Support System of the SSRF Storage Ring

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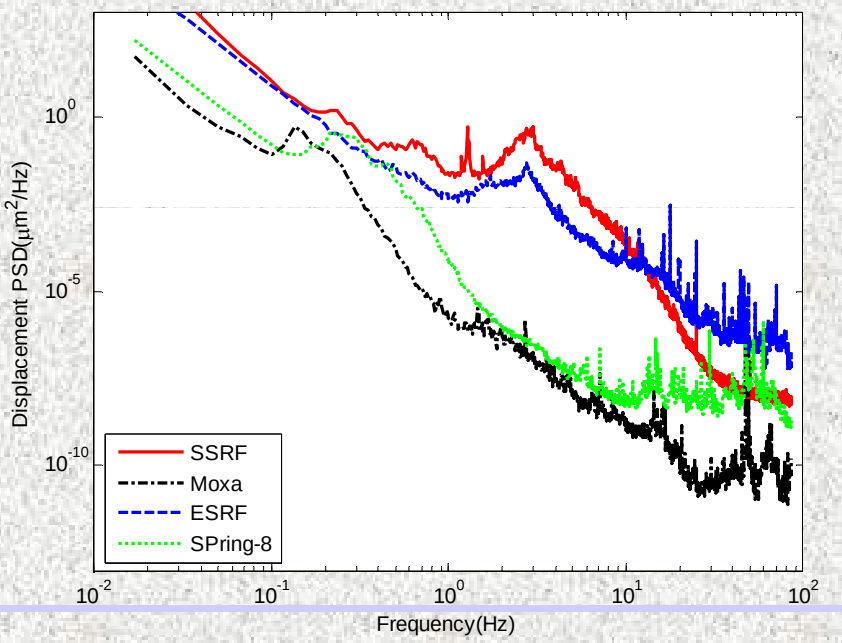
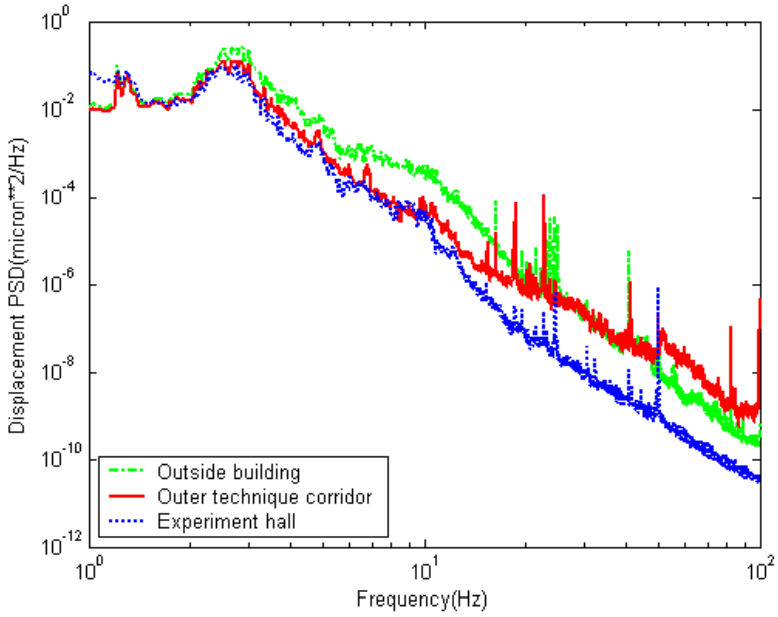
Ground Vibration in SSRF

- Ground vibration is the most determinative effect in SSRF !
- Minimize noise sources.
- Optimize the support system

- Slab vibration:
  Vertical rms value
  ~ 0.15μm (quiet time)
  ~ 0.25μm (noisy time)



PSD in site



PSD on slab

Main Requirements for the Support System

❑ Performance

- ➢ First eigenfrequency = > 30Hz
- ➢ The frequency response function value at the first eigenfrequency < =10

❑ Alignment

	Between girder	Inside girder
H	0.15mm	0.08mm
V	0.15mm	0.08mm
L	0.5mm	
R	0.2mrad	

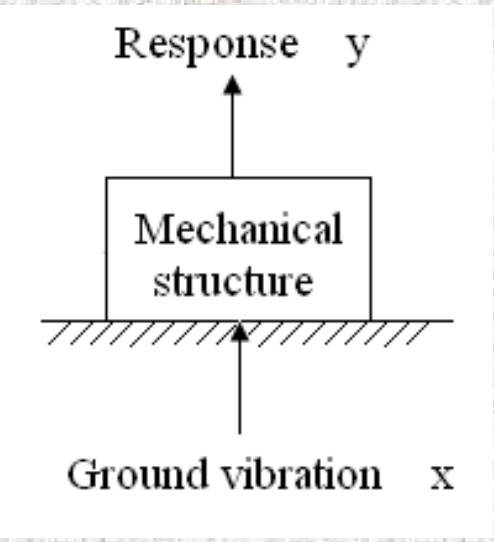
Basic theory (A)

$$x_{rms} = \sqrt{\int_{f_i}^{f_j} S_x(f)df} \qquad y_{rms} = \sqrt{\int_{f_i}^{f_j} S_y(f)df}$$

$$T = \sqrt{\frac{1+\frac{1}{Q^2}(\frac{f}{f1})^2}{[1-(\frac{f}{f1})^2]^2+\frac{1}{Q^2}(\frac{f}{f1})^2}}$$

$$S_x(f) = 10^c / f^4 \qquad S_y(f) = T(f)^2 S_x(f)$$

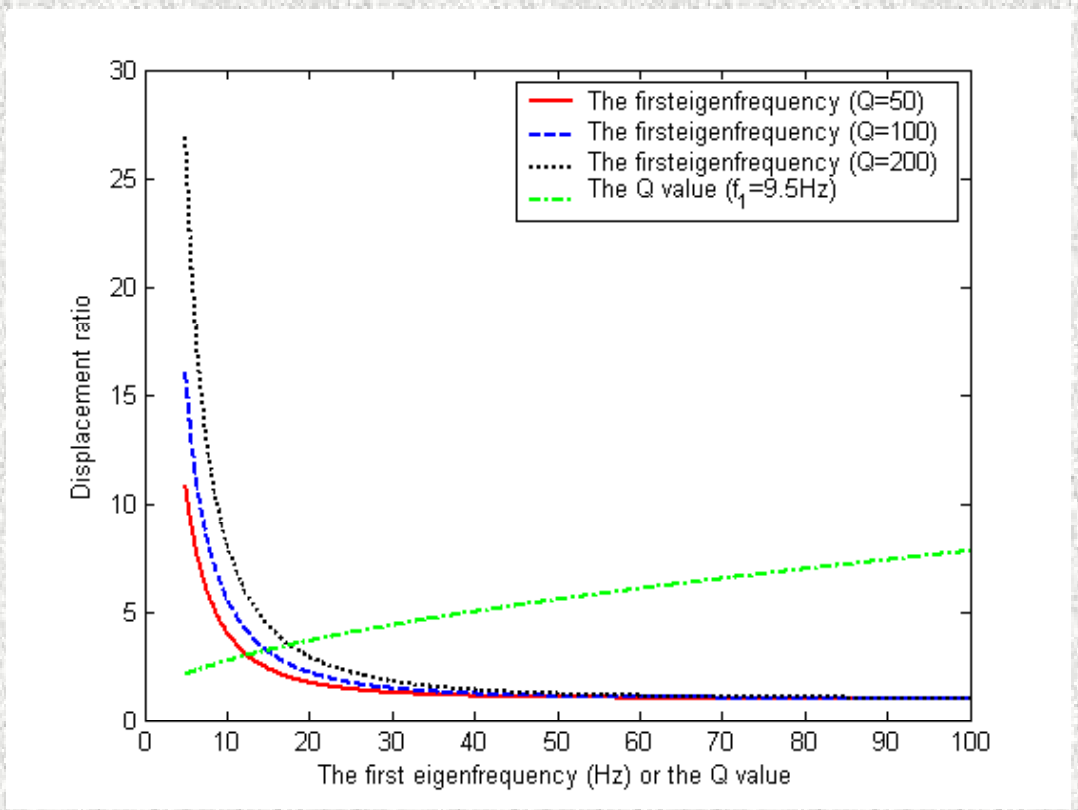
$$r = \frac{y_{rms}}{x_{rms}} = \frac{\sqrt{3*\int_{f_i}^{f_j} \frac{1+\frac{1}{Q^2}(\frac{f}{f1})^2}{[1-(\frac{f}{f1})^2]^2+\frac{1}{Q^2}(\frac{f}{f1})^2} * f^{-4} df}}{\sqrt{f_i^{-3} - f_j^{-3}}}$$

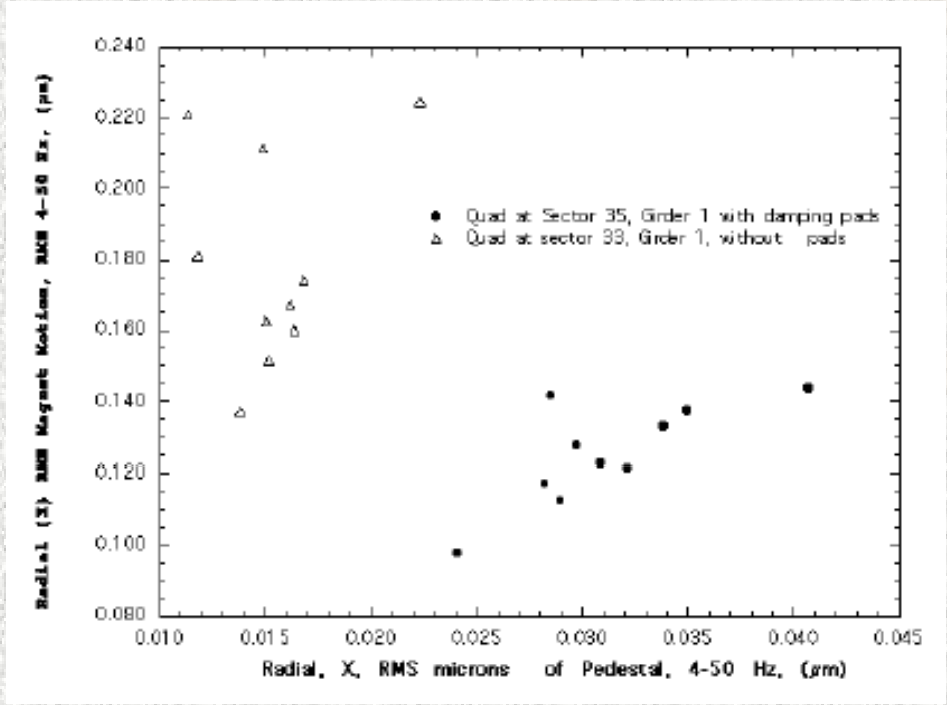


S: Displacement power spectral density, [f_i f_j]: frequency interval,

f: frequency, T: transmissibility, f_1: the first eigenfrequency

Basic theory (B)





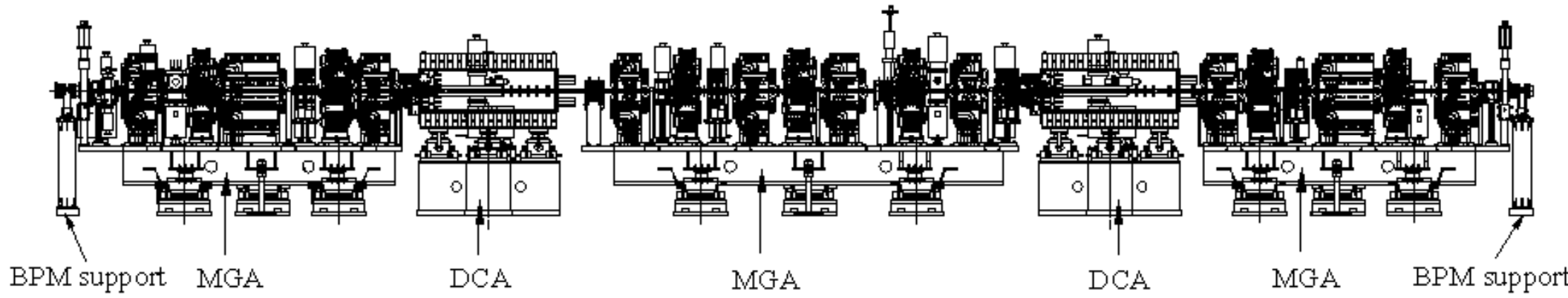
- D. Mangra, S. Sharma, Passive vibration damping of the APS machine components, Review of scientific instruments, 67 (9), 1996.

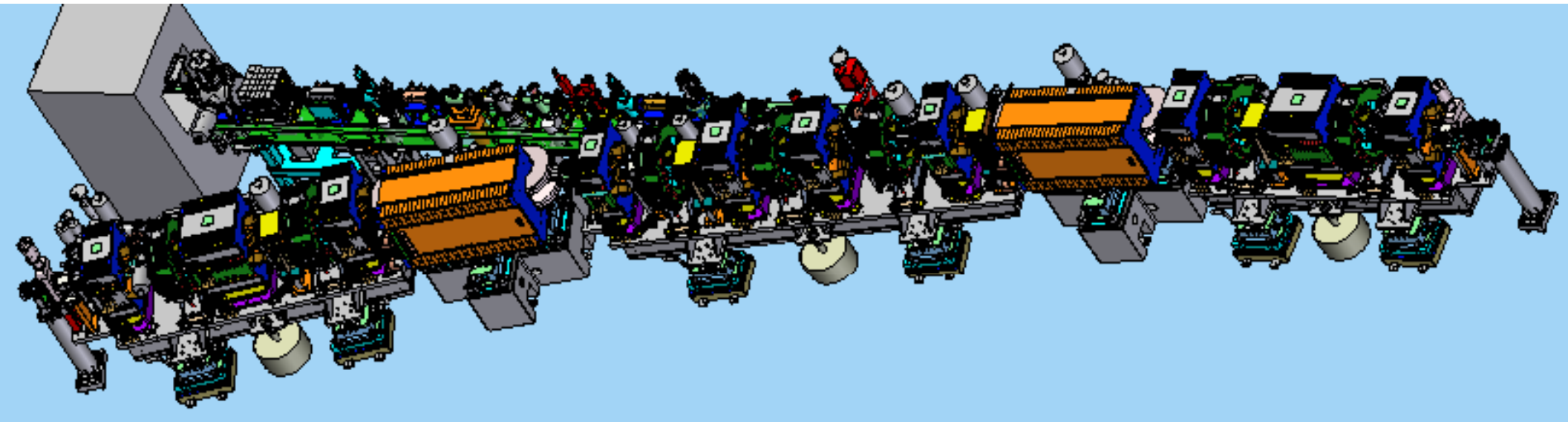
1. For given constant frequency interval [f_i, f_j], both increasing the first eigenfrequency f_1 and decreasing the Q value can drop the displacement ratio r; moreover, the former method seems more effective, especially when the mechanical structure's frequency lower than 20 Hz.

2. It is unnecessary to improve excessively the value of f_1,Because we can see that when Q=50, it makes no obvious effect to increase further f_1 when it has reached at about 30 Hz. When Q=100, the critical frequency is about 35 Hz, and when Q= 200,it is about 45 Hz.

SSRF Storage Ring Mechanical System

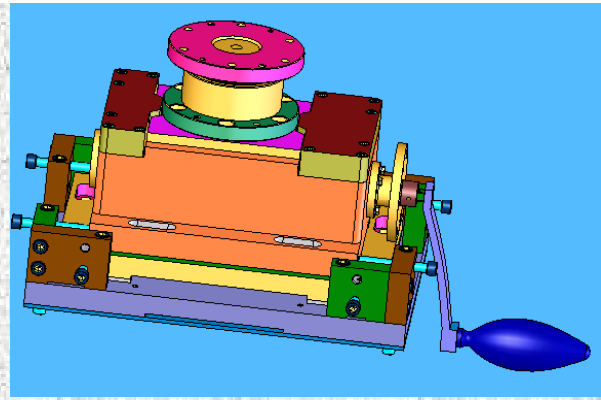
- 19 magnets per cell
- 3 girders and 2 pedestals per

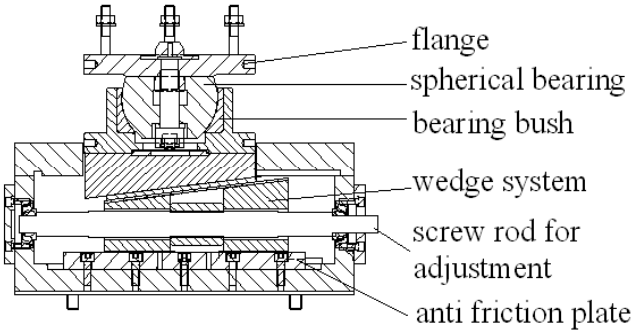


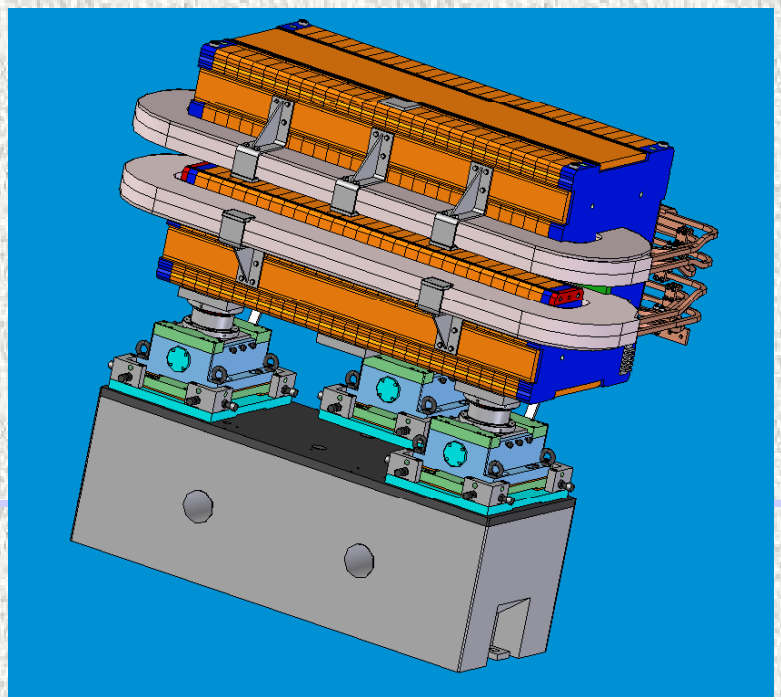


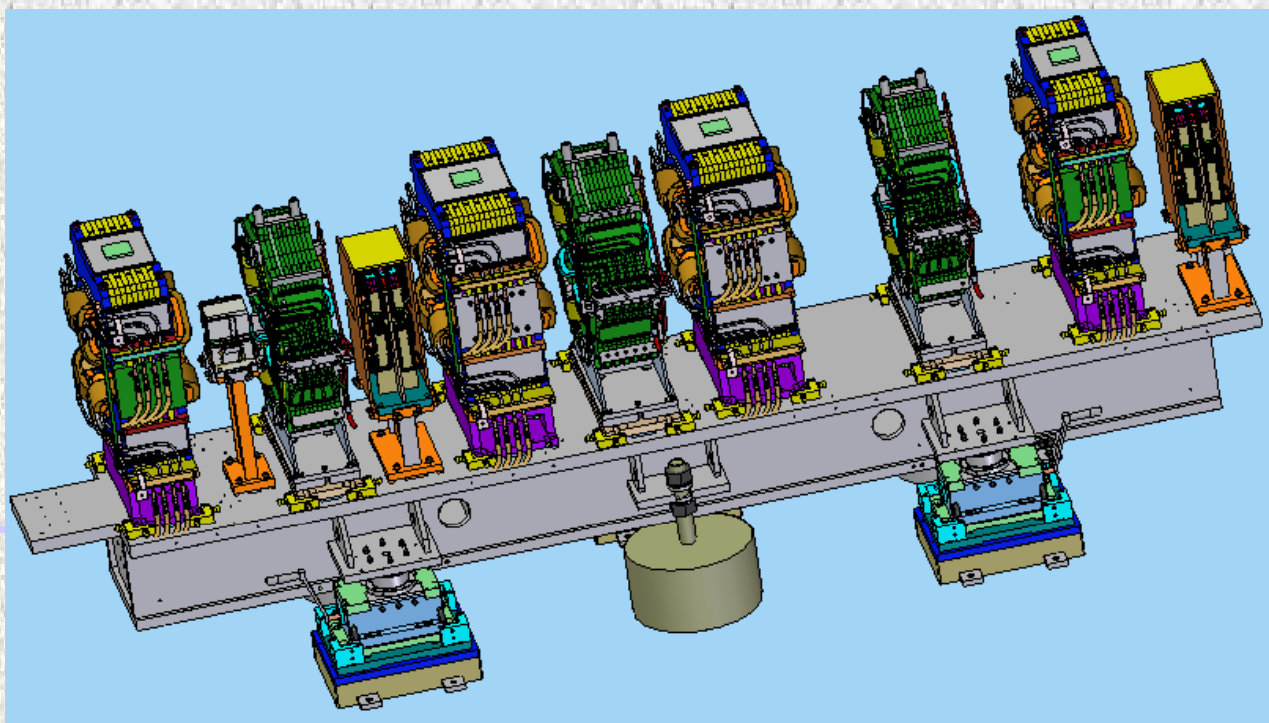
Girder Magnet Assembly

- Three point support for girder and dipole.
- The pedestals are fixed on ground by anchor bolts and filled with unshrinking concrete between them.
- Three Assistant supports are fixed on ground and reinforced with concrete.
- Wedge structure and ball bearing are used to adjust the hight.







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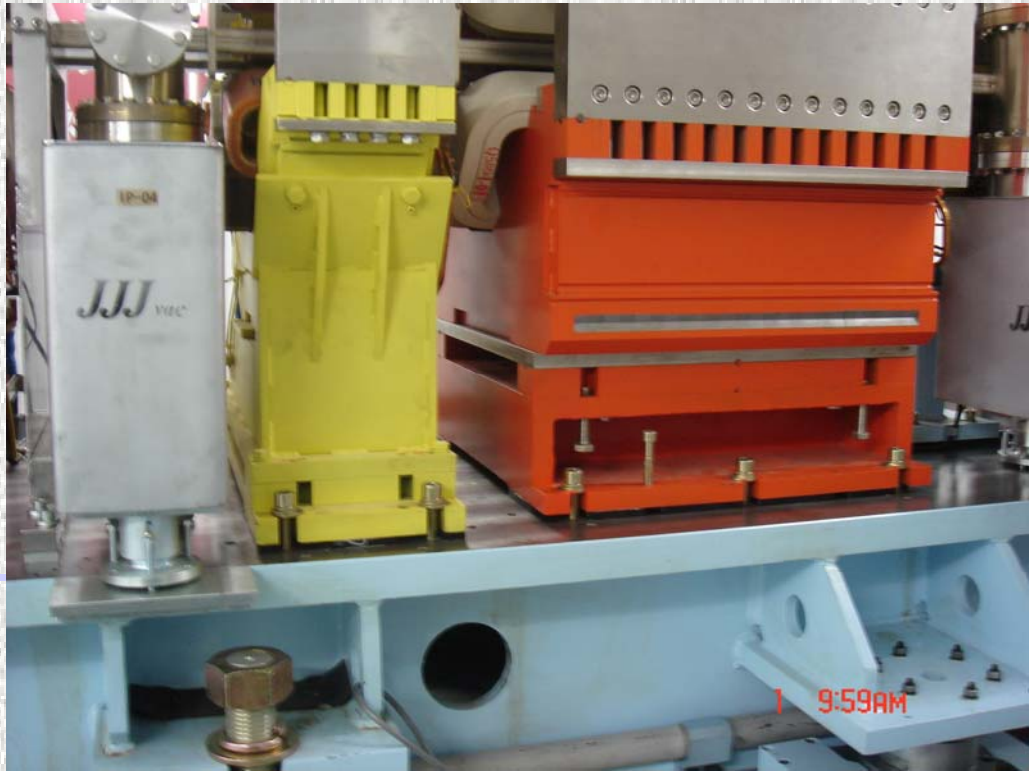
1 9:52AM


1 10:04AM


JJJ
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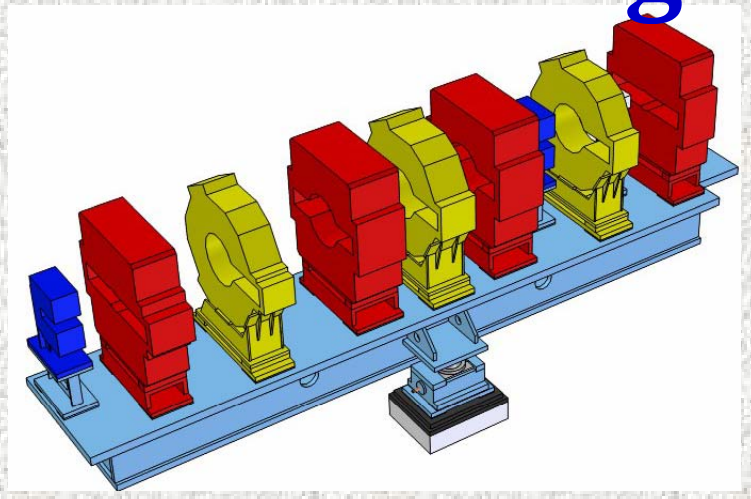
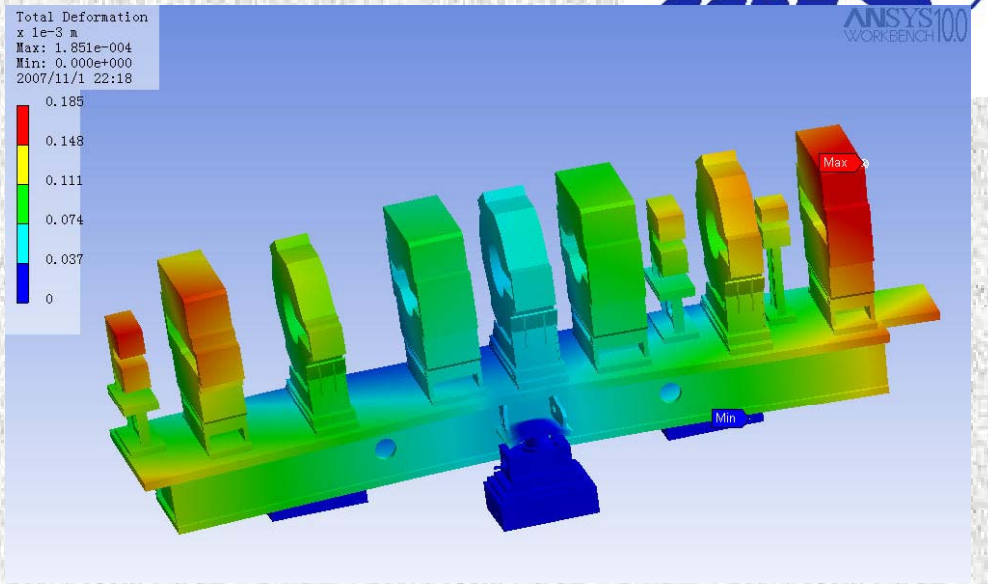
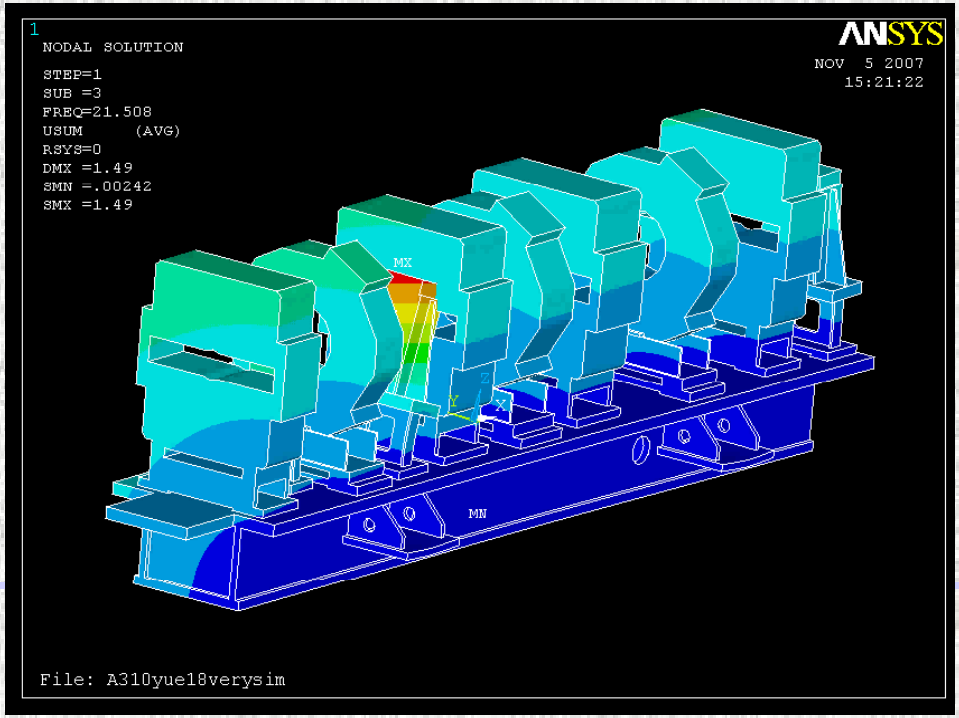
Design Simulation



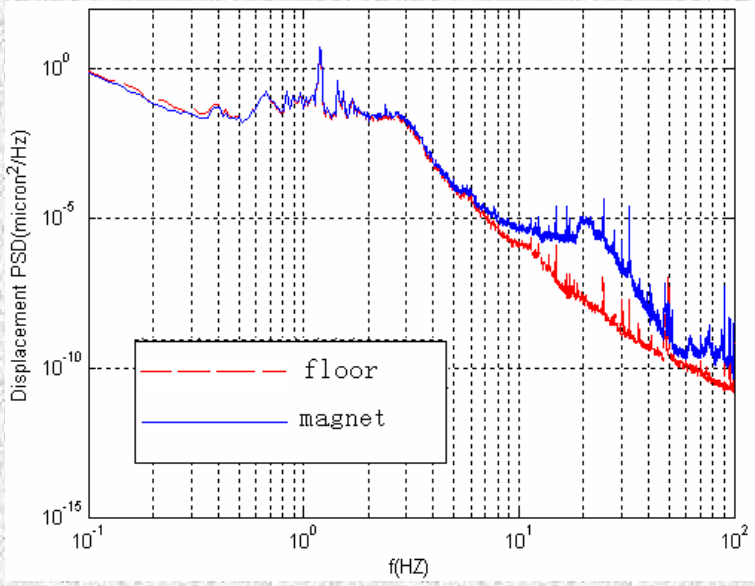


Mode	Frequency	Mode Shape
1	21.9 Hz	Girder translation
2	23.57 Hz	Girder roll
3	34.4Hz	Girder roll
4	40.43Hz	Girder translation
5	47.2Hz	SM yaw
6	47.86Hz	
7	52.24Hz	
8	58.74Hz	
9	59.79Hz	QM yaw
10	69.09Hz	SM yaw

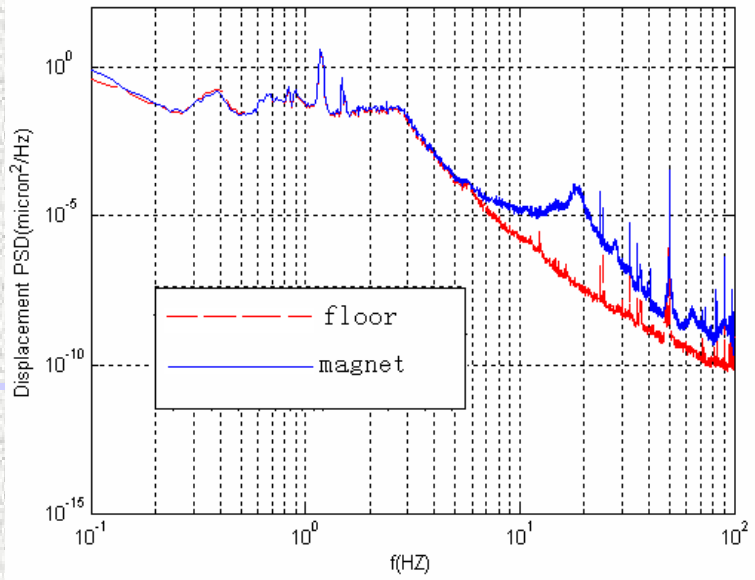


Prototype Test

Four-point support (H)



Three-point support (H)



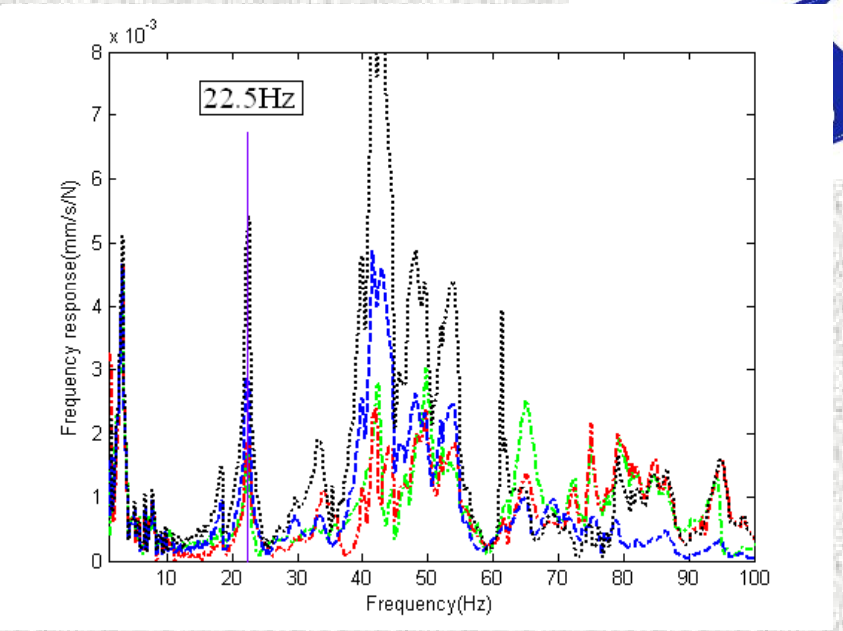
- To confirm the simulation results.
- To compare and decide the support structure for GMA.

		Floor	Quadrupole magnet	Ratio
Three-point support	Lateral	0.01411	0.01828	1.30
	vertical	0.02738	0.03267	1.19
Four-point support	Lateral	0.01845	0.02273	1.23
	vertical	0.03081	0.03464	1.12
Bad four-point support	Lateral	0.02885	0.06532	2.26
	vertical	0.03201	0.04508	1.41
Five-point support	Lateral	0.02681	0.03195	1.19
	vertical	0.02828	0.03058	1.08

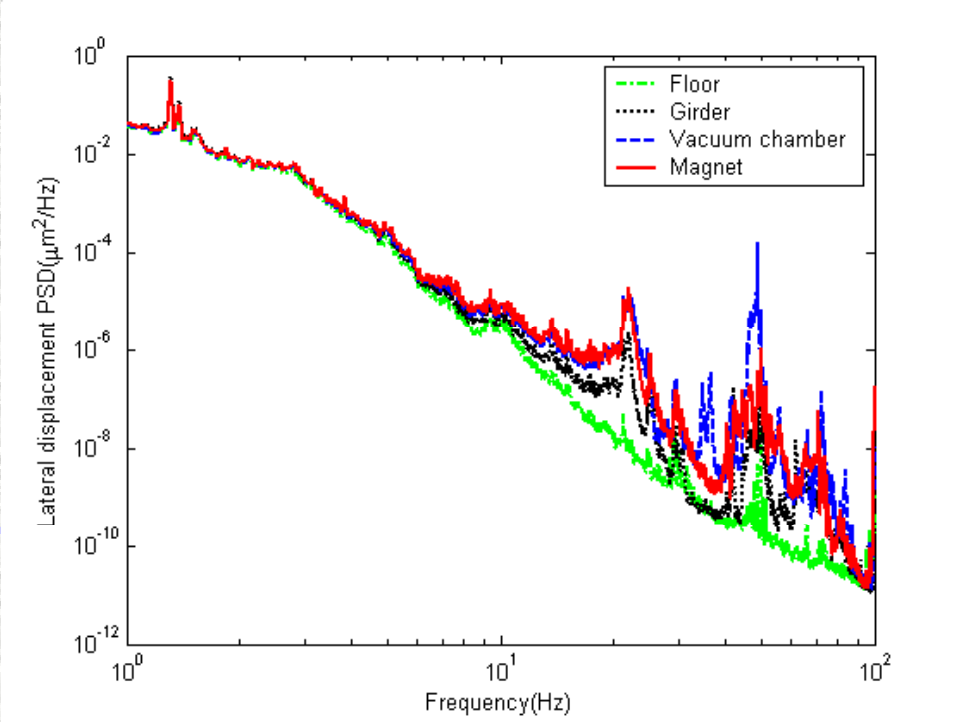
Test for Machine

- The first eigenfrequency
  21.9Hz (H)
  22.5Hz (V)
- Response of quadrupole to floor vibration in first eigenfrequency

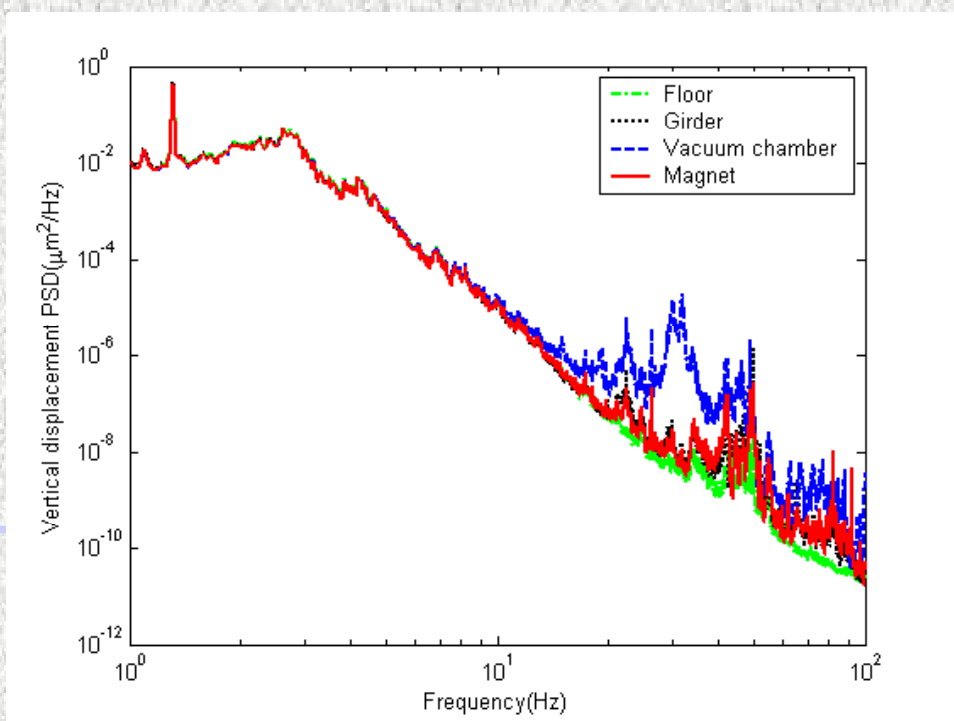
  34.8 (H); 1.6 (V)
- The first eigenfrequency can be improved to 27.7Hz with assistant support.



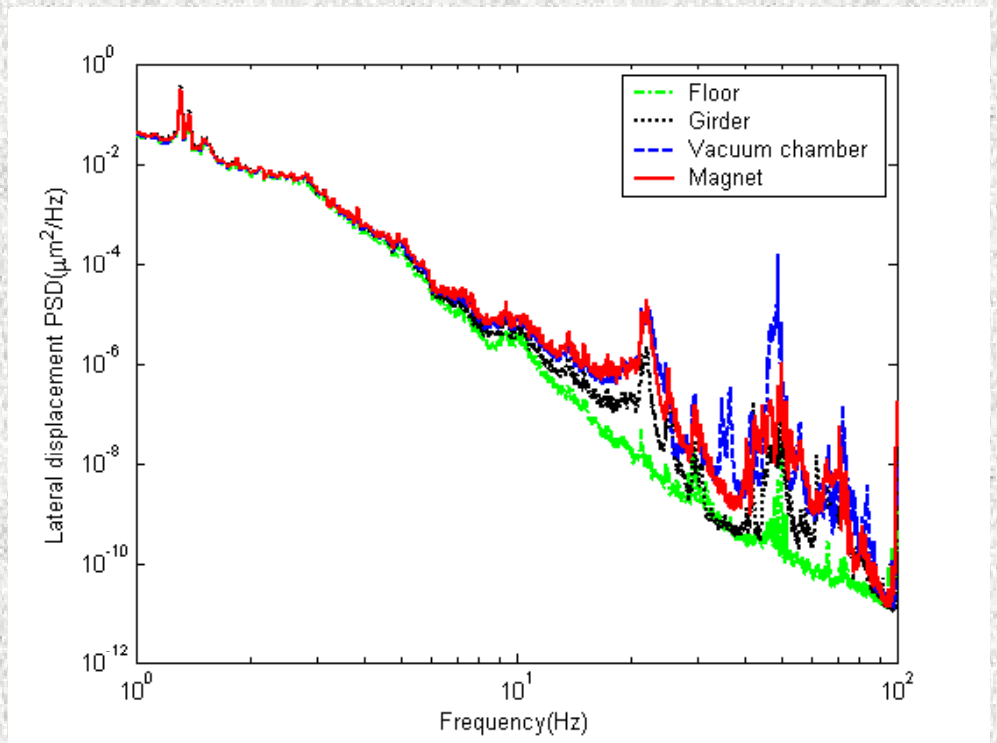
PSD in lateral direction

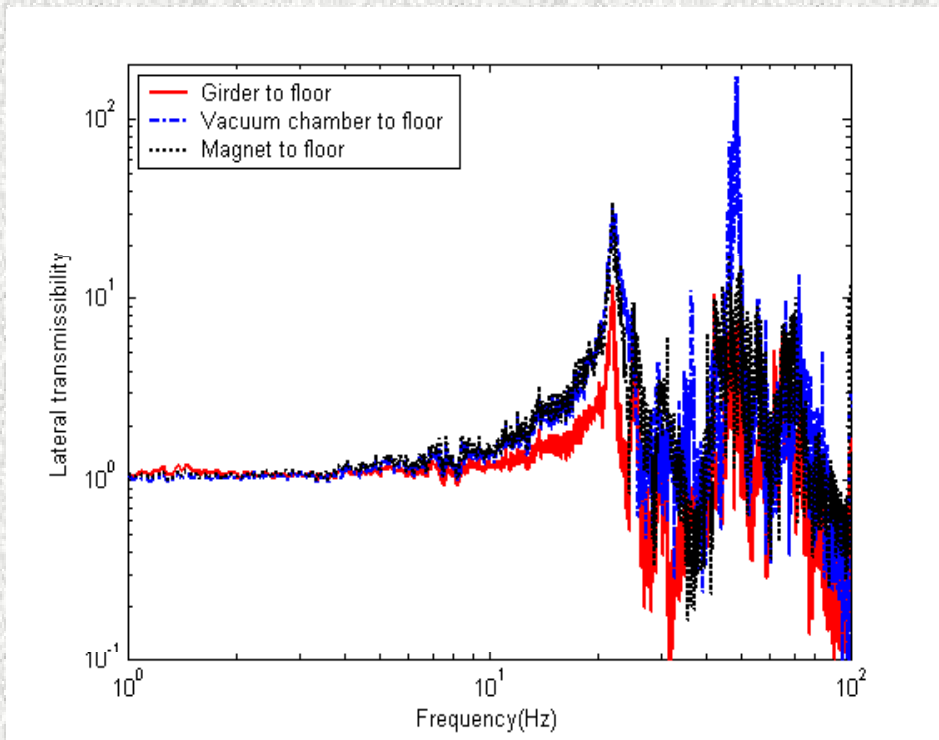


PSD in vertical direction

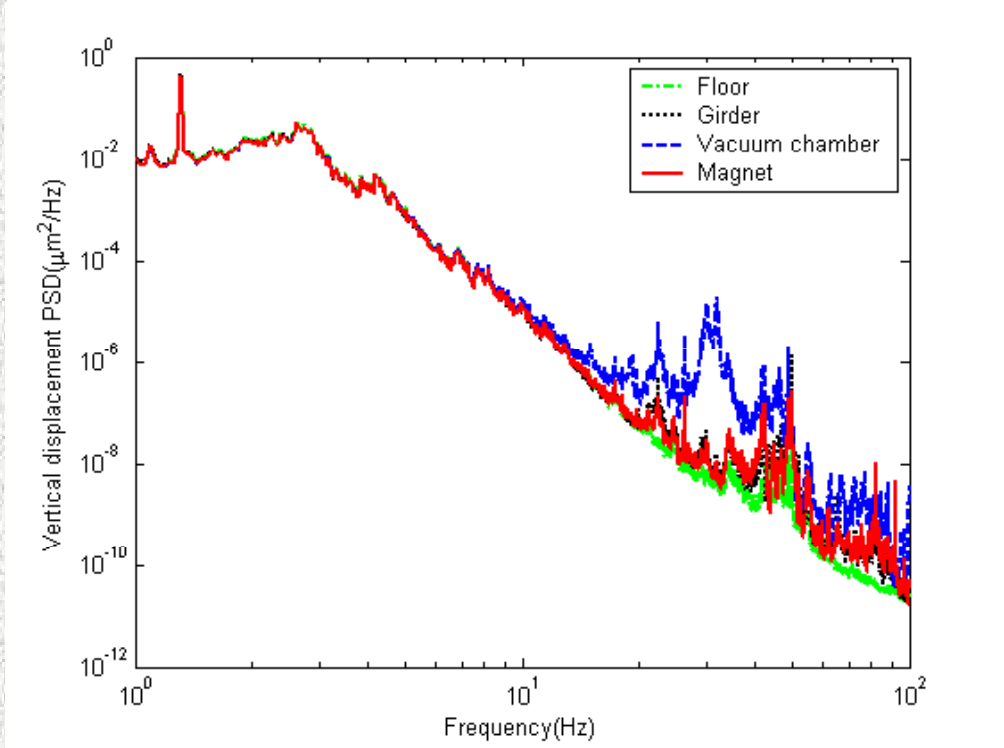


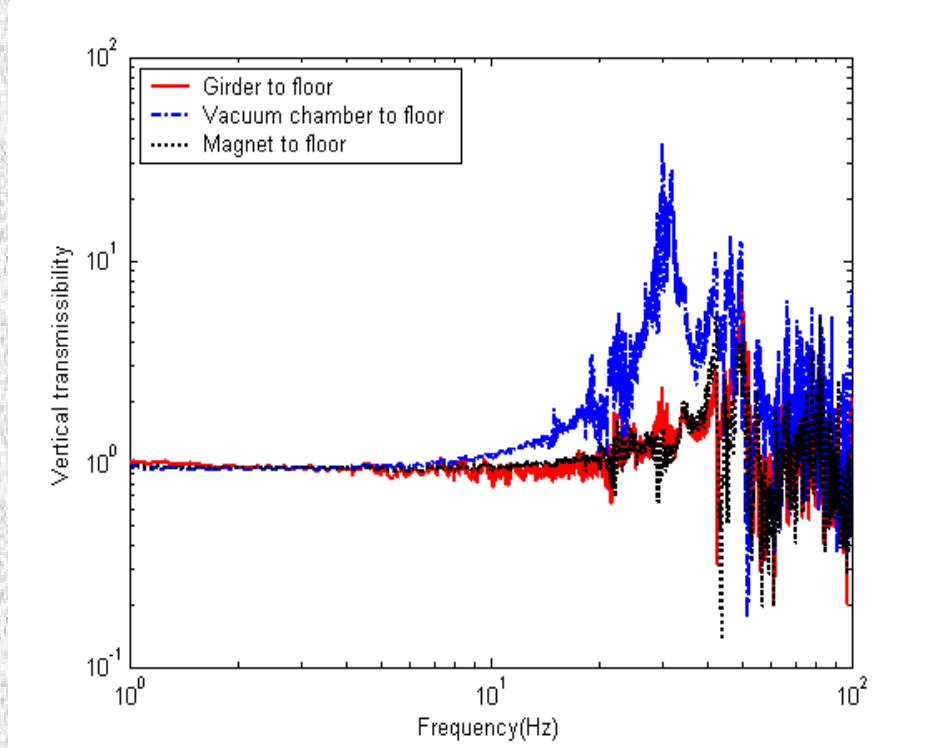
Lateral spectra





Vertical spectra

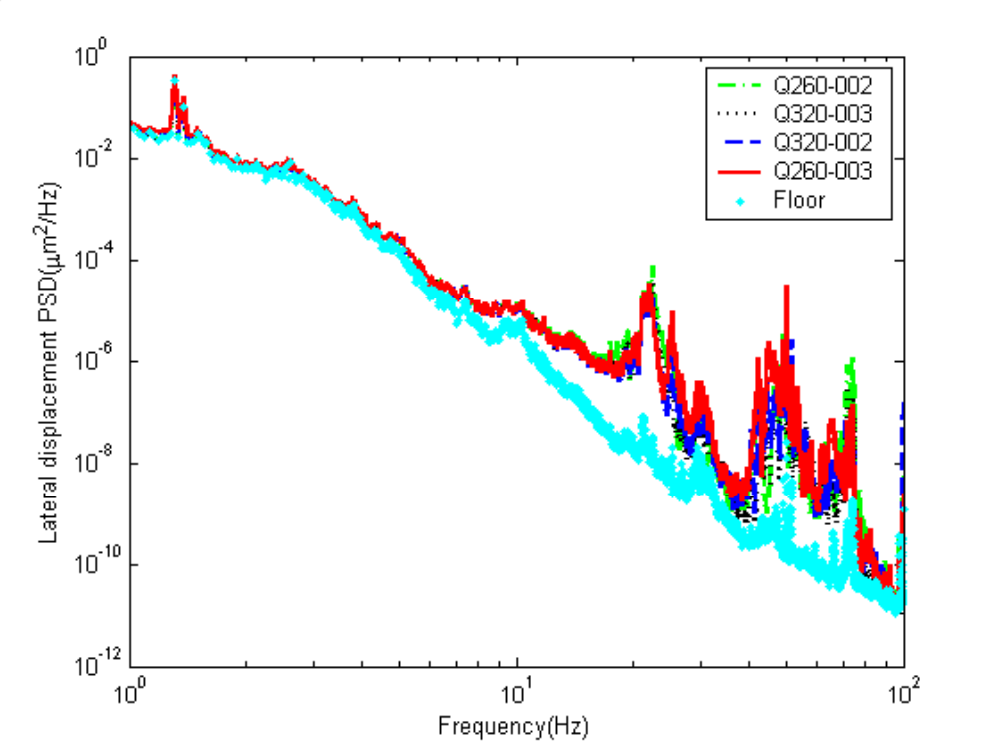


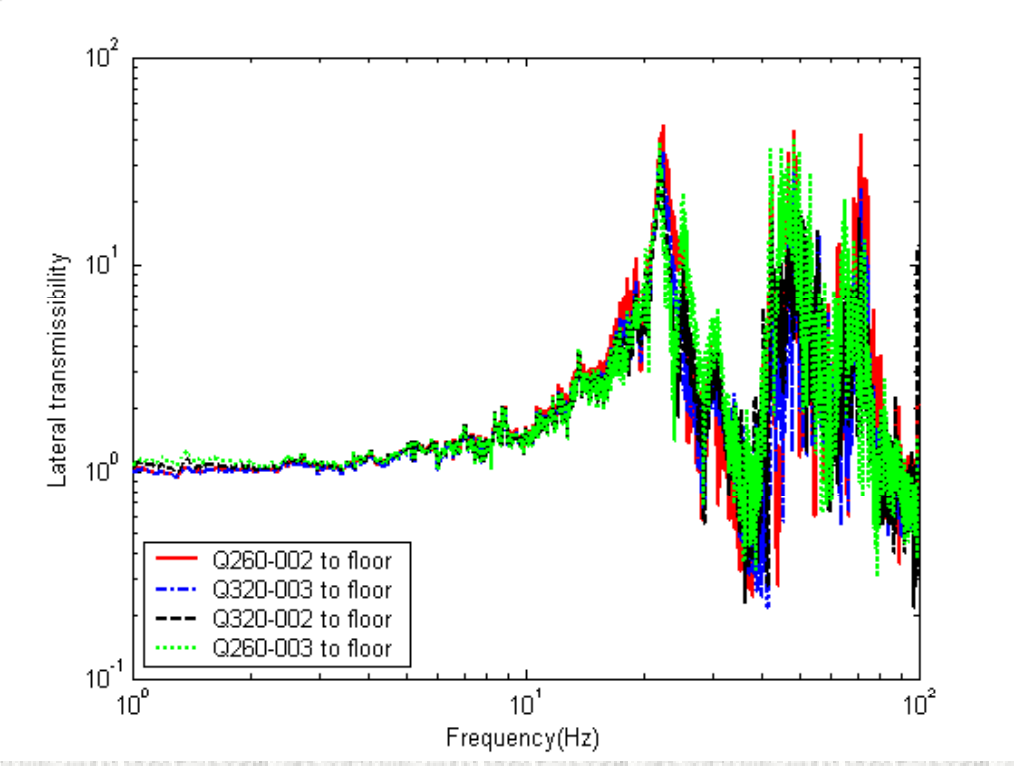


Measurement Results

		Lateral				Vertical			
		Daytime		Night		Daytime		Night	
Frequency range (Hz)		2-50	4-50	2-50	4-50	2-50	4-50	2-50	4-50
Floor	Displacement	81.1	19.5	49.5	11.9	18.8	52.5	79.5	14.9
Girder	Displacement	88.1	22.1	54.8	13.5	18.9	52.6	80.4	15.0
	Ratio	1.09	1.13	1.11	1.13	1.00	1.00	1.01	1.02
	Q value	11.9		10.3		1.8		1.1	
Vacuum	Displacement	87.6	24.6	53.1	14.6	19.0	54.1	80.5	15.5
chamber	Ratio	1.08	1.26	1.07	1.23	1.00	1.03	1.01	1.04
	Q value	35.3		25.3		5.7		5.8	
Magnet	Displacement	89.8	25.2	55.2	14.9	19.9	55.2	84.4	15.7
	Ratio	1.11	1.29	1.12	1.25	1.06	1.05	1.06	1.05
	Q value	34.8		28.2		1.6		1.1	
Measurement time									
(Mar. 6th, 2007)		Daytime: 15:41:11 - 16:01:11				Night: 22:01:12 - 22:21:12			

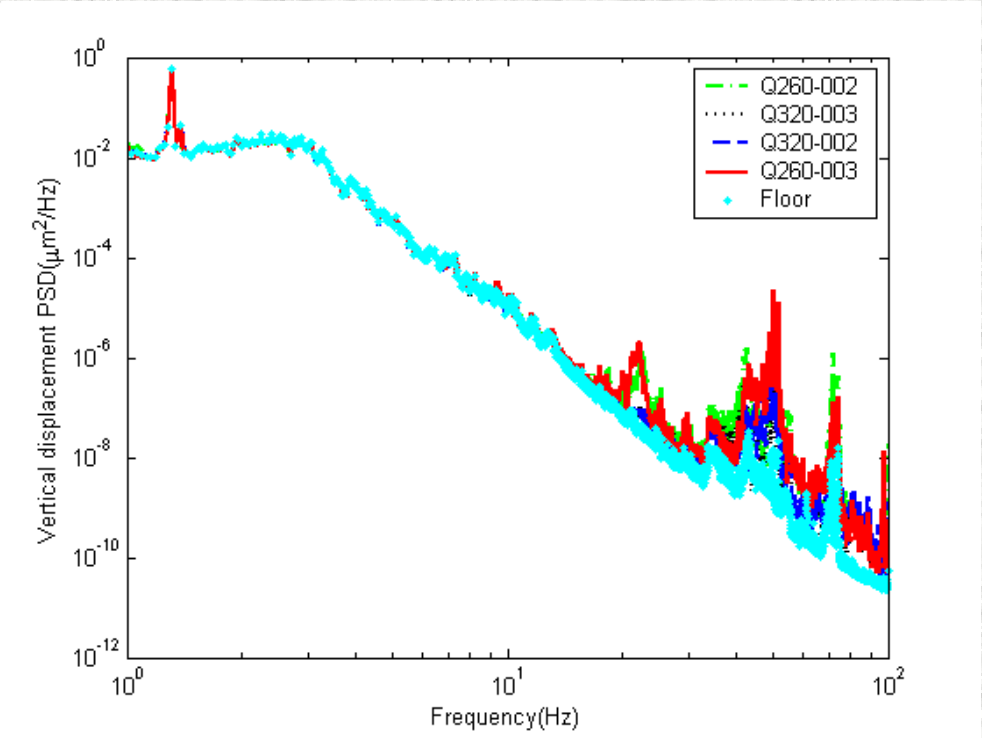
Lateral spectra for each magnet

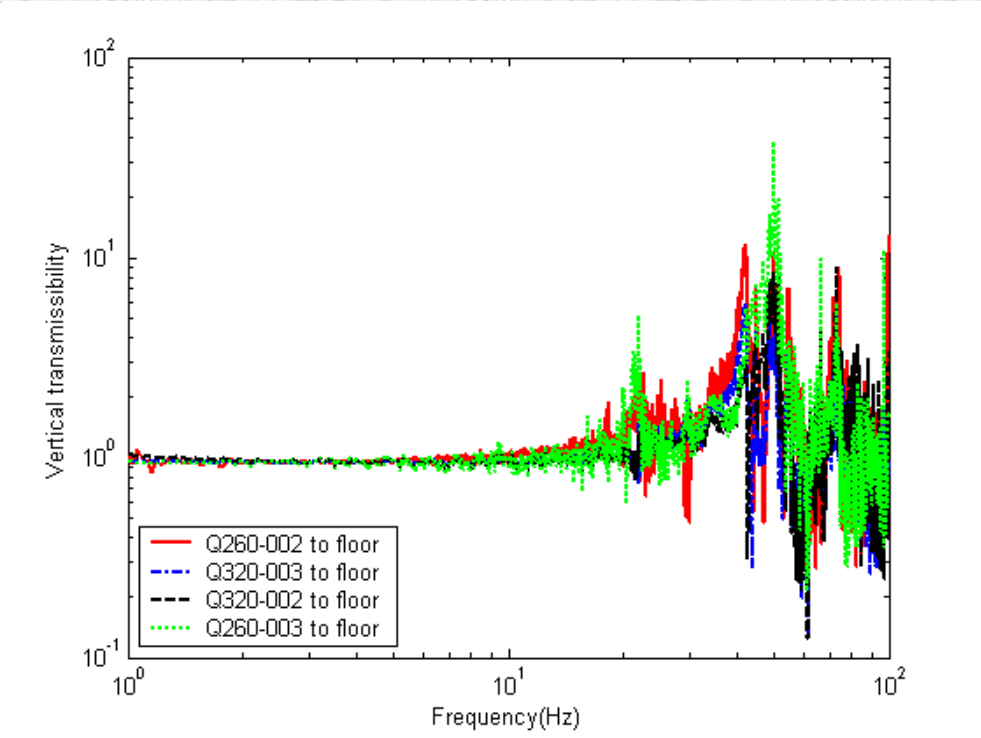




The lateral first eigenfrequency : 21.9 Hz

Vertical spectra for each magnet



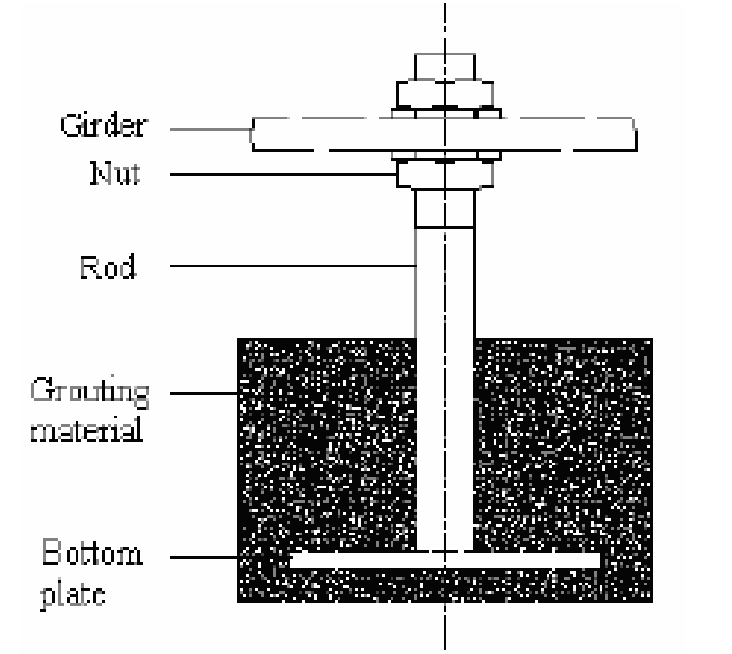


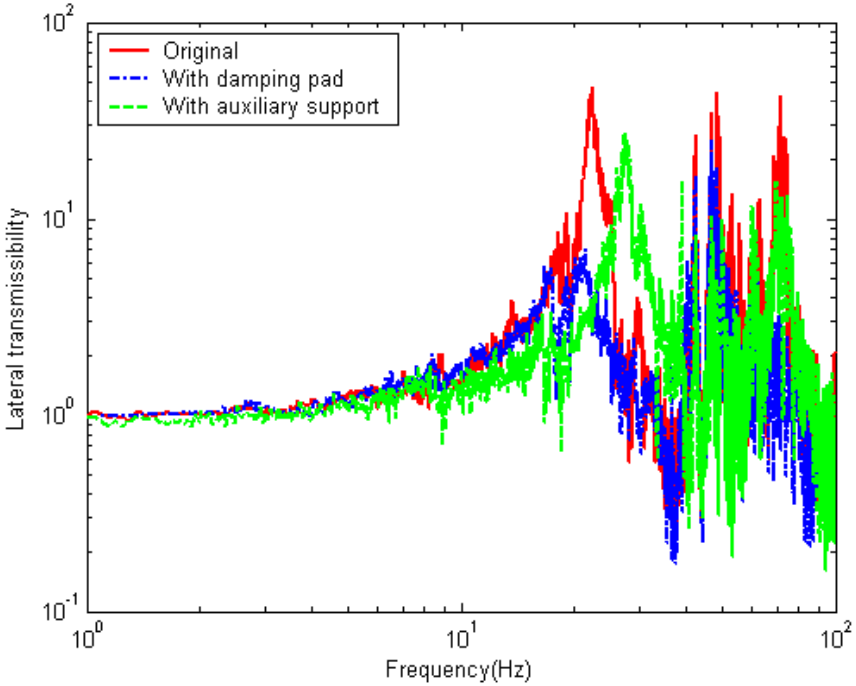
The vertical first eigenfrequency : 22.5 Hz

Measurement results

		Lateral			Vertical	
Frequency range (Hz)		2-50	4-50	6.5-100	2-50	4-50
Floor	Displacement	81.4	18.8	5.3	163.1	39.0
Q260-002	Displacement	88.5	25.1	11.6	173.0	41.1
	Ratio	1.09	1.34	2.19	1.06	1.05
Q320-003	Displacement	87.6	24.2	10.3	163.5	39.7
	Ratio	1.08	1.29	1.94	1.00	1.02
Q320-002	Displacement	91.1	24.7	10.1	165.2	39.2
	Ratio	1.12	1.31	1.91	1.01	1.01
Q260-003	Displacement	93.5	25.1	10.8	164.2	40.0
	Ratio	1.15	1.34	2.04	1.01	1.03
Measurement time		14:57:45 - 15:17:45, Mar. 6th, 2007				

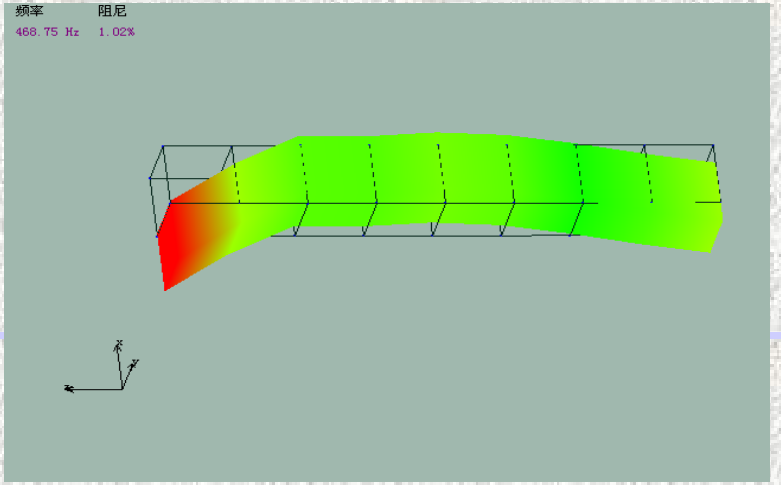
Improve the mechanical stability





	Ground	Magnet	Ratio
Original	18.8	25.1	1.34
With damping pad	26.9	35.1	1.30
With auxiliary support	17.0	21.1	1.24

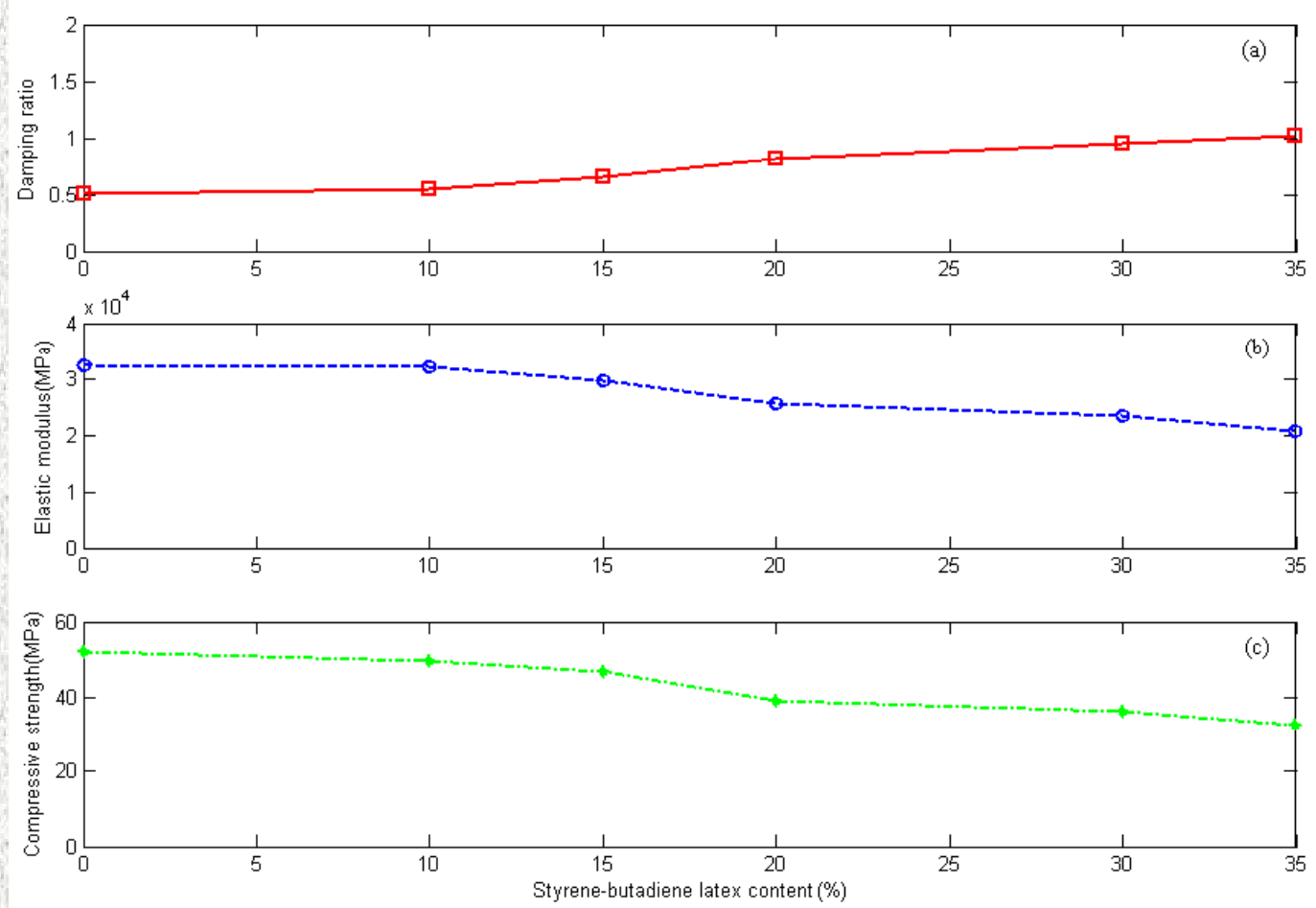
Polymer Modification Concrete (PMC)



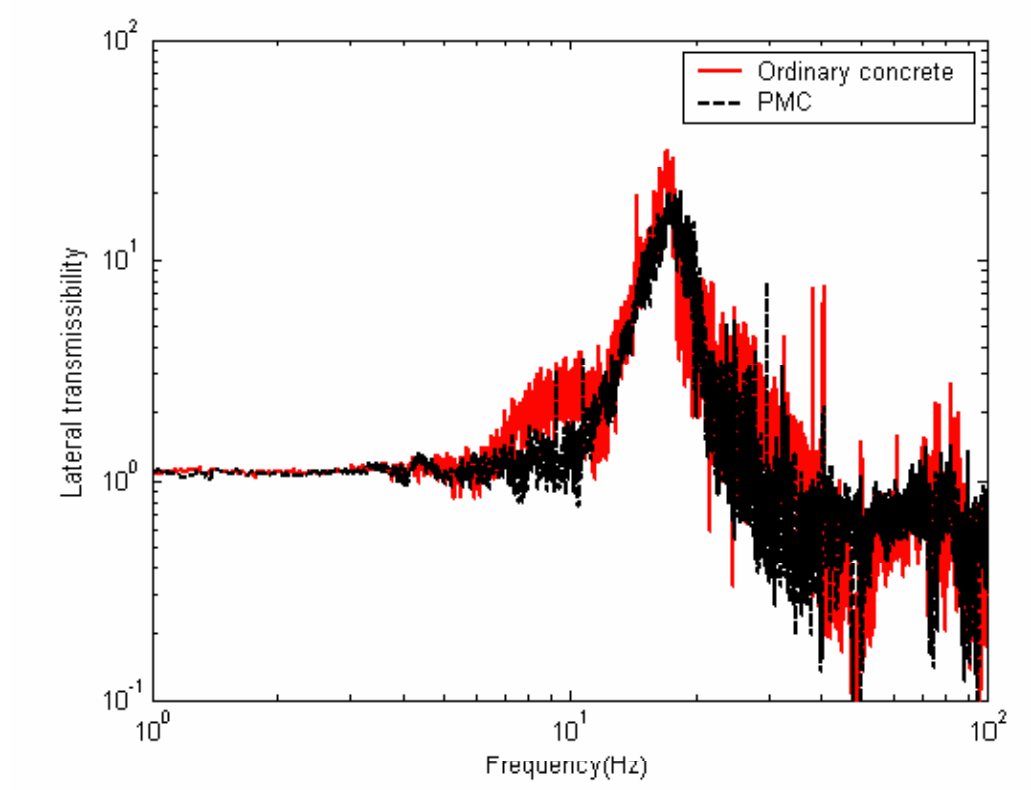
Characteristic of the PMC

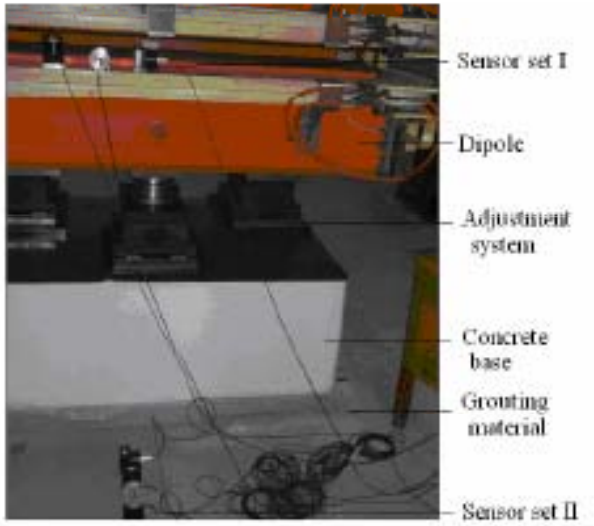
Properties of styrene-butadiene latex

Content	Value
Solid content (%)	50-52%
PH	7.8-10
Viscosity (mPa·s)	35-150
Surface tension coefficient (mN/m)	31-35



Measurement for PMC concrete

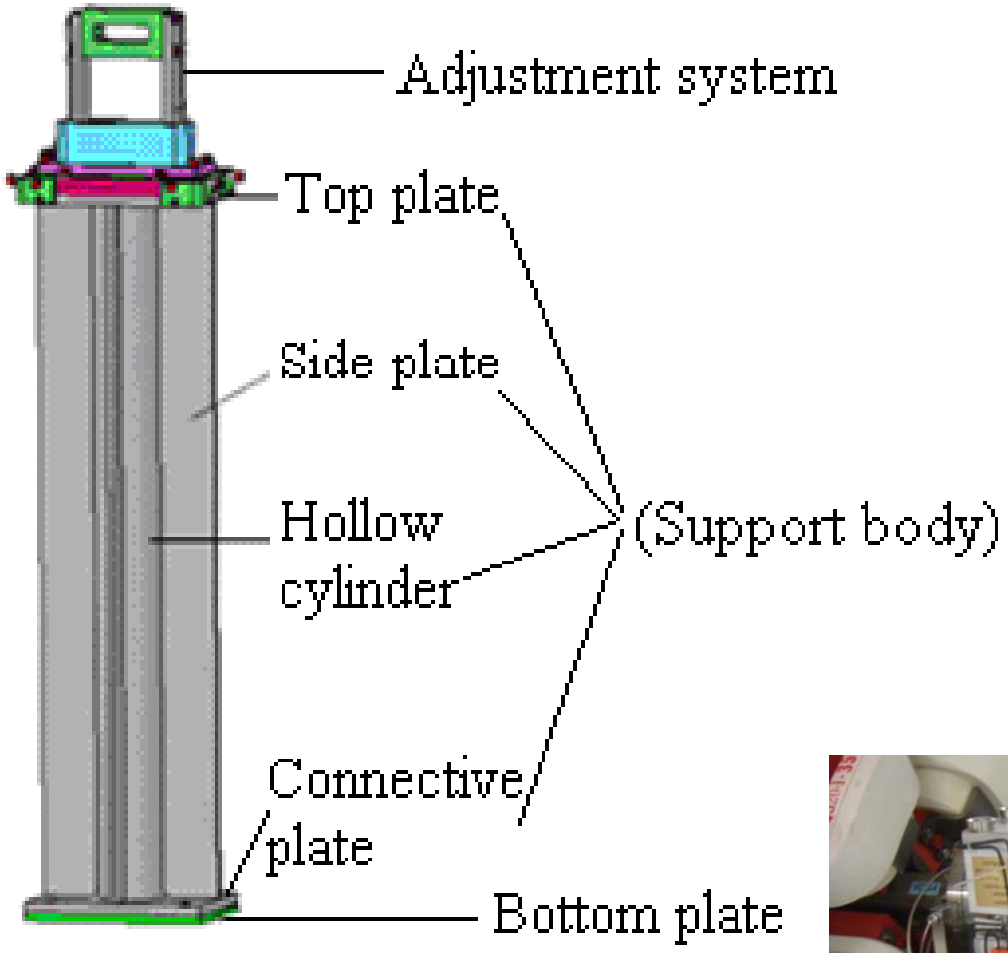


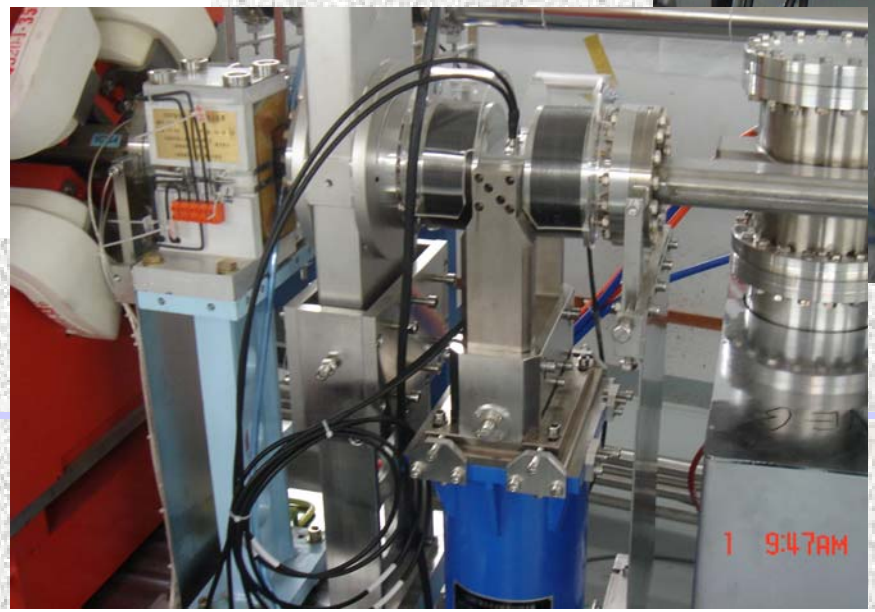


Location	Ground	Magnet	Ratio
Ordinary concrete	20.8	31.4	1.51
PMC	26.8	33.8	1.26

For DCA

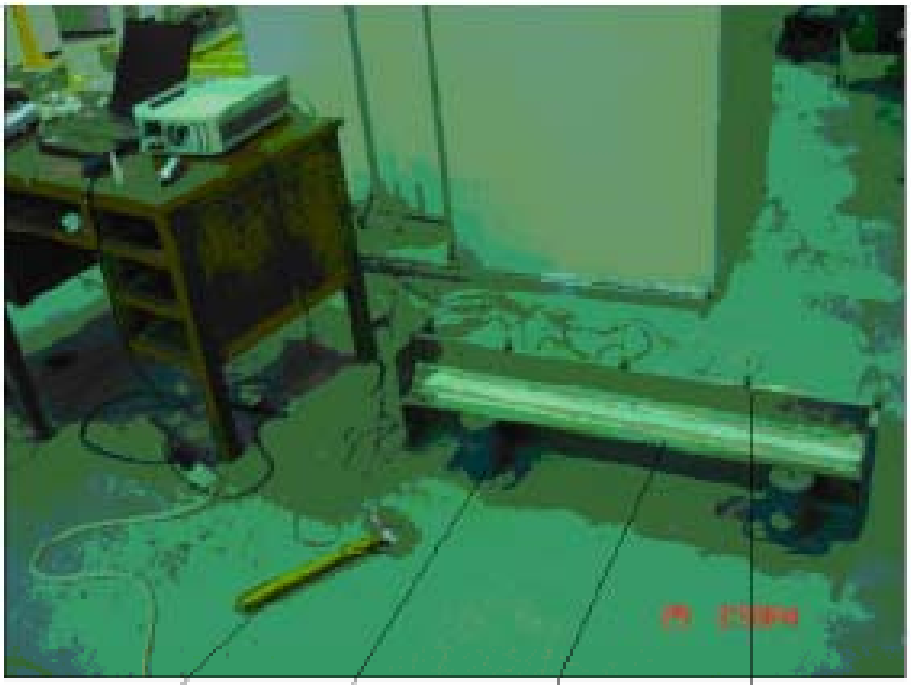
High precision BPM support

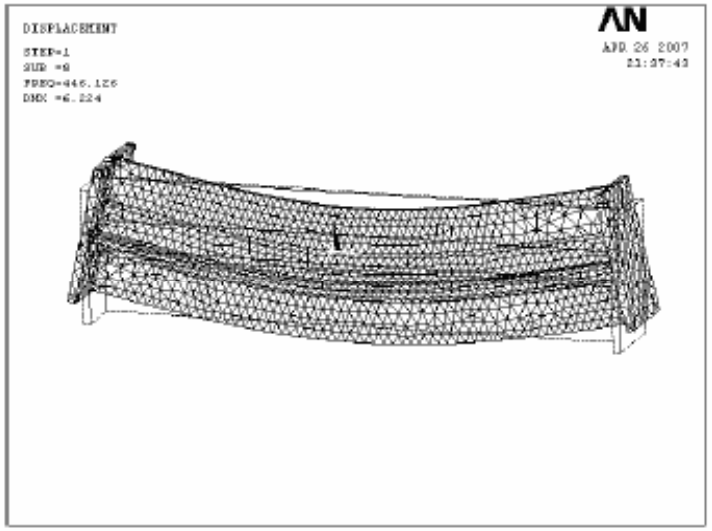


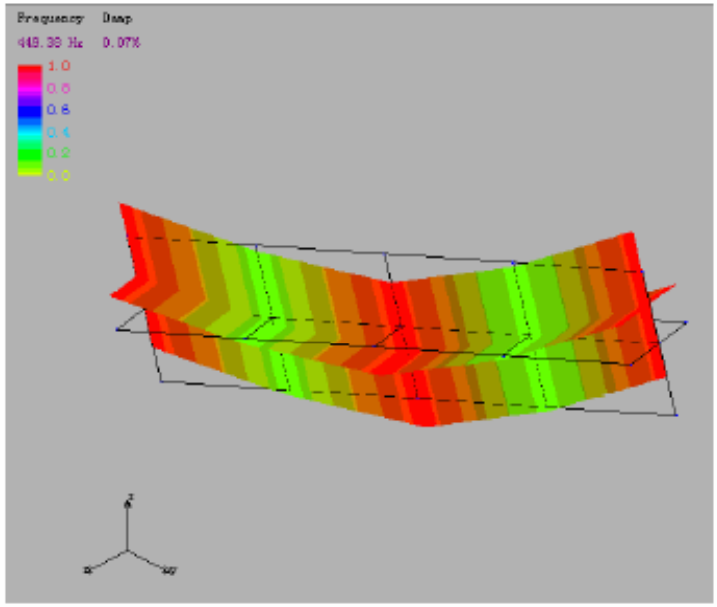


- **Supported on ground with Invar cylinder**
- **Mechanical isolated to chamber by bellows**

Measurement on BPM support body

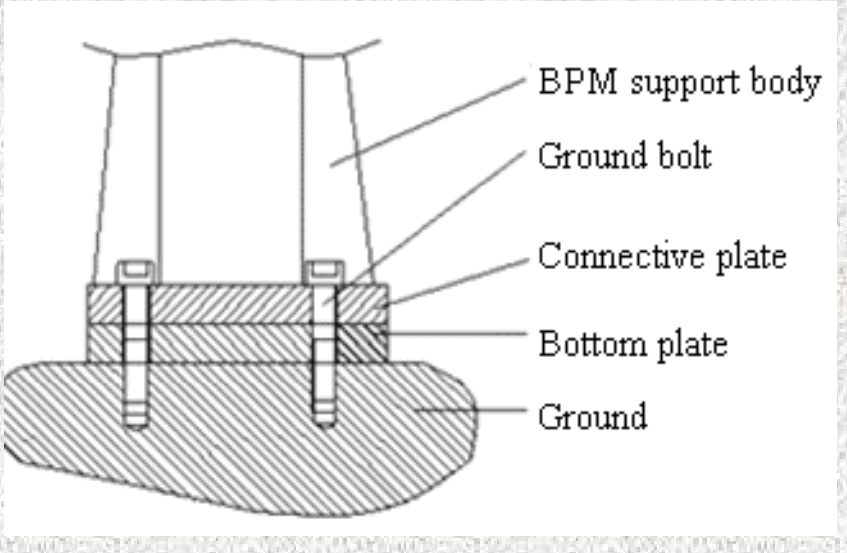


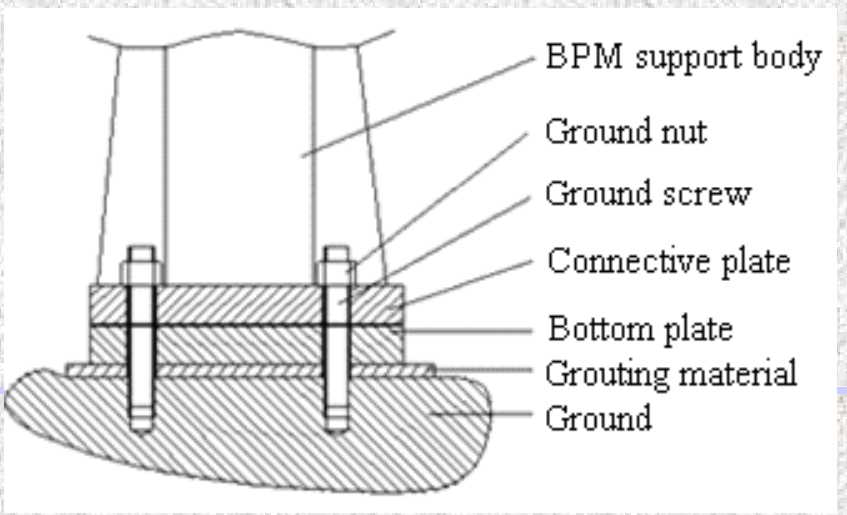


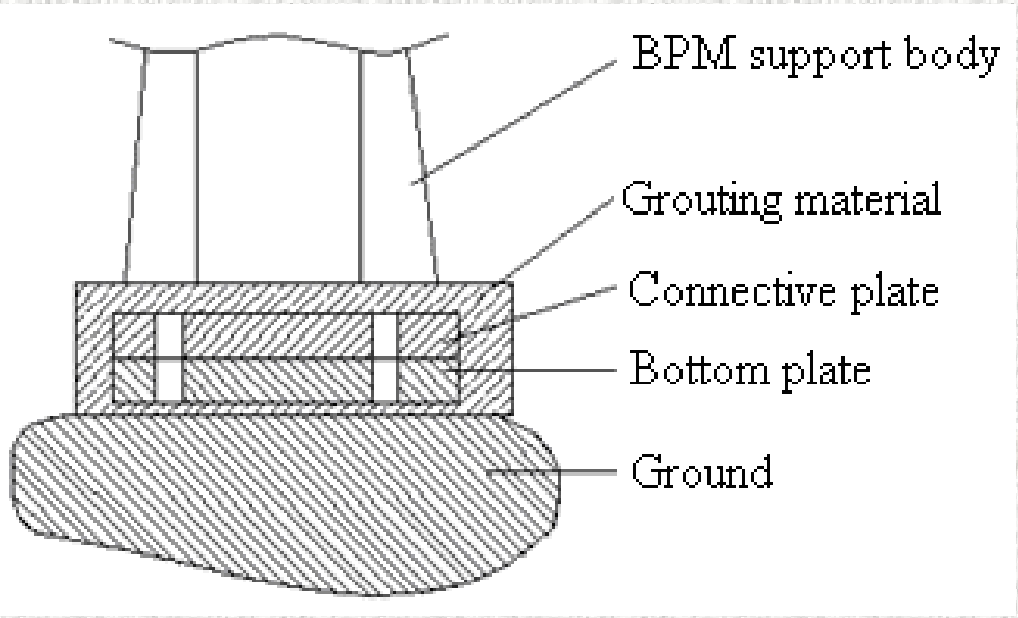


No.	Modal shape	Eigenfrequency (Hz)		
		FE	Measurement	Relative error
1	Longitudinal bend	308.2	307.8	0.13%
2	Lateral bend	446.1	449.4	0.73%
3	Lateral torsion	516.3	> 500	

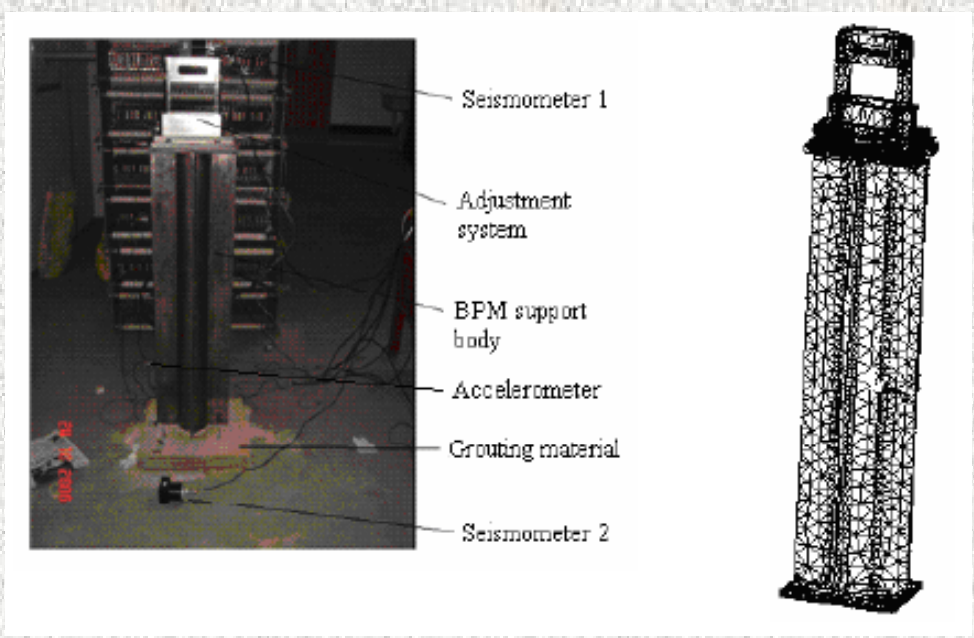
Different connection ways

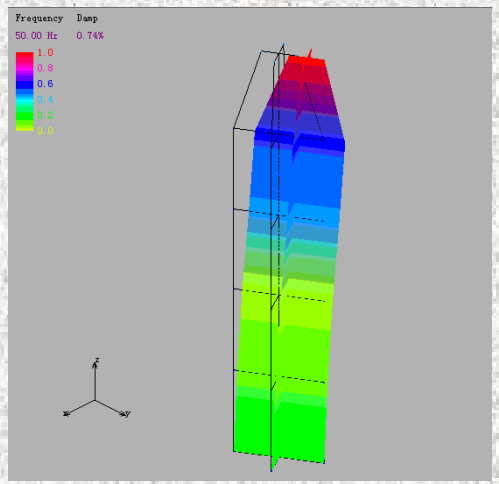


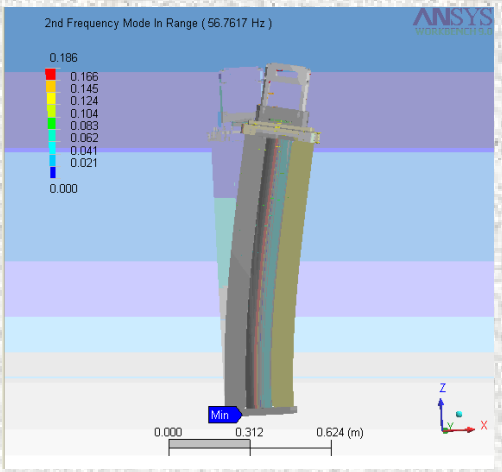




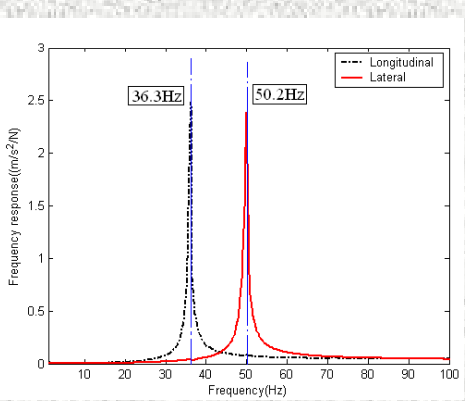
Modal shape

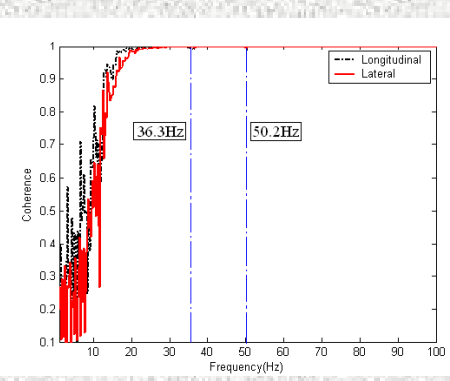




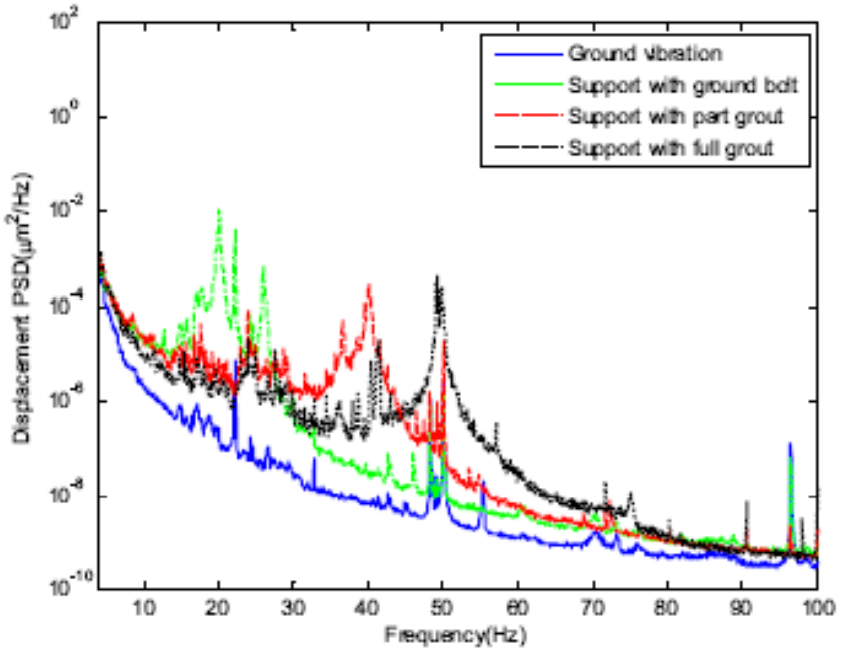


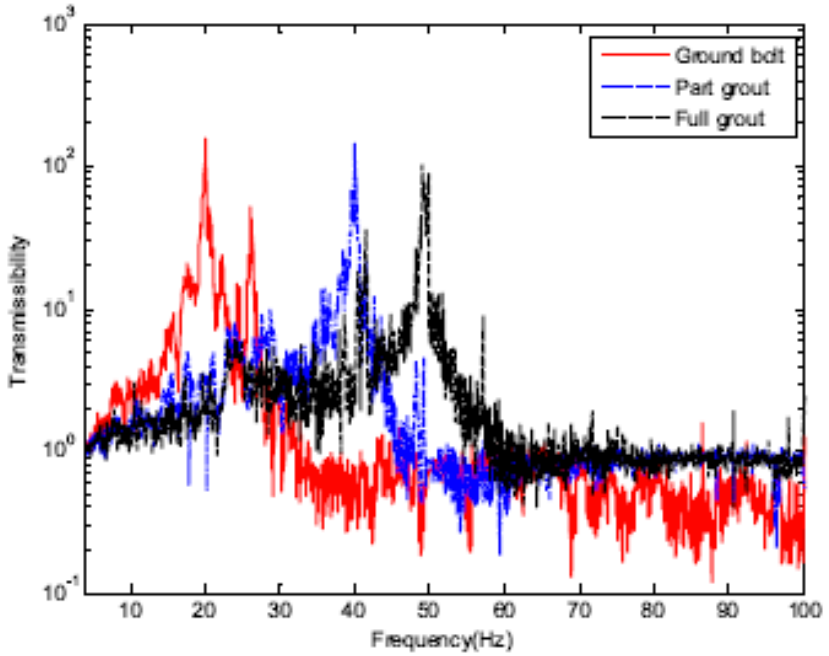
		Eigenfrequency (Hz)			
		With the adjustment system		Without the adjustment system	
		Lateral	Longitudinal	Lateral	Longitudinal
FE		56.7	42.4	71.1	54.2
Measurement	Ground bolt	20.2	24.4	24.2	32.1
	Part grout	39.4	36.9	48.1	48.4
	Full grout	50.2	36.3	64.7	47.1

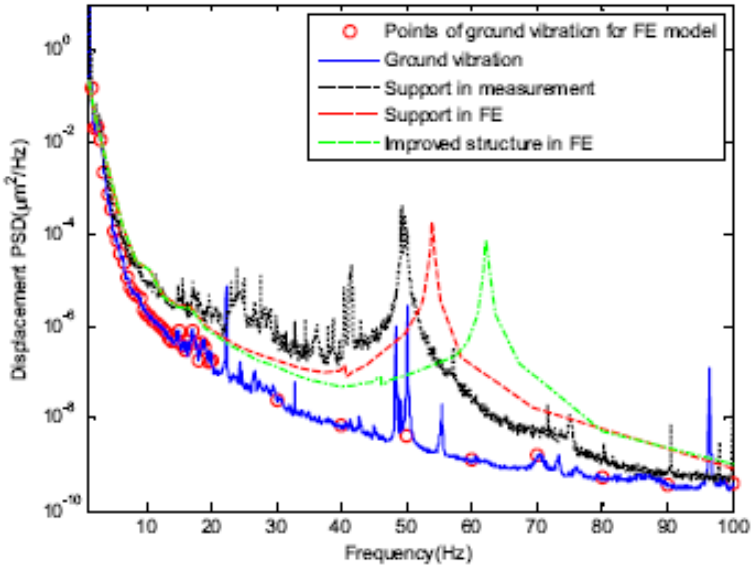




Response measurement

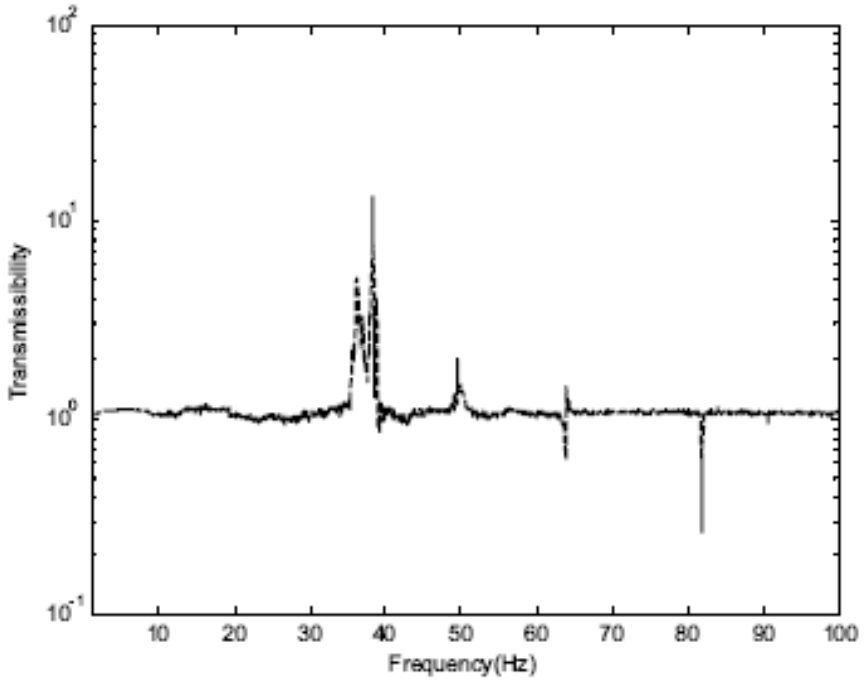


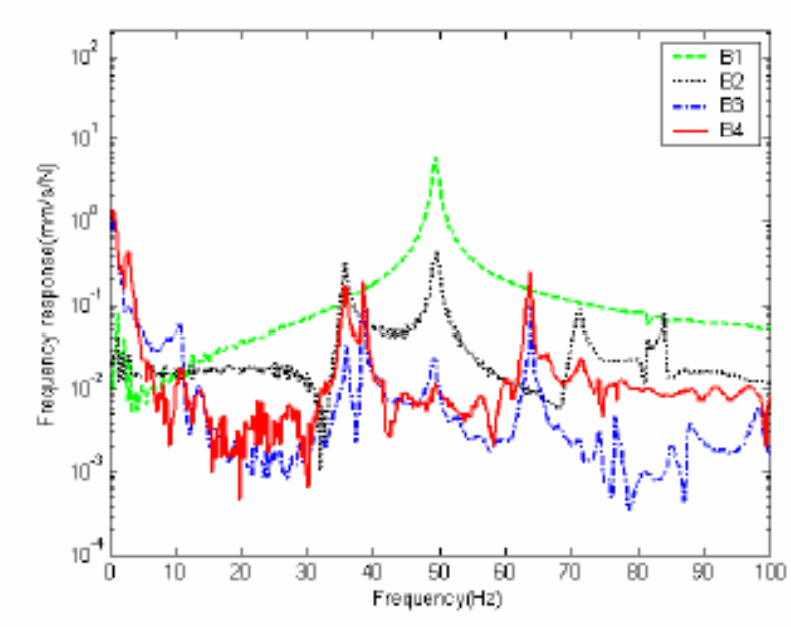




	Connection	Ground	Top of BPM support	Ratio
Measurement	Ground bolt	22.3	97.2	4.36
	Part grout	20.8	27.5	1.32
	Full grout		27.2	1.23
FE	Full grout	22.1	26.4	1.19
	Full grout (improved)		25.4	1.15

Coupling measurement





B1. Lateral response & lateral excitation;
B2. Lateral response & longitudinal excitation;
B3. Vertical response & lateral excitation;
B4. Vertical response & longitudinal excitation.

Conclusion

- The first eigenfrequency of MGA: Lateral 21.9 Hz, Vertical 22.5 Hz. Ratio of RMS displacement from magnet to floor: 1.34 in 4~50 Hz.
- After adding auxiliary, the lateral first eigenfrequency can be improved 27.7 Hz, Ratio of RMS displacement from magnet to floor in 4~50 Hz can arrive 1.24.
- The PMC has advantage of mechanical stability.
- The connection ways to ground have huge influence on BPM mechanical stability, and coupling influence is existed in BPM support.

Thank you for your attention !