465	0.	0.	-193.	0.	0.	0.	Rigid Z	
top ex	19.	-174.	157.	275.	86.	101.	Rigid ANC	
BASE_0	65.	-534.	548.	-1281.	-350.	-368.	Rigid ANC	
615	-15.	0.	0.	0.	0.	0.	Rigid X	

In this figure, only the nodes with “text labels” are external restraints. All other nodes are internal (CNODE) restraints. Because of these text labels this distinction is easy to view, but what if text labels were not used. Then the review of external loads would be more tedious.

Version 4.40 provides a new option on the “Restraint Filter”, as shown in the figure below. This option allows restraints to be filtered based on whether or not a CNODE is associated with the node.



In this figure, the filter is set to show on restraints “without CNODE” associations. This will produce a report containing only external restraints, as shown in the figure below.

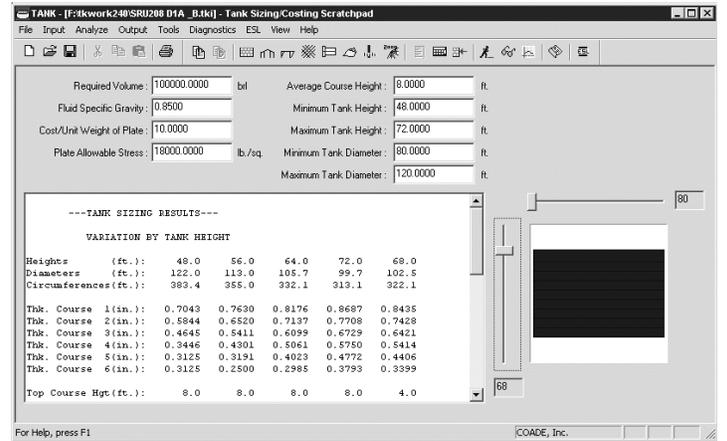
CASE 2 (OCC) WAV1		DATE: JUN 7, 2002						
-----Forces (lb.)-----			-----Moments (ft. lb.)-----					
NODE	FX	FY	FZ	MX	MY	MZ	TYPE	
BASE_I	18.	-182.	199.	-366.	-99.	-106.	Rigid ANC	
top ex	19.	-174.	157.	275.	86.	101.	Rigid ANC	
BASE_0	65.	-534.	548.	-1281.	-350.	-368.	Rigid ANC	
topex1	66.	-532.	425.	1083.	295.	346.	Rigid ANC	
1810	634.	0.	0.	0.	0.	0.	Rigid X	
1810	0.	1423.	0.	0.	0.	0.	Rigid Y	
1810	0.	0.	1278.	0.	0.	0.	Rigid Z	
1810	0.	0.	0.	0.	255.	0.	Rigid RY	
1870	0.	0.	219.	0.	0.	0.	Rigid GUI	
1870	180.	0.	0.	0.	0.	0.	Rigid GUI	

The restraint loads in this figure can be summed to obtain, in this case, the total applied wave load on the riser system.

TANK Version 2.40 Released

The primary purpose for the release of TANK Version 2.40 is to address the new API-650 (Edition 10, Addendum 2) and the new API-653 (Edition 3). Both of these codes were published just as TANK Version 2.30 was released.

In addition to addressing the changes necessitated by these code revisions, a number of other enhancements have been made to the software. Most noticeable of these changes is the addition of a “dynamic sizing tool”, on the “tank sizing scratchpad”. This dynamic sizing tool, shown in the figure below, allows users to adjust the height and / or width of the proposed tank by using the “slider bars”.



As these bars are adjusted, the tank sketch reflects the new size, and the required shell course thicknesses (in the 5th column of the table above) are recomputed.

Current Approach to Defining Ground Motion

By: Dave Diehl

Introduction

B31.3 paragraph 301.5.3 (Earthquake) states: “Piping shall be designed for earthquake-induced horizontal forces. The method of analysis may be as described in ASCE 7 or the Uniform Building Code.” B31.1 paragraph 101.5.3 (Earthquake) is similar but does not reference ASCE 7 or UBC. However, B31.1 adds that the effects of earthquakes shall be considered “using data for the site as a guide in assessing the forces involved”. This article will review the current method of defining the nature of ground shaking (the ground acceleration as a function of frequency or period) as it would be applied in a modal analysis of the piping systems installed at a particular site. Anyone who has no interest in seismic analysis can move on to the next article. If you are interested in seismic analysis but you don’t want to read another article on how they do things in the US – ASCE 7 and UBC are both US building codes – please hang on for a little longer. This article will be useful in setting useful ground shaking data for sites around the world. Additionally, you’ll get a quick overview of the current authorities on this subject and their documents.

Before defining ground shaking, I want to briefly talk about that B31.3 quote. ASCE 7 is alive and well but UBC – the Uniform Building Code – is no longer an active document. The preface of the 1997 UBC states “The ICBO¹ code development process has been suspended by the Board of Directors and, because of this action, changes to the Uniform Building Code will not be processed.” There will be no more UBC. I called the ICBO about this situation and received a thoughtful e-mail from Roger Mensink. Quoting Roger, “I don’t believe there is anything in print that explains the suspension of the code development process for the UBC in more detail. As you probably know, ICBO, BOCA, and SBCCI are integrating with the ICC (International Code Council). Together, these organizations have already published the International Codes, of which the International Building Code essentially replaces the 97 Uniform Building Code. The code development process continues for the IBC. However, many jurisdictions are still under the UBC, and printings incorporating errata continue to be published. I believe we are currently in the seventh printing of the 97 UBC.” Yes, it’s a “suspended” document but as long as there are laws on the books referencing UBC, it will remain in print. For more information visit <http://iccint.intlcode.org/>.

¹ International Conference of Building Officials

What Ground Shaking Data is in COADE Products Now?

Both **CAESAR II** and **PVELite** offer standard shock spectra as defined in US Nuclear Regulatory Guide 1.60. **CAESAR II** also offers canned shock spectra from 1994 UBC. For a complete definition of ground shaking for Reg. Guide 1.60 and 1994 UBC, the user need only enter the Zero Period Acceleration or ZPA for the site. **CAESAR II** and **PVELite** provide data from the highly documented El Centro, California earthquake. El Centro requires no additional input but has limited application to sites outside southern California. **PVELite** also collects ground shaking data for ASCE 7 and IBC. The definition for ground acceleration is identical for both of these codes and these will be discussed below. So this article will review the method for setting an ASCE 7 shock spectrum and, in doing so, bring you up to date on shock definition.

Let me also add that spectrum analysis is only one approach for evaluating piping systems in a seismic zone. Most piping systems and pressure vessels do not require a response spectrum analysis. Many piping systems do not require even a simpler, static equivalent load as in many cases, depending on pipe size and service, simple rules dictate the location of lateral and axial (horizontal) restraints in order to circumvent any seismic analysis. But if you are going to use spectrum analysis you might as well be familiar with today’s approach.

Alphabet Soup! Who Sets the Rules?

1994 UBC

The oldest building code² referenced in **CAESAR II** is the 1994 Uniform Building Code published by International Conference of Building Officials (ICBO). 1994 UBC Figure 16-3 shown here in Figure 1 illustrates the nature of horizontal ground motion. For any given period (inverse frequency) of a structure there is a corresponding acceleration. The response is also affected by ground composition (rock, soil, or clay). Using this chart, a structure having a (fundamental) mode of vibration of 0.5 seconds (2 Hz) would “see” a load of 2g if constructed on rock and 2.5g if built on clay (assuming the earth has a maximum acceleration of 1 g).

² U.S. Nuclear Regulatory Commission Guide 1.60 (Revision 1) *Design Response Spectra for Seismic Design of Nuclear Power Plants* dates back to 1973 but it is not what you would call a building code.

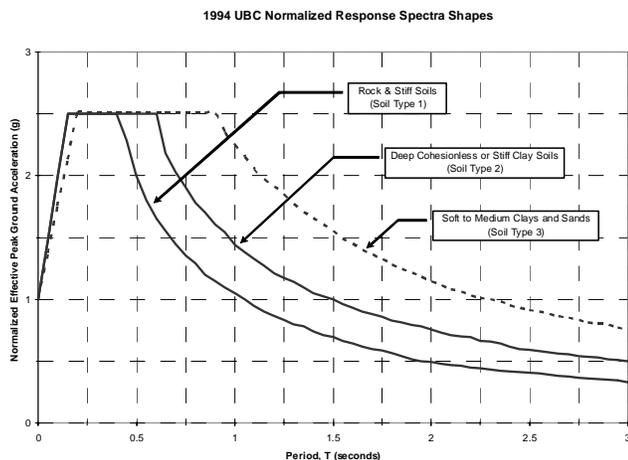


Figure 1

These curves are stored as shock spectra in **CAESAR II**. You can select them based on soil type. The only other piece of data required is the Zero Period Acceleration or ZPA for the site. Note that these “normalized” spectra all show 1g acceleration at T = 0 which is a ZPA = 1. The user-specified ZPA will multiply these accelerations across the entire spectrum. ZPA is a function of the seismic zone (0, 1, 2A, 2B, 3 & 4) associated with the site. Figure 16-2 in 1994 UBC maps these zones across the US. Appendix Paragraph 1655.4 states that these normalized spectra can be scaled by the product ZN where Z is the seismic zone factor (based on seismic zone)³ and N is the near-field coefficient⁴ (a value between 1.0 & 1.5 based on the magnitude of the ground shaking and proximity to the active fault). So for a structure constructed in seismic zone 4 more than 15 km from an active fault (Z=0.40 and N=1.0), the ZPA is 0.40 and, if constructed on rock, the calculated response would be 0.80g for that example above (having a fundamental period of 0.5 seconds).

Unfortunately, Appendix Chapter 16 from which these factors come is titled Division III – Earthquake Regulations for Seismic-Isolated Structures and there is no similar calculation found in the main body of the code for all other structures. But there is a way back. In the

³ Table A-16-C:

Zone	Z
0	0
1	0.075
2A	0.15
2B	0.20
3	0.30
4	0.40

⁴ In Table A-16-D, N is a value between 1.0 & 1.5 based on the magnitude of the ground shaking and proximity to the active fault.

dynamic procedures (paragraph 1629.5.3 *Scaling of Results*), it says dynamic loads should be scaled up or down so that the structure’s base shear using static analysis methods essentially match the base shear using dynamic methods. The static method calculates design base shear (V) in Equation 28-1: $V = (ZIC/R_w) \cdot W$ which has a form of load = (factor) times (weight). This factor, then, serves as the acceleration or g load on the structure – the g load we should see in the dynamic analysis. The static factor has three parts – ZC, I and R_w . Guidelines for Seismic Evaluation and Design of Petrochemical Facilities⁵ on page 4-9 states “The product ZC represents the spectral acceleration corresponding to the period of the structure. ...the spectral ordinate corresponding to the period of the structure may be used in lieu of the ZC value, subject to the approval of building officials.” So this ZC, alone, should approximate the response from our ground shaking response spectrum but there are two other values I and R_w . I varies between 1.0 and 1.5 and reflects the importance of the structure; buildings which must remain operational through an earthquake or have higher consequences with failure have the higher value of I. Now since the actual earthquake magnitude does not change based on what you build, this value reflects an increased factor of safety instead of an increase in ground motion. However, since the static and dynamic base shear must match, it seems sensible to include this importance factor in the ground shaking spectrum. So now the ZPA in **CAESAR II** would be ZNI rather than just ZN. And what of that R_w ? Again to quote Guidelines⁶, “ R_w is a measure of energy absorbing capability or ductility inherent in a particular type of structural system or structure. It represents an equivalent reduction in seismic forces by allowing energy dissipation once the structure begins to respond in the inelastic range.” Local yielding in the structure dampens or reduces the response to the earthquake; a typical value for tall towers and piping range between 3.0 and 4.0. There is no clear indication of how this factor could be fit back into the shock spectrum but there is one interesting note in Guidelines⁷, “When a dynamic analysis is performed, various building codes generally require that the base shear (after dividing by R_w) be compared to that of an equivalent static analysis.” “After dividing by R_w ” indicates that the dynamic results do not reflect this ductility factor and it must be incorporated in the dynamic results prior to comparison with the static base shear. The conclusion, then, is to use ZNI as the **CAESAR II** value for ZPA but then compare the total shear (or total restraint reaction in the appropriate direction) to the calculated value V.

Another piece of information from 1994 UBC will be noted here for future reference. Paragraph 1629.2 *Ground Motion* states “The

⁵ Published by ASCE in 1997

⁶ *ibid.*, page 4-10

⁷ *ibid.*, page 4-22

ground motion representation shall, as a minimum, be one having a 10 percent probability of being exceeded in 50 years.” Note 2 of that paragraph says use damping ratio of 0.05 and Note 5 says the vertical shock component may be defined as two thirds of this horizontal shock.

1997 UBC

The 1997 issue of the Uniform Building Code, the last UBC, dropped the normalized shock spectra and broke away from the rigid structure of response spectrum timing. The shock spectra still maintained shape of the 1994 code but the fixed periods starting and ending the flat peak portion of the spectra are calculated based on seismic zone and soil characteristics. Paragraph 1631.2 *Ground Motion* again refers to a shock with a 10 percent probability of being exceeded in 50 years; Note 2 says use damping ratio of 0.05; and Note 5 says vertical can be 2/3 horizontal. As no COADE package offers canned data for 1997 UBC we will move on to the other authorities. To learn more about the ICBO visit http://www.icbo.org/About_ICBO/.

IBC 2000

The International Building Code is published by the International Code Council, Inc. (ICC) and is the result of the combined efforts of three organizations – Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International, Inc. (SBCCI). These “International” codes are intended to replace the existing group of Uniform codes. I understand that in the future IBC will, in turn, delete its seismic provisions and refer, instead, to ASCE-7. The first thing you notice in the IBC is the detail and number of seismic maps – no more simple set of six zones. The second is the number of new terms – mapped spectral response accelerations at short period (S_s) and at 1 second (S_1), the maximum considered earthquake (MCE) spectral response accelerations at short period (S_{MS}) and at 1 second (S_{M1}), and the damped design spectral response accelerations at short period (S_{DS}) and at 1 second (S_{D1}). Common to each set of terms is the short period and 1 second period reference. Each component of this mapped pair is multiplied by a site coefficient (F_a for S_s and F_v for S_1) to get the MCE data and that then is scaled down to the design data.

These maps show MCE accelerations for Site Class B. Site Class B is assigned to soil profiles consisting of rock. If your structure is to be built on rock (and there is a definition of hard rock, rock and soft rock) you can use these values directly. But what if you are constructing the building, vessel or piping system on a different soil profile, say, stiff soil or hard rock? Different soil profiles have different site coefficients to convert *mapped* accelerations to MCE accelerations. You must back-calculate the mapped accelerations from the listed Site Class B MCE accelerations and then re-calculate the MCE accelerations for the proper Site Class. However, all the

site coefficients (F_a & F_v) for Site Class B are 1.0. That means that the MCE accelerations for Site Class B are equivalent to the mapped accelerations used with any site. (For Site B, $S_{MS}=S_s$ and $S_{M1}=S_1$.) The maps appear in pairs – one for short period and one for 1 second period; all are for 5% critical damping; and the MCE maps reference NEHRP – more on that later. Although I could not locate a direct reference in the maps, these response spectra are now based on 2% probability of exceedance within a 50 year period rather than the 10% used in earlier codes. It’s this change in the mapped earthquake magnitude that requires the MCE data be scaled down to the design data (converting S_{MS} to S_{DS} and S_{M1} to S_{D1}). This reduction in load will match load magnitudes in previous codes.

The shock spectra produced here appears identical to that in ASCE 7 so it will not be developed here. You can visit <http://www.intlcode.org/about/index.htm> to learn more about the International Code Council.

ASCE 7-98

ASCE 7-98 is entitled *Minimum Design Loads for Buildings and Other Structures* and is published by American Society of Civil Engineers. The home page for ASCE is <http://www.asce.org>. This document is the other standard listed in B31.3 and the focus of this article

The tables, maps and equations found here are identical to the IBC terms. Once again, you go to the maps and collect the mapped spectral acceleration for an imaginary oscillator tuned to a period of 0.2 seconds (a frequency of 5 Hz) and then an oscillator tuned to 1 sec (1 Hz). Tables provide site multipliers for these accelerations which then are converted to Maximum Considered Earthquake, or MCE, accelerations. These site multipliers are based on average shear wave velocity, average penetration resistance and average undrained shear strength of the rock or soil. If these data are not known, the code allows you to use Class D to set the multipliers (see Exception to 9.4.1.2.1). Site Class D is considered stiff soil while Site Class B is rock. We’ll build a shock spectrum in accordance with ASCE 7 after reviewing a few more documents.

NEHRP

NEHRP is not a document; instead it is a government program. The National Earthquake Hazards Reduction Program was established by an act of Congress in 1977 to “reduce the risks to life and property from future earthquakes in the United States”. The lead agency for this program is FEMA, the Federal Emergency Management Agency. The United States Geological Survey (USGS) also plays a role and has published seismic data maps for NEHRP. These are the maps that appear in IBC 2000 and ASCE 7. I mentioned that these response acceleration maps are based on 5% critical damping. You may ask... “What’s that have to do with my piping system?” Modal analysis, by necessity, eliminates damping from the equations of motion but includes its effect by increasing or

decreasing the applied load. So a system having 10% critical damping would use a lesser response acceleration than a 5% system. Fortunately for us, piping systems shall be designed assuming a 5% critical damping. (See ASME Boiler & Pressure Vessel Code Section III Division 1 Appendix N paragraph N-1231.) Therefore, we can use the mapped data without modification for damping.

You don't have to have the actual map to find your local mapped spectral response accelerations S_s & S_1 . US ground motion data are available online through USGS. With a specification of latitude and longitude or even a simple Zip (postal) code, the site will list local ground motion data. This data is available at <http://eqint.cr.usgs.gov/eq/html/zipcode.shtml>. We will use this data source in the example.

FEMA 302 & 303 and 368 & 369

These NEHRP documents are prepared by the Building Seismic Safety Council for the Federal Emergency Management Agency. These books containing *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* are produced in pairs: *Part 1 – Provisions* in one book (about the size of a phone book) and *Part 2 – Commentary* in the other. The 302/303 pair form the 1997 edition and the 368/369 pair make up the 2000 Edition. These four documents are available online in PDF files at <http://www.bssconline.org/> or they can be sent to you by mail. There is no charge for these government documents and the order-takers are quite friendly. The FEMA web site is <http://www.fema.gov/> but I couldn't locate their entire document catalog there. In North America call 1(800)480-2520 and either ask for these documents or have them send you a FEMA Publications Catalog. The catalog will provide instructions for faxing in your complete order. It's more than just earthquakes; they have information on fires, floods, hazardous materials and the like.

If you have trouble reading those small US maps in ASCE 7 or UBC, order a set from FEMA. They are quite large – Architectural E format. You will get response accelerations at both 0.2 seconds and one second. They are defined as Maximum Considered Earthquake (MCE) Ground Motion Site Class B but again you can read these as mapped accelerations since Site Class B multipliers to convert mapped to MCE accelerations are all 1.0. Maps 27, 28, 31 & 32 are labeled as “Probabilistic Earthquake Ground Motion and appear to match Maps 1,2, 3 & 4 respectively. These maps show the mapped accelerations and do not reference Site Class B. I guess they wanted to show it both ways. Use the ones that are based on 2% probability of exceedance. They throw in one set of California and Nevada maps (Maps 29 & 30) that show accelerations based on 10% probability of exceedance in 50 years – the old 1994 UBC standard. Naturally, an earthquake that has a one in ten chance of occurring is smaller in magnitude than an earthquake that has only a one in fifty chance of occurring. And yes, a point with 0.55g acceleration on the 10% map shows as about 1.20g on the 2% map. As you would expect, most of the big numbers are along the west

coast. What may be surprising is the very high g loads along the Mississippi River bordering Kentucky and Tennessee. I couldn't find anything in California that exceeded the 3g acceleration (at 0.2 seconds) here. South Carolina, too, has impressive numbers of over 1.5g (again at 0.2 seconds) about halfway up the coast.

The Provisions (FEMA 302 & 368) recommend rules for the seismic design of structures and cover several methods, many of which are not applicable to our piping systems. Our intent is to use these documents to define the ground shaking and not the method of system analysis. Chapter 4 – Ground Motion – serves that purpose well. The Commentaries (FEMA 303 & 369) provide the background and justification for these rules. So if you want to learn more of the why's and where's to seismic load specification, these documents are a great place to start. They're certainly priced right.

TI 809-04

A CAESAR II user alerted me to this document. (Thank you Tej.) Not knowing what it was or who created it, I just went to the internet and searched on the phrase “TI 809-04” and came up with a web page containing this document authored by the US Army Corps of Engineers – their “Technical Instructions, Seismic Design of Buildings”. The Corps of Engineers has the entire document broken into chapters and downloadable as PDF files. I know of no hard copy available for this document. The intent is to have the latest information immediately available for interested parties through the internet at <http://www.hnd.usace.army.mil/techinfo/ti/809-04/ti80904.htm>. There are many references to NEHRP 1997 and FEMA 302 in TI 809-04.

Paragraph 2-2 – Ground Motion – in Chapter 2 states “the art of ground motion prediction has progressed in recent years to the point that nationally approved design criteria have been developed by consensus groups of geotechnical and building design professionals.” So that's what we are doing here – applying those national design criteria.

One gem in this document is the conversion factors for the old (1991) UBC data. This gives you a way to relate the old methods to the new. Additionally, international sites with old UBC data can now use this conversion to build the new shock spectrum. The document provides a table showing S_s & S_1 for many cities around the world. Download Chapter 3 from the web site to learn more.

TI 809-04 also defines two ground motions – Ground Motion A and Ground Motion B. Ground Motion A matches that found in FEMA 302 and is used for Performance Objectives 1A (Life Safety) and 2A (Safe Egress for Special Occupancy) while Ground Motion B is used for Performance Objectives 2B (Safe Egress for Hazardous Occupancy) and 3B (Immediate Occupancy for Essential Facilities). A is scaled to 2/3 of the mapped spectral acceleration while B is scaled to 3/4 of the same acceleration. You apply A (2/3) or B (3/4) depending on the building use – the more “important” the building,

the higher the design load. Other codes handle this by increasing the detail of analysis for the “more important” structures or tightening design limits (see, for example, Seismic Design Categories in ASCE 7).

Summary

Everybody appears, now, to be saying the same thing when it comes to ground shaking. If you are interested in such detail, visit the web site of S. K. Ghosh Associates Inc. at <http://www.skgshassociates.com/Comparisons%20of%20seismic%20codes.htm>. They provide a detailed comparison of IBC 2000, 1997 NEHRP & ASCE 7-98 and even throw in 1997 UBC

What terms do we use?

That USGS web site lists more numbers than we need. So what do we need?

Here’s the data for my house in Houston, Texas, zip code 77069 – certainly not an exciting place in terms of ground motion but it shows what data is available.

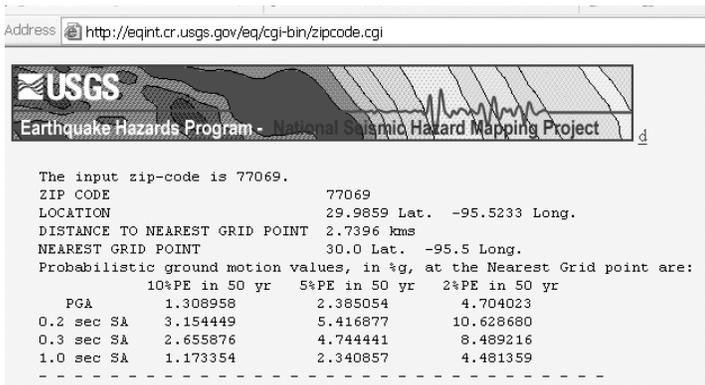


Figure 2

We will use the last column in the table – 2%PE in 50 yr or 2% probability of exceedance in 50 yrs. The 2% probability of being exceeded in 50 years equates to an equivalent return period of 2475 years⁸. A return period is an estimate of how long it will be between events of a given magnitude; here, you can expect an earthquake of this magnitude to come around once in 2475 years. The 1994 UBC

⁸ “The relation between return period, T and probability of exceedance for a Poissonian distribution is given as: $T = -t/\ln(1 - p)$ where p is the probability of exceedance in t years.” – *Guidelines for Seismic Evaluation and Design of Petrochemical Facilities* Published by ASCE 1997

code used the first column or 10% in 50 years (once in 475 years) and called it the maximum capable earthquake, now (2% in 50) is called maximum considered earthquake or MCE. There are four rows in this table: PGA or Peak Ground Acceleration, 0.2, 0.3 and 1.0 SA or spectral accelerations for oscillators tuned to 0.2, 0.3 and 1.0 second. We will use the values for 0.2 and 1.0 seconds. The codes refer to these MCE accelerations as S_{MS} and S_{MI} . S_{MS} is short period acceleration where short here means 0.2 seconds. If I attach a simple cantilever to the ground and this cantilever has a first mode of vibration of 5 Hz. (a frequency of 5 cps is the same as a period of 0.2 seconds), its maximum acceleration would be the value shown in the table above. S_{MI} is the acceleration for a one second oscillator. Accelerations are listed as percent g so, for my home, $S_{MS} = 0.1063$ g and $S_{MI} = 0.0448$ g.

For now we need not consider PGA or Peak Ground Acceleration but it may become a useful term in the future. The B31 codes are working on a new document B31S for the seismic design of piping systems. At this time it looks like B31S will use PGA (for my house it’s 0.0470 g) in its design rules. You may ask how my site can have S_{MS} and S_{MI} values greater than PGA. PGA is the actual ground acceleration while S_{MS} and S_{MI} are system *responses* to that acceleration. That’s what makes dynamic loads interesting – the response can be greater than the applied load.

Although I could not find an explicit statement, these accelerations assume a 5% critically damped response. That’s what we should use for piping systems.

Well, what if you do not have a US Zip Code associated with your site? Go back to that TI 809-04 web site and open up the Chapter 3 PDF. Table 3-3 (starting on page 13) lists mapped accelerations (S_s & S_l) for over 200 sites around the world. If you can’t find your city but know your UBC zone, page 11 starts a discussion on converting old 1991 UBC data to the needed values. I should also note that these calculations are approximate and you should always look for more recent or more applicable data. Even the USGS data carries a disclaimer stating the data may not match those NEHRP maps.

Localizing your shock spectrum

Another note on the USGS web site states: “These ground motion values are calculated for ‘firm rock’ sites which correspond to a shear-wave velocity of 760 m/sec. in the top 30m. Different soil sites may amplify or de-amplify these values.” For a given earthquake event, the ground response will vary according to the “hardness” of the ground – either increasing or decreasing the g load to the structure. This characteristic is accounted for through a term called Site Class in ASCE 7. Looking at the Site Class definitions in ASCE 7, we find that the ‘firm rock’ site referenced here matches Site Class B. As mentioned earlier in the discussion on the FEMA maps, Site Class B has multipliers of 1.0 to convert *mapped* MCE to MCE or S_s to S_M and S_{MS} to S_{MI} . To keep things straight, the authorities create mapped earthquake accelerations and you convert

these values to MCE's using these site conversions. ASCE 7 Table 9.4.1.2 defines six Site Classes:

Class	Definition
A	Hard rock
B	Rock
C	Very dense soil and soft rock
D	Stiff soil
E	Soil
F	Soils requiring site specific evaluation

These classes are sorted by shear wave velocity, penetration resistance and undrained shear strength. So what sort of soil do I have at my house? How do I convert the mapped accelerations to my ground accelerations? Fortunately, ASCE 7 provides this exception in paragraph 9.4.1.2.1: "When the soil properties are not known in sufficient detail to determine the Site Class, Class D shall be used. With multipliers greater than 1.0, Class D sites will increase the mapped accelerations.

How do you build a seismic shock spectrum from S_s & S_1 ?

Eventually, we need a shock spectrum similar to the 1994 UBC spectra illustrated at the beginning of this article. Referring again to that figure we see g load plotted versus period. Once we calculate the piping system's important natural frequencies, we can read the ground accelerations for these frequencies (the inverse of the period) from the chart and load the individual system mode shapes accordingly. We must create something similar to that original spectrum in Figure 1 for these ASCE 7 numbers. Note, too, that the figure shows three curves for the three soil types found in that code.

Here are the terms needed to create an ASCE 7 shock spectrum:

S_s = mapped short period acceleration read from the maps or the USGS zip code site

S_1 = mapped 1 second acceleration read from the maps or the USGS zip code site

S_{MS} = short period Maximum Considered Earthquake (MCE) acceleration

S_{M1} = one second MCE acceleration

$$S_{MS} = F_a \cdot S_s$$

$$S_{M1} = F_v \cdot S_1$$

F_a = acceleration-based site coefficient from Table 9.4.1.2.4a, based on Site Class and S_s , values range between 0.8 to 2.5

F_v = velocity-based site coefficient from Table 9.4.1.2.4b, based on Site Class and S_1 , values range between 0.8 to 3.5

S_{DS} = design spectral acceleration at short periods (0.2 seconds)

S_{D1} = design spectral acceleration at a one second period

$$S_{DS} = \frac{2}{3} \cdot S_{MS}$$

$$S_{D1} = \frac{2}{3} \cdot S_{M1}$$

(TI 809-04 states in paragraph 3.1c that using 2/3 of MCE will compare well with the prior codes that were based on 10% probability of exceedance in 50 years rather than the new 2% probability of exceedance in 50 years.)

With S_{DS} and S_{D1} , the response spectrum for ASCE 7 can be built. Paragraph 9.4.1.2.6 provides the parameters to build the following curve:

Fig. 9.4.1.2.6 Design Response Spectrum from ASCE 7-98 (also, 2000 NEHRP / FEMA 368)

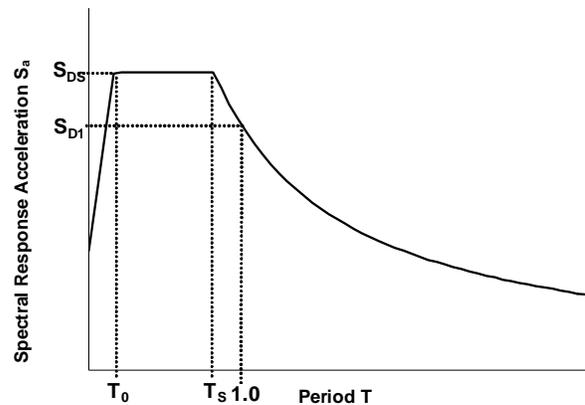


Figure 3

The S_a curve is broken into three sections: 1) the straight line S_a for periods less than T_0 , 2) the flat S_a between T_0 and T_s and 3) the S_a curve above T_s .

$$T_0 = 0.2 \cdot \frac{S_{D1}}{S_{DS}}$$

$$T_s = \frac{S_{D1}}{S_{DS}}$$

$$S_a = S_{DS} \cdot \left(0.4 + 0.6 \cdot \frac{T}{T_0} \right) \text{ for } T \leq T_0$$

$$S_a = S_{DS} \text{ for } T_0 < T \leq T_s$$

$$S_a = \frac{S_{D1}}{T} \text{ for } T > T_s$$

PVELite will collect the values that you enter for S_s , S_1 , F_a and F_v and build this spectrum for you. In **CAESAR II** you must collect data from the resulting shock spectrum and enter the table in the **CAESAR II** dynamic input or access the table as a text file stored on the hard disk.

ASCE 7 sample

Let's finish up by building a shock spectrum used to design a piping system in my back yard. Again, the USGS web site displays S_{MS} and S_{M1} (as 0.1063 g and 0.0448 g, respectively) for Site Class B but since Site Class B has F_a and F_v equal to 1.0, these Maximum Considered Earthquake values are equivalent to the *mapped* values S_s and S_1 . I guess that my back yard is soft soil but since I do not have sufficient information to determine the soil profile, I may assume Site Class D. That is unless I have Site Class E or F soils.

$$S_s = 0.1063 \text{ g}$$

$$S_1 = 0.0448 \text{ g}$$

$$F_a = 1.6 \text{ for Site Class D where } S_s \cdot d \cdot 0.25 \text{g (Table 9.4.1.2.4a)}$$

$$F_v = 2.4 \text{ for Site Class D where } S_1 \cdot d \cdot 0.1 \text{g (Table 9.4.1.2.4b)}$$

$$S_{MS} = F_a \cdot S_s = 1.6 \cdot 0.1063 = 0.170 \text{ g}$$

$$S_{M1} = F_v \cdot S_1 = 2.4 \cdot 0.0448 = 0.108 \text{ g}$$

$$S_{DS} = \frac{2}{3} \cdot S_{MS} = \frac{2}{3} \cdot 0.170 = 0.113 \text{ g}$$

$$S_{D1} = \frac{2}{3} \cdot S_{M1} = \frac{2}{3} \cdot 0.108 = 0.072 \text{ g}$$

$$T_0 = 0.2 \cdot \frac{S_{D1}}{S_{DS}} = 0.2 \cdot \frac{0.072}{0.113} = 0.127 \text{ sec}$$

$$T_s = \frac{S_{D1}}{S_{DS}} = \frac{0.072}{0.113} = 0.637 \text{ sec}$$

$$S_a = S_{DS} \cdot \left(0.4 + 0.6 \cdot \frac{T}{T_0}\right) = 0.113 \cdot \left(0.4 + 0.6 \cdot \frac{T}{0.127}\right) = (0.0452 + 0.534 \cdot T) \text{ g}$$

for $T \leq T_0$

$$S_a = S_{DS} = 0.113 \text{ g for } T_0 < T \leq T_s$$

$$S_a = \frac{S_{D1}}{T} = \frac{0.072}{T} \text{ g for } T > T_s$$

Plotting these three S_a curves we have:

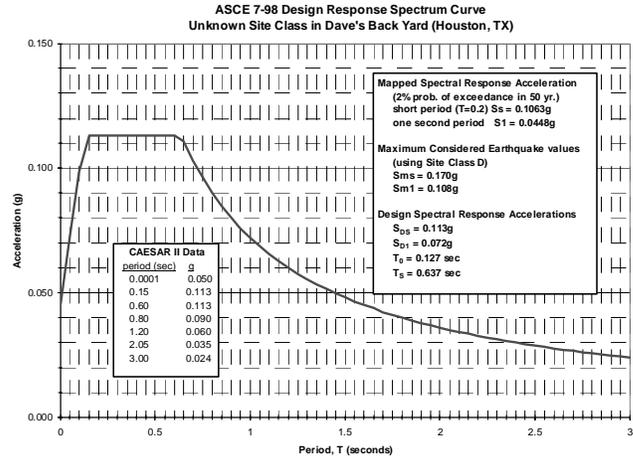


Figure 4

It's not much of an earthquake; I would focus on wind loads, here, instead.

To enter this shock spectrum in **PVELite**, enter values for S_s , S_1 , F_a and F_v . The **CAESAR II** input for this spectrum is accomplished in three components listed below and highlighted in Figure 5.

1. Set the spectrum name and parameters in the Spectrum Definitions tab
2. Build the spectrum table using the Spectrum Data Points button (using data similar to the period vs. g table shown in Figure 4). Here, for example:

Period (sec)	g
0.001	0.050
0.15	0.113
0.60	0.113
0.80	0.090
1.20	0.060
2.05	0.035
3.00	0.024

3. Reference the spectrum name in the shock load case(s) in the Spectrum Load Cases Tab and supply the appropriate factor to convert g to acceleration in terms of length/time²

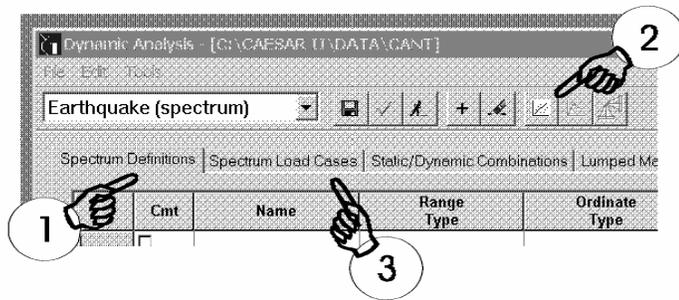


Figure 5

Application

Building codes evaluate buildings more on strength methods rather than stress methods and piping and vessel just don't act like buildings. For example, the building codes focus on base shear and story drift – terms important in building design but useless in piping design. Where piping is itemized, the codes reduce the ground shaking to a static equivalent load on the supports and the relative displacement of the different supports; again focusing on the building loads and not the piping response. For the building codes, vessels and piping are essentially rigid components attached to the building. They allow a full response spectrum modal analysis but the guidance given is not as complete as the static Equivalent Lateral Force or ELF approach.

While the ground motion as defined above can be used directly in COADE's programs, ASCE 7 and its implementation in **PVelite** introduces three additional terms: The Occupancy Importance Factor (I), the Response Modification Coefficient (R), and the Deflection Amplification Factor (C_d). The response Modification Coefficient, R, "essentially represents the ratio of the forces that would develop under the specific ground motion if the structure had an entirely linearly elastic response".⁹ I consider R analogous to a shape factor for our pipe. We calculate and evaluate stress at the outer fiber of the pipe but for the section to form a plastic hinge and yield across the entire section, a higher bending moment is required. This ratio of bending moments, $M(\text{complete yield})/M(\text{outer fiber yield})$ is the shape factor for the cross section and is a function of section geometry. Likewise, significant yield of one element of a building may not produce building failure as load will transfer to other elements creating an increased building capacity. So R reflects the building ductility. Values for R range from 3 to 8 for most plant structures with skirt supported towers having a value of 4 and piping systems at around 3.5. But accounting for ductility also

accepts damage to the building. Since some buildings are too important to permit such damage, the R value is reduced by the Occupancy Importance Factor, I. I runs from 1.0 for most buildings to 1.5 for structures that must function throughout an earthquake.

Usually the modal masses are each multiplied by their corresponding ground acceleration to produce the modal inertial load but here each of the modal ground accelerations taken from the response spectrum is first divided by R/I. So instead of $F = m \cdot a$ on the modal level, you have $F = m \cdot a / (R/I)$. In the dynamic analysis, these reduced loads would produce lower system deflections. While these loads may be appropriate for ASCE 7 evaluation, the resulting deflections may not. To correct this, ASCE 7 introduces the Deflection Amplification Factor, C_d . Values for C_d are greater than 1.0 but less than R. The modal deflections are multiplied by (C_d/I) in order to "back out" the load adjustments and produce a more accurate deflected shape. One way to calculate these deflections in **CAESAR II** would be to run a second dynamic analysis where the ground accelerations are multiplied by the ratio C_d/R . ASCE 7 Table 9.5.2.2 lists Values for R and C_d by building type. Occupancy Importance Factors are listed in Table 9.1.4 based on Seismic Use Groups (Table 9.1.3) which is defined according to Occupancy Category (Table 1-1).

The ratios R/I and C_d/R can be easily included in the **CAESAR II** analysis by specifying the appropriate Factor in the Spectrum Load Case Definition. A spectrum factor is already implied in the data above since the shock table shows g load and **CAESAR II** requires acceleration in terms of length/time². Converting from g's to inches per second squared requires a factor of 386. If the ratio R/I is to be included, simply divide 386 by R/I. So if R = 3.5 and I = 1.0, then the spectrum factor will be entered as $(386)/(3.5/1.0)$ or 110.

These R, I and C_d factors are fully incorporated in **PVelite** analyses in accordance with the modal analysis guidelines outlines in ASCE 7. Modal accelerations are automatically divided by the R/I ratio. Additionally, modes occurring at a period greater than 4 seconds (or at frequencies less than 0.25 cycles per second) use a different multiplier found in Equation 9.5.4.5-4. Likewise the modal deflections are multiplied by the C_d/I ratio.

But would this be appropriate in a piping system analysis where yield is to be avoided? I think not. Yield plays a large role in secondary load analysis. Local yielding is acceptable as the piping system grows to its operating position. This is known as shakedown.

⁹ FEMA 303 (1997 Edition of NEHRP Recommended Provisions, Part 2 – Commentary) page 61.

Primary stress evaluation, however, has as its limit the yield stress of the piping material. Generally, the pipe's outer fiber may not be greater than 88% of the yield stress¹⁰. If a good design does not permit local yielding, then yield adjustments such as R and C_d should not be included in the calculations.

Closing

So here I go through this long narrative on creating a shock spectrum using building code guidelines and I end up suggesting we pick and choose some rules and ignore others. The building codes don't look at piping as distributed flexible structures as we do. They see piping as a building component that responds to the shock but does not amplify it. Another issue, so far avoided, is what shock actually hits the piping system. I have outlined a quick method for generating a localized *ground* response spectrum but many piping systems are not attached to the ground. The structure between the piping and earth will also modify the pipe's shock spectrum. If the structure is flexible and it carries relatively large piping loads, then the interaction of piping and structure would require the inclusion of the structural steel in the seismic analysis of the piping system. We'll leave that for another article. Let's close by saying we now have a robust means of setting a local ground response spectrum and a good review of useful internet sites.

¹⁰ B31.3 limits sustained plus occasional stresses to 1.33 times the hot allowable stress (S_h). In most cases, the hot allowable stress is $2/3$ yield stress (S_y) at temperature. $1.33 \times 2/3$ is 0.88 so there is no yield. Nuclear piping analyzed for earthquakes which may cause local yielding (a safe shutdown earthquake, SSE) address yield in two ways 1) the allowable stress runs up to $1.8S_h$ or $1.2S_y$ and 2) percent critical damping for SSE was twice as great as the percent critical damping for an operating basis earthquake (OBE) thereby reducing seismic load in a manner similar to the ASCE 7 methods using R . The Nuclear Code now uses the higher percent critical damping for both the OBE and SSE.

Determination of Stresses on a Vertical Vessel due to Earthquake, Pressure and Weight Loads

By: Scott Mayeux

In a previous article we compared the generation of loads on a tall vertical vessel using the Response Spectrum Analysis and the static equivalent method. In this article, we will investigate how to compute bending stresses on a tower using the UBC 1994 earthquake code and combine them with pressure and axial weight stresses.

With any engineering analysis a set of design parameters must be specified, typically in a design specification. Information in the design specification must then be entered into **PVelite**. The earthquake Design data for this analysis is as follows:

- Importance Factor [I] - 1.05
- Soil Type - Rock
- Horizontal Force Factor [R_w] - 3.0
- Seismic Zone - 4

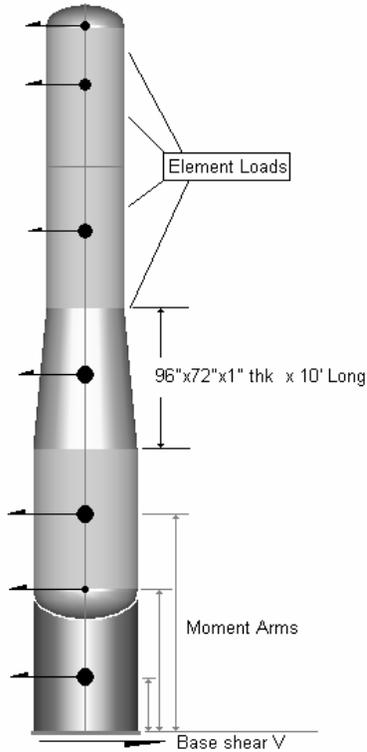
One objective of the analysis is to determine the longitudinal bending stresses at each section. To determine the stresses there are a number of steps that must be followed.

These steps are:

1. Compute the Elevations of the beginning and mid points of each element.
2. Design or Analyze the Vessel for Internal and External Pressure as required.
3. Determine the weights of the vessel elements as well as the nozzles, platforms, rings and other attachments to the vessel.
4. Determine the mechanical properties of each element such as the moment of inertia and cross sectional area.
5. Determine the Fundamental period of Vibration.
6. Use the equations listed in the Earthquake code to calculate the base shear.
7. Distribute the base shear to each element. This will be a concentrated lateral force that acts at the center of each element.
8. From the top down, sum all of the moments at the beginning of each section.

9. Compute the tensile and compressive stresses and compare to appropriate Code allowable stresses.
10. If the vessel is being re-rated or designed, determine acceptability. If the geometry is overstressed and the vessel is being designed, increase the thickness and return to step 2.

A sketch of the vessel is shown in the figure below:



As shown each element is 10 feet long. The major diameter is 96 inches, the minor diameter is 72 inches and all elements are 1 inch thick. The heads have a 2-inch straight flange. The coordinates of element are shown in the table below. The values shown in the “Y” column are the distances from the bottom of the base to the end of the element. Because we will be computing the stresses at the beginning of the element, the vertical dimension of those points will be computed in addition to the element mid point.

XY Coordinate Calculations					
From	To	X (Horiz.) ft.	Y (Vert.) ft.	DX (Horiz.) ft.	DY (Vert.) ft.
10	20	0.00000	10.0000	0.00000	10.0000
20	30	0.00000	10.1667	0.00000	0.16667
30	40	0.00000	20.1667	0.00000	10.0000
40	50	0.00000	30.1667	0.00000	10.0000
50	60	0.00000	40.1667	0.00000	10.0000
60	70	0.00000	50.1667	0.00000	10.0000
70	80	0.00000	50.3333	0.00000	0.16667

The pressure design for this tower has already been completed so proceed to step 3. The weights of each element are shown below.

Element and Detail Weights							
From	To	Element		Corroded		Corroded	
		Metal Wgt. lb.	ID Volume in ³	Metal Wgt. lb.	ID Volume in ³		
10	20	10348.8	0.00000	10348.8	0.00000		
20	30	3359.40	130288.	3359.40	130288.		
30	40	10348.8	868588.	10348.8	868588.		
40	50	9114.26	669536.	9114.26	669536.		
50	60	7788.26	488580.	7788.26	488580.		
60	70	7788.26	488580.	7788.26	488580.		
70	80	1934.79	57001.1	1934.79	57001.1		
Total		50683	2702574	50682	2702574		

Next, calculate the cross sectional properties such as the area and section modulus.

Longitudinal Stress Constants							
From	To	Metal Area		New & Cold		Corroded	
		New & Cold in ²	Corroded in ²	Sect. Mod. in. ³	Sect. Mod. in. ³		
10	20	304.734	304.734	7315.18	7315.18		
20	30	304.734	304.734	7315.18	7315.18		
30	40	304.734	304.734	7315.18	7315.18		
40	50	304.734	304.734	7315.18	7315.18		
50	60	229.336	229.336	4129.60	4129.60		
60	70	229.336	229.336	4129.60	4129.60		
70	80	229.336	229.336	4129.60	4129.60		

Determine the fundamental period of vibration (POV). This is achieved by using the Freese method or the Eigen solution method. The POV for this tower turned out to be 10.0067 cycles per second. The natural frequency is used in many wind and seismic codes. Altering the fundamental POV can change wind and seismic loads.

Compute the base shear V. This is a single force that acts at the base of the skirt and is then distributed to all elements. This distribution depends on the height and mass of each element. From the Uniform Building Code 1994 Ed. Volume 2, Structural Engineering Design Provisions section 1628, the base shear is computed as follows:

$$V = \frac{ZIC}{R_w} W \text{ where } C = \min \left[\frac{1.25S}{T^{2/3}}, 2.75 \right]$$

The terms in these equations are:

- Z - the seismic zone factor given in UBC 94 table 16-I
- I - the specified importance factor
- C - numerical Coefficient specified in UBC Section 1628.2.1
- W - the total dead weight
- S - site coefficient for soil characteristics in table 16-J
- T - fundamental period of vibration in seconds
- R_w - numerical coefficient found in tables 16-N and 16-P

For Zone 4, a highly active zone area, the value of Z from the table is 0.4. The site coefficient S is 1.0 for rock-like soils. I, the importance factor as specified above is 1.05 and R_w is 3.0. W, the total dead load is the sum of all component and element weights.

W is 50683 pounds. In order to determine V, the soil and frequency factor C must also be computed. $C = \min(5.80, 2.75) = 2.75$.

Now, the total base shear

$$V = \frac{0.4 * 1.05 * 2.75}{3.0} 50683 = 19512.8 \text{ lbsf}$$

With a known base shear and element masses, a single concentrated load can be computed for each element in the vessel. The equations for vertical distribution of force are found in UBC 94 paragraph 1628.4. In addition to computing the force at each level, the concentrated top force F_x must also be computed.

$$F_t = 0.07TV$$

There are some restrictions on F_t and it is zero if T is less than 0.7 seconds. In our case $T = 1/10.00067 = 0.09999$, therefore $F_t = 0.0$. Now, compute the force at level x, the midpoint of each element. This is determined by using the following relation:

$$F_x = \frac{(V - F_t)w_x h_x}{\sum_{i=1}^n w_i h_i}$$

The first task in solving this equation is to acquire the mass at each level and multiply by the distance from the base of the skirt to the center of the element and add them all together. After the summation is complete, F_x can be computed. Evaluation of the expression

$\sum_{i=1}^n w_i h_i$ provides a result of 1194830 ft.-lbs. Next, determine the element load on each section. Take the skirt element 10-20 and use the relation above to compute the equivalent lateral force at the skirt mid point.

$$F_x = \frac{(19512.8 - 0)10348.8 * 5.0}{1194830} = 845.03 \text{ lbsf}$$

In a similar manner, compute the element loads for the other tower elements. The results for the F_x calculation are shown in the table below and are displayed as the "Element Load".

Earthquake Load Calculation				
From	To	Earthquake Height ft.	Earthquake Weight lb.	Element Load lb.
10	20	5.00000	10348.8	845.030
20	30	10.0833	3359.40	553.195
30	40	15.1667	10348.8	2563.26
40	50	25.1667	9114.26	3745.93
50	60	35.1667	7788.26	4472.85
60	70	45.1667	7788.26	5744.75
70	80	50.2500	1934.79	1587.75
Top		51.8333		0.00

With the element loads and centroidal distances known, the bending moment at the beginning or base of each element can be computed. The summation of the moments is given in the following report:

Wind/Earthquake Shear, Bending							
From	To	Elevation of Node ft.	Cummulative Wind Shear lb.	Earthquake Shear lb.	Wind Bending ft.lb.	Earthquake Bending ft.lb.	
10	20	5.00000	3779.64	19512.8	97458.3	640560.	
20	30	10.0833	3047.31	18667.7	63323.5	449658.	
30	40	15.1667	3035.10	18114.5	62816.7	446593.	
40	50	25.1667	2300.45	15551.3	36138.9	278264.	
50	60	35.1667	1557.42	11805.4	16849.5	141480.	
60	70	45.1667	852.013	7332.50	4802.35	45791.1	
70	80	50.2500	94.3213	1587.75	70.6834	1189.84	

At the base of the large cylindrical shell course element 30-40, it can be seen that the bending moment is 446593 ft.-lbs. The axial weight stress at the element base is the weight above that section divided by the cross sectional metal area. That result is:

$$\sigma_w = \frac{Weight}{Area} = \frac{36974}{304.73} = 121.33 \frac{lbs}{in^2}$$

In a similar manner compute the bending stress. The bending stress is tensile on one side and compressive on the other. **PVELite** computes all of the individual stresses and classifies them in the "Stresses due to..." report. This is the bending stress:

$$\sigma_b = \frac{Moment}{SectionModulus} = \frac{446593(12)}{7315.18} = 732.6 \frac{lbs}{in^2}$$

Another important stress to compute is the longitudinal pressure stress. Rearrange the ASME or appropriate code formula to obtain this value. It should be about 1/2 the value of the hoop stress.

$$\sigma_{lp} = \frac{(P_{int} (r_{ins} - 0.4T_{ca}))}{2T_{ca}} = \frac{(150 * (48 - 0.4 * 1))}{2 * 1} = 3570 \frac{lbs}{in^2}$$

On the tensile side the stress due to pressure adds with the stress due to bending. The weight stress compresses the section, so that stress component subtracts. The resulting combination of these stresses is: $3570 + 732.6 - 121.33 = 4181.3$ psi (tension). On the compressive side the combined stress is $3570 - 732.6 - 121.33 = 2716$ psi (tension). So for this combination of loads it is seen that the compressive side is not in compression. This is why the pressure element compressive stresses are blank in the table below. The allowable tensile stress is $1.2 * \text{Allowable Tensile Stress} * \text{Circumferential Joint Efficiency}$. After each stress combination has been computed, divide that result by its allowable. If the result is greater than 1, the section is overstressed. The tensile ratio is $4181.27/24000$, which equals 0.1742.

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	884.47	24000.00	-1217.11	-18948.07	0.0369	0.0642
20	4175.27	24000.00		-18948.07	0.1740	
30	4181.27	24000.00		-18948.07	0.1742	
40	3939.10	24000.00		-18948.07	0.1641	
50	3004.76	24000.00		-19825.55	0.1252	
60	2760.67	24000.00		-19825.55	0.1150	
70	2665.02	24000.00		-19825.55	0.1110	

These results are for a typical operating scenario. The components IP, OW and EQ listed above are the values computed above. IP designates internal pressure stress, OW designates Operating Weight Stress and EQ designates Bending Stress due to Earthquake Loads. It is important to note that it is empirically difficult to determine which load case will govern the overall analysis. PVELite computes a broad range of scenarios and lists those results in the “Stress due to Combined Loads” report.

In conclusion, we have determined how to compute combinations of stresses using PVELite and the Uniform Building Code 1994 Edition. Most all of the other earthquake codes work in a similar manner. As with any Engineering Code Analysis, the rules will change periodically as the industry’s understanding of load generation on structures improves.

The Bend Flexibility Factor

By: Dave Diehl

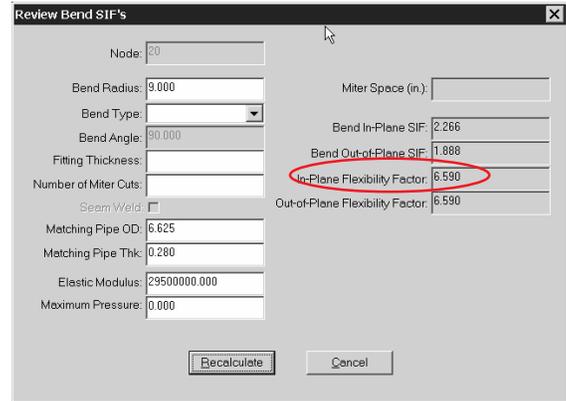
Introduction

CAESAR II Version 4.40 now has another input item for bends – a user-specified flexibility factor. To use it properly, one should know what it is and, then, how it can be used to improve piping models.

Definition

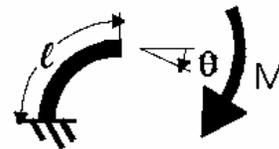
Simple beam models which work well in the mathematical representation for straight pipe do not reflect true distortion for other piping components such as bends and branch connections. Unlike the simple cylinder of straight pipe, the bend’s cross section will distort and ovalize when a bending moment (either in or out of plane) is applied. This change in cross section will reduce the moment of inertia of the bend thereby making it more flexible. This added component flexibility is represented by a flexibility factor. To quote Markl¹, the “so-called flexibility factor ... can be defined as the relation of the rotation per unit length of the part in question produced by a moment, to the rotation per unit length of a straight pipe of the same nominal size and schedule or weight produced by the same moment.”

The flexibility factor is defined (by Markl) in Appendix D of B31.3 as $1.65/h$ where h , the flexibility characteristic, is defined as $h = \bar{T} \cdot R_1 / r_2^2$ ². CAESAR II lists this bend flexibility factor in the Bend SIF scratchpad in the input processor (reproduced below) and also in the Miscellaneous Data output report.



So a straight pipe of length ℓ , having an anchor at one end and a moment M on the other, will have an end rotation of θ while a piping elbow (of the same cross section, material and support) with a centerline length of ℓ with the same in-plane bending moment M , will have an end rotation of $k\theta$, where k is the flexibility factor. In equation form:

$$\text{Bend end rotation: } \theta_{\text{bend}} = k \cdot (M \cdot \ell / E \cdot I)$$

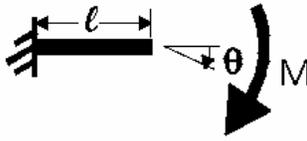


Model A

¹ Piping-Flexibility Analysis by A.R.C. Markl, from Tube Turns’ Piping Engineering sixth edition, 1986. Piping Engineering can be purchased directly from Tube Turns Technologies, Inc. in Louisville Kentucky. The book contains many tables, charts and nomographs of piping properties and several important technical papers in addition to Markl’s (a Tube Turns employee) significant works.

² \bar{T} is nominal pipe thickness, R_1 is bend radius, and r_2 is mean pipe diameter

Cantilever end rotation: $\theta_{cant} = M \cdot \ell / E \cdot I$



Model B

or $k = \theta_{bend} / \theta_{cant}$

Since end rotation is linearly related to beam length, another way to look at this is to say a bend of arc length ℓ will exhibit the *same* rotation as a cantilever of length $k\ell$ under the same moment.



Model C

Two ways to illustrate this

Compare the end rotation of a 6 inch standard, A106 Gr. B long radius bend ($R_1=9$ inches) to a straight run of an equivalent length. Both components will be anchored at one end and carry a moment of -1200 in-lbf on the other. The length of the straight run will be equal to the arc length of the elbow or 14.137 inches ($(\pi/2)R_1$). The reported free-end rotation for the bend (Model A) is -0.0772 degrees and the reported rotation for the straight (Model B) is -0.0117 degrees. The ratio $\theta_{bend} / \theta_{cant}$ can be calculated as $(-0.0772) / (-0.0117) = 6.59^3$. The flexibility factor for this elbow is reported as 6.59002. The ratio of the *deflections*, on the other hand, *does not* follow this ratio:

$$\delta_{bend} / \delta_{cant} = (-0.0078) / (-0.0014) = 5.57$$

Or, you can change length of the straight run to k times the elbow's arc length as shown in Model C. Here, the new length is $6.59002 \cdot 14.137$ inches or 7.764 feet and the end rotation is once again -0.0772 degrees which matches the elbow.

³ Based on the values and uncertainty of the input (± 0.00005), the uncertainty of the quotient is ± 0.0324 . The calculated value for k , then, is 6.59 ± 0.0324 .

Code-defined values for k

Let's return to the definition of k . The piping codes define k for us in Appendix D. Markl's paper provides the history of the flexibility factor starting with work by von Kármán in 1911 and then by Hovgaard in 1926. Even then the parameter known as the flexibility characteristic ($h = \bar{T} \cdot R_1 / r_2^2$) was in use. But the von Kármán-Hovgaard flexibility factor of that day – $k = (12 \cdot h^2 + 10) / (12 \cdot h^2 + 1)$ – erred when this h dropped below 0.3. (A 6 inch std long radius elbow has $h=0.25$.) It was Beskin, in 1945, who suggested a much simpler equation for k as in $k = 1.65/h$ and $k \geq 1$. And that is the elbow flexibility factor in use today.

Markl went on to discuss adjustments for conditions that prevent the bend from ovalizing and allowing this higher flexibility. He described corrections for internal pressure and attached flanges. Both of these adjustments are defined in Appendix D and both are available in CAESAR II⁴.

An interesting aside here is that we still work with flexibility factors in a stiffness package. Computerized pipe flexibility models were originally based on the flexibility method rather than today's stiffness method. They used to solve $X=AF$ (where A is the flexibility matrix of the piping system) while today's programs use $F=KX$ as the basis equation. Even so, the basic 12 x 12 elbow flexibility matrix as found in the original Mare Island program (MEC 21) is still in use in CAESAR II and probably all the other pipe flexibility and stress analysis programs. The bend flexibility factor, k , adjusts the coefficients in the flexibility matrix. This matrix is then inverted to serve as the bend stiffness matrix used with the rest of the stiffness model.

Application

Now so far, all of these calculations are automatically performed for bends and miter joints and there is no need for explicitly setting a bend flexibility factor. But Mr. Markl has another comment in his paper *Fatigue Tests of Piping Components*⁵ "If the inherent flexibility of a curved tube is to be fully utilized, a tangent length equal to at least two pipe diameters, preferably greater, must be present between its ends and adjoining flanges or anchors." The adjustment to k for

⁴ Specifying one or two attached flanges in the CAESAR II bend definition will only change the stiffness and stress intensification for the bend, CAESAR II will not automatically add flange weight or a short, rigid section for the flange length itself. Likewise, rigid elements connected to bends will not automatically adjust this bend stiffness.

⁵ Also in Tube Turns' *Piping Engineering*.

attached flanges addresses this issue but there are other situations that may reduce the flexibility of the bend. Three situations come to mind – refractory-lined pipe, FRP pipe and bends with support attachments. Refractory or brick, as an insulator in high temperature piping, will certainly modify the bend's ability to distort and flex. In fact, direct entry of the flexibility factor was added to **CAESAR II** at the request of users modeling refractory-lined pipe. Bends made up of fiberglass reinforced plastic pipe also fail to respond like homogeneous materials. One source states that "The results showed that the bend was up to a factor of 20 stiffer than what is found by improper but common use of the (B31.3) standards."⁶ And, "It was recommended that flexibility and stress intensification factors should be measured and supplied by the manufacturers."

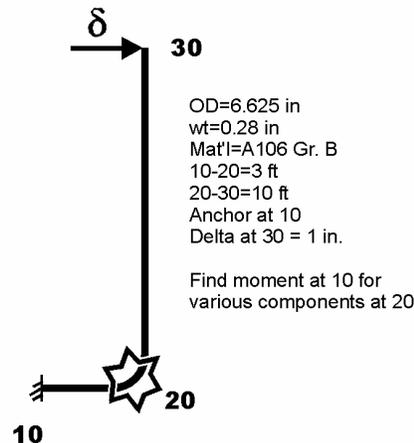
The third item, change in stiffness due to attachments, is common in many systems where a dummy leg is welded to the bend extrados. This attachment will certainly stiffen up the bend and some **CAESAR II** users, for want of a better method, have modeled this added stiffness by indicating a flange attached to the bend. Equations are available for this added stiffness but, with today's easy access to finite element methods, programs such as FE/Pipe⁷ can also produce a value for k . One equation in the literature appears in a paper presented at the Seventh Annual Convention of SPED (Society of Piping Engineers and Designers) in 1987 entitled *Flexibility of Trunnion Piping Elbows* by G. D. Lewis of Duke Power and Yuh-Jin Chao of the University of South Carolina. The paper produced an equation for in-plane bend flexibility: $k = 0.81 \cdot k_e - (d/D)$, where k_e is the standard bend flexibility factor, d is the trunnion pipe diameter and D is the elbow pipe diameter. This equation is qualified only where $D/2 \leq d < D$ and $T \leq t \leq 2 \cdot T$ (t is the trunnion wall thickness and T is the elbow pipe thickness). If a 3.5 inch, 0.3 inch wall pipe is attached to the 6 inch standard elbow, the flexibility factor reduces from 6.59 to 4.81. Compare this value to the calculated flexibility of the clean elbow with one flange attached – 5.232 – and with two flanges attached – 4.154.

Comparison

Simply to say that the flexibility factor changes from 6.59 to, say, 4.81 is not significant. However, if that same change to bend flexibility greatly increases a thermal load on a nozzle, then it would be important. The simple system shown below illustrates the change in anchor load with different bend flexibilities calculated or specified. In this example, the trunnion model which reduced the flexibility factor by 27%, increased the bending moment by 19%.

⁶ See http://www.sintef.no/units/matek/2490/prosj/deep_water.htm - the web site of SINTEF (The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology)

⁷ FE/Pipe is a trademark of Paulin Research group



Component at 20	k	Moment at 10
Short radius elbow	9.885	-3735 ft-lbf
Long radius (LR) elbow	6.590	-3920 ft-lbf
LR elbow with 1 flange	5.232	-4472 ft-lbf
LR elbow with trunnion	4.810	-4677 ft-lbf
LR elbow with 2 flanges	4.154	-5036 ft-lbf
Square corner	n/a	-7563 ft-lbf
Elbow with $k=1$	1	-7978 ft-lbf

Conclusion

CAESAR II Version 4.40 now provides direct specification of bend flexibility. By understanding its application and effect on a piping model, the user can decide if and when bend flexibility should be explicitly defined.

The Pressure Equipment directive (PED) and CE marking

By: Mandeep Singh

What is the PED?

The European Parliament and European Council adopted the Pressure Equipment Directive (97/23/EC) on May 1997. After the 2½ year transition period, it became mandatory in May 29, 2002. Now, the pressure equipment that is stated for installation in European Economic Area (European Union plus Norway, Iceland and Liechtenstein), must comply with the PED requirements. Equipment (vessels, piping, assemblies etc) that complies with this directive will attain a CE marking. Pressure equipment that has a design pressure that is less than or equal to 7.25 psig (0.5 barg) is excluded (as long as it is not a generic safety accessory).

This Directive arises from the European Community's program for the elimination of technical barriers to trade and is formulated under

the “New Approach to Technical Harmonization and Standards”. Its purpose is to harmonize national laws of Member States regarding the design, manufacture, testing and conformity assessment of pressure equipment and assemblies of pressure equipment. Equipment with a CE marking is accepted any where in the European Economic Area countries. There may be some additional local restrictions (similar to state level restrictions in the USA).

The PED concerns manufacturers of items such as vessels, pressurized storage containers, heat exchangers, steam generators, boilers, industrial piping, safety devices and pressure accessories. Such pressure equipment is widely used in the process industries (oil & gas, chemical, pharmaceutical, plastics and rubber and the food and beverage industry), high temperature process industry (glass, paper and board), energy production and in the supply of utilities, heating, air conditioning and gas storage and transportation.

What are the requirements of the PED?

The PED does not contain detailed technical requirements as in ASME or PD 5500. It consists of Conformity Assessment procedures that should be followed to demonstrate that the essential safety requirements are met. These Conformity Assessment procedures are based on the hazard category of the pressure equipment. Pressure equipment is classified into hazard category 1,2,3 or 4, (in increasing order), depending upon:

- Type of equipment (vessel, piping, boiler)
- Type of fluid (dangerous, non-dangerous)
- Nature of fluid (gas, liquid)
- Service condition (pressure, volume/nominal pipe size)

For a higher hazard category, the Conformity Assessment procedures to be followed are more involved and usually require more involvement of the notified body. These procedures involve documentary checks, materials, design approval, quality assurance, manufacturing etc. The European Union member states have designated some semi-official or private technical organizations, either for approval and monitoring of the manufacturer’s quality assurance system or for direct product inspection. These organizations are termed as notified bodies. Notified bodies must verify and certify that the equipment complies with all the requirements of Conformity Assessment procedure selected. Many of the notified bodies are also ASME Authorized Inspection agencies operating in USA and Canada.

How is the PED related to the design Code?

As mentioned earlier, the PED is not a design code. It permits the use of any established National code and standard (ASME, PD 5500, CODAP, AD-M), provided all the provisions of the PED are satisfied. If the equipment is designed per Unified European codes

(also referred as the Harmonized Standard) then it is presumed to conform to the PED. Following are the EN Harmonized standards related to this directive:

- EN 13445 : Unfired Pressure Vessels
- EN 13480 : Industrial Piping
- EN 12 952 : Water Tube Boilers
- EN 12 953 : Shell Boilers

Conclusion:

For US pressure equipment manufacturers, exporting to Europe has been a major challenge. Traditionally, each European country used to have independent pressure vessel/piping codes and standards, making the exports across the borders costly and challenging especially for smaller manufacturers. With the PED, there is one set of requirements for exporting to over 18 European countries. Manufacturers can also keep using their current code, utilize the existing in-house QA procedures and work with the notified bodies to upgrade the procedures that are required.

The margin of safety built in the ASME codes is typically higher compared to most major European codes, but the production/QA requirements are less stringent. Now for manufacturers exporting to Europe having to satisfy the PED requirements, it will probably be more economical to build per the unified European code.

Useful Urls:

1. PED’s official website – <http://ped.eurodyn.com/> (information on PED, guidelines on PED, list of notified bodies)
2. Harmonized standards - <http://europa.eu.int/comm/enterprise/newapproach/standardization/harmstds/reflist/equippre.html>
3. Some related directives - Simple pressure vessels (87/404/EC), transportable pressure equipment (99/36/EC) and Aerosol Dispensers (75/324/EEC).

PC Hardware/Software for the Engineering User (Part 33)

Windows XP and Java

As a result of the court agreement between Microsoft Corporation and Sun Microsystems, the latest operating system from Microsoft (Windows XP) doesn’t directly support Java applications. This results in some applications being unable to run, and some webs sites being rendered improperly when accessed from a computer running Windows XP.

There is however a solution to this dilemma. On Sun's web site at <http://java.sun.com/> there is a link (shown below) to download a small "plug-in". This "plug-in" will provide the missing pieces of the operating system, allowing Windows XP to properly handle Java applications.



CAESAR II Notices

Listed below are those errors & omissions in the **CAESAR II** program that have been identified since the last newsletter. These corrections are available for download from our WEB site, for Version 4.40.

- 1) **Accounting Module:**
 - Changed the method used to get the "date range" off of the dialog box. This avoided a crash when generating accounting reports.
- 2) **Large Job Printing Module:**
 - Updated "versioning information", to comply with new 4.40 file structures.
 - Corrected the labeling of the ChinaPower spring size.
- 3) **Dynamic Output Module:**
 - Corrected the "Input Echo" dialog box to include the new "node names" option.
- 4) **Static Solution Module:**
 - Corrected stiffness matrix adjustment when using the new "spring hanger control" options and switching from the hanger status from "rigid" to "ignore".
 - Corrected the stiffness for constant effort supports when changing the hanger status.
- 5) **Static Stress Computation Module:**
 - Corrected the computation of allowables for DNV piping code when more than a single thermal vector was specified in the job.
- 6) **Static Output Module:**
 - Corrected printing of "configuration parameters" in the input echo.
 - Corrected the labeling of the ChinaPower spring size.
- 7) **Static Load Case Setup Module / Dynamic Input:**
 - Corrected the presentation of nodal displacement data in the input echo.
 - Corrected the memory allocation for "node names".
 - Corrected the use of the "revised" number of spring hanger design cases instead of the "old" number from existing .J files, when verifying load case data..
 - Corrected the upgrade of load cases when pre-440 jobs included (XYZ) spring and rod type restraints.
 - Corrected an error message if "reuse Eigen solution" was activated and the Eigenvalue file was missing.
 - Corrected an error where if the first run of a job was "batch run from input", the friction multipliers were not set, and zero was used.
 - Corrected the import of "pre-4.40" static load case definitions when load cases incorrectly included undefined primitive load components.
- 8) **Piping Error Checker:**
 - Corrected the display of "warning 162".
 - Corrected the storage of the new "bend flexibility factor" for "included" piping jobs.
 - Modified all error/warning/note messages to include the letter "E" following the ID number. This is to avoid confusion with "fatal errors" that may occur during other operations.
- 9) **Piping Input Module:**
 - Corrected printing of "configuration parameters" in the input echo.
 - Corrected the "axis labeling" on the "LIST Duplicate" dialog for mirroring, when the "Z" axis is up.
 - Corrected the presentation of nodal displacement data in the input echo.
 - Fixed a problem in the "standard graphics" where clicking on the "Spreadsheet" button caused a crash.
 - Fixed a problem preventing usage when including piping/structural files and global coordinates were set.
 - Changed the grid cell style for nodes 1 & 3 in the "bend list" to display as integer values.
- 10) **Buried Pipe Module:**
 - Modified the generation of element lengths to avoid extremely small elements.

TANK Notices

Listed below are those errors & omissions in the **TANK** program that have been identified since the last newsletter. These corrections are available for download from our WEB site.

- 1) **Solution Module:**
 - Corrected the use of “St” for the test case in API-653 thickness determination.
 - Corrected the use of fluid height in the seismic routines to avoid using the pressure increase.
 - For rafter supported cone roofs, initialized the value for “percent roof weight supported by the shell”.
- 2) **Main/Input Module:**
 - Corrected the startup of the Material Database Editor.
 - Addressed the handling of zero-byte length user material files.

CodeCalc Notices

Listed below are those errors & omissions in the **CodeCalc** program that have been identified since the last newsletter.

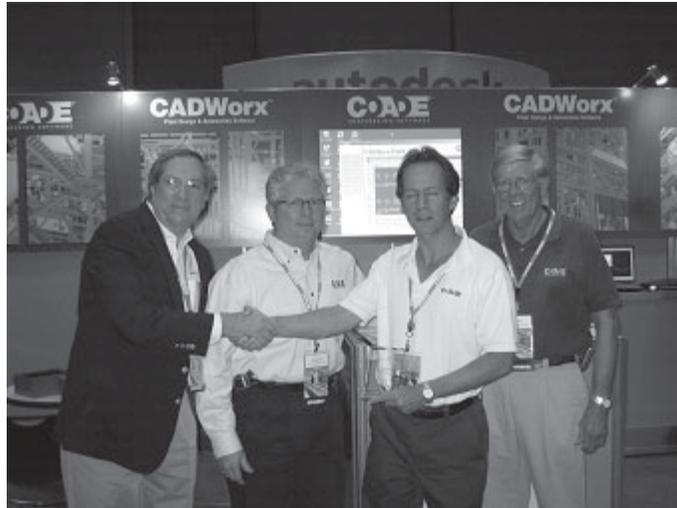
- 1) **ASME and TEMA Tubesheets:**
 - Fixed the selection of design optimization option in U-tubesheet design.
 - (Re)added input for user specified bolt root area.
 - For the fixed tubesheet design with the multiple load cases selected, when the tube corrosion input field was left blank, the tube corrosion allowance was not being correctly applied. This has been fixed now.
- 2) **Nozzles:**
 - Corrected the UG-45 computation for a nozzle on a flat head with user supplied req. thk.
 - Corrected pad width for hillside nozzle.
 - Fixed some issues in the large nozzle (App 1-7) bending calculations.
 - Corrected the nozzle reinforcement calculations for some cases where the reinforcement limit cut through welds.
- 3) **Horizontal Vessels:**
 - Added inputs for sliding saddle’s friction coefficient, user longitudinal load, user wind pressure and saddle reaction force factor.

- Corrected the moment used in the AISC unity check on the saddle ribs.
- 4) **Shell:**
 - Corrected the weld size status bar message.
 - 5) **WRC 107:**
 - Corrected the mean shell diameter value used.
 - Printout/Graphics/Nozzle Pro interface Enhancements.
 - 6) **WRC 297/Annex G:**
 - Corrected some graphs and modified the stress combination method for a sphere for Annex G calcs.
 - 7) **Leg & Lug:**
 - Corrected the Wind Exposure category selection.

PVElite Notices

Listed below are those errors & omissions in the **PVElite** program that have been identified since the last newsletter. These corrections are available for download from our WEB site.

- 1) Several changes were made for PD:5500 Closely Spaced Nozzles. The program was showing that many were close when they were not.
- 2) A ft. in. units problem that resulted in the stress due to overturning by items such as nozzles were off by the conversion factor of 12.
- 3) The Aspect Ratio for 2:1 Elliptical heads for PD:5500, Nozzle Analysis was taken based on inside dimensions and not outside dimensions.
- 4) The value of Ft, the top load in UBC 97 was not divided by 1.4.
- 5) For cones with knuckles, the program was using the cone thickness and not the knuckle thickness to compute moment of inertia and cross sectional area.
- 6) Held up packing liquid was not being considered in seismic calculations.
- 7) The moments used in the cone calculations may have been one element off in some cases. Other miscellaneous fixes to the cone calculations involving moments at the large and small end were made.
- 8) For ASME nozzles when the diameter and thickness limits cut the nozzle/shell weld the weld area calculations may have been in error.



COADE Sponsors Autodesk World One Team Conference and Autodesk University

This year, COADE has joined Hewlett Packard, Intel, Microsoft, IBM, and nVidia as sponsors of Autodesk's two premier conferences – the World One Team Conference and Autodesk University, held September 11-13 and December 3-6, 2002 respectively, at the MGM Grand Hotel in Las Vegas, Nevada.

Whereas One Team Conference is conducted for the benefit of Autodesk's dealers, distributors, and development partners, Autodesk University is, as its name implies, four days of courses, offering users of Autodesk products the chance to improve their skills and understanding of both software and the industries they serve.

COADE and its CADWorx product figure prominently in both conferences. In the above picture taken at One Team Conference, Jim Meyer, Autodesk's Director of Strategic Marketing, presents a sponsor's recognition award to COADE's John Brinlee, Tom Van Laan, and Bill Evans (left to right). This event gave COADE a good chance to visit with many of our dealers from throughout the world, as well as meet new ones interested in representing COADE. At Autodesk University, COADE personnel are scheduled to lead two seminars dealing with the plant design industry, as well as a tutorial on plant design using CADWorx. This will give us further opportunity to speak to many of our long-term (and newer) users.

We'd like to see you all come out and visit us at Autodesk University!



COADE Engineering Software

**12777 Jones Rd. Suite 480
Houston, Texas 77070**

**Tel: 281-890-4566
Fax: 281-890-3301**

**Web: www.coade.com
E-Mail: techsupport@coade.com**
