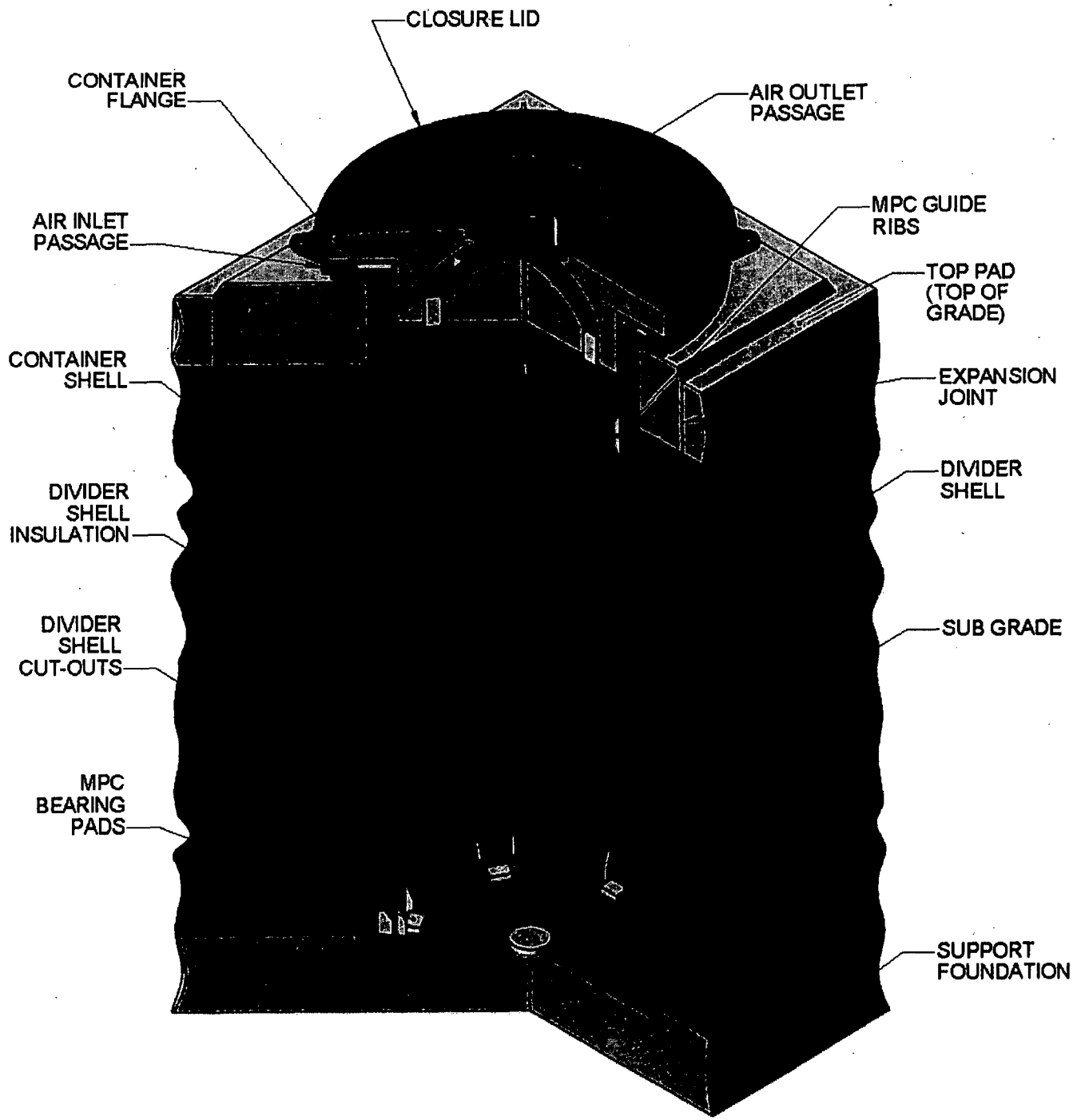
HI-STORM 100U

- SUBMITTED AS SELF CONTAINED SUPPLEMENT I AS PART OF LAR 1014-3.
- ROUND 1 RAI'S HAD NO SIGNIFICANT STRUCTURAL QUESTIONS.
- ROUND 2 RAI'S HAD MANY STRUCTURAL QUESTIONS.
- TO EXPEDITE APPROVAL OF LAR 1014-3, SUPPLEMENT I WITHDRAWN.
- SUPPLEMENT I TO BE RESUBMITTED AS LAR 1014-6. IN NEAR FUTURE.


CLOSURE LID
CONTAINER FLANGE
AIR OUTLET PASSAGE
AIR INLET PASSAGE
MPC GUIDE RIBS
TOP PAD (TOP OF GRADE)
CONTAINER SHELL
EXPANSION JOINT
DIVIDER SHELL
DIVIDER SHELL INSULATION
SUB GRADE
DIVIDER SHELL CUT-OUTS
MPC BEARING PADS
SUPPORT FOUNDATION

HI-STORM 100U STRUCTURAL CONCERNS

- CLARIFICATION AND CONSISTENCY CONCERNS.
- COMPLETENESS OF LICENSING DRAWING INFORMATION.
- CRITICAL CHARACTERISTICS – COMPLETENESS OF INFORMATION.
- COMPLETENESS AND CONSERVATISM OF PROPOSED DESIGN BASIS SINGLE VVM MODEL.

CLARIFICATION AND CONSISTENCY CONCERNS

- MPC BEARING PADS UPGRADED TO "ITS C".
- GOVERNING CONCRETE CODE IS NOW ACI 318-05
- CLARIFICATION OF SKETCHES TO SHOW EXPLICIT LOCATION OF FLEXIBLE JOINTS.
- STATEMENT REGARDING TSUNAMI HAS BEEN REMOVED.

COMPLETENESS OF LICENSING DRAWINGS

- LICENSING DRAWINGS ARE HIGHEST LEVEL DRAWINGS AND SHOULD CONTAIN SUFFICIENT INFORMATION TO FACILITATE REVIEW.
- FOR COMPLETENESS OF THE SUPPLEMENT, DRAWINGS FOR HI-STORM 100U HAVE BEEN MOVED TO SECTION 1.I.5.
- DRAWINGS HAVE BEEN UPDATED TO INSURE THAT ALL "ITS" COMPONENTS HAVE THEIR DIMENSIONS INDICATED TO FACILITATE STAFF REVIEW.

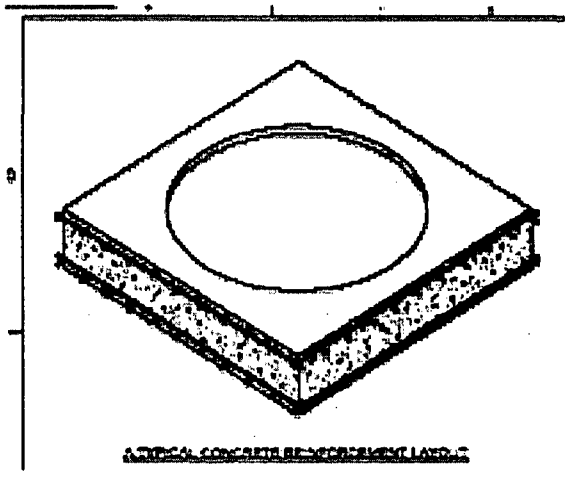
CRITICAL CHARACTERISTICS – COMPLETENESS OF INFORMATION

- THE STAFF HAS RECOGNIZED THE VALUE OF IDENTIFYING "CRITICAL CHARACTERISTICS" TO ALLOW FOR MATERIAL OBSELESENCE.
- LAR 1014-6 SUBMITTAL NOW HAS CRITICAL CHARACTERISTIC FOR STRUCTURAL STEEL FOR "ITS" COMPONENTS LISTED IN TABLE 2.I.9 WITH EXPLICIT MINIMUM VALUES PRESENTED.

COMPLETENESS AND CONSERVATISM OF DESIGN BASIS SINGLE VVM MODEL

- ENHANCEMENT OF VVM LATERAL RESTRAINT CONFIGURATION
  - ANCHOR HOUSING AND ANCHOR CLIPS ELIMINATED
  - STIFFENING GUSSETS ELIMINATED
  - LATERAL RESTRAINT PROVIDED BY GEOMETRY OF SUPPORT FOUNDATION

ENHANCED VVM LATERAL CONSTRAINT



SINGLE VVM DESIGN BASIS CONCERNS

- DOES SINGLE VVM ADEQUATELY CAPTURE THE NEAR FIELD GEOMETRY OF THE SUBSTRATE?
- IS NON-LINEAR SIMULATION OF A SINGLE VVM ABLE TO PROVIDE A SOLUTION THAT BOUNDS EFFECTS OF MULTIPLE VVMs WITH VARIOUS LOADING ARRAYS?

RESPONSE TO CONCERNS

- ENHANCED SINGLE VVM MODEL CAPTURES IMPORTANT FEATURES OF NEAR FIELD.
  - INCORPORATES SUBSTRATE UNDER PAD
  - INCORPORATES PADLET TO MAXIMIZE VVM ROCKING
  - INCORPORATES TWO DIFFERENT SUBGRADES REFLECTING ENGINEERED FILL UNDER PAD AND LESS STIFF MATERIAL SURROUNDING VVMs.
  - NON-LINEAR MODEL WITH ABILITY TO SIMULATE COMPRESSION ONLY CONTACT AND STRATIFIED SUBSTRATES.

RESPONSE TO CONCERNS (CONT.)

- CONFIRMING ANALYSES WITH MULTIPLE VVMs WITH DIFFERENT LOADED ARRAYS.
- SOLUTION METHOD IS SASSI, AN INDUSTRY STANDARD SSI CODE (LINEAR ELASTIC).
- SASSI MULTIPLE VVM MODEL AND LS-DYNA SINGLE VVM MODEL HAVE SAME SEISMIC EVENT AND SUBGRADE PROPERTIES.

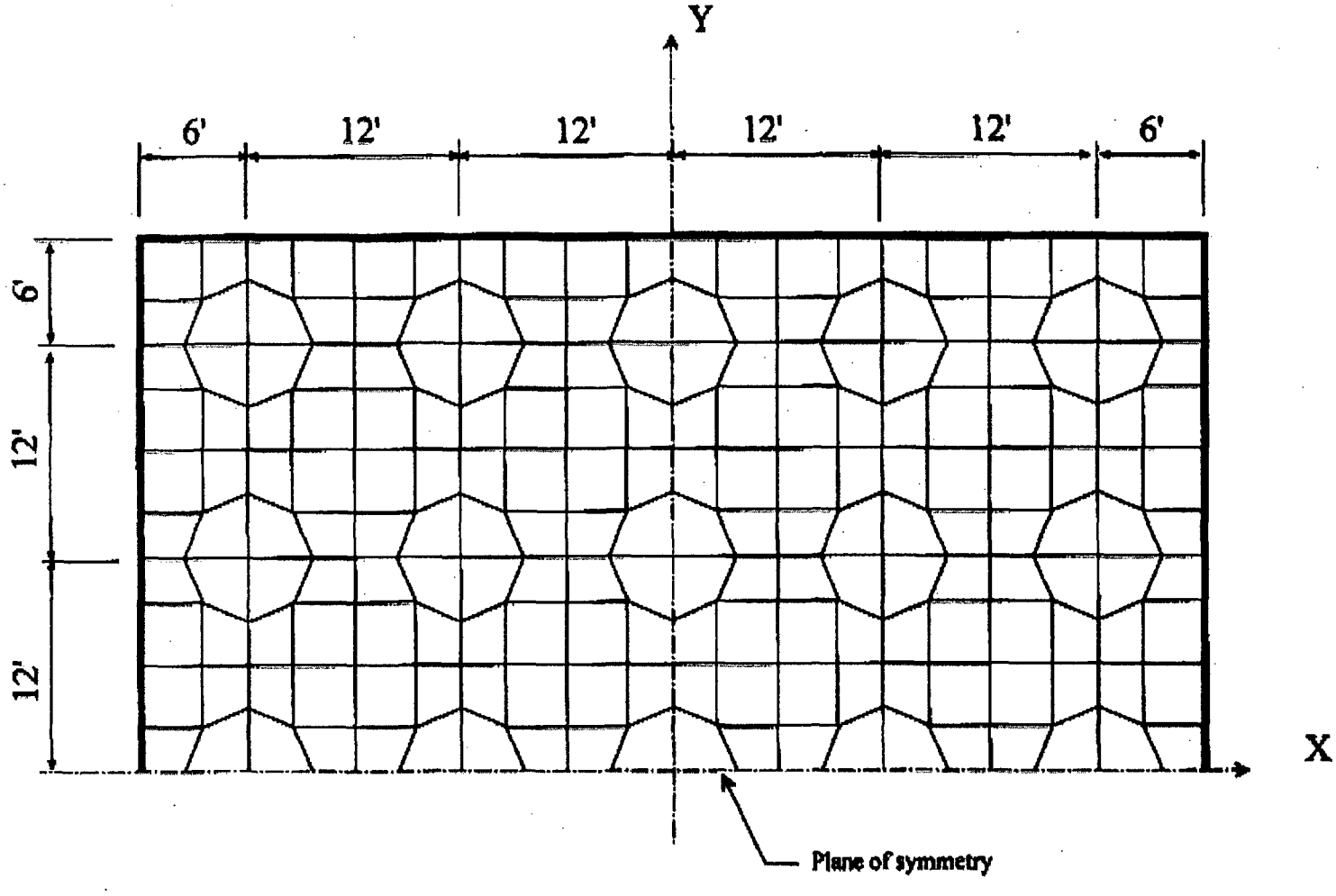
SEISMIC AND SUBSTRATE INPUT

- REG. GUIDE 1.60 EVENT, APPLIED AT BEDROCK: HORIZONTAL ZPA=0.5; VERTICAL ZPA = 0.333.
- SUBSTRATE UNDER PAD – SHEAR WAVE SPEED =800 FT./SEC.; DENSITY = 140 LB./CU.FT.
- SUBSTRATE SURROUNDING VVMs = 500 FT./SEC.; DENSITY = 120 LB./CU.FT.

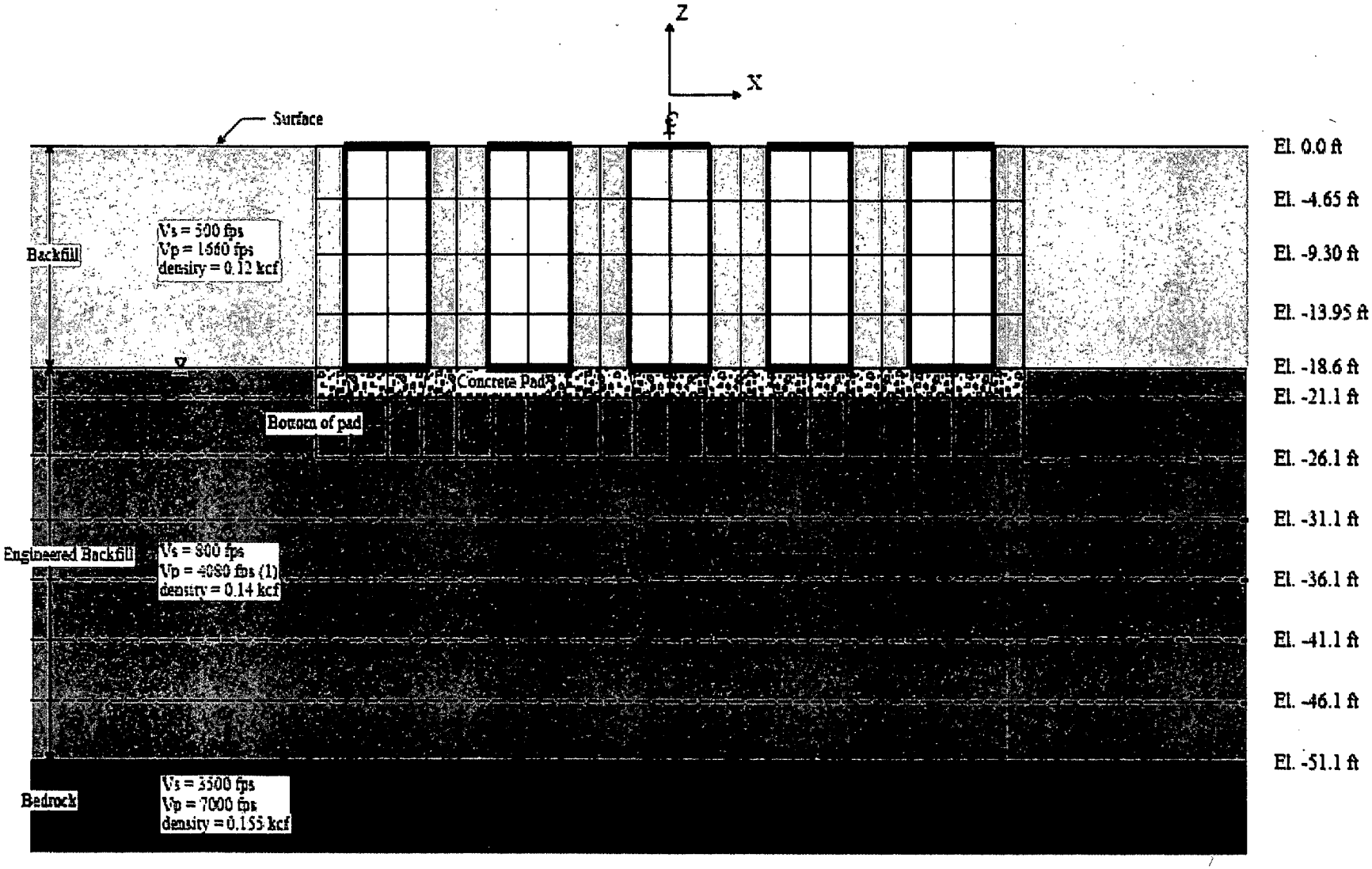
ACCEPTANCE CRITERIA

- CONTENTS OF VVM MUST BE RETRIEVABLE.
  - CEC PERMANENT DECREASE IN DIAMETER LESS THAN 1" (MPC GUIDES WILL CONTACT MPC ACROSS A DIAMETER). AWAY FROM GUIDES, DIAMETER DECREASE LESS THAN 5".

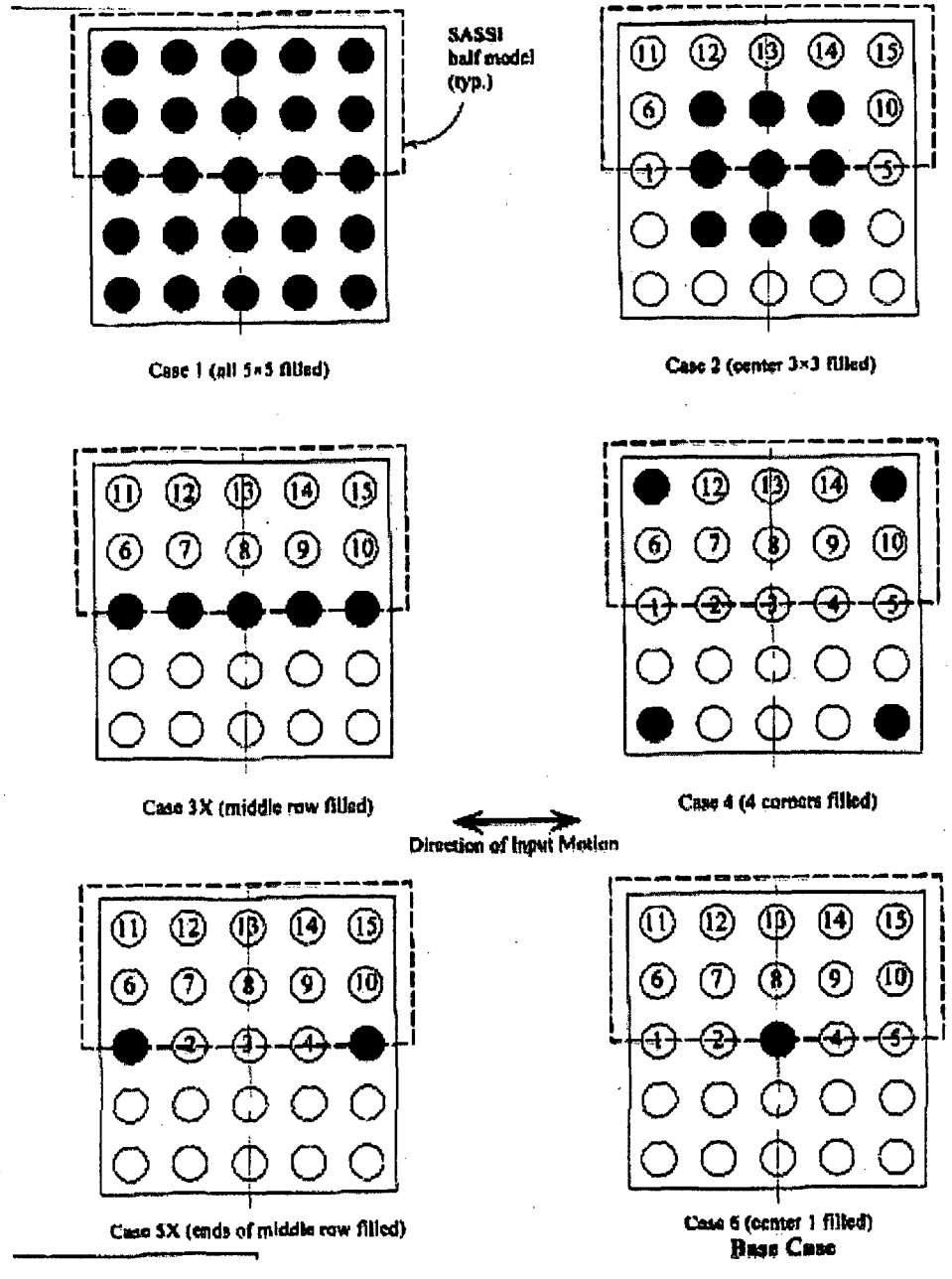
SASSI FEM GRID (LOOKING DOWN)



VVM CONFIGURATION (SASSI)



CONFIGURATIONS CONSIDERED



RESULTS FROM SASSI (LINEAR ELASTIC) ANALYSES

Case Number	Cavity Number with Maximum Ovalization	Seismically Induced Container Shell Ovalization (in.)	Cavity Number with Maximum Seismic Longitudinal Primary Membrane Stress in the CEC Container Shell	Maximum Seismic Longitudinal Primary Membrane Stress (ksi)
1	#11, #15	0.02	#12, #14	4.8
2	#7, #9	0.01	#2, #4, #7, #9	3.8
3	#1, #5	0.01	#1, #5	4.4
4	#11, #15	0.02	#11, #15	4.3
5	#1, #5	0.01	#1, #5	4.4
6	#3	0.00	#3	3.5

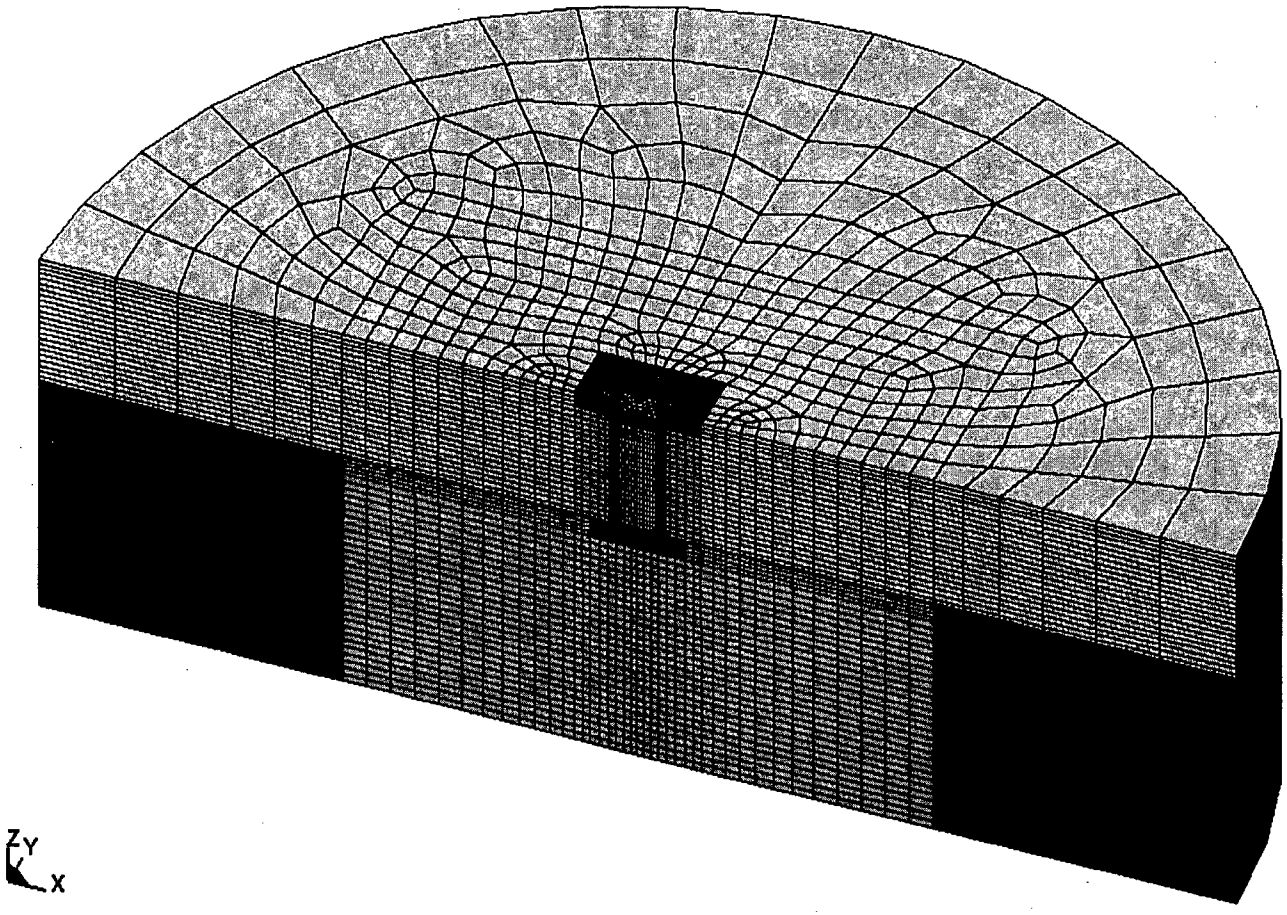
CONCLUSIONS FROM SASSI

- LOCATION AND NUMBER OF CAVITIES LOADED IS A SECOND ORDER EFFECT ON DIFFERENCES IN COMPUTED CEC OVALIZATION AND CEC BENDING STRESS. PRIMARY EFFECT IS LOCATION OF CEC ON PAD.
- CONFIGURATION IS SOIL DRIVEN. VVMs MOVE BASICALLY WITH SOIL WITH SMALL LOCAL DIFFERENCES.
- SYSTEM RESPONSE IS SMALL COMPARED TO ALLOWABLE VALUE.

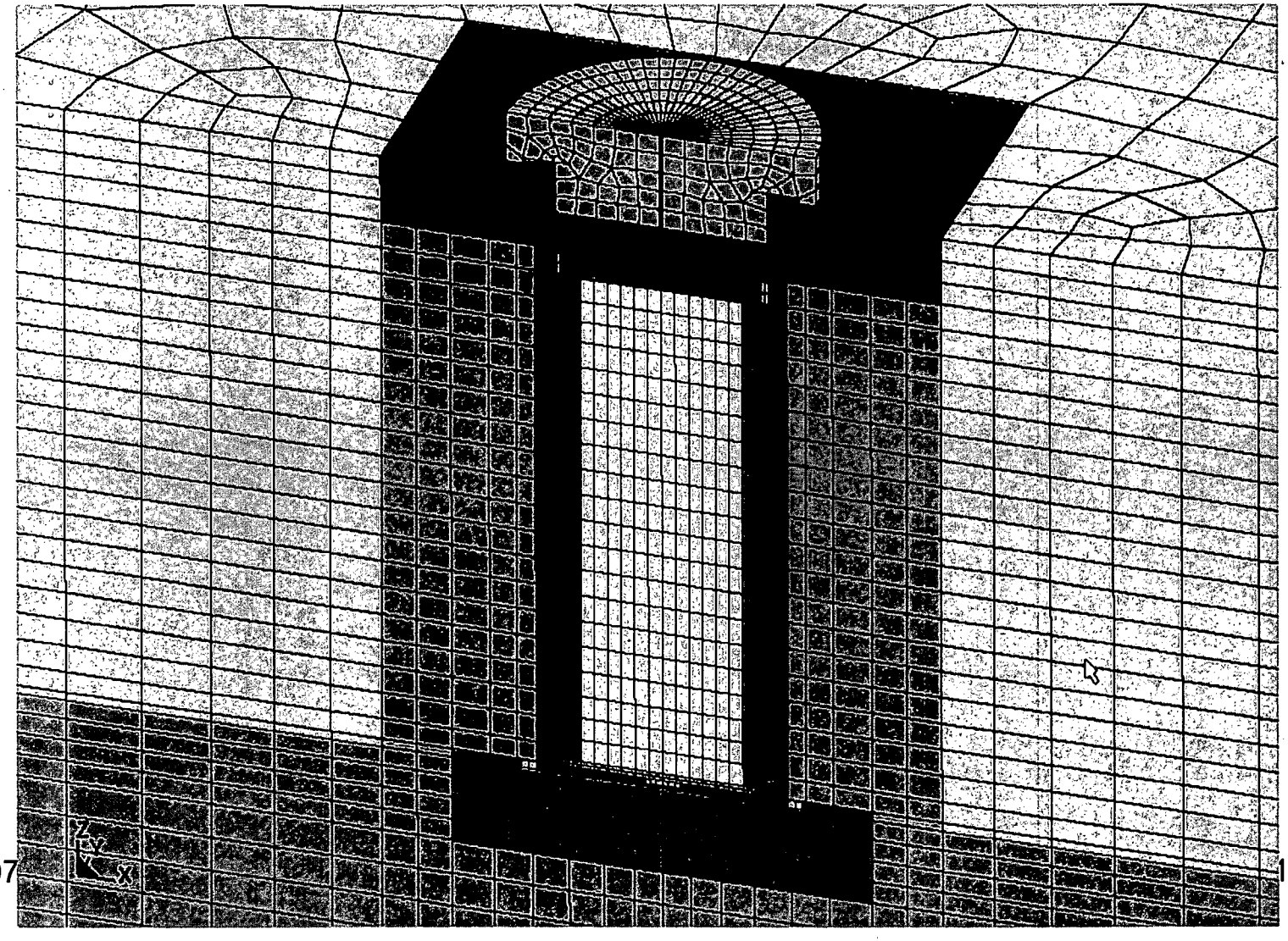
LS-DYNA SINGLE VVM MODEL

- LS-DYNA VVM MODEL INCLUDES MPC AND INTERNALS SO ACTUAL LOAD PATH IS REPRODUCED.
- THE MASS OF THE TOP PAD(S) IS INCREASED TO INCLUDE A LOADED TRANSPORTER.
- LS-DYNA MODEL CAN SIMULATE STRATIFIED SUBSTRATE WITH RELATIVE MOTION; ONLY STRATIFICATION IN EXAMPLE IS BETWEEN ABOVE PAD AND BELOW PAD; HOWEVER, REQUIREMENTS FOR SITE SPECIFIC MODEL REQUIRES INCLUSION, IF GEOMECHANICS DICTATES.

LS-DYNA OVERALL VIEW

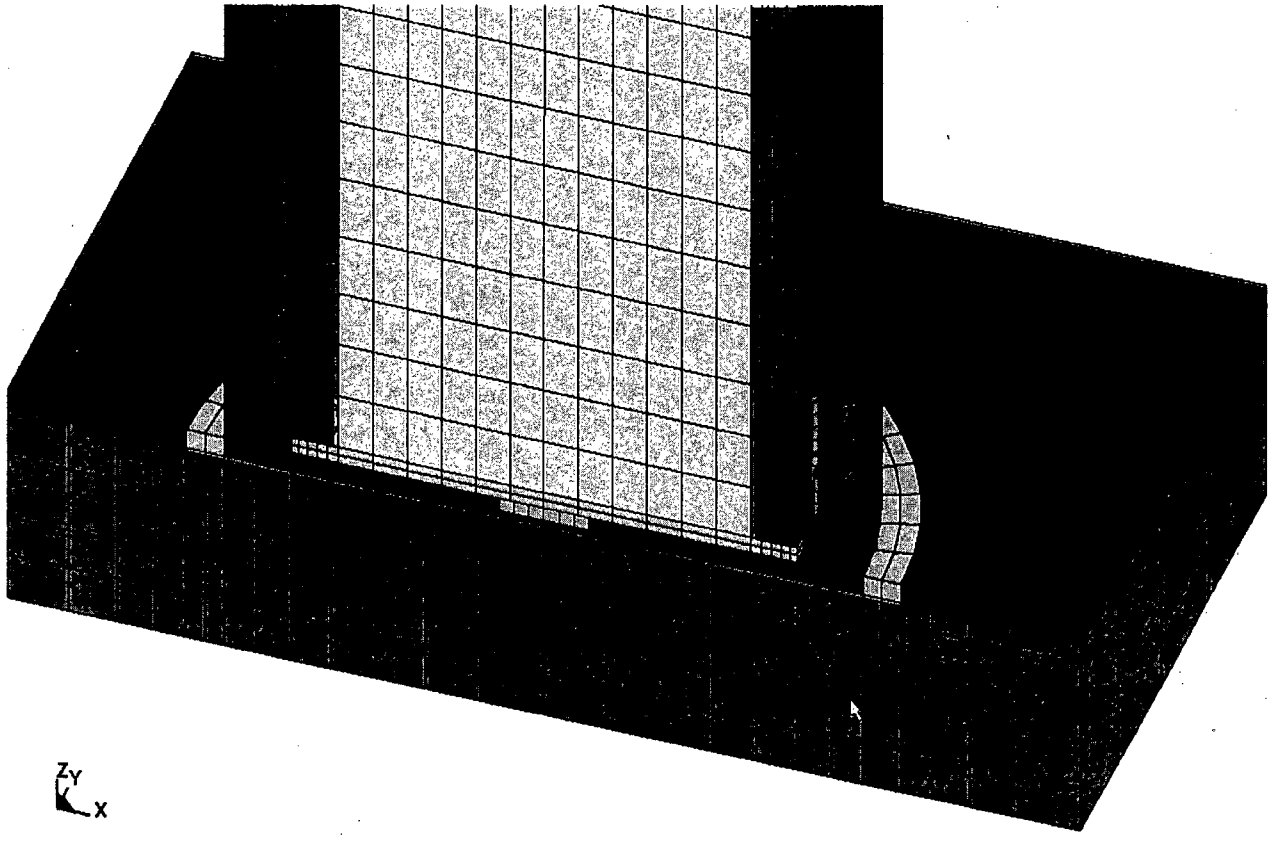


VVM DETAILS



DETAILS OF LOWER PORTION OF VVM

- 5 layers thru thickness of CEC Shell, 4 layers thru thickness of Divider Shell



LS-DYNA RESULTS

- MAXIMUM OVALIZATION (CHANGE IN DIAMETER IN DIRECTION OF EARTHQUAKE) AT ANY TIME = 0.13".
- BEAM BENDING STRESS (INFO ONLY FOR SASSI COMPARISON) IS APPROXIMATELY 9,000-10,000 PSI

SUMMARY

- LS-DYNA RESULTS BOUND SASSI RESULTS WITH LARGE MARGINS BY VIRTUE OF CONSERVATIVE CONFIGURATION USED FOR THE DESIGN BASIS CALCULATION METHOD.

- BECAUSE OF LARGE MARGINS OVALIZATION, EVEN WITH .5G HORIZONTAL SEISMIC EVENT AT BEDROCK, THERE IS NO CREDIBLE EXPECTATION FOR HARDWARE CHANGES DUE TO SITE-SPECIFIC CONDITIONS FOR ANY USA PLANT.

- BASED ON COMPARATIVE STUDY, IT IS OUR POSITION THAT THE NON-LINEAR SINGLE VVM MODEL, ON A PADLET SUPPORT FOUNDATION, PROVIDES A CONSERVATIVE BOUNDING RESULT FOR THE SAFETY FACTOR ADRESSING MPC RETRIEVABILITY.

PROPOSED CoC (APPEND. B, SEC. 3)

d. Each CEC CONTAINER SHELL shall be restrained by the SUPPORT FOUNDATION to limit relative lateral motion between the base of the CONTAINER SHELL and the SUPPORT FOUNDATION.

For underground casks, a site-specific seismic evaluation of an isolated cask (i.e., a single VVM) shall be performed using the methodology set forth in Subsection 3.I.7.4.1 of the HI-STORM 100 FSAR. Subsections 3.I.7.4.1 of the HI-STORM 100 FSAR is hereby incorporated by reference into the HI-STORM 100 CoC. Resulting seismic loading at the CEC/SUPPORT FOUNDATION interface shall be considered in structural analysis of the SUPPORT FOUNDATION.