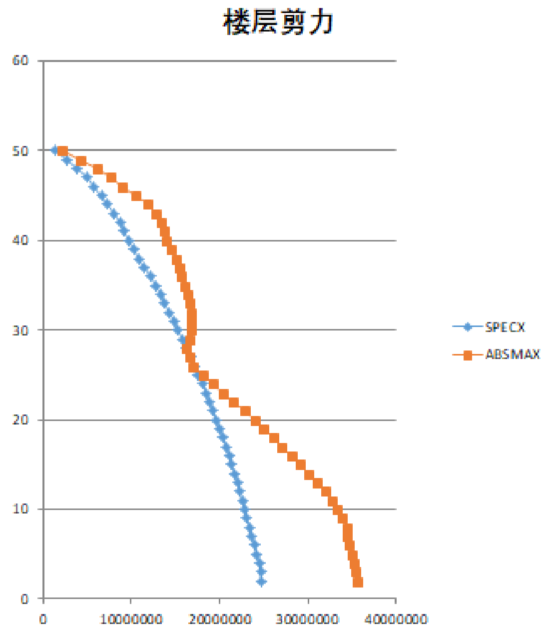
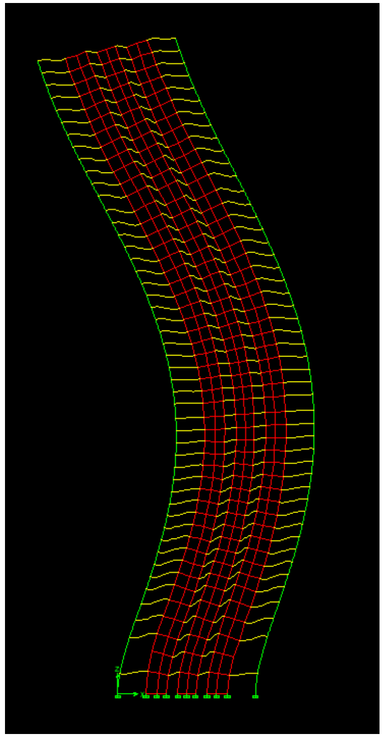
Dino结构笔记 DINO’S NOTEBOOK

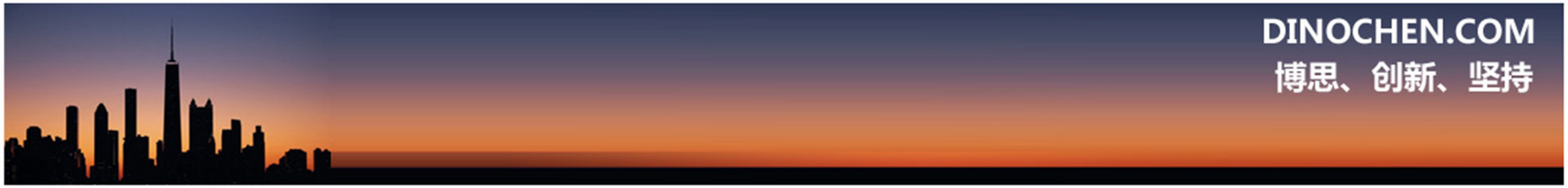
弹性时程分析顶部剪力变大的原因

The reason of Top Shear Increment in Elastic time history analysis

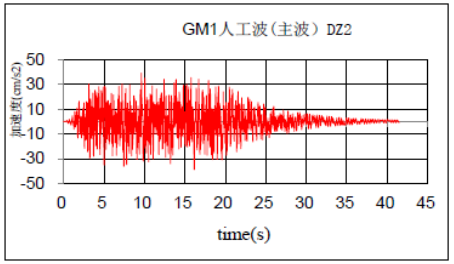
微信公众号 DINOSTRU

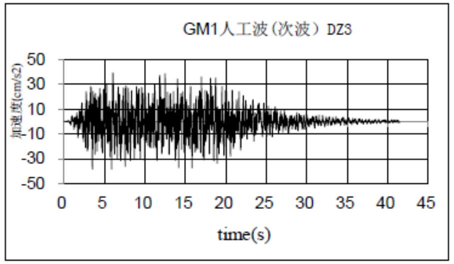




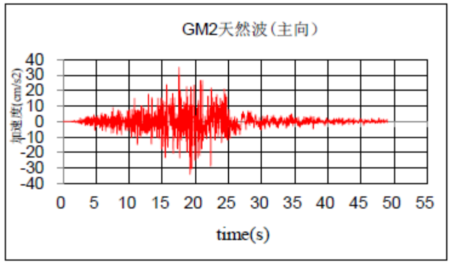


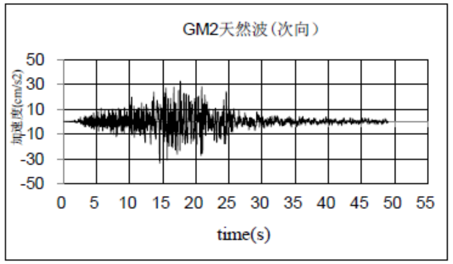
GM1 人工波两个方向各选取两组，选自安评报告附件，峰值加速度 0.038g



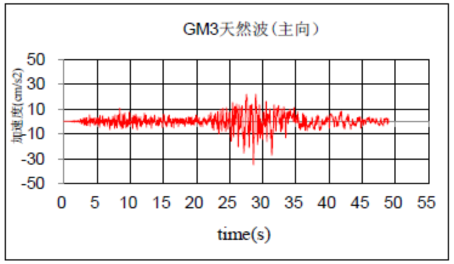


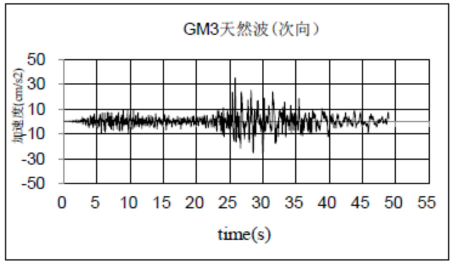
GM2 天然波 1786，地震： HECTOR MINE FRI OCT 15, 1999 02:46, HEART BAR STATE PARK

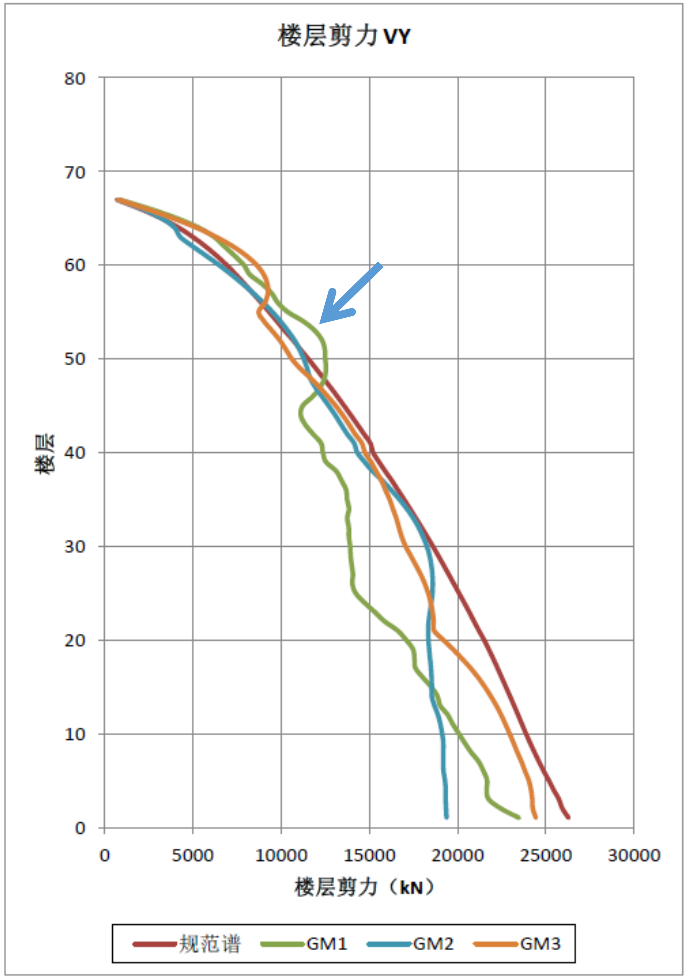




GM3 天然波 1761，地震：HECTOR MINE OCT 16, 1999,ALTADENA - EATON CANYON PARK







由于选取天然波的原因，在楼层剪力的顶部经常算出来比反应谱要大

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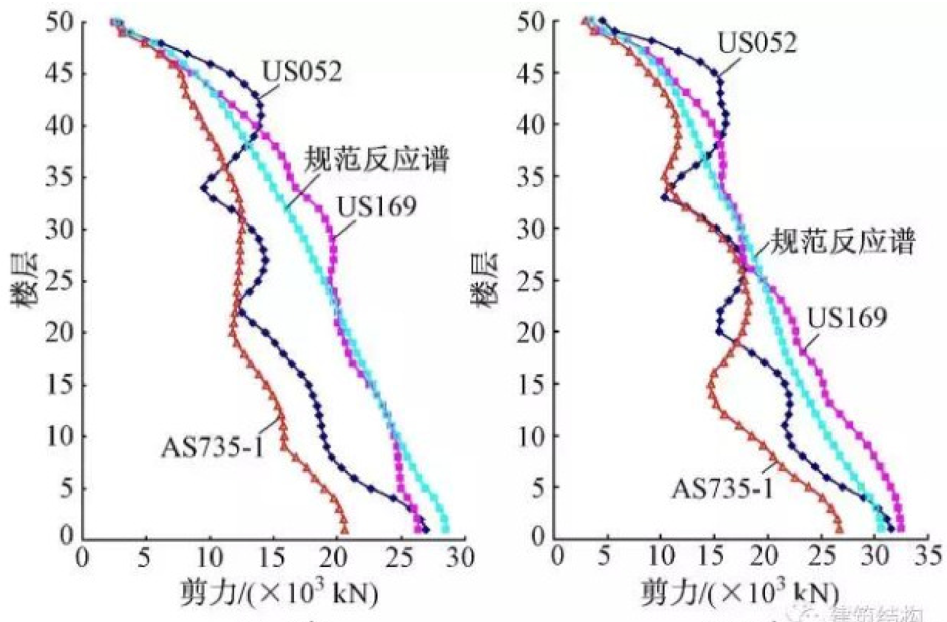
微信公众号：Dino结构笔记

2.1小震作用下的计算结果

（1）楼层水平地震剪力分布：对于高层建筑，通常可由此判断结构是否存在高阶振型响应并发现薄弱楼层。图7为某幢高层建筑结构小震弹性时程分析得到的楼层剪力分布，可见结构存在高阶振型响应，应对结构上部相关楼层地震剪力加以调整放大。

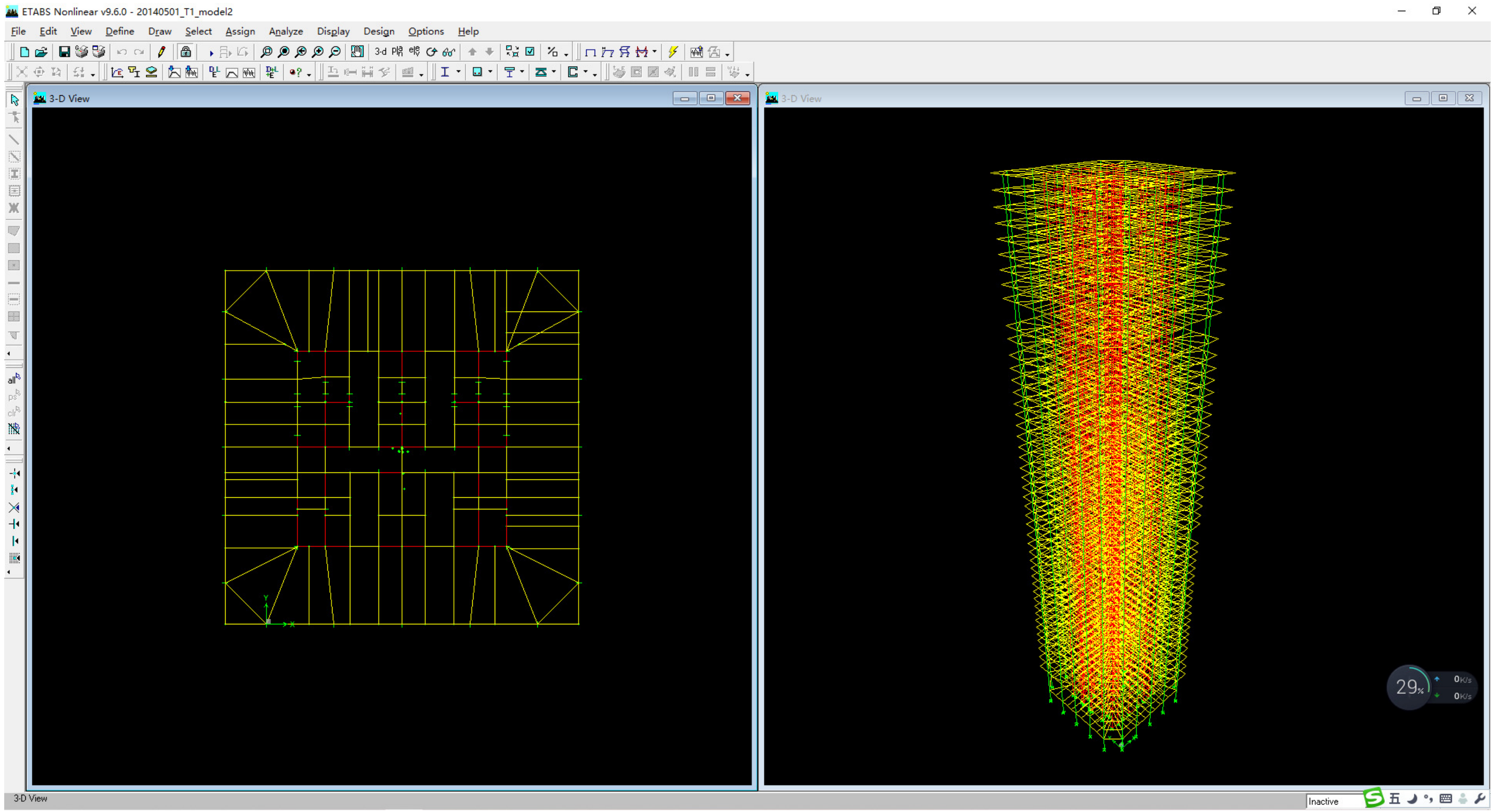


(a) X向　(b) Y向

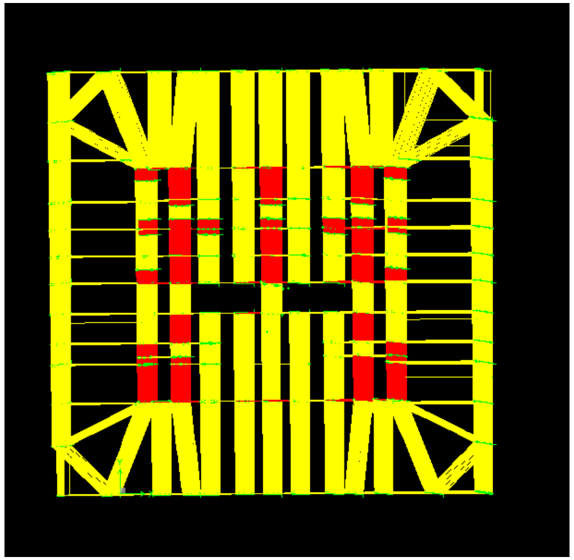
什么原因引起顶部剪力放大？

很多超限报告与文献都写是因为高阶振型的影响，但是越高阶的振型对宏观剪力与位移的影响会越来越小

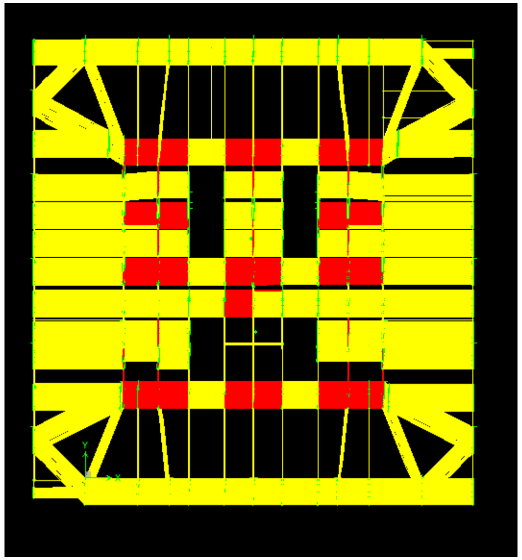
为了调查原因，我采用数值分析方法进行调查。这是一个普通的框筒结构



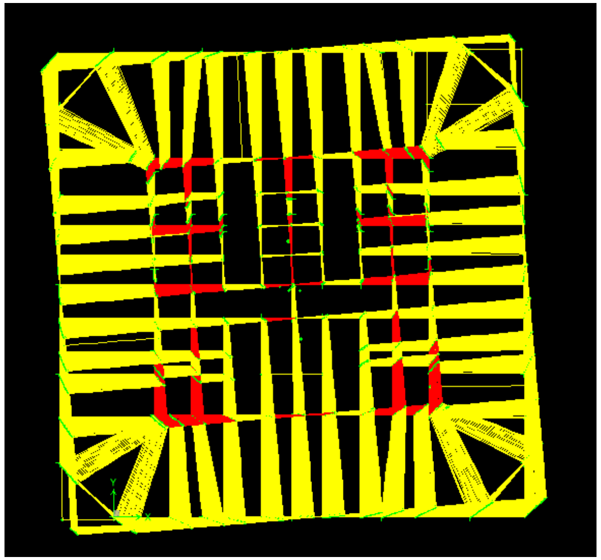
Model sample



T1 = 4.2824 sec



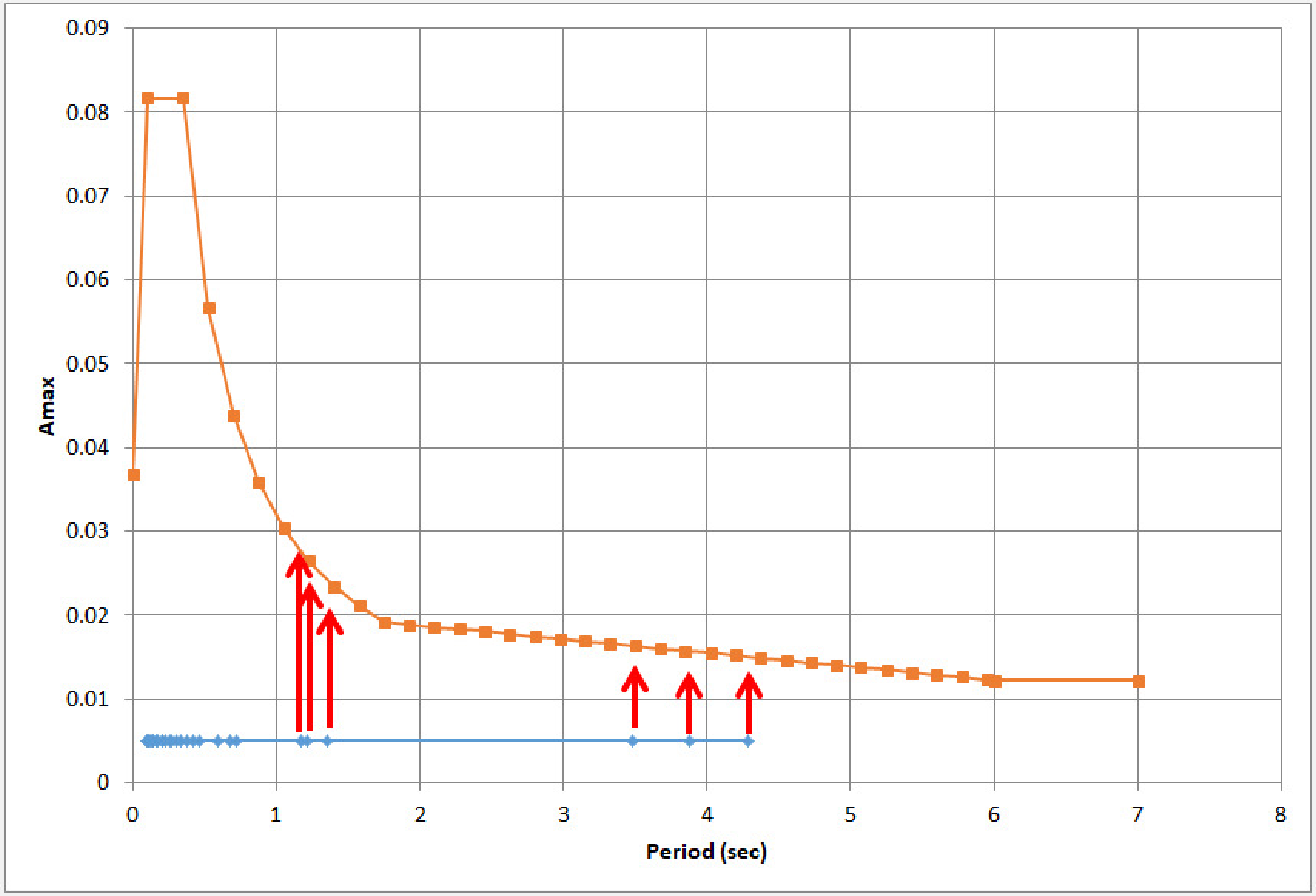
T2 = 3.8736 sec



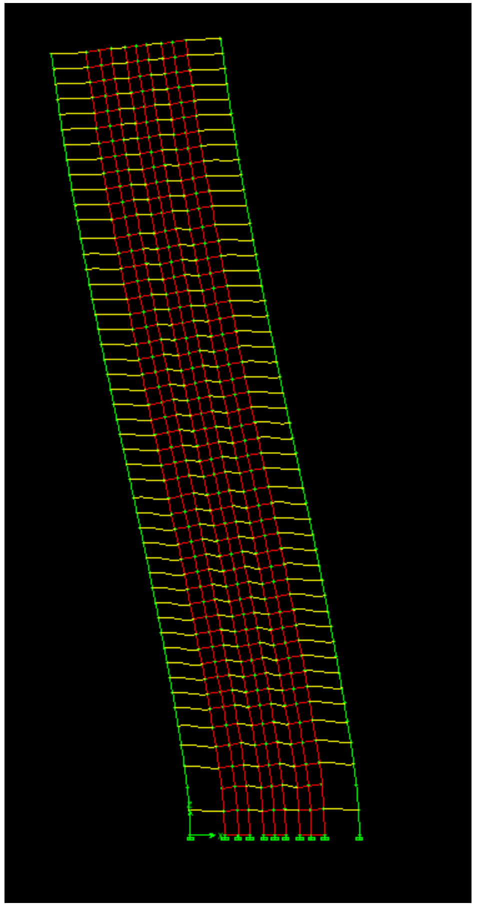
T3 = 3.4813 sec

这个是我们模态分析得到的前三个振型，我们选取一个X方向为作研究，所以X方向的前三阶型并不是这三个

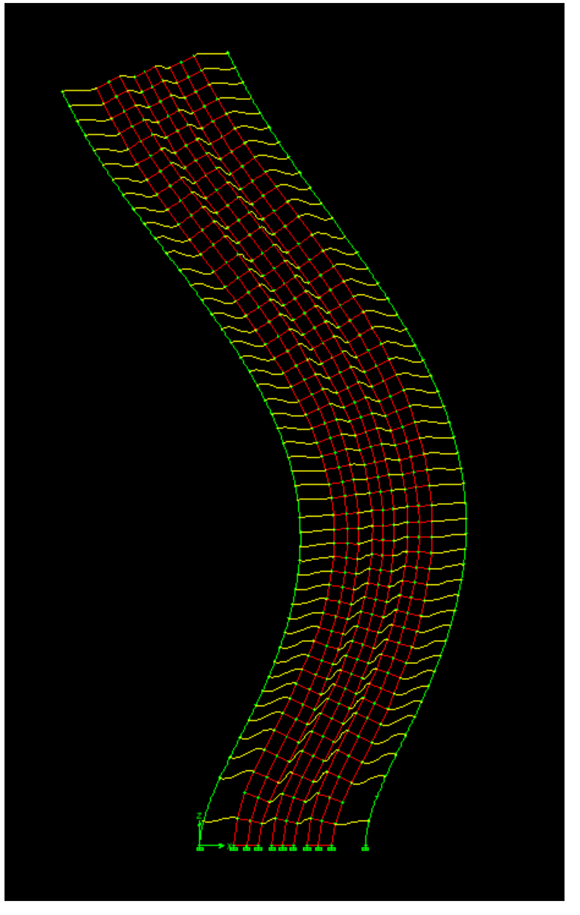
Mode	Period
1	4.2824
2	3.8736
3	3.4813
4	1.3553
5	1.2193
6	1.1762
7	0.7259
8	0.6726
9	0.5926
10	0.4670
11	0.4251
12	0.3773
13	0.3315
14	0.2971
15	0.2681
16	0.2544
17	0.2234
18	0.2076
19	0.2018
20	0.1729
21	0.1658
22	0.1629
23	0.1376
24	0.1360
25	0.1341
26	0.1145
27	0.1138
28	0.1120
29	0.0992
30	0.0981



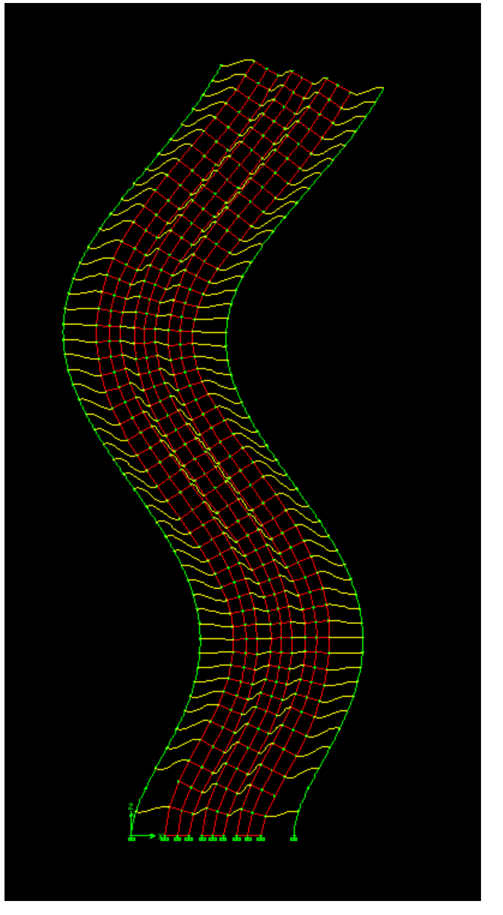
这个是整体结构空间前几阶振型对应的位置



T1 = 4.2824 sec



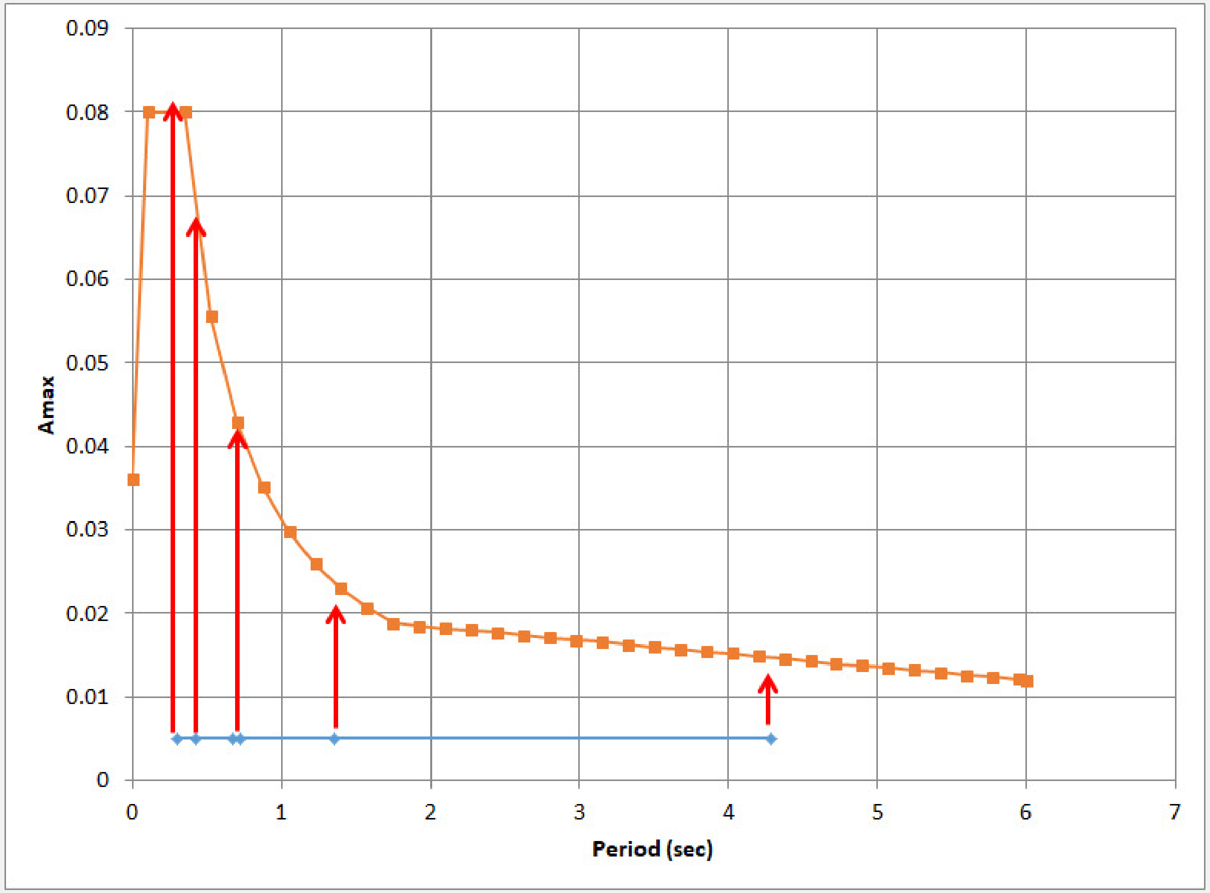
T4 = 1.3553 sec



T7 = 0.7259 sec

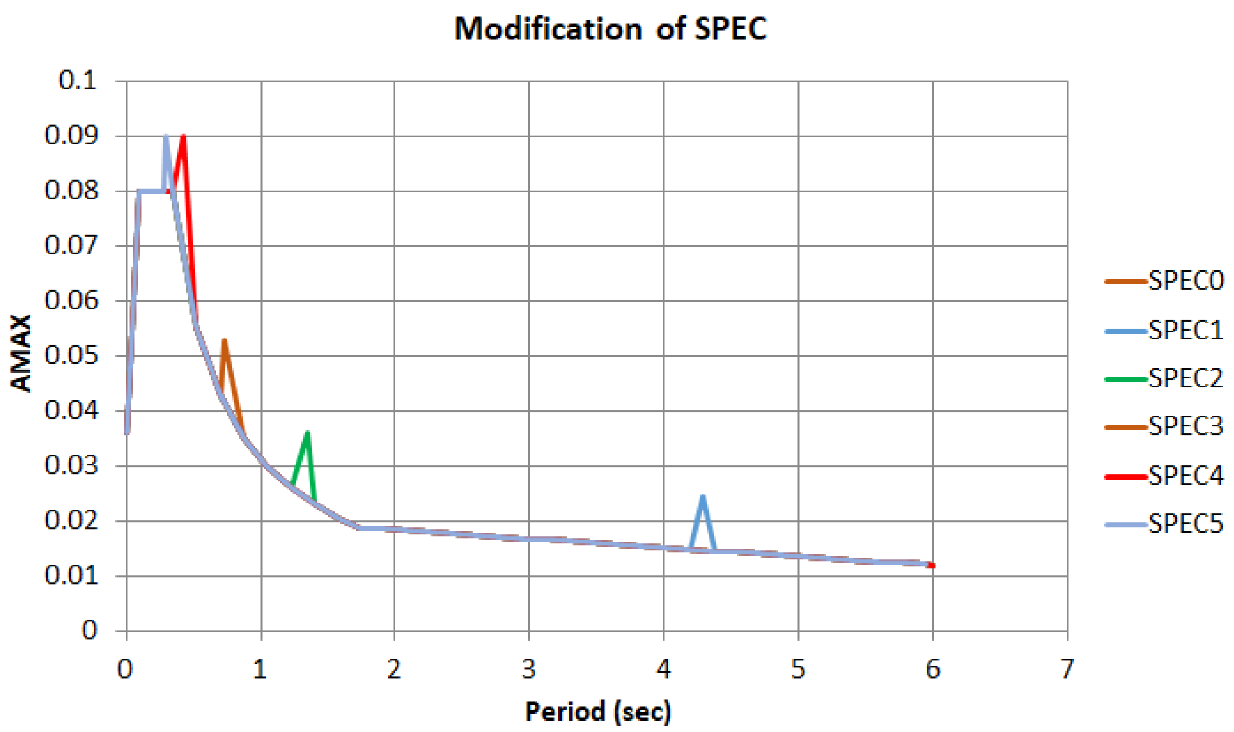
这三个振型才是X方向的前三阶振型， 可以看出明显的正弦曲线

Mode	Period	UX
1	4.2824	70.4767
2	3.8736	0.0519
3	3.4813	0.9064
4	1.3553	13.9202
5	1.2193	1.2476
6	1.1762	0.0151
7	0.7259	1.854
8	0.6726	2.6915
9	0.5926	0.0028
10	0.4670	0.5421
11	0.4251	1.6195
12	0.3773	0.0016
13	0.3315	0.2215
14	0.2971	1.122
15	0.2681	0.0012
16	0.2544	0.0929
17	0.2234	0.8223
18	0.2076	0.0015
19	0.2018	0.0513
20	0.1729	0.6889
21	0.1658	0.0022
22	0.1629	0.0485
23	0.1376	0.497
24	0.1360	0.0049
25	0.1341	0.0869
26	0.1145	0.0037
27	0.1138	0.0027
28	0.1120	0.4475
29	0.0992	0.004
30	0.0981	0.0001

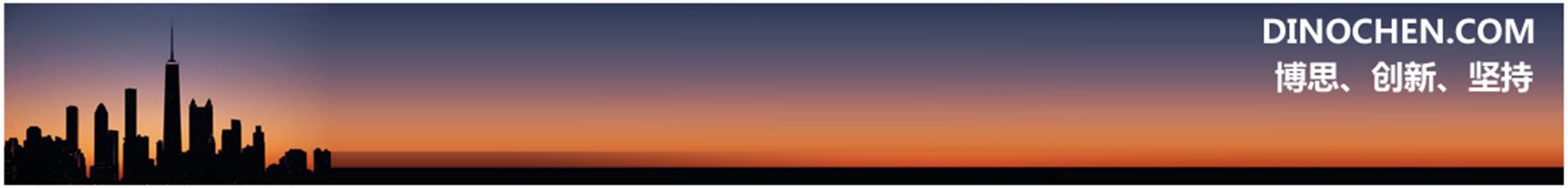


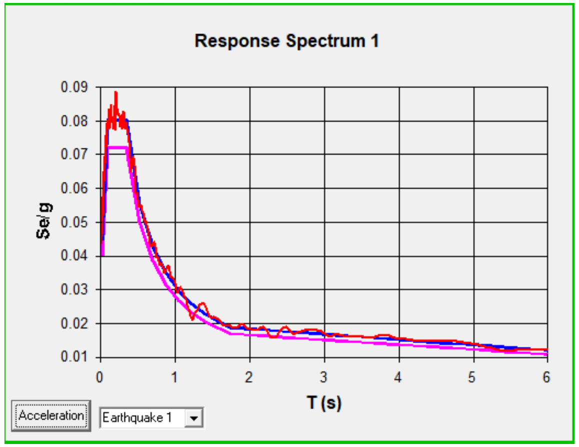
这三个振型才是X方向的前三阶振型所在反应谱的位置，从表格也可以看出前几阶振型对X方向变形与剪力的影响，从70%降到1.122%，越高阶影响越小。

Mode	Period	UX
1	**4.2824**	**70.4767**
2	3.8736	0.0519
3	3.4813	0.9064
4	**1.3553**	**13.9202**
5	1.2193	1.2476
6	1.1762	0.0151
7	**0.7259**	**1.854**
8	**0.6726**	**2.6915**
9	0.5926	0.0028
10	0.4670	0.5421
11	**0.4251**	**1.6195**
12	0.3773	0.0016
13	0.3315	0.2215
14	**0.2971**	**1.122**
15	0.2681	0.0012
16	0.2544	0.0929
17	0.2234	0.8223
18	0.2076	0.0015
19	0.2018	0.0513
20	0.1729	0.6889
21	0.1658	0.0022
22	0.1629	0.0485
23	0.1376	0.497
24	0.1360	0.0049
25	0.1341	0.0869
26	0.1145	0.0037
27	0.1138	0.0027
28	0.1120	0.4475
29	0.0992	0.004
30	0.0981	0.0001

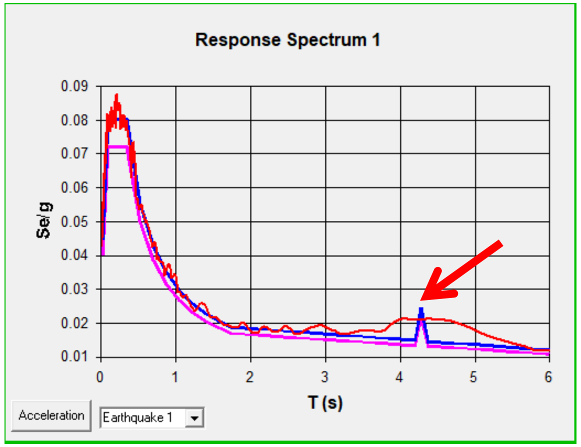


我们假定高阶振型并不会引起剪力的“R”型突变，而是前几个振型，
我们对前几阶振型的反应谱进行扰动，如上图所示，基于这些扰动，我们进行造人工波。

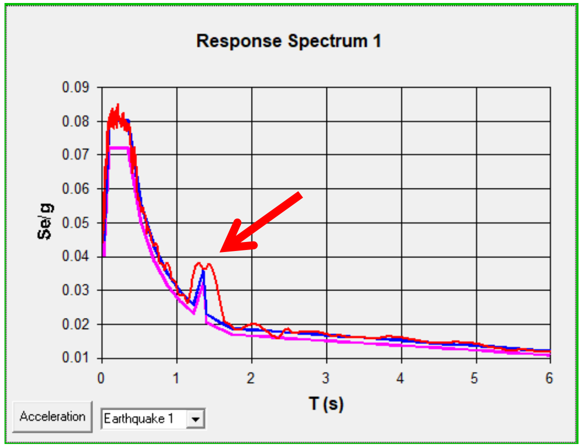




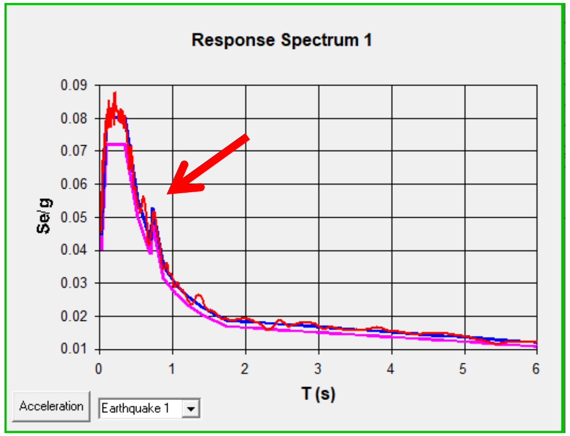
GM0



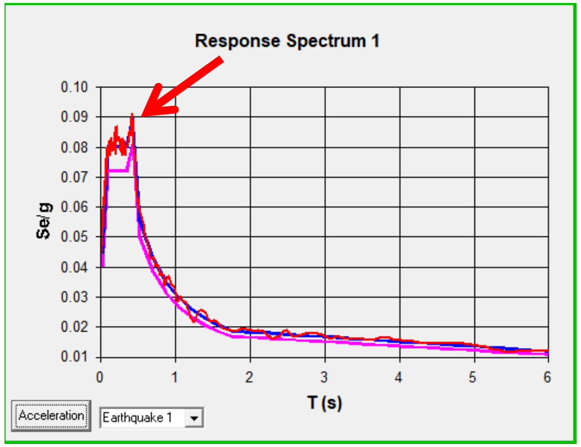
GM1



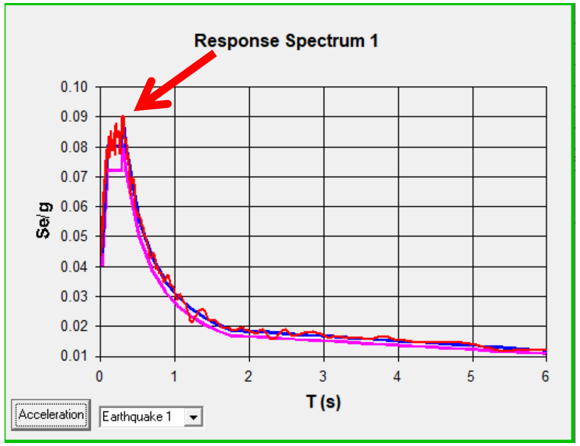
GM2



GM3

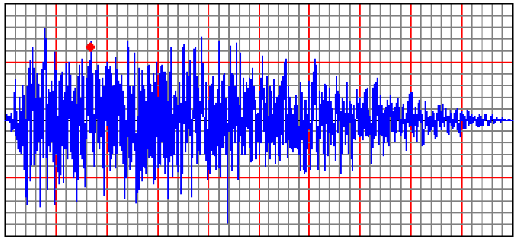


GM4

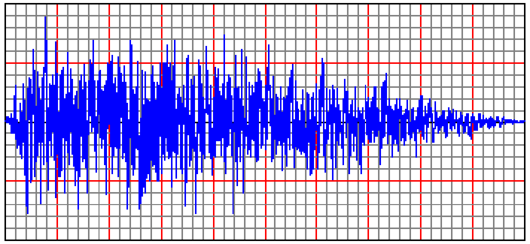


GM5

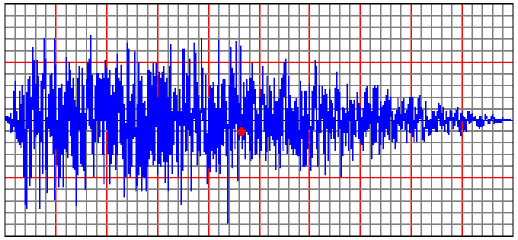
我们基于扰动进行了造波，得到的人工波反应谱如图所示。



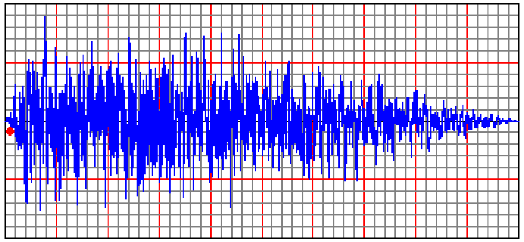
GM0



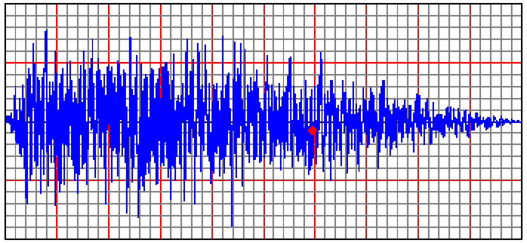
GM1



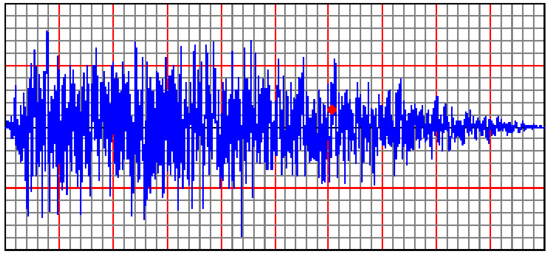
GM2



GM3

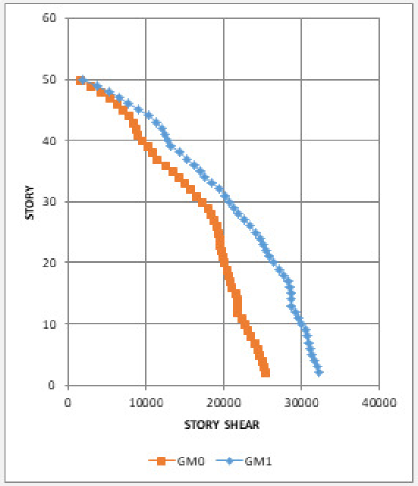


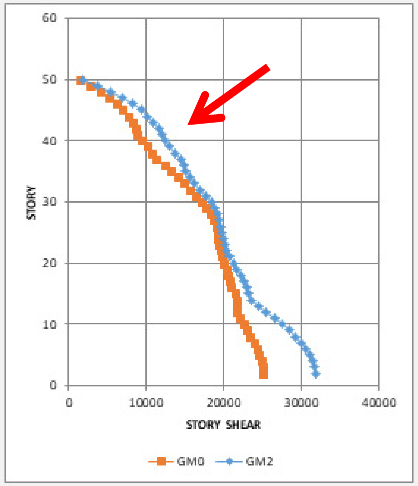
GM4



GM5

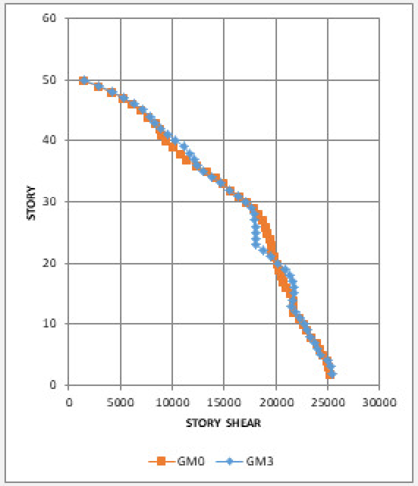
得到的人工波数据如图所示，峰值为35 gal

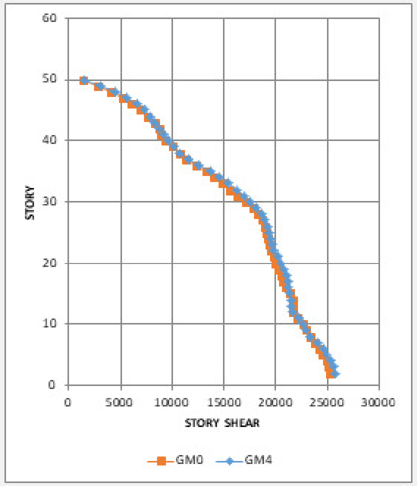


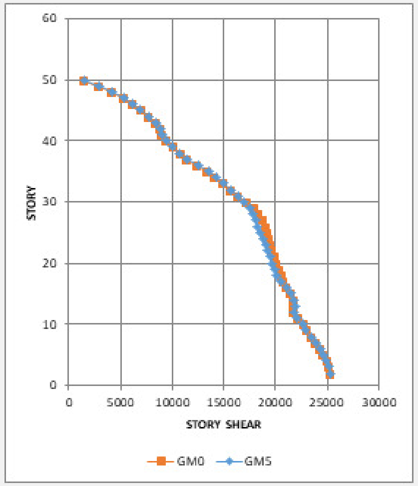


小结：

（1）从第三阶开始，扰动基本不影响剪力分布，基本可以排除高阶振型对剪力R形突变的影响
（2）第一二阶的扰动，对总剪力影响较大，第一阶扰动并不会引起R形突变
（3）第二振型是关键 ，第二振型开始出现R形突变
（4）为了进一步研究，我们增加对第二阶的扰动







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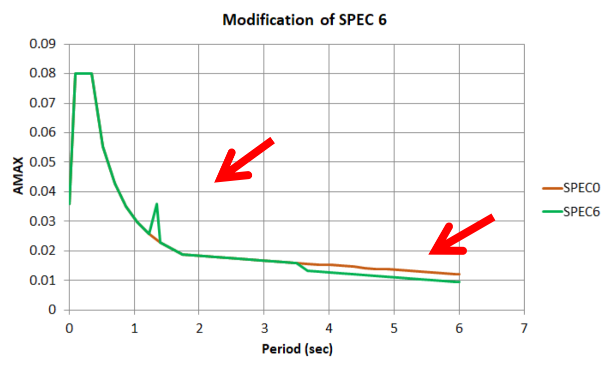
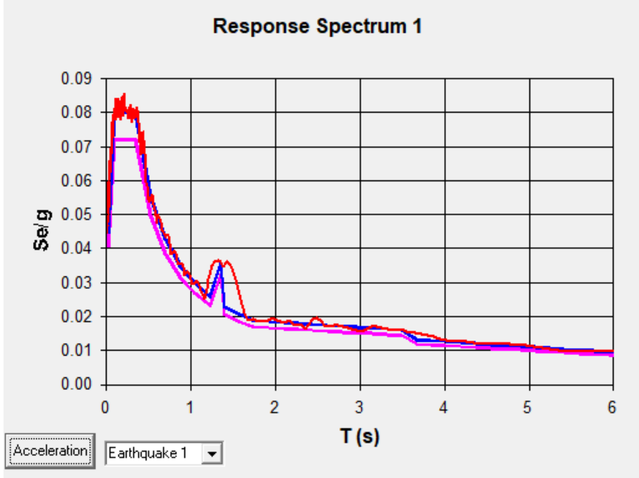
6	1.1762	0.0151
7	0.7259	1.854
8	0.6726	2.6915
9	0.5926	0.0028
10	0.4670	0.5421
11	0.4251	1.6195
12	0.3773	0.0016
13	0.3315	0.2215
14	0.2971	1.122
15	0.2681	0.0012
16	0.2544	0.0929
17	0.2234	0.8223
18	0.2076	0.0015
19	0.2018	0.0513
20	0.1729	0.6889
21	0.1658	0.0022
22	0.1629	0.0485
23	0.1376	0.497
24	0.1360	0.0049
25	0.1341	0.0869
26	0.1145	0.0037
27	0.1138	0.0027
28	0.1120	0.4475
29	0.0992	0.004
30	0.0981	0.0001

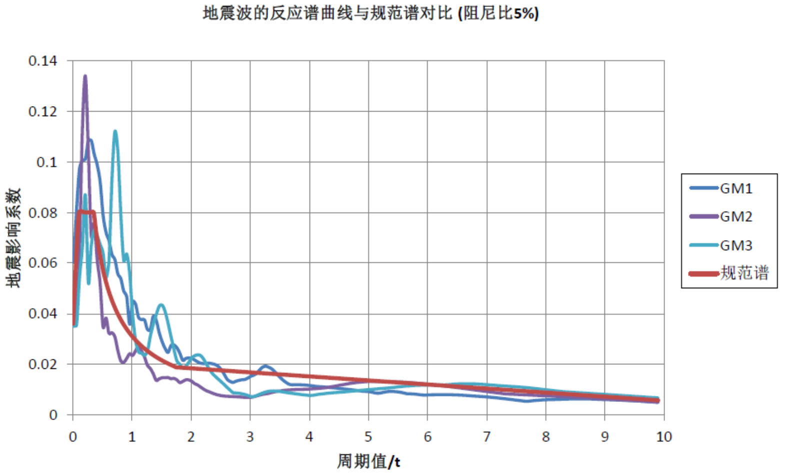




操作：

（1）降低第一阶附近的地震影响系数
（2）增加对第二阶周期附件的扰动

在天然波的选择中，这的确是一个普遍现象，在周期大于4S的情况下，大部分地震波的影响系数小于规范值为满足总剪力的需要，很多满足条件的地震波会在1~3s的区间有较大的影响系数值 。



明显出现剪力的R形突变，也就是顶1/3以上剪力大于反应谱值

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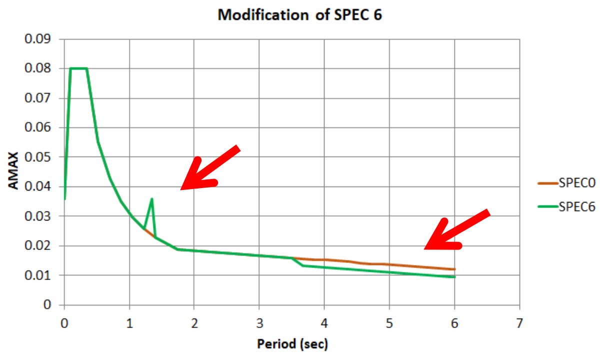

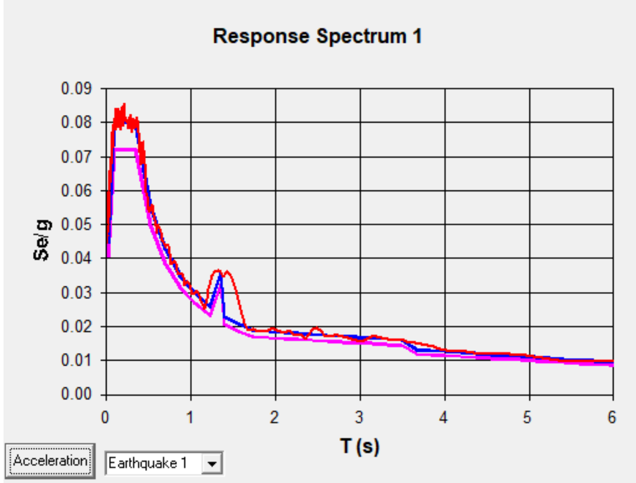

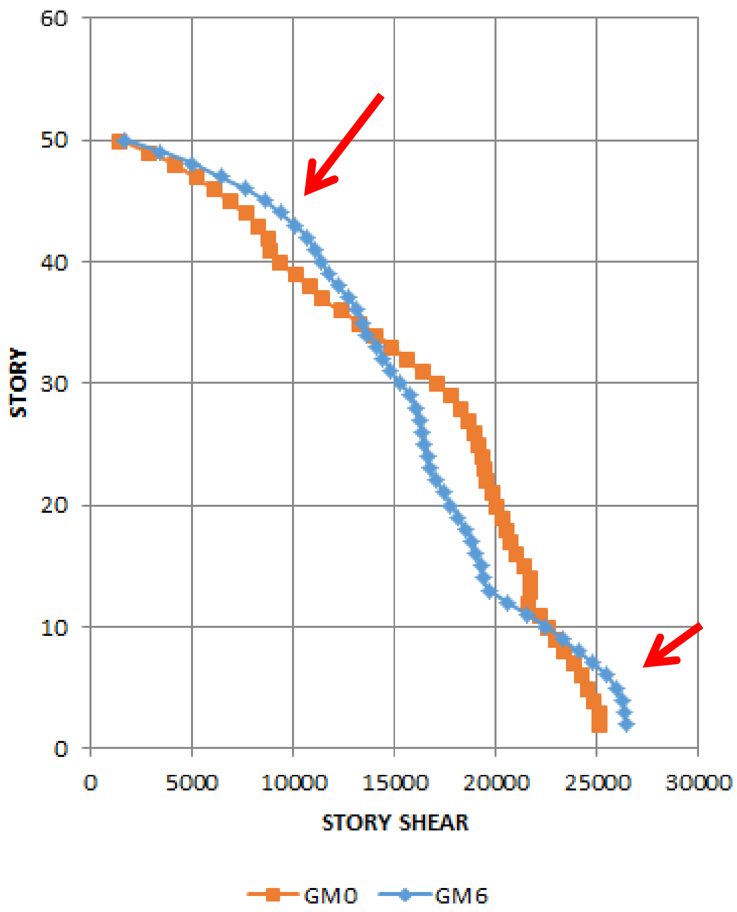

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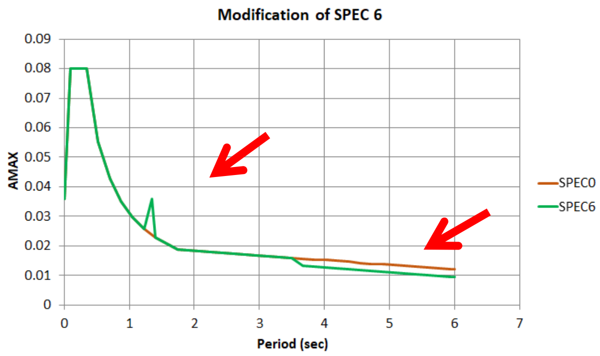
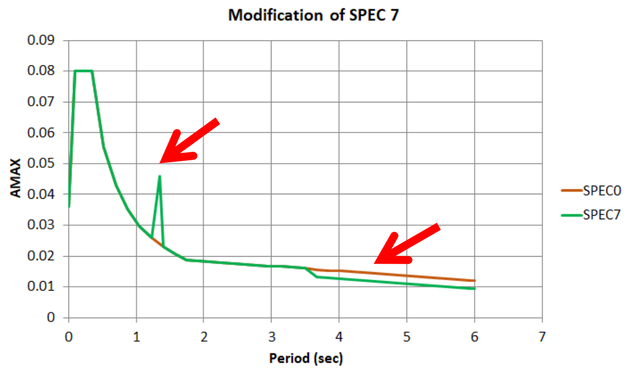
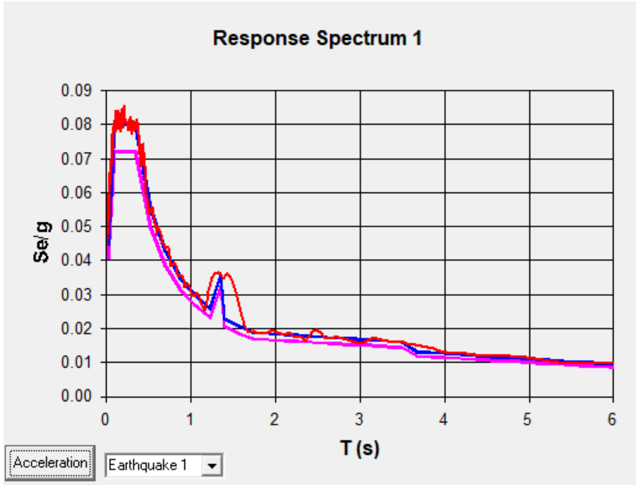
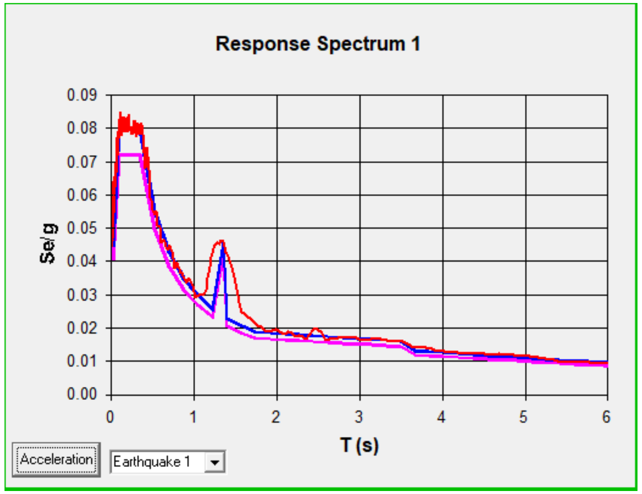
23	0.1376	0.497
24	0.1360	0.0049
25	0.1341	0.0869
26	0.1145	0.0037
27	0.1138	0.0027
28	0.1120	0.4475
29	0.0992	0.004
30	0.0981	0.0001

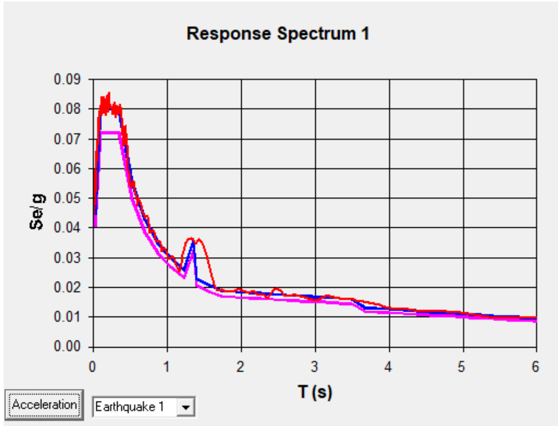


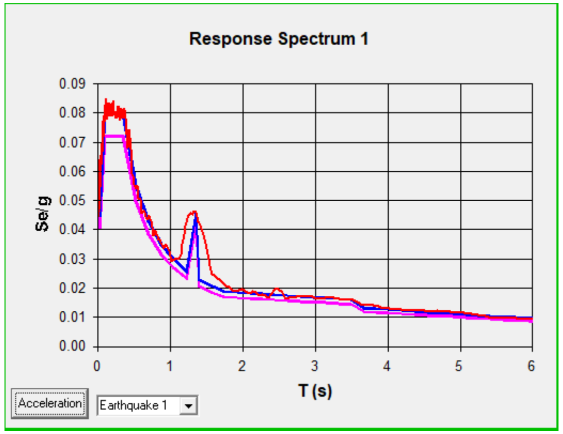
再次增加扰动

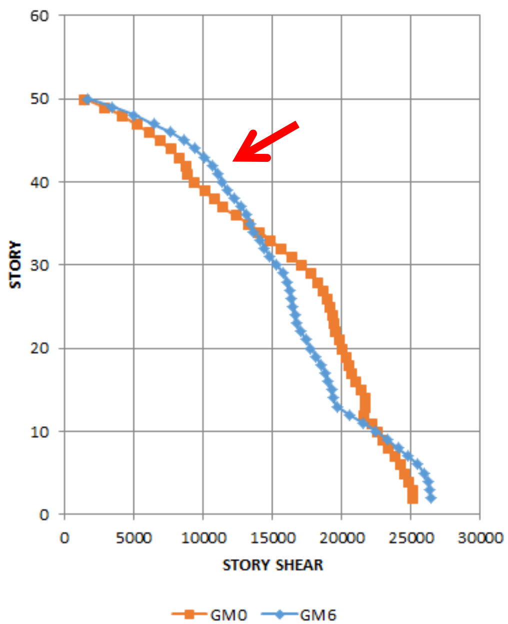


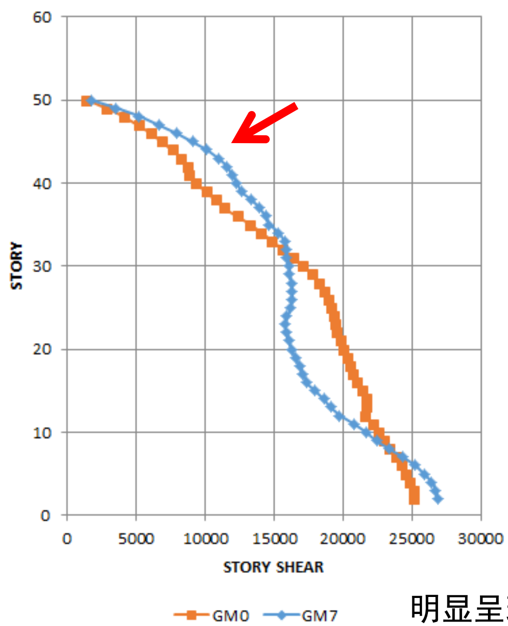


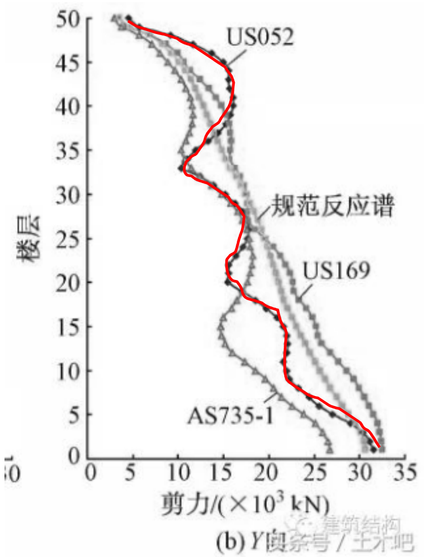



Response Spectrum 1
Se/g
T (s)
Acceleration
Earthquake 1

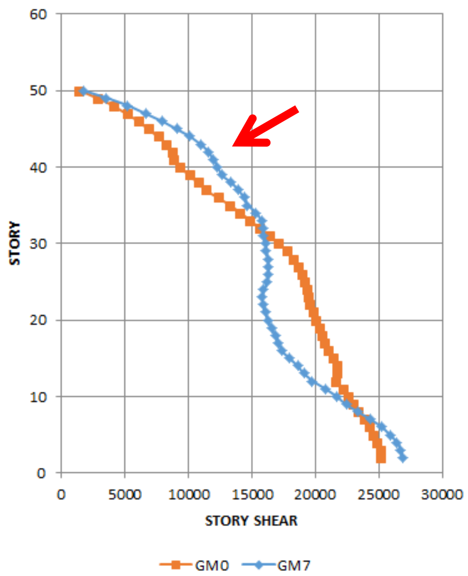

Response Spectrum 1
Se/g
T (s)
Acceleration
Earthquake 1

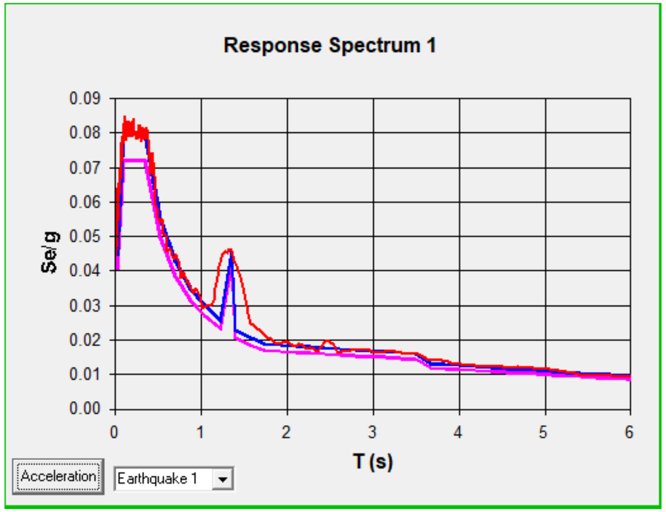

STORY
STORY SHEAR
GM0
GM6


STORY
STORY SHEAR
GM0
GM7


US052
规范反应谱
US169
AS735-1
楼层
剪力/(×10³ kN)
(b) Y向

明显呈现R形突变





目前的结论：

（1）高阶振型并不会影响剪力的分布，特别不会引起R形突变

（2）通过修改反应谱造人工波，证明剪力的R形突变是第二振型与反应谱的形状引起的。

（3）天然波产生的基底剪力不足，经常会第一不够第二来凑，因此产生R形突变

（4）本文只用了一个算例，提供数值如附件所示，大家可以测试与测算

（5）本文基于数值分析得到小结，如果有大神可以采用解析公式法进行证明就更好了

本人才疏学浅，以上只是学习小结，以供参考，如有不对，请指正。