Natural Frequency for the Steel Dunnage used in FHEP

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The steel dunnage, used in FHEP, is designed by Ernie Villegas. This calculation is to estimate the natural frequency for the dunnage. There are two models. First one is just the dunnage itself. The second one is the dunnage plus the weight of table +extrusion as a lump mass acting at a distance Lc, away from top of the super jack. The FEA model uses the Ernie's beam model[1] as shown in Fig 1. The calculation result is summarized in Table 1 and Table 2.

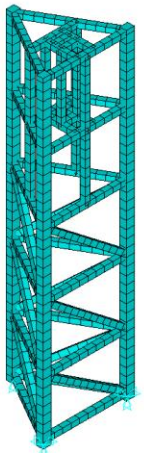


Fig 1 FEA model

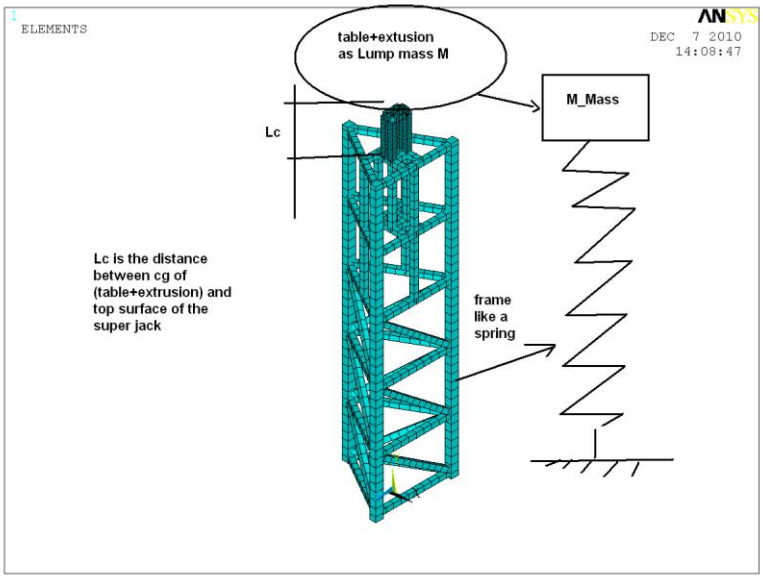


Fig 2 2nd FEA model __"spring + lump mass"

Table 1 Natural Frequency for the steel dunnage

The steel dunnage itself	1st mode _bending mode	2nd mode_twisting mode	3rd mode_ c shape
Natural Frequency (HZ)	15.3	26.8	49.2

Table 2 Natural Frequency for the dunnage with a lump mass M (spring-mass model) (M=21000 lb/each dunnage from reference 2)

Lc (inch)	1 st mode_ bending mode	2nd mode_ twisting mode	3rnd mode_ vertical (up and down)
30	2.55	12.54	15.9
40	2.31	11.25	15.75
50	2.08	10.24	15.63
60	1.86	9.55	15.5

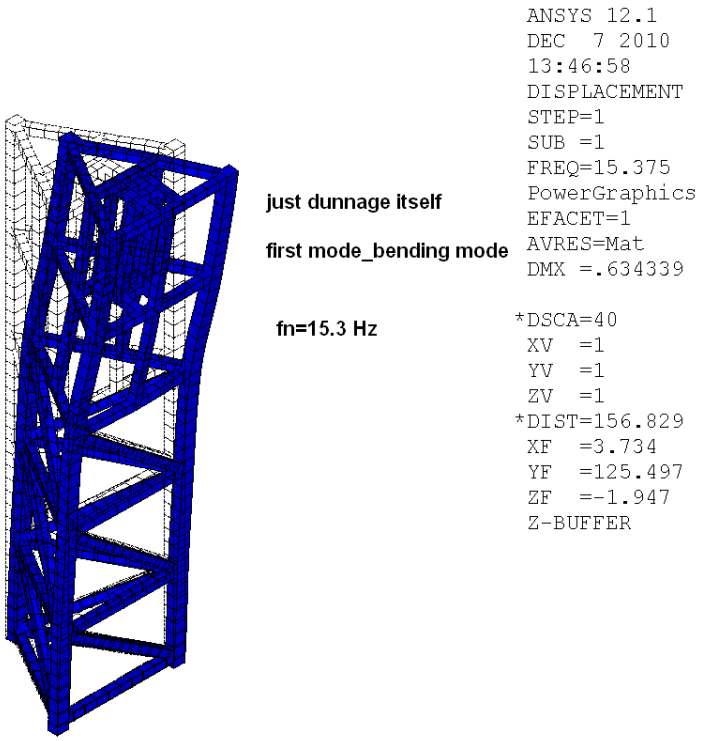
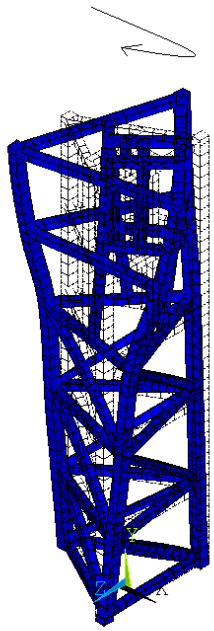


Fig3 First mode for the dunnage

2nd mode_twist mode
f2=26.8 HZ

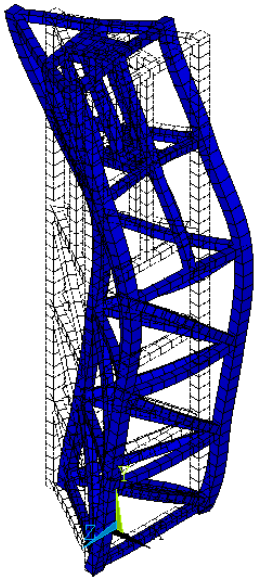


ANSYS 12.1
DEC 7 2010
13:50:57
DISPLACEMENT
STEP=1
SUB =3
FREQ=26.811
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.895685

*DSCA=40
XV =1
YV =1
ZV =1
*DIST=198.784
XF =5.865
YF =124.657
ZF =-8.619
Z-BUFFER

Fig 4 2nd mode _ twist mode

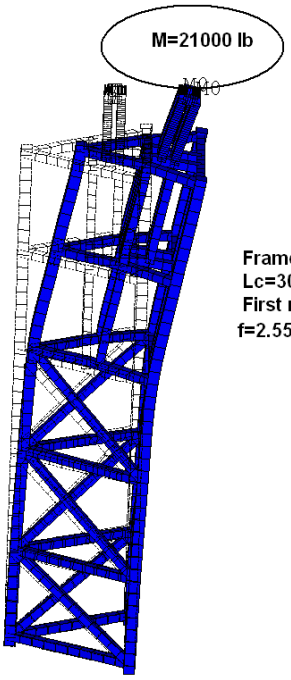
Third mode__ C shape
f3=49.19 HZ



ANSYS 12.1
DEC 7 2010
13:55:22
DISPLACEMENT
STEP=1
SUB =4
FREQ=49.197
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.586568

*DSCA=40
XV =1
YV =1
ZV =1
*DIST=198.784
XF =-5.377
YF =123.944
ZF =-.961057
Z-BUFFER

Fig 5 3rd mode.

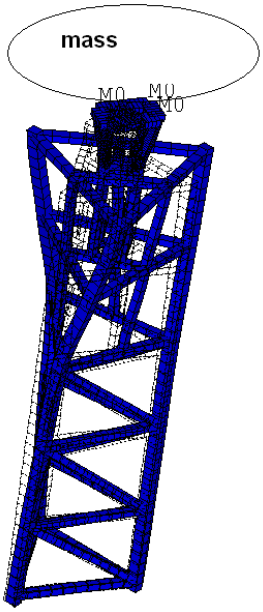


Frame+lump mass
Lc=30"
First mode_ bending mode
f=2.554

```
 ANSYS 12.1
 DEC  8 2010
 13:21:26
 DISPLACEMENT
 STEP=1
 SUB =1
 FREQ=2.554
 PowerGraphics
 EFACET=1
 AVRES=Mat
 DMX =.135665

*DSCA=300
 XV  =-.27816
 YV  =.370631
 ZV  =.886149
*DIST=219.831
*XF  =-4.013
*YF  =138.944
*ZF  =-.026886
 A-ZS=-7.023
 Z-BUFFER
```

Fig6 1st mode of dunnage with a lump mass



frame+ lump mass
Lc=30"
f=12.53 HZ (twisting mode)

```
 ANSYS 12.1
 DEC  8 2010
 13:21:57
 DISPLACEMENT
 STEP=1
 SUB =3
 FREQ=12.545
 PowerGraphics
 EFACET=1
 AVRES=Mat
 DMX =.341848

*DSCA=100
 XV  =-.663262
 YV  =.564352
 ZV  =.491519
*DIST=219.831
*XF  =-4.013
*YF  =138.944
*ZF  =-.026886
 A-ZS=-7.903
 Z-BUFFER
```

Fig 7 2nd mode for dunnage with a lump mass

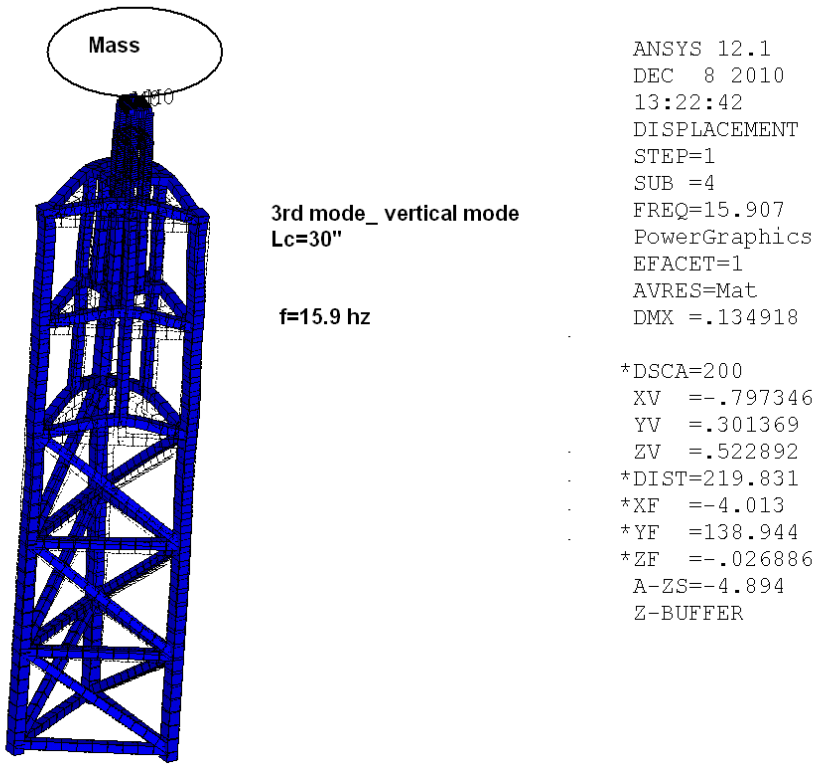


Fig8 3rd mode _ vertical direction

Reference

1) Ernie Villegas,"Pivoter Table Dunnage", MD-ENG-251 ,May 28th,2010

2) Dave Pushka, "Nova FHEP Pivoter Dunnage Stability", MD-EN-291, Nov29th ,2010