Application of Mammoth Vibro-Tamper (MVT) for the shallow compaction at airport runway expansion project in Florida

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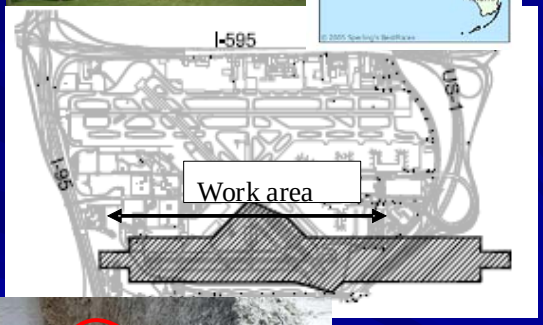
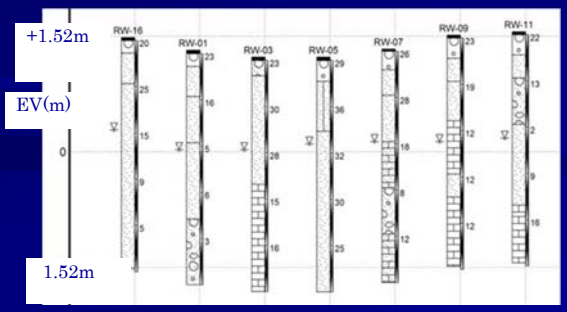
- Fort Lauderdale International airport runway expansion（WP302)
- Comparison of Energy level between MVT（Mammoth Vibro-Tamper）and DDC（Deep Dynamic Compaction)
- Compaction effect
- Vibration reduction effect

Summary of the project

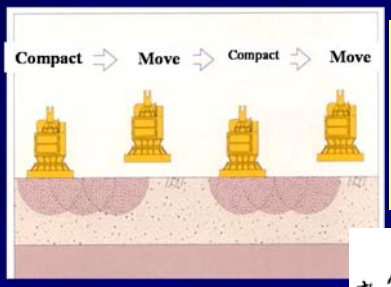
- 2012.11-2014.2
- Total 3-Rigs, Double shifts
- 462,000m2, Depth=5m
- Many voids in Limestone ground, hard to collapse
- Relative density >70%

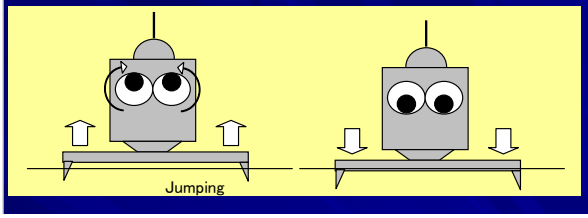
$$Dr = \sqrt{\frac{N}{17 + 11.8\sigma_v'}} \times 100(\%) \ldots\ldots Eq(1)$$



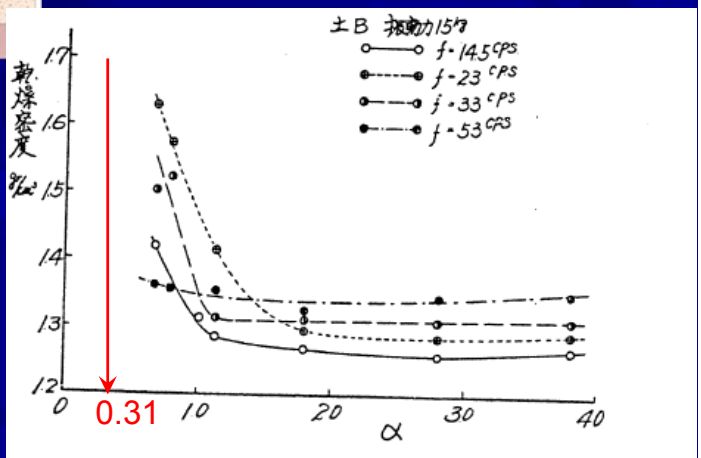


Compaction sequence by MVT





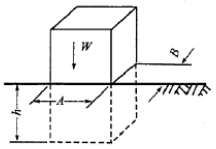
Dry Density



α = (Dead weight) / (Vibration force)
= 25ton / 80ton = 0.31 (for MVT)
Murayama, 1957

Energy Level of MVT & DDC

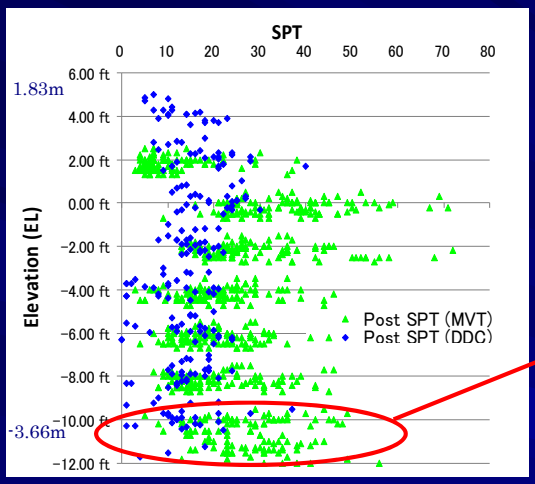
Mammoth vibro Tamper (MVT)				Dynamic Compaction (DDC)			
E=E0*n*t*60/(A*B*h) E0=2a(W+F/2)*(f/60)				E=W*H*N/(A*B) tf ft/SF			
E0	Compaction neregy to ground per unit time			W	weight		15 tons
n	Number of Compaction	3		H	height	=18.3m	60 ft
t	Duration (min)	1		N	Time of drop		5 drops
A,B	Effective width (cm)	300		A,B	Effective width		8.48 ft
h	Thickness of layer (cm)	500					
a	Vibration amplotude (cm)	2.63					
W	Weight (tf)	25	*)				
F	Vibration force (tf)	80					
f	Frequency (rpm)	560					
E0=	3191.067 tf cm/sec			E=	62.57787 tf ft/SF	(per unit area)	
E=	0.012764 tf cm/cm3			E= 205.3 tf m/m2			
	127.6427 tf m/m3						
E=	638.2133 tf m/m2	(per unit area)					
	194.5274 tf ft/SF	(per unit area)					

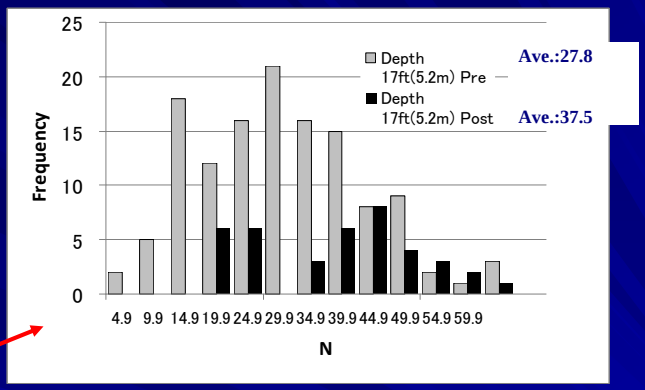


a : Amplitude (cm)	1.1	B : Effective width (cm)	310
W : Weight (tf)	21.5	n : Number of applications (No.)	2~4
F : Oscillatory force (tf)	87.7	t : Time of application (min)	
f: Frequency (cpm)	560	h : Thickness of improvement (cm)	400
A: Effective width (cm)	310		

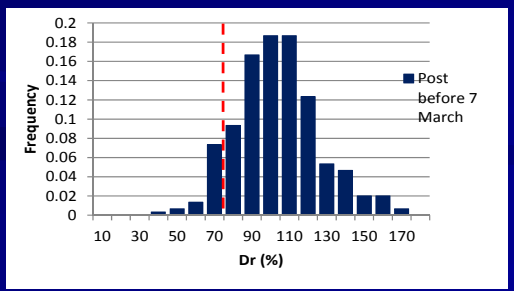
Energy Calculation:
DDC: E=Weight x Drop height x Number/Area
MVT: E= (Weight+Vibration Force) x Frequency x N/Area

Compaction Effect

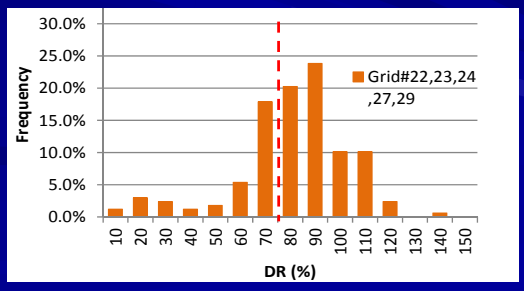




Even at deeper area (depth=5.2m), some compaction effect was founded.

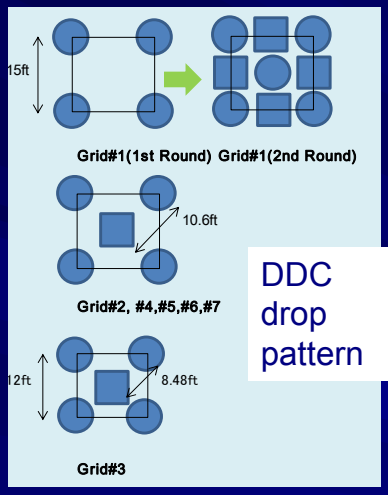


MVT: Fail rate 9.7%

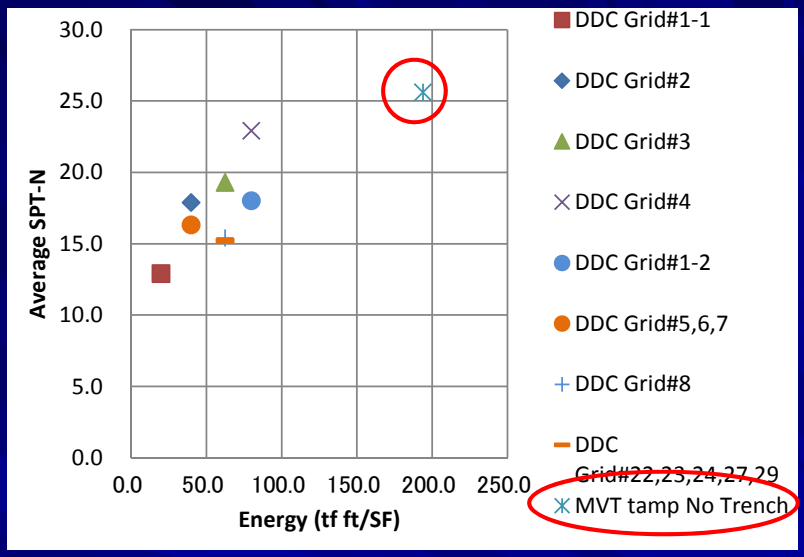


DDC: Fail rate 32.7%

Energy level & SPT data after tamping

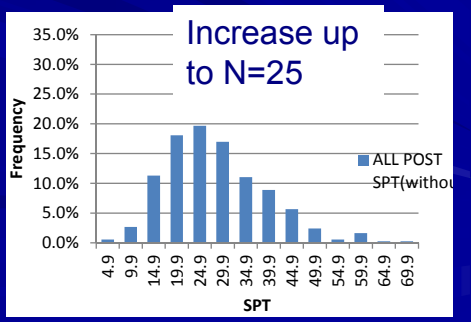


DDC drop pattern



	Spacing (FT)	Effective area(SF)	Number of Drop	Energy (tf ft/SF)	Average SPT-N	Fail Rate (%)
DDC Grid#1-1	15.0	225.0	5	20.0	12.9	42.1%
DDC Grid#1-2	7.5	56.3	5	80.0	18.0	30.4%
DDC Grid#2	10.6	112.4	5	40.1	17.9	18.3%
DDC Grid#3	8.5	71.9	5	62.6	19.3	11.6%
DDC Grid#4	10.6	112.4	10	80.0	22.9	6.9%
DDC Grid#5,6,7	10.6	112.4	5	40.1	16.3	20.5%
DDC Grid#8	8.5	71.9	5	62.6	15.4	20.0%
DDC Grid#22,23,24,27,29	8.5	71.9	5	62.6	15.2	32.7%
MVT tamp No Trench				194.0	25.6	9.7%

Increase up to N=25



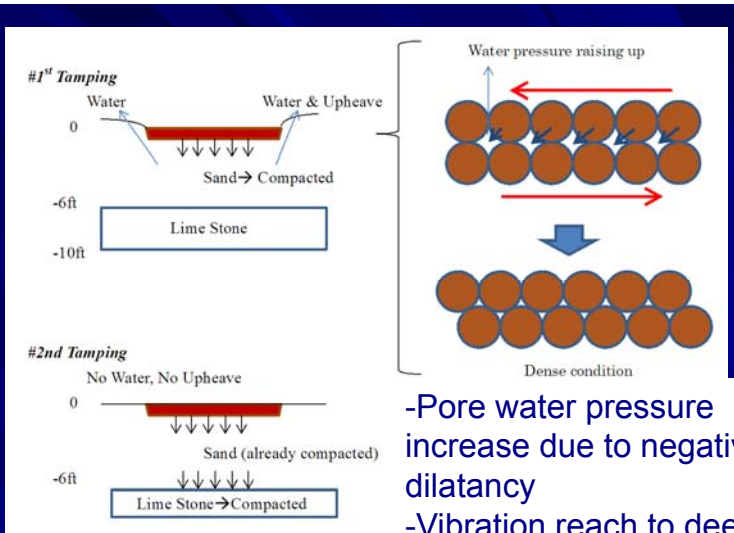
SPT after MVT

1st Tamping

Water come up

2nd Tamping

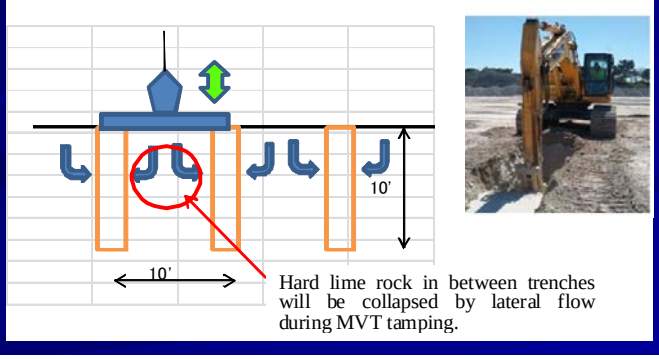
No water



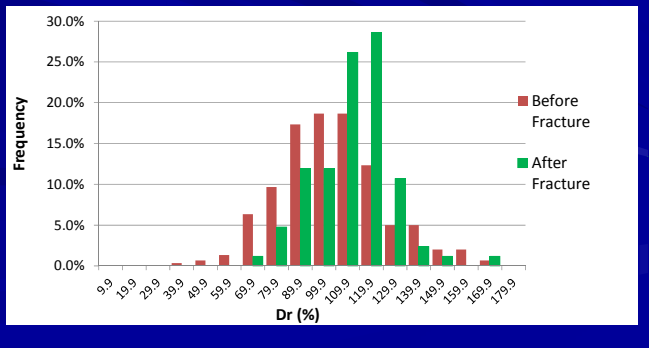
-Pore water pressure increase due to negative dilatancy

-Vibration reach to deeper zone at 2nd tamping

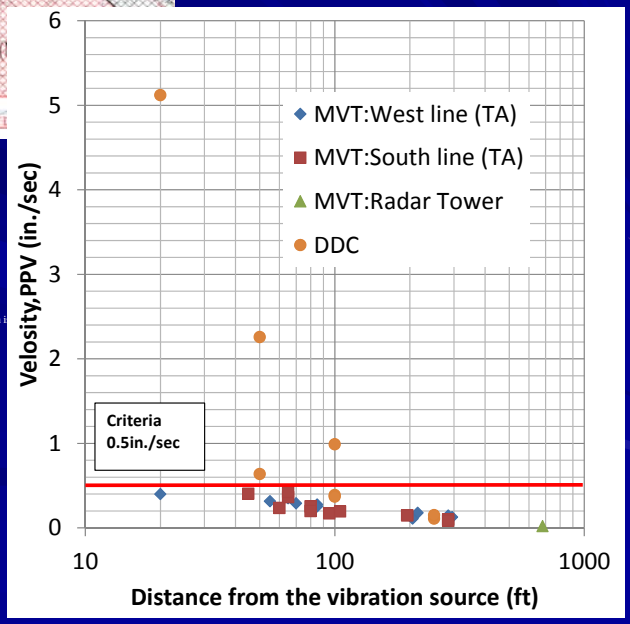
Trench work effect



Hard lime rock in between trenches will be collapsed by lateral flow during MVT tamping.



Vibration reduction effect



Conclusion

- Murayama et. al. have revealed that the following 'Compaction factor' α is the key factor for the plate compaction and higher densification will be achieved in the case of α<1. In this MVT, **α =** (Dead weight) / (Vibration force) = 25ton / 80ton = 0.31<1, it means that huge amount of surface energy due to lift up effect could be generated.
- Calculated surface energy level relates to the observed densification effect through SPT-N data.
- At 1st Tamping, ground surface area is compacted, and at 2nd Tamping, deeper zone is densified since the vibration go through the surface hardened zone (Double Tamping Effect).