















Details are shown in the chart below:

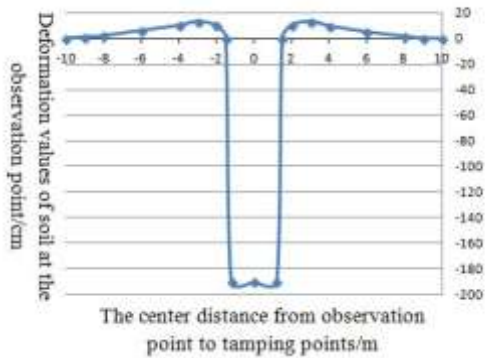


Fig.11 The curve of uplift around the pit at tamping point 1(The first time)

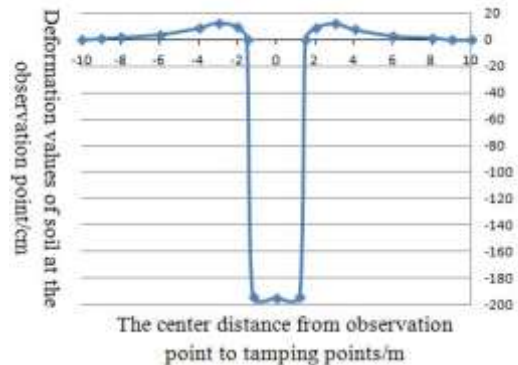


Fig.12 The curve of uplift around the pit at tamping point 2(The first time)

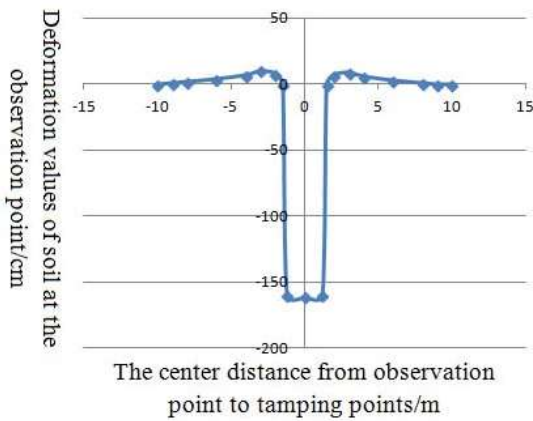


Fig.13 The curve of uplift around the pit at tamping point 1(The second time)

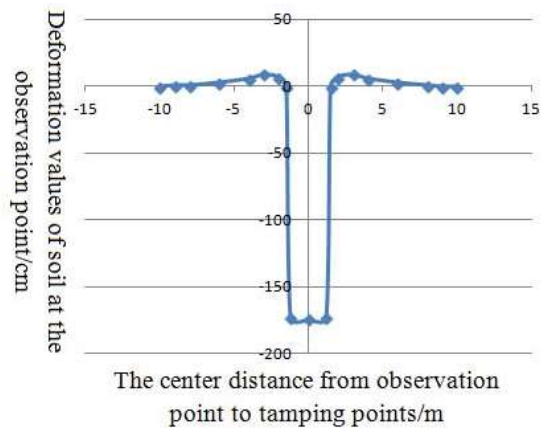


Fig.14 The curve of uplift around the pit at tamping point 2(The second time)

As shown in picture, after secondary backfill dynamic compaction, the uplift of the soil around the pit has been reduced and there is no obvious abnormal phenomenon. Tamping times should be controlled during the construction reasonably to complete the project more efficiently. What is given below is the 4000 kN•m energy level ration curve of the tamping subsidence and tamping times,



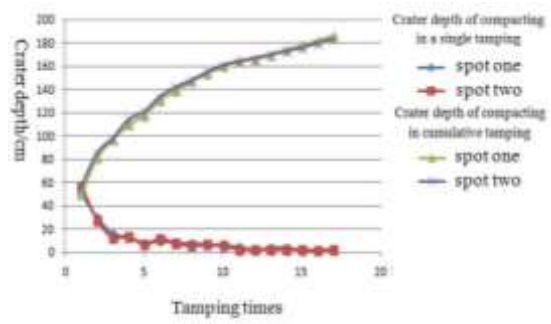


Fig.15 The relation curves of tamping times and settlement of dynamic compaction

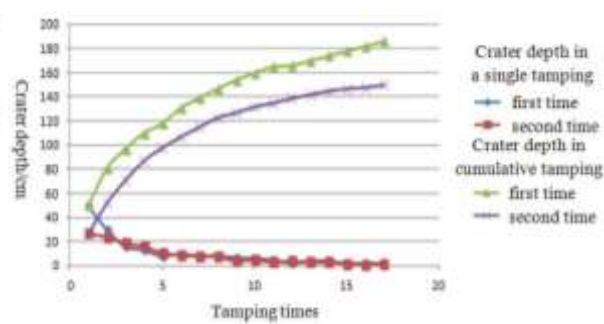


Fig.16 The relation curves of tamping times and settlement of dynamic compaction under 4000kN·m

When 4000kN·m level trial tamping, for the last three tamping of 17~19 times tamping set, the tamping subsidence value is less than 9 cm. The average compacting factor is 0.94.

The results show that for the original foundation, the best tamping compaction times of 2000 kN·m, 3000 kN·m and 4000 kN·m is 10, 13, 15 respectively.

### 3. CONCLUSIONS

#### 3.1 Trial ramming effect assessment

Through relation curve of the number of single tamping and the tamping settlement, the rammer curve almost have the same shape in all the experimental zones. In the early stage of dynamic compaction, settlement is bigger, but with the compaction continuing, gradually the curve become smooth. For the last three strikes, the settlement value barely changes.

Through the detailed observation and analysis of the experimental zone at both rammer points, experimental designed ram-stop standard is consistent with point tamping ram-stop standard average ram sink in the last two strike, which also suggests that ram-stop standard of dynamic compaction follows also meets the requirements.

Spring back and uplift values by observation around the pit in all experimental zones are under control and there is no obvious abnormal situation, which also suggests that within the required ramming times, tamping effect is good.

Overall, the dynamic compaction test has guiding. According to the specific construction condition, if it has any problems, it should be discussed in time.

After the completion of the final trial ramming, exploratory well should be set in ram pit and between the pits in order to test compaction effect of the soil samples, test results are shown in Tab.3 to Tab.5.

Tab.3 The original foundation compaction contrast list before and after dynamic compaction under 2000kN·m

direction	depth (m)	Before tamping		After tamping			
		Moisture content (%)	Compaction factor	Moisture content (%)	Compaction factor	Moisture content (%)	Compaction factor
N	1	17.18	0.88	16.11	0.98	19.88	0.89
	2	21.26	0.84	19.76	0.90	21.04	0.91
	3	18.9	0.86	20.34	0.91	18.87	0.93
	4	19.18	0.86	21.12	0.90	23.44	0.89
	5	22.53	0.86	22.76	0.86	22.85	0.86
S	1	16.51	0.91	15.66	0.98	18.53	0.86
	2	21.46	0.82	19.22	0.93	20.31	0.92
	3	16.47	0.90	19.58	0.93	19.18	0.94
	4	19.35	0.87	21.43	0.88	22.23	0.87
	5	23.00	0.85	23.36	0.85	23.71	0.85

Tab.4 The original foundation compaction contrast list before and after dynamic compaction under 3000kN·m

direction	depth (m)	Before tamping		After tamping			
		Moisture content (%)	Compaction factor	Moisture content (%)	Compaction factor	Moisture content (%)	Compaction factor
N	1	11.78	0.92	16.99	0.83	17.44	0.96
	2	19.33	0.88	17.45	0.97	18.90	0.93
	3	19.30	0.87	22.04	0.90	19.65	0.93
	4	21.96	0.86	19.54	0.93	29.69	0.78
	5	20.19	0.87	22.34	0.89	24.99	0.86
	6	21.01	0.87	21.36	0.87	22.32	0.86
S	1	14.96	0.88	16.24	0.84	17.95	0.95
	2	20.46	0.87	18.22	0.95	19.84	0.93
	3	20.50	0.88	13.33	0.98	20.1	0.91
	4	22.62	0.85	21.88	0.89	30.14	0.79
	5	20.66	0.86	22.88	0.91	24.73	0.87
	6	20.45	0.87	21.35	0.87	22.59	0.87

Tab.5 The original foundation compaction contrast list before and after dynamic compaction under 4000kN·m

direction	depth (m)	After tamping					
		Before tamping		Hammer Center			
		Moisture content (%)	Compaction factor	Moisture content (%)	Compaction factor	Moisture content (%)	Compaction factor
N	1	12.63	0.91	17.29	0.84	17.86	0.96
	2	18.31	0.88	16.53	0.96	18.92	0.94
	3	18.27	0.87	21.34	0.91	19.83	0.92
	4	20.76	0.86	19.17	0.95	28.11	0.77
	5	20.09	0.87	22.54	0.93	25.13	0.86
	6	21.01	0.87	22.62	0.91	24.12	0.86
	7	21.41	0.87	22.78	0.90	23.59	0.85
	8	21.32	0.86	21.59	0.87	21.92	0.85
S	1	14.96	0.88	12.76	0.86	18.33	0.95
	2	20.21	0.87	18.01	0.96	18.95	0.93
	3	20.33	0.87	14.13	0.97	20.16	0.91
	4	21.62	0.86	21.92	0.90	30.06	0.82
	5	20.48	0.87	22.98	0.91	24.93	0.88
	6	20.45	0.87	21.69	0.90	23.62	0.89
	7	20.36	0.86	21.03	0.90	22.74	0.88
	8	20.41	0.87	20.56	0.88	20.61	0.87

By analyzing of the data above we can see, after treating foundation soil with dynamic compaction, the void ratio and dry density increased. The shallow soil of foundation changes obviously, and it is getting wake gradually with depth. Compression moduli of foundation soil after processing has a larger degree of increase--from high compressibility into low compressibility and the foundation bearing capacity have been improved obviously. The ground surface moisture of soil that rammed spreads significantly and decreases, which leads to the moisture content of the soil between ram location sincreased. While with increasing depth, soil moisture content changes before and after tamping gradually decrease. For the original foundation, effective reinforced depth of dynamic compaction of 2000kN·m, 3000 kN·m and 4000kN·m is respectively 4 m, 6 m, 8 m. To the fill zone: silty clay thickness which is less than 4 m, dynamic compaction level should choose 2000 kN·m, the silty clay thickness which is 4 ~ 6 m, dynamic compaction level should choose 3000kN·m, thickness of silty clay is more than 6 m, dynamic compaction level should choose 4000kN·m.

#### 4. Numerical simulation verification

Tab.6 Physico-mechanical properties of soil

Deformation modulus $E_0$ (MPa)	Natural weight ( $\text{kN/m}^3$ )	Poisson ratio $\nu$	Cohesion C(kPa)	internal friction angle
10	17.2	0.30	10	15
40	18.7	0.25	15	24

For further research on the effect of dynamic compaction, with the aid of the finite element software MIDAS, three-dimensional analysis model is established. The soil constitutive model adopts the mohr-coulomb model and the concentrated load is transformed. Model size is 15 m x 15 m x 15 m. The soil parameters are shown in Tab.6. The boundary conditions is ground supporting. 215 hexahedron units is formed. Deformation analysis is under nonlinear static. The influence of initial stress is not eliminated and basic parameters of soil are shown in Tab.4.

The cloud picture of MIDAS software simulation is shown below. As the Fig.17 shows, when the tamping energy is 2000kN·m, the obvious boundary caused by tamping in the ground horizontal direction is about 5 m from rammer central point. The settlement of rammer heart point is about 2m, which is consistent with the test results in Fig.3.

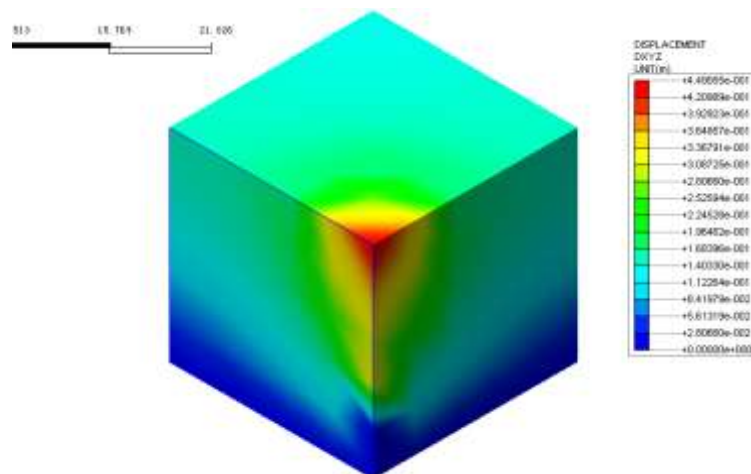


Fig.17 The strain contour of tamping soil under 2000kN·m

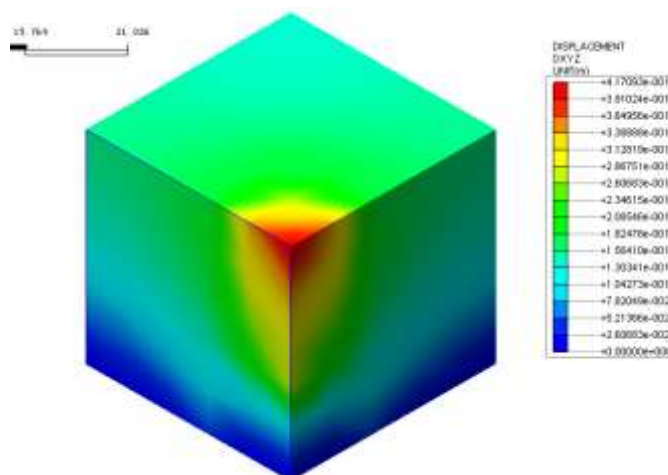


Fig.18 The strain contour of tamping soil under 3000kN·m

As Fig.18 shows, when the tamping energy is 3000 kN·m, the obvious boundary caused by tamping in the ground horizontal direction is about 8m from rammer central point. The settlement of rammer heart point is about 2.5 m, which is consistent with the test results in Fig.7..

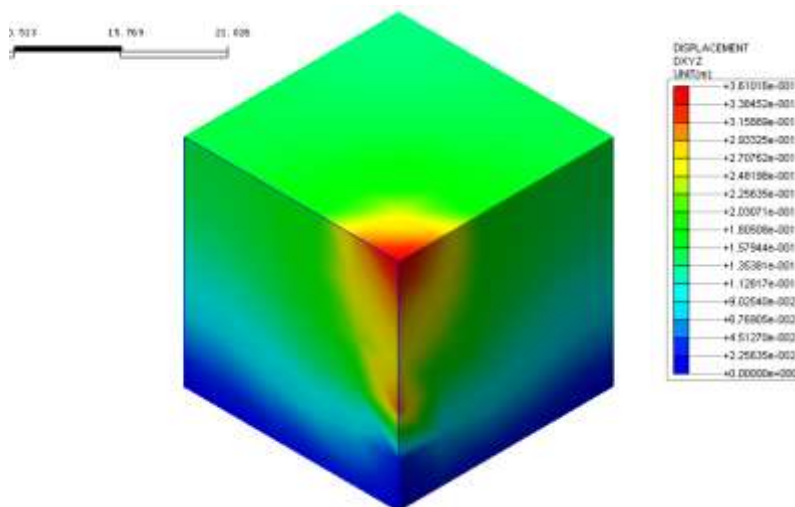


Fig.19 The strain contour of tamping soil under 4000kN·m

As Fig.19 shows, when the tamping energy is 4000 kN·m, the obvious boundary caused by tamping in the ground horizontal direction is close to the top of the cloud picture, which means that is, the border is close to unit boundaries and it is about 15 m from rammer central point. While in the field test, the uplift boundary is 10 m from the rammer central point. It is seen that when the tamping energy is larger, the accuracy of the numerical simulation will be reduced.

## 5. Conclusion

(1) To fill zone, when the thickness of the silty clay is less than 4 m, dynamic compaction level is 2000 kN • m, the thickness of the silty clay 4 ~ 6 m, dynamic compaction is level 3000 kN • m, thickness of silty clay is more than 6 m, dynamic compaction is level 4000 kN, m. Compression modulus of foundation soil is improved largely.

(2) The single-point tamping test results show that for the original foundation, the best tamping times is 10, 13, 15 for 2000 kN·m, 3000kN·m, 4000kN·m respectively. Effective reinforcement depth is 4 m, 6 m, 8 m respectively.

(3) According to the result of trial ramming, with the improvement of dynamic compaction energy levels, although the effective processing depth increase, the required compactness or the number of stroke control standards in last three rammer heavy volume increases, resilience value and crack of pit increases accordingly, and it is go against the control of coefficient of consolidation of foundation soil.

(4) The MIDAS software numerical simulation is consistent of the field test results. It is capable to simulate deformation of the soil in the deflection of the horizontal and vertical direction more accurately and show the actual impact on the surrounding soil.

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