Final Examination Stability Analysis in Geotechnical Engineering
(by Dr J. Takemura)
9th February 2004

1. **Table 1 show a geological data on a site. (Ground water table is GL-2m)**

   (1) Obtain F_L values on the liquefiable layers using 1990 version Design Specification for Highway Bridges in Japan. Horizontal seismic coefficient at the ground surface is assumed to be 0.2 considering seismic zone factor and ground condition factor.

   (2) Obtain P_L value on the ground.

Table 1

depth (m)	soil type	N value	γ_{sat} (kgf/cm^3)	σ_v (kgf/cm^2)	σ_v' (kgf/cm^2)	F_C (%)	D_{50} (mm)	R	r_d	L	FL
1	sand	8	1.9	0.19	0.19	20	0.35		0.99		
2		9	1.9	0.38	0.38	20	0.35		0.97		
3		3	1.9	0.57	0.47	20	0.35		0.96		
4		4	1.9	0.76	0.56	20	0.35		0.94		
5		5	1.9	0.95	0.65	10	0.35		0.93		
6		5	1.9	1.14	0.74	10	0.35		0.91		
7		5	1.9	1.33	0.83	10	0.35		0.90		
8		5	1.9	1.52	0.92	10	0.35		0.88		
9		5	1.9	1.71	1.01	10	0.35		0.87		
10		5	1.9	1.9	1.1	10	0.35		0.85		
11	clay	10	1.8	2.08	1.18	−	0.005		0.84		
12		10	1.8	2.26	1.26	−	0.005		0.82		
13		10	1.8	2.44	1.34	−	0.005		0.81		
14		10	1.8	2.62	1.42	−	0.005		0.79		
15		10	1.8	2.8	1.5	−	0.005		0.78		
16	gravel	40	2	3	1.6	−	10		0.76		
17		50	2	3.2	1.7	−	10		0.75		
18		50	2	3.4	1.8	−	10		0.73		
19		50	2	3.6	1.9	−	10		0.72		
20		50	2	3.8	2	−	10		0.70		

2. **There are many kinds of countermeasure against liquefaction. Discuss suitable countermeasures against soil liquefaction for the following four situations with their principles. You can choose more than one method for each situation.**

   (1) Quay walls in a newly reclaimed land with very loose sand.

   (2) Old tank yard with large number of tanks and pipes founded on a relatively thick loose sand deposit. .

   (3) Existing utility tunnel in a liquefiable sand layer.

   (4) Level ground of loose silty sand with high plasticity (e.g., Fc< 35% but P_L>15)

3. **Figure 1 shows a cross section of gravity type quay wall. Using pseudo-static analysis, calculate the caisson width (B) to satisfy the factor of safety (Fs=1.2) on sliding failure for the following two cases with the given conditions below.**

Case 1) No liquefaction occurs so that the vertical effective stresses in the backfill are the same as the ordinary state.

Case 2) Liquefaction occurs and the vertical effective stresses in the backfill sand vanish. (no liquefaction in the seabed soil)

Given conditions

- **Height of the caisson wall: H=10m;**
- **Sea water and ground water level: top of the caisson;**
- **Average unit weight of the caisson: γ_c=20kN/m^3;**
- **Saturated unit weight of the backfill sand: γ_{sat}=20kN/m^3;**
- **Unit weight of water: γ_w=10kN/m^3;**
- **Effective friction angel of the backfill sand: ϕ'=30 degree;**
- **Friction coefficient between the caisson and rubble mound: μ=0.7;**
- **Design horizontal seismic coefficient: k_h=0.2;**
- **Effective active earth pressure $\sigma'_{ha}(z)$ on the wall can be given by**

$$\sigma'_{ha}(z) = K_a \sigma'_v(z)$$

where $K_a = \tan^2(45° - \frac{\phi'}{2})$ **and $\sigma'_v(z)$ is effective vertical stress.**

- **Dynamic water pressure is negligible.**

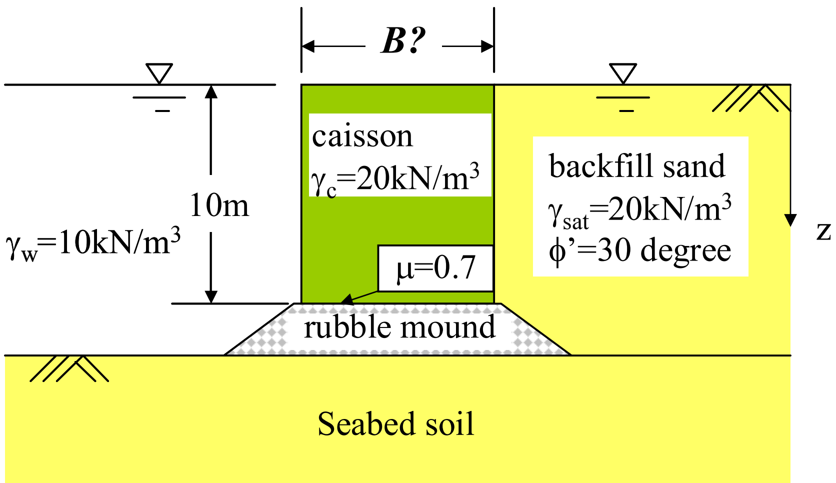

Figure 1