Seismic Analysis for New and Spent Fuel Storage Racks

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Abstract

Nonlinear time history analysis is usually used for the seismic analysis of new and spent fuel storage racks. For the seismic analysis of a base-fixed new fuel storage rack, the impact and the friction between a fuel assembly and a rack are considered. For the seismic analysis of a free-standing spent fuel storage rack, the hydro-coupling of water, the impact and the friction of the fuel assembly-to-poison insert and the poison insert-to-rack, and the rigid sliding and tipping motions are considered. Additionally, the multi-rack analysis is needed to increase the accuracy of analysis by considering the effects of adjacent racks. In this paper, the three-dimensional seismic analysis procedure and results including the multi-rack analysis are provided for new and spent fuel storage racks in PWR nuclear power plant. As results, the seismic loads and displacements of racks in horizontal and vertical directions could be calculated simultaneously, which should be calculated respectively in two-dimensional analysis, and the proposed procedure can be applied usefully for the rack analysis in PWR nuclear power plant.

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(3, 4 , 1, 2)

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, ANSYS[4]

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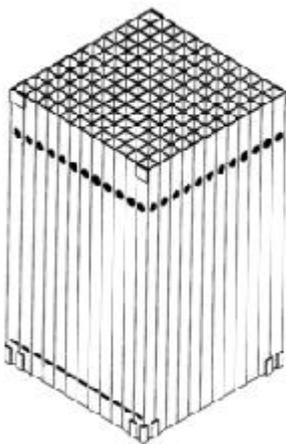
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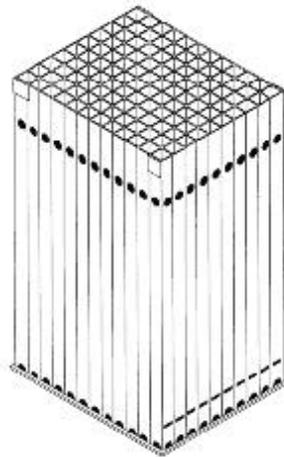
1 2 12x12 12x10

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1.   2

(50%) , 4

. 50% 75%

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(100%)   .

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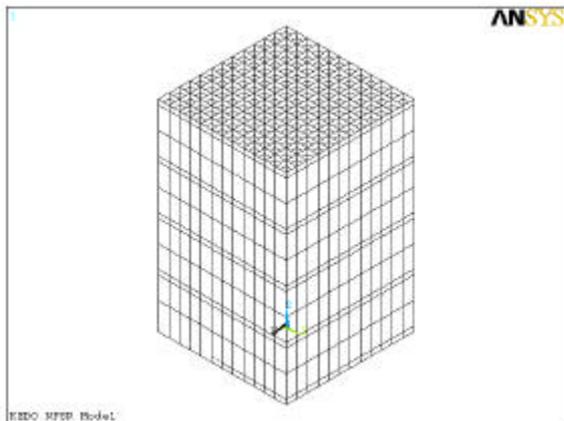
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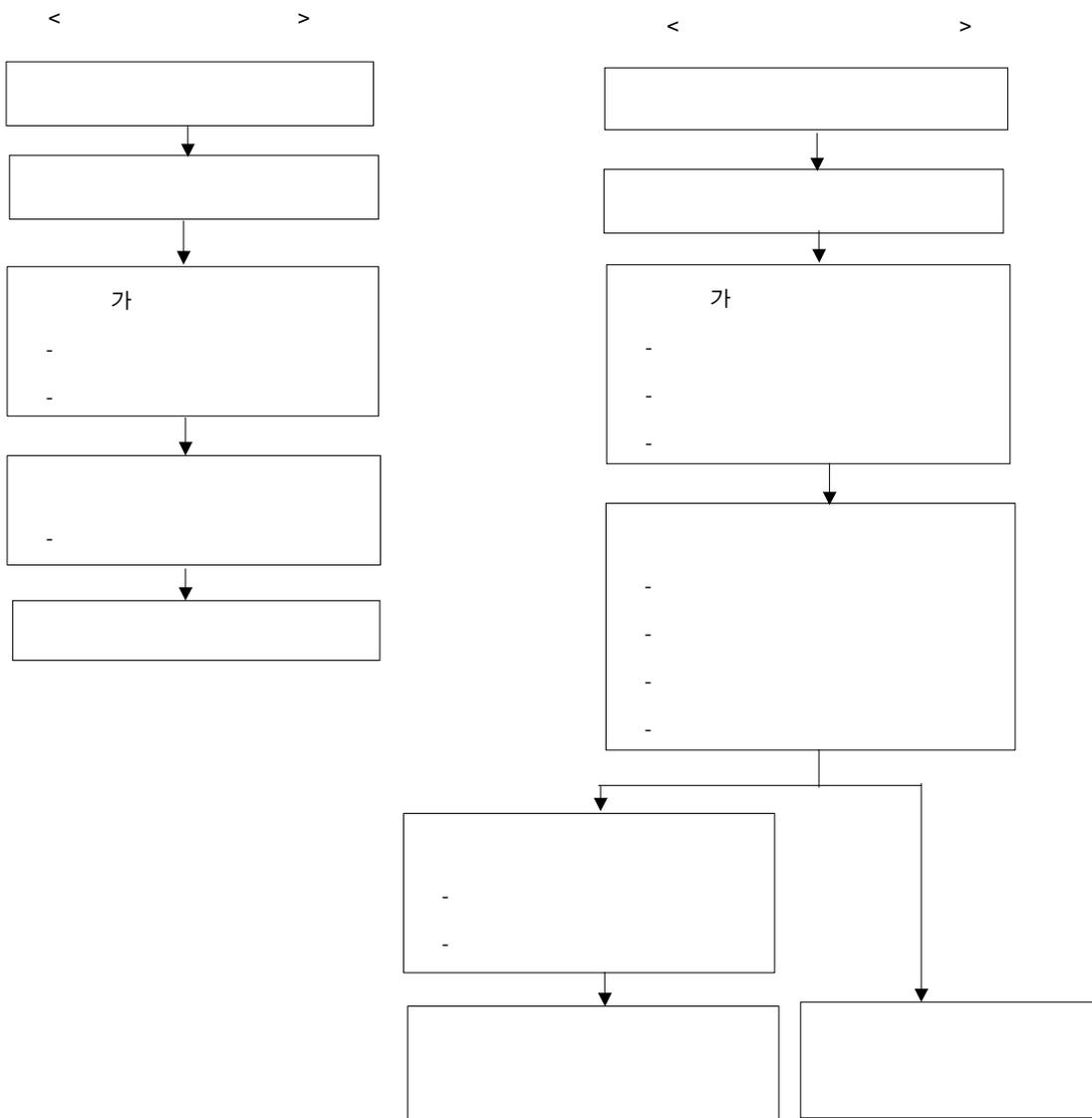
2.3

4   5   .   ,

ANSYS   (contac52)   .

图 4.   图 5.
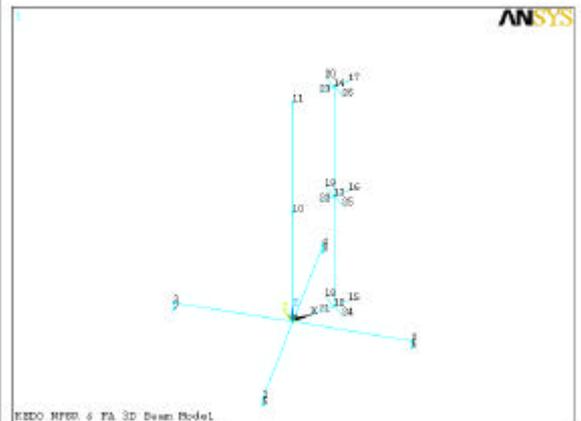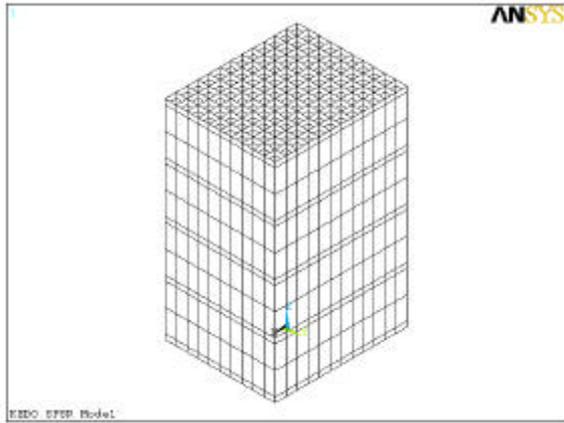

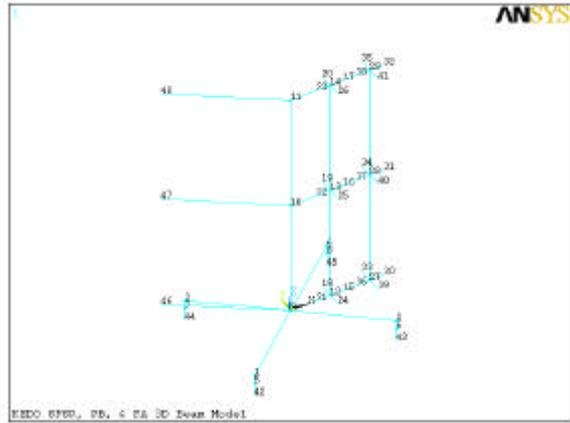6   7   .   (contac52)

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(contac52)   .

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(fluid38)   .
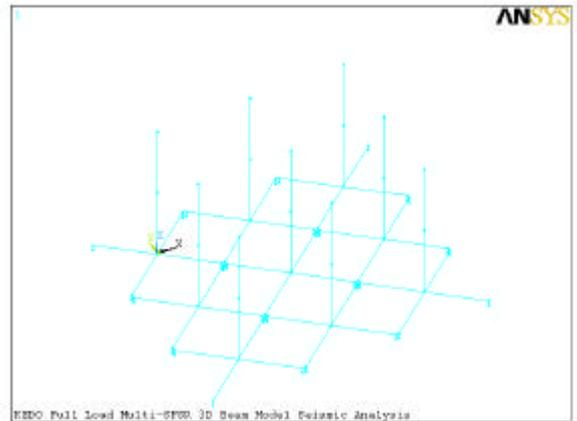
6.   7.

8   .   9
,   7   9
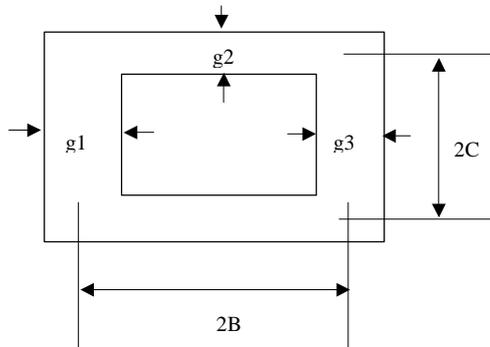.

(contac52, matrix27)   .

RACK 1	RACK 2	RACK 3
RACK 4	RACK 5	RACK 6
RACK 7	RACK 8	RACK 9

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8.   9.

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.   Fritz[5]

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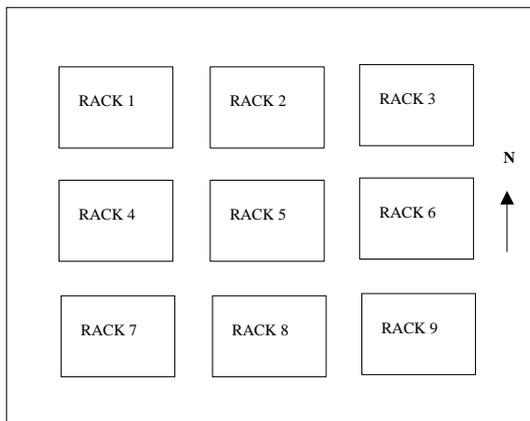
(1)　　　　　　.

$$M_H = 2 \mathit{rh}C^2 \left[\frac{C}{3g1} + \frac{C}{3g3} + \frac{2B}{g2} \right] \qquad (1)$$

,　M_H =

　　h　=

　　ρ　=

　　g1,g2,g3 =

2)

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3)

. Rabinowitz

0.53,　　　　0.125　　　　　[7].　　　　　　　　　　[2]

0.2 ~ 0.8

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4)

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2. 5

. 50%

4. 11 Hz , 100 %

1. 49 Hz .   ,

10 ~   12   .   (EW, NS)

10   11

.   12

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13 ~   15   ,

16 ~   18   .

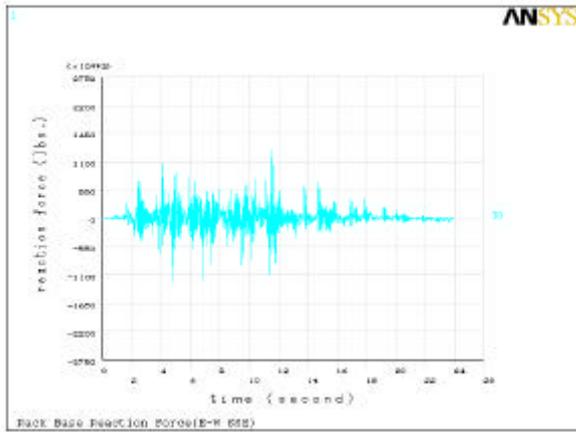(EW, NS)   13   14,

16   17   .
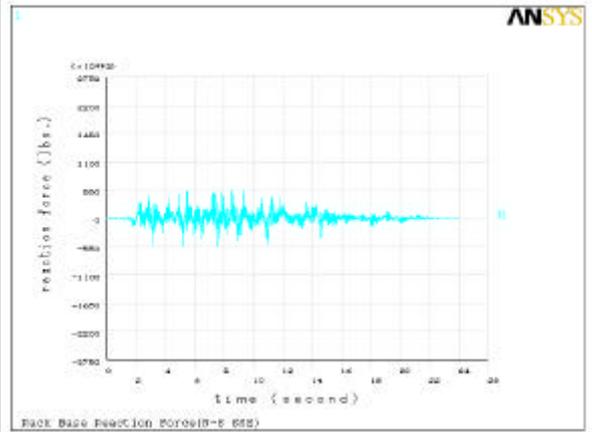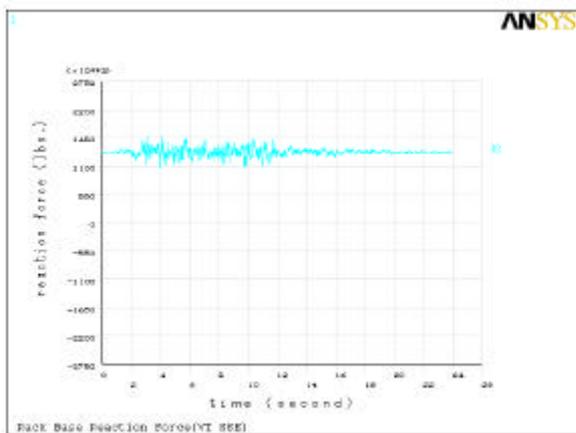
15   18   ,

.

,

30%

(13   14   16   17   ).

,   (in-phase)

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19   20   ,

(EW   2. 3   , NS   0. 6   )   (EW

0. 75   , NS   0. 4   )   .

,

.   19   20   (VI)

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3. 0

3   .

[1]   G. DeGrassi, "Review of Seismic Analysis Methods Used in the Design of High Density Spent Fuel Racks", BNL Technical Report, A-3841-10/89.

[2]   G. DeGrassi, "Review of the Technical Basis and Verification of Current Analysis Methods Used to Predict Seismic Response of Spent Fuel Storage Racks", NUREG/CR-5912, BNL-NUREG-52335(1992).

[3]   G. M. Lee, "Three-Dimensional Seismic Analysis for Spent Fuel Storage Rack", Journal of the Korean Nuclear Society Volume 30, Number 2, April 1998.

[4]   ANSYS Revision 5.5, "ANSYS User's Manual", ANSYS, Inc., 1999.

[5]   Fritz, R.J., "The Effects of Liquids on the Dynamic Motions of Immersed Solid", Journal of Engineering for Industry, Trans., ASME, February 1972.

[6]   Singh, S., Putnam, S.F., and Pop, J., "Structural Evaluation of Onsite Spent Fuel Storage: Recent Developments", Proceedings of the Third Symposium, Orlando, FL, December, 1990, pp. V/4-1 through V/4-18.

[7]   Rabinowicz, E., "Friction Coefficients of Water-Lubricated Stainless Steel for a Spent Fuel Rack Facility", MIT, 1976.
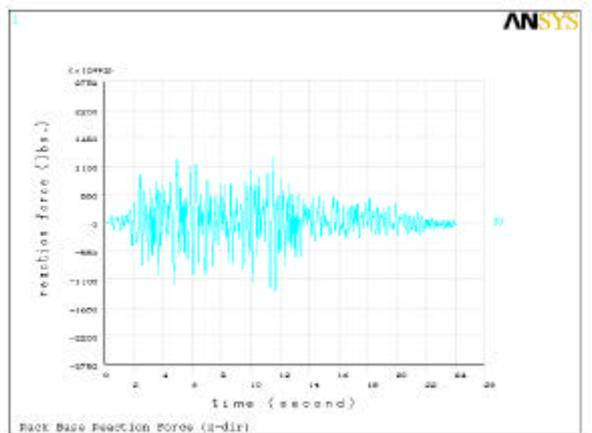
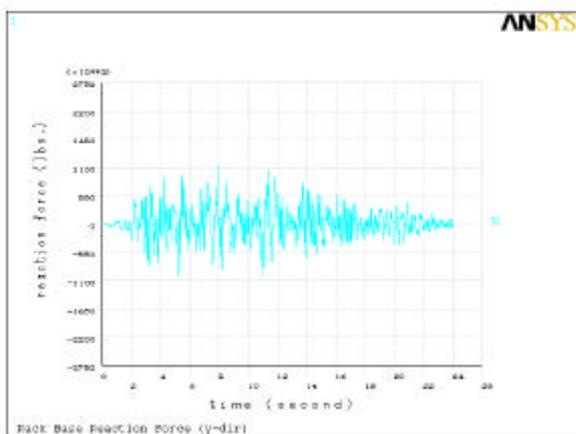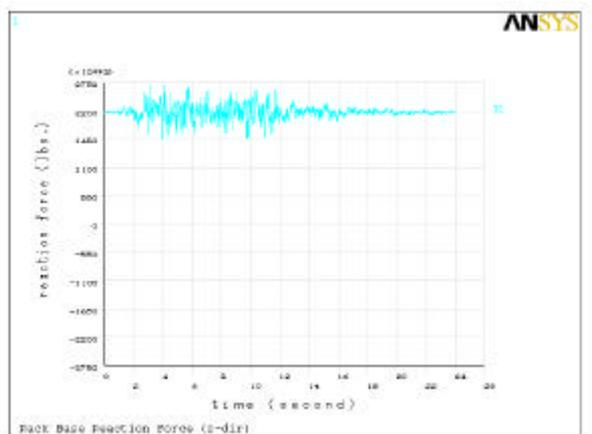图 10. (EW-SSE)　　　　　　　　　　　　图 11. (NS-SSE)
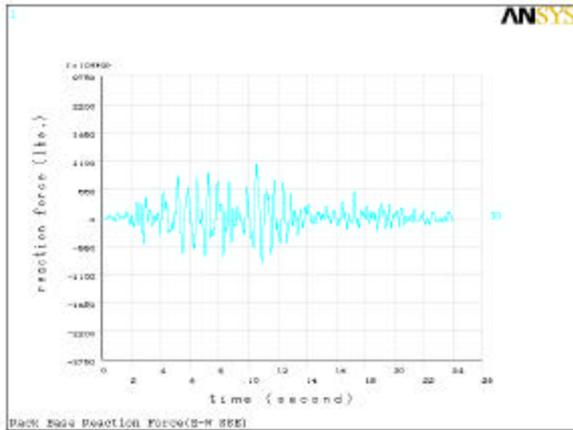

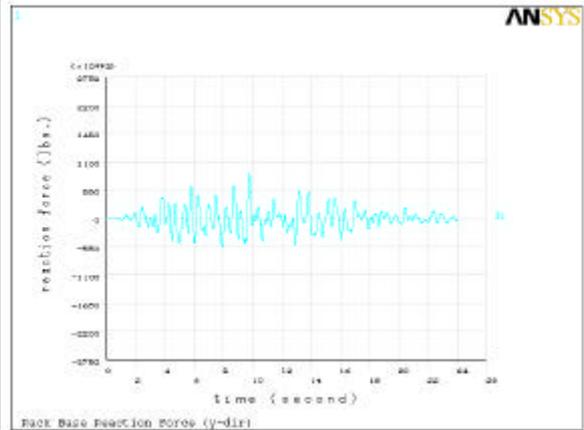图 12. (VT-SSE)　　　　　　　　　　　　图 13. (EW-SSE)
( )

图 14. (NS-SSE)　　　　　　　　　　　　图 15. (VT-SSE)
( )　　　　　　　　　　　　　　　　　( )

16.   (EW-SSE)   17.   (NS- SSE)

           (   )   (   )

18.   (VT- SSE)   19.

           (   )   (   )
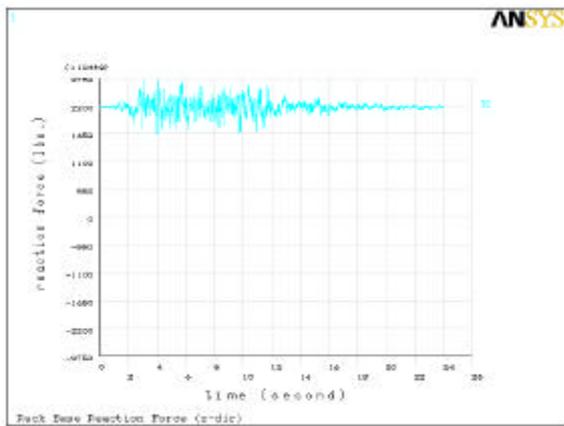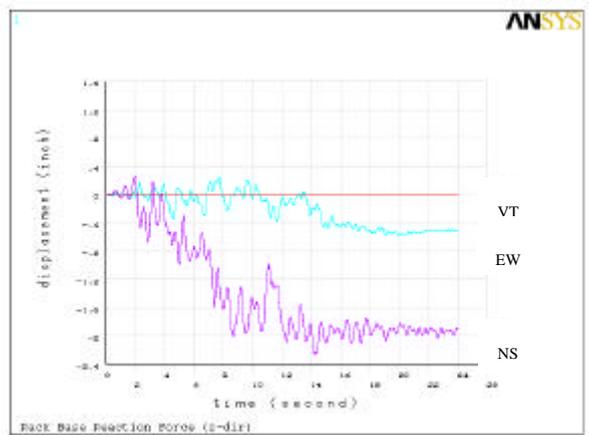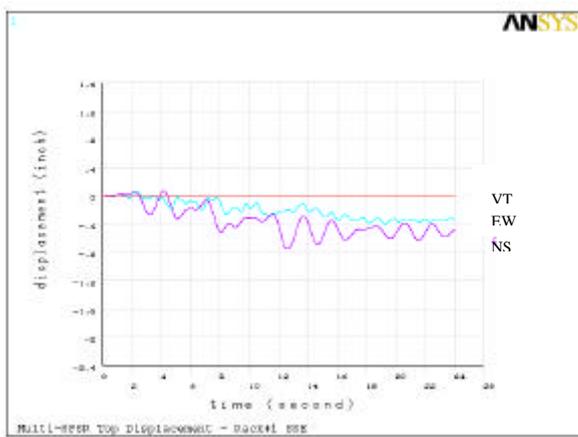

20.

           (   )