



Vulnerability Assessment of Heritage structure (Ramappa Temple)

OBJECTIVE

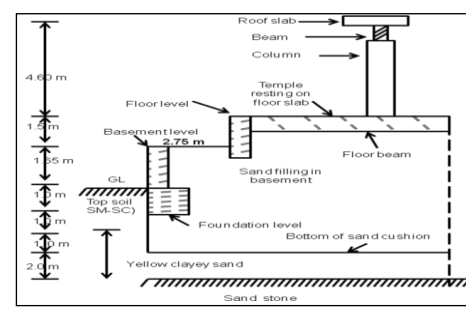
- Quantify the ground motion generated due to blasting for different blast loads
- Estimation of structural response due to blasting at different levels of temple
- Safety assessment of Ramappa temple due to ground motions from blasting.

Material Properties used in the Structure:

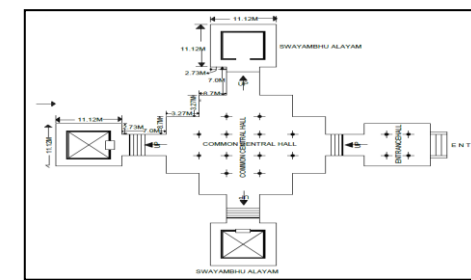
Rock type	Density (kN/m ³)	Porosity	Compressive strength	Tensile strength	Shear strength
Rock	26.0-26.5	0.20%	100-200	8-20	14-50
Dolerite	30.0-31.0	0.10%	200-300	15.32	25.60
Sullavai Sandstone	24.0-26.0	0.8-0.9%	60-100	5-11	8-25



Photograph of the temple



Elevation of temple



Plan of temple

CONCLUSION

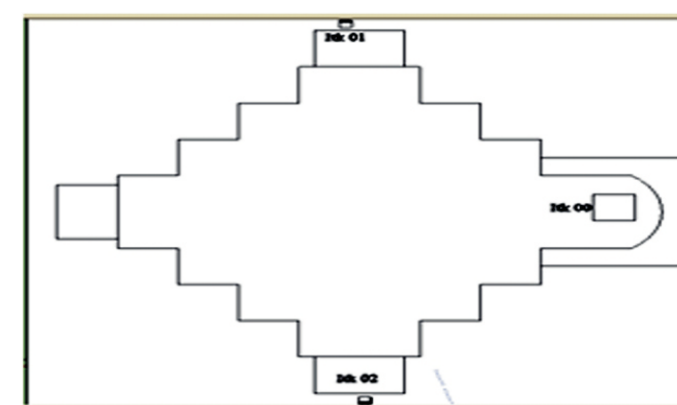
- There is no likelihood of increased response of temple structure as the fundamental period of the structure and the soil strata are near.
- For all blast loads, the spectral amplitudes decrease with increasing distance from the blast site indicating attenuation in the amplitudes of horizontal ground motion.
- The maximum acceleration at the ground surface is ~0.00006 g while at the top is ~0.00019 g.
- Also, the peak particle velocity at the temple site for the maximum charge (70.59 kg) is about 0.1 mm/s to 0.39mm/s, which is much smaller than the permissible limits of 5 mm/s at dominant excitation range of frequencies (8-25 Hz) as per the DGMS Circular of 1997.
- The blasting at Adit 4 Tunnel with a blast charge of 70.59kg and two sticks per hole, 900m from the temple does not affect the dynamic response.

STRUCTURAL INVESTIGATION

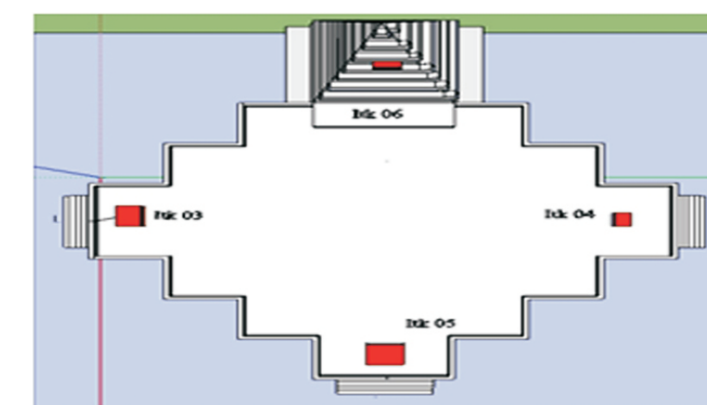
Natural Frequency of soil around temple

Direction	Peak Acceleration (mm/s ²)						
	0	1	2	3	4	5	6
NS	0.088	0.091	0.04	0.078	0.14	0.075	0.126
EW	0.051	0.052	0.038	0.089	0.096	0.134	0.141
Vertical	0.135	0.035	0.113	0.554	0.23	0.084	0.057

Vibration	Direction	Peak Acceleration (mm/s ²)						
		0	1	2	3	4	5	6
Blast 1	NS	0.52	0.98	0.84	0.79	0.82	1.89	1.01
	EW	0.67	0.83	0.99	0.72	0.70	0.68	1.52
	Vertical	0.95	1.82	1.75	2.56	0.90	5.17	0.89
Blast 2	NS	0.34	0.62	0.56	0.56	0.70	0.41	0.51
	EW	0.59	0.68	0.49	0.89	0.56	0.82	1.14
	Vertical	0.98	0.99	0.78	2.27	0.74	1.32	0.88
Blast 3	NS	0.85	0.87	0.88	1.06	0.99	0.76	1.18
	EW	0.86	0.68	0.53	1.09	1.10	0.98	1.67
	Vertical	1.25	1.27	1.49	3.17	1.14	1.65	1.95
Blast 4	NS	0.64	0.94	0.65	1.00	0.95	0.86	0.94
	EW	0.80	1.18	0.78	1.13	0.90	0.84	1.94
	Vertical	1.65	4.86	2.13	4.88	1.20	3.00	1.22



Sensor location at ground floor



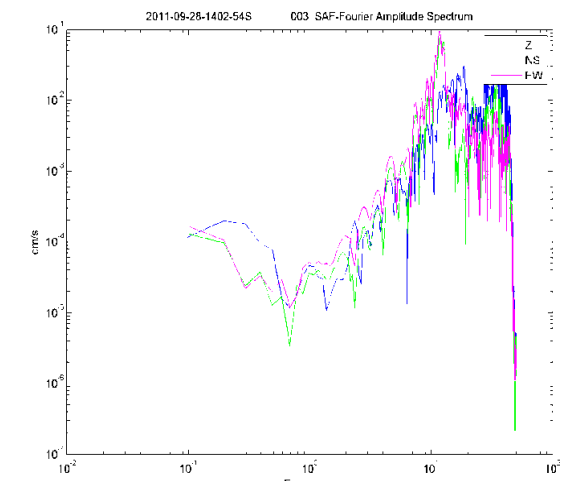
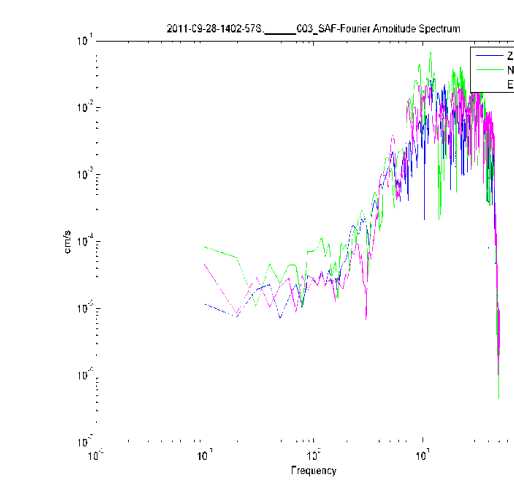
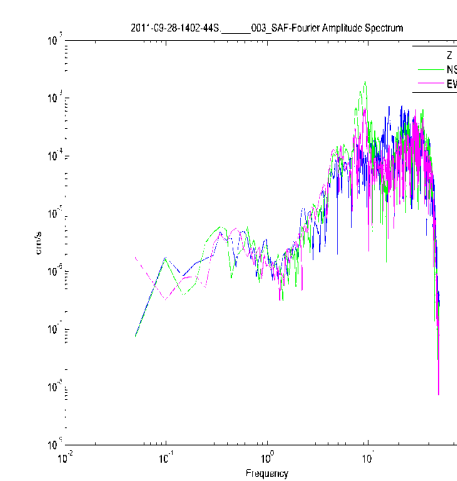
Sensor location at first floor

GEOPHYSICAL INVESTIGATION

Natural frequency of soil at 5 locations near temple

S. No.	Location	Average Predominant Frequency (Hz)
1	West of temple	3.5
2	East of temple	6.0
3	North of temple	7.0
4	South of temple	9.0
5	Surge pool	6.0

Dates of the blast	PGA at various stations (mm/s ²)				Peak Particle Velocity (mm/s)		Peak Displacement (mm)	
	1	2	3	4	Temple	Tunnel	Temple	Tunnel
2011-09-28-1403	0.49	21.63	1.82	19.30	0.008	0.27	0.80	24.40
2011-09-29-0438	0.41	14.91	1.62	14.39	0.007	0.24	0.51	14.50
2011-09-29-1437	0.55	22.32	1.88	15.52	0.10	0.27	0.66	23.90
2011-09-30-0558	0.59	28.34	2.61	22.72	0.10	0.38	0.94	25.90



Fourier Spectrum at (a) Temple and (b) Tunnel (c) 100km from tunnel