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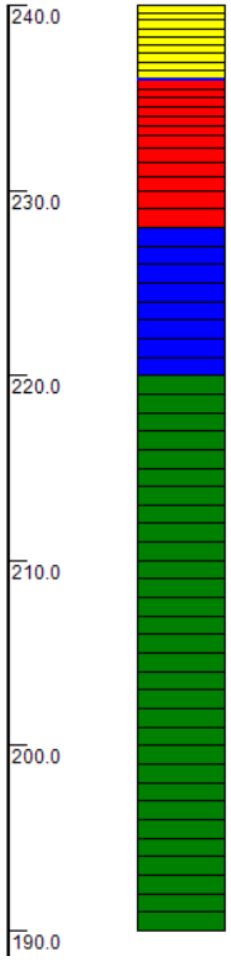
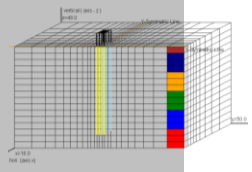
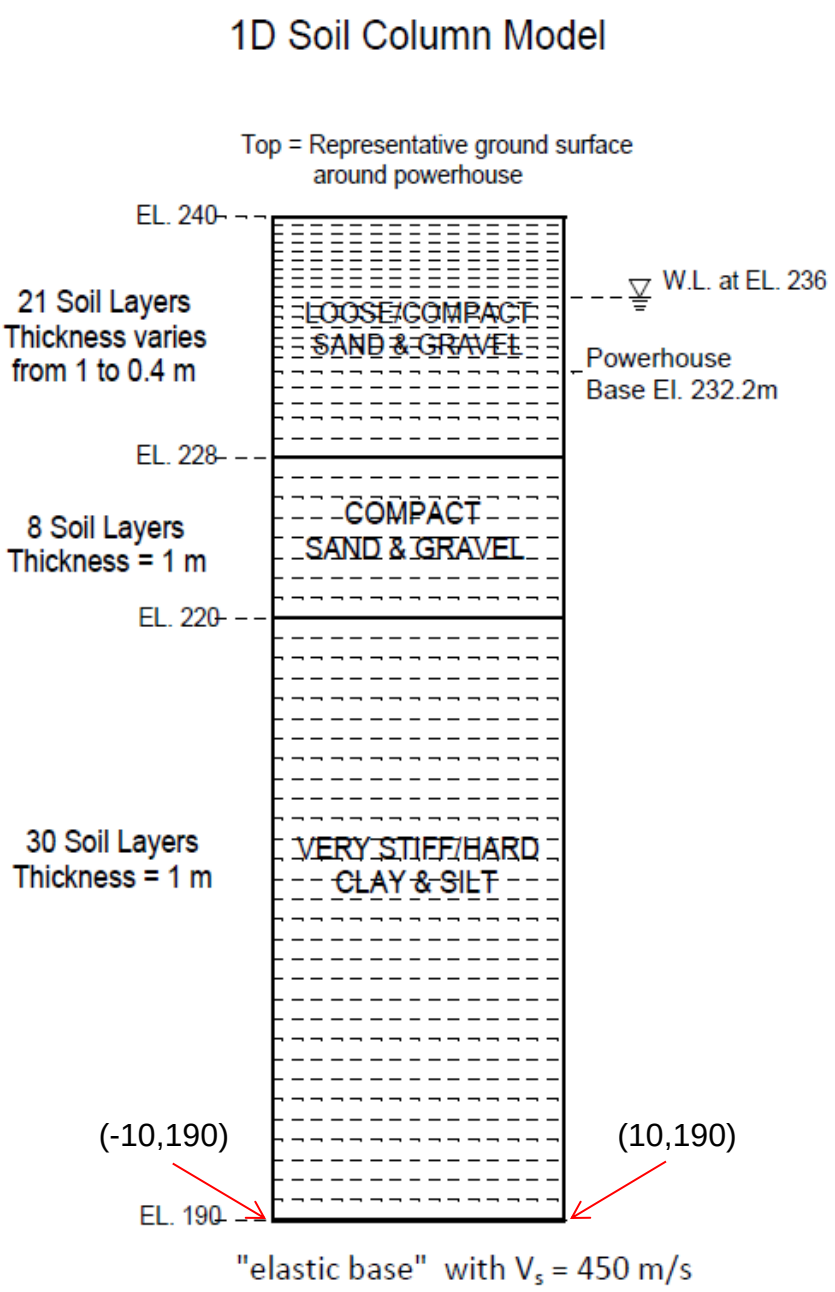
- 2.4 Example 2 – prepared in March 2018
  Comparison between SHAKE and VERSAT-1D at low-moderate level c earthquake shaking:

1D column: VERSAT-1D MODEL







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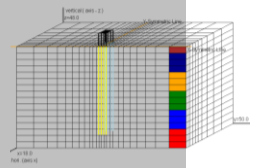
- 2.4 Example 2: Comparison between SHAKE and VERSAT-1D at low-moderate level of earthquake shaking: 7 input crustal ground motions

Table 2.1 Meta Data of the Seven Crustal Earthquake Records

No.	Short Name	NGA Record Number	Earthquake Name	Year	Station Name	Magnitude	Mechanism	Rjb (km)	Rrup (km)	Vs30 (m/sec)
1	FTR	63	"San Fernando"	1971	"Fairmont Dam"	6.6	Reverse	26	30	634
2	CPE	164	"Imperial Valley-06"	1979	"Cerro Prieto"	6.5	strike slip	15	15	472
3	SCN	369	"Coalinga-01"	1983	"Slack Canyon"	6.4	Reverse	26	27	648
4	SJR	472	"Morgan Hill"	1984	"San Justo Dam (R Abut)"	6.2	strike slip	32	32	544
5	G06	769	"Loma Prieta"	1989	"Gilroy Array #6"	6.9	Reverse Oblique	18	18	663
6	CHL	989	"Northridge-01"	1994	"LA - Chalon Rd"	6.7	Reverse	10	20	740
7	LV3	1029	"Northridge-01"	1994	"Leona Valley #3"	6.7	Reverse	37	37	499

Set	Dir	N points	dt [sec]	Max.Accel. [g]	Max. Vel. [m/s]	Max. Disp. [m]	Arias Int. [m/s]	Duration 5%-95%[sec]
7 Crustal EQ Records - Horizontal (X) and Vertical (Z)								
1	X	6112	0.01	0.202	0.167	0.038	0.342	17.86
2	X	6382	0.01	0.131	0.082	0.041	0.562	33.7
3	X	5999	0.01	0.139	0.147	0.026	0.175	13.51
4	X	5673	0.005	0.125	0.131	0.071	0.408	21.98
5	X	7998	0.005	0.136	0.126	0.05	0.261	13.23
6	X	3107	0.01	0.106	0.087	0.017	0.183	9.08
7	X	1600	0.02	0.145	0.163	0.04	0.316	12.54



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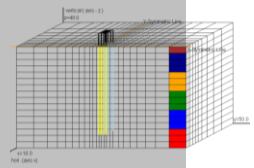
- 2.4 Example 2: Comparison between SHAKE and VERSAT-1D at low-moderate level of earthquake shaking: soil profiles and parameters

Table 2.2 Soil Unit Weights and Shear Wave Velocities for SHAKE and VERSAT-1D

No.	Soil Layer Description	Unit Weight (kN/m^3)	Shear Wave Velocity, V_s (m/s)
1a	Wet Loose to Compact Sand and Gravel (above water level)	19.5 (a.wt)	160
1b	Saturated Loose to Compact Sand and Gravel (below water level)	21.2 (b. wt)	300
3	Compact Gravel to Gravel	21.2	400
4	Very Stiff to Hard Clay and Silt	20.4	360
5	Very Dense/Hard Silt and Sand	21.7 ("elastic base" input)	450

Table 2.3 Soil Stiffness and Strength Parameters for VERSAT-1D (*viscous damping 0.5% for mass & stiffness*)

Layer	VERSAT-1D Soil Zone #	Soil Layer Description	G_{max} (kPa)	K_G	c (kPa)	ϕ (°)	R_f
1a	M1	Wet Loose to Compact Sand and Gravel (a.wt)	50887	502	0	3	1500
1b	M2	Saturated Layer 1a (b.wt)	194495	1920	0	35	1500
3	M3	Compact Gravel to Gravel	345770	3413	0	35	1500
4	M4	Very Stiff to Hard Clay and Silt	269505	2660	30	25	750
Elastic base		Very Dense/Hard Silt and Sand	Elastic base, V_s = 450 m/s				



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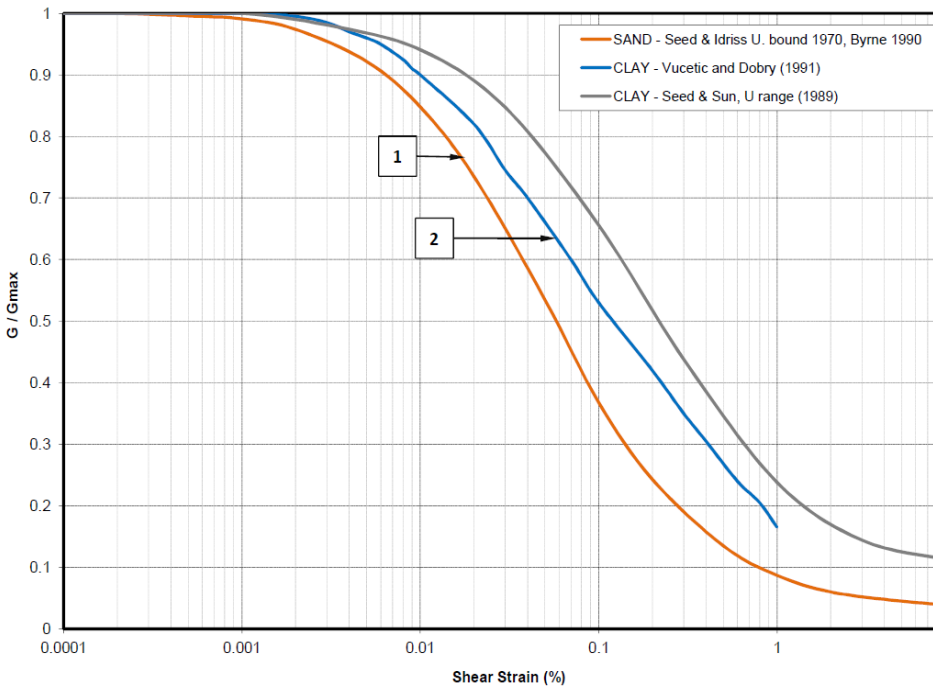
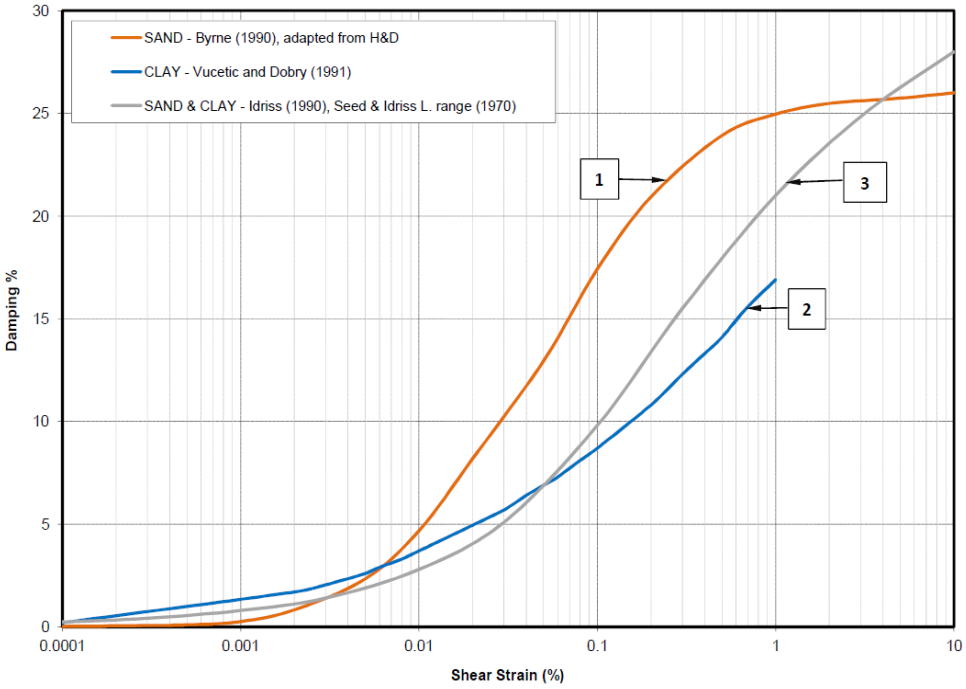
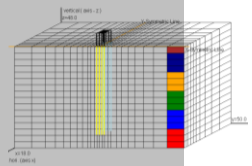
- 2.4 Example 2: Comparison between SHAKE and VERSAT-1D at low-moderate level of earthquake shaking:
  G/G_{max}, and damping curves used in SHAKE analyses







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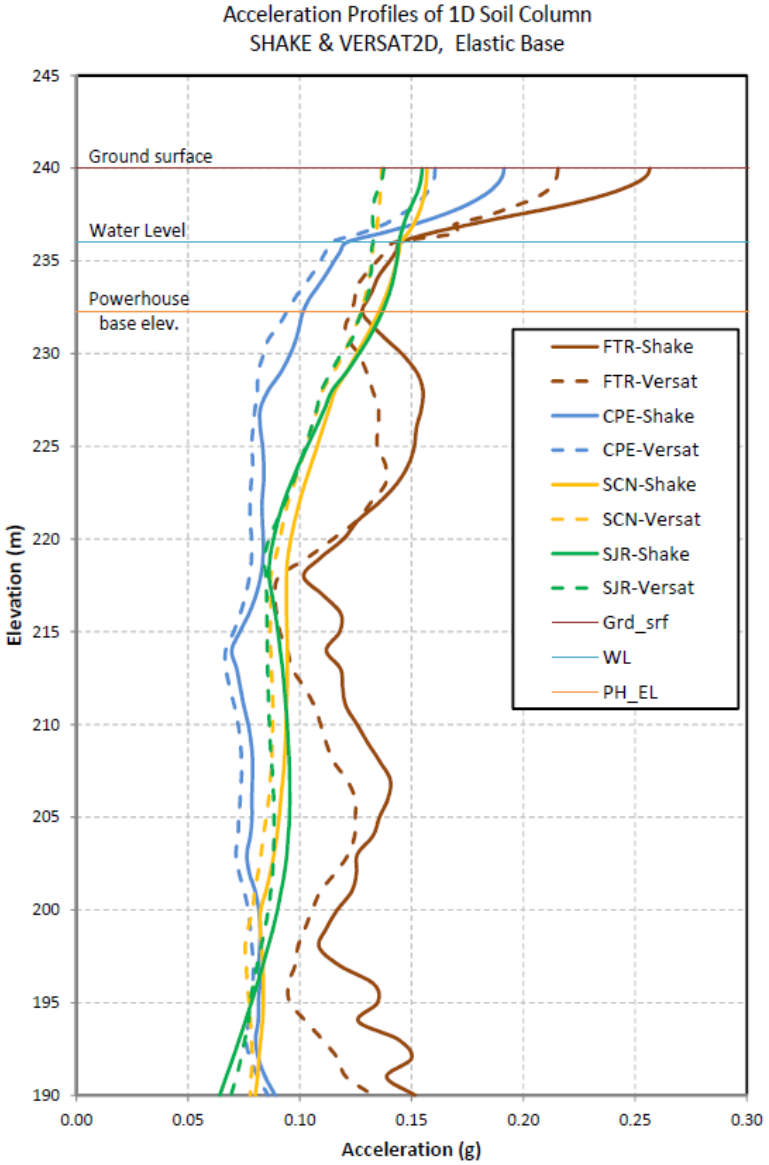
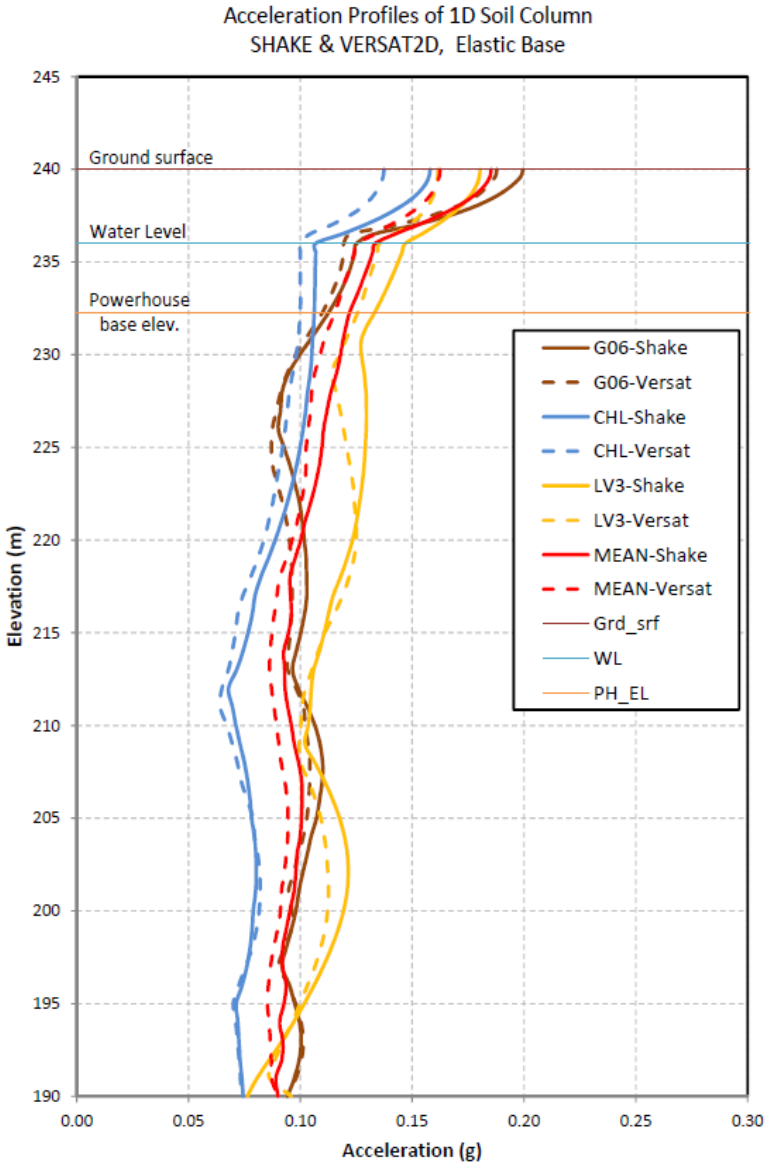
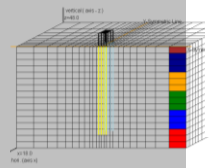
- 2.4 Example 2 Comparison between SHAKE and VERSAT-1D:

RESULTS - at low-moderate level of earthquake shaking, *SHAKE equivalent linear approximation is able to produce very good representation of true soil nonlinear hysteresis behavior*







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