

Topic 1. Foundations on loess subsidence soils

Content

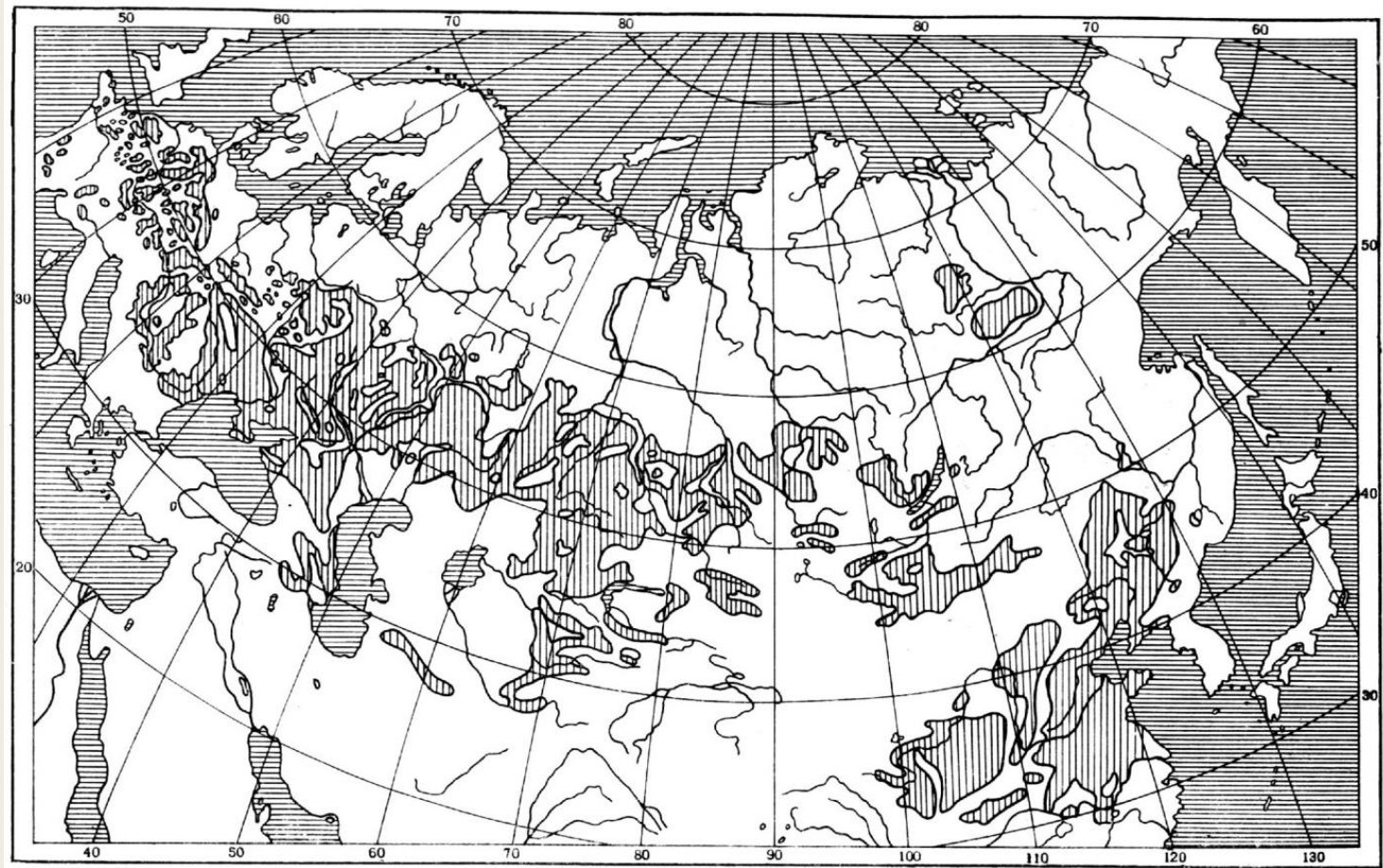
1. Simple and difficult engineering and geological conditions
2. Subsiding loess soils
3. Distribution of loess deposits
4. The origin of loess
5. Characteristics of subsidence
6. Types of soil conditions by subsidence
7. Surface compaction
8. Soil piles
9. Compaction of the loess base using explosives
10. Soil cushions
11. Silicatization
12. Cutting through subsidence soil with piles

SIMPLE AND DIFFICULT ENGINEERING AND GEOLOGICAL CONDITIONS

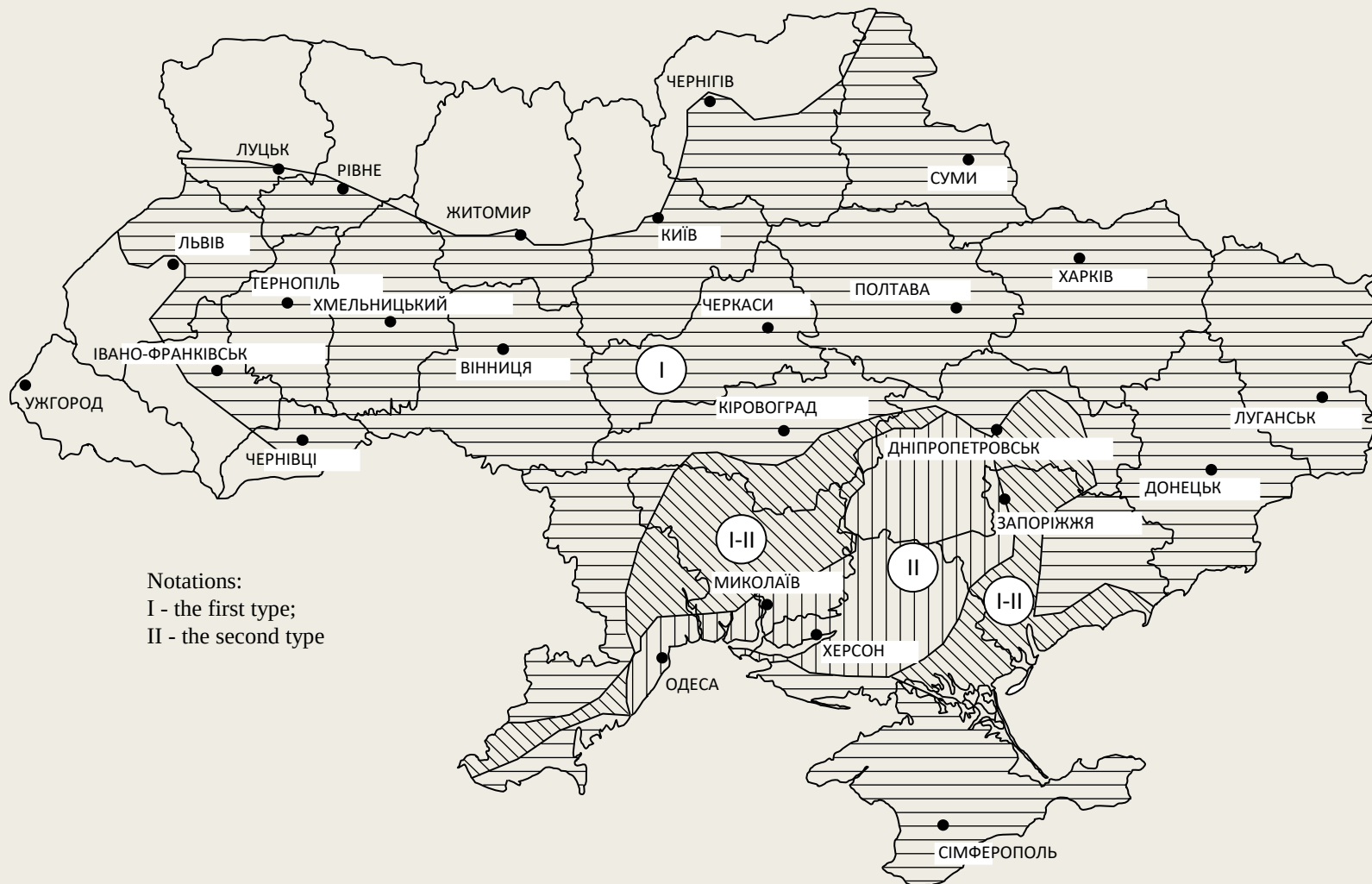
- *Bases* are considered simple, when strong, low-deformation, stable - reliable soils lie close to the surface, and therefore the depth of laying the foundations depends mainly on the purpose, volume-planning decision and structural features of the building.
- *Bases* are called difficult if any geological or engineering-geological processes can occur on the construction site, or reliable soils lie deep enough. In this case, the installation of foundations in open pits requires a great depth of their laying or the installation of deep laying foundations, including pile foundations that cut through weak soils. In this case, it is also possible to arrange an artificial base.

№№ п/п	Type of difficult soil conditions	Special processes and phenomena	Types of base deformations
1	Loess subsiding soils	Deterioration of soil strength indicators; pseudo karst, transition to a weak base, the appearance of negative friction on the lateral surface of piles, underground walls.	Subsidence during the humidification process due to its own weight or under the influence of additional pressure. Forecasting the magnitude of the subsidence is possible, Ssl.
2	Clay soils that can swell	An increase in soil volume, the appearance of swelling pressure; shrinkage upon drying.	Bulging of soil under swelling pressure. The forecast of the magnitude of the uplift is possible, hsw.
3	Weak soils (peat, mules, sapropels, water-saturated clayey soils)	Mineralization and decomposition of organic matter; significant compressibility; thixotropic phenomena.	Slow and long-term deformation of the base, which can be predicted; additional deformation due to mineralization.
4	Bulk and alluvial soils	Gradual compaction of the soil from its own weight, in the presence of additional pressure; decomposition of organic matter.	Uneven deformation of the base; additional deformation due to mineralization or decomposition of organic matter.
5	Salinized soils	Suffusion; dissolution of salts when moistened.	Suffosion compression deformations. Deformation forecast possible, Ssf.
6	Seasonally frozen and frozen soils	Bulging of frozen soil, decreasing strength during thawing.	Compressive deformation in the thawing zone. Prediction of the magnitude of deformation is possible, Sth.
7	Flooded areas	Decreased soil strength, increased weight or weighing of the soil.	The occurrence of additional deformations of the base depending on soil conditions.
8	Territories with underground cavities	Gradual development of the trough shifts; karst and suffusion processes.	The occurrence of additional vertical and horizontal deformations, the prediction of which is possible, but difficult.
9	Seismically hazardous areas	Sudden intended dynamic impact.	The occurrence of additional deformations, the prediction of which is almost impossible.
10	Areas with technogenic impact have been built	Static and dynamic additional load on existing buildings and structures.	The occurrence of additional deformations, the prediction of which is difficult
11	Landslide-prone areas	The movement of soil masses under the influence of gravity down a slope.	Development of complex deformations, the prediction of which is almost impossible. Only slope stability is predicted.

SUBSIDING LOESS SOILS



- Map of distribution of loess species in Eurasia (according to K.I. Lukashev, 1971)



Loess soils placement scheme by type of subsidence (according to Chornyi G.I.)

DISTRIBUTION OF LOESS DEPOSITS



Loess deposits in northeastern China

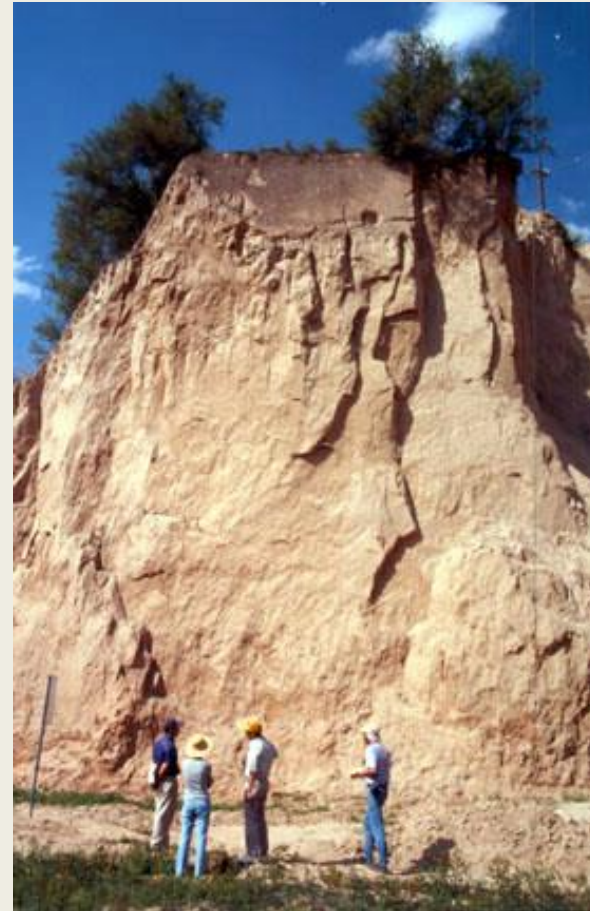


Yellow River – Huáng Hé (China).
The water is colored yellow due to constant erosion of loess deposits

THE ORIGIN OF LOESS



*Loess deposits: with interbeds of
Pleistocene fossil soil, Poltava
region, Ukraine;*



Loess deposits: Germany
The loess holds vertical slopes well

CHARACTERISTICS OF SUBSIDENCE

- p_{sl} – The initial subsidence pressure
- w_{sl} – The initial subsidence moisture content
- $\varepsilon_{sl,i}$ – relative subsidence

$$\varepsilon_{sl} = \frac{h_p - h_{sl}}{h_g}$$

h_p – the height of the soil sample of natural moisture, under pressure p (without the possibility of lateral expansion), equal to the pressure from the own weight of the higher soil and the calculated load from the foundation;

h_{sl} – the height of the same sample after soaking it to full water saturation while maintaining pressure p ;

h_g – the height of the same soil sample of natural moisture, under pressure from the weight of the higher soil at a given depth.

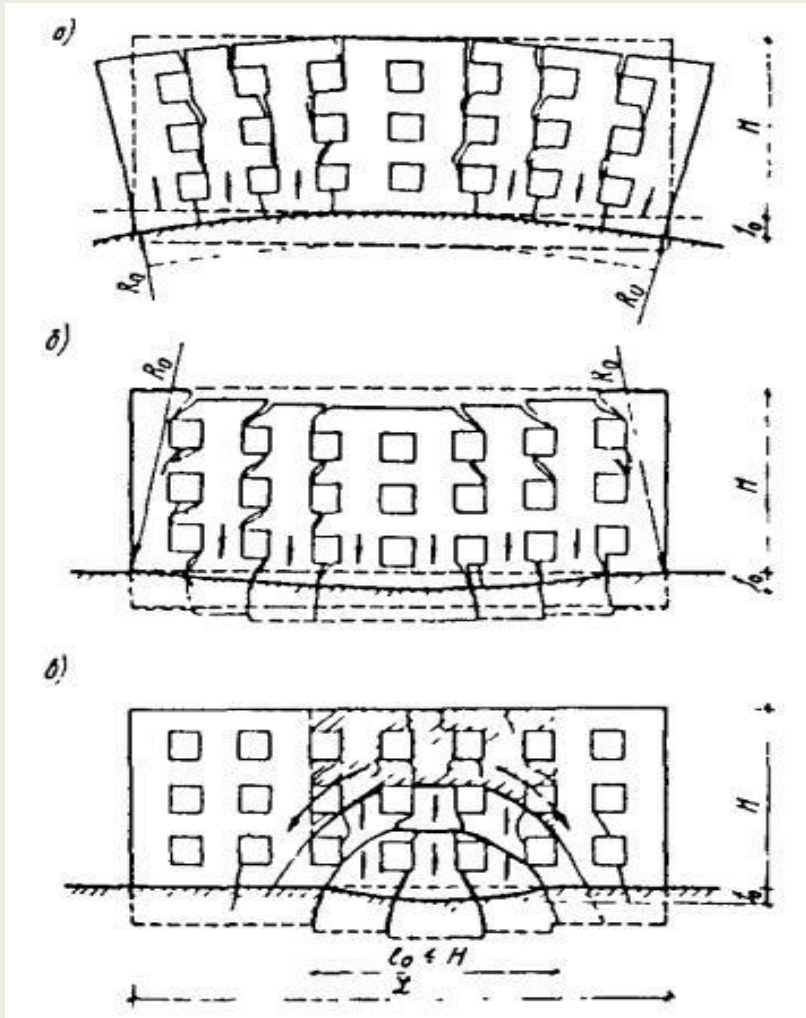
Classification of soils according to the relative deformation of subsidence

Types of soils	Relative subsidence deformation ε_{sl} , д.е.
Non-subsiding	$\varepsilon_{sl} < 0,01$
Weakly-subsiding	$0,01 \leq \varepsilon_{sl} \leq 0,03$
Moderately-subsiding	$0,03 < \varepsilon_{sl} \leq 0,07$
Highly subsiding	$0,07 < \varepsilon_{sl} \leq 0,12$
Extremely subsiding	$\varepsilon_{sl} > 0,12$

TYPES OF SOIL CONDITIONS BY SUBSIDENCE

- Type I - subsidence is possible due to external load, and due to the soil's own weight, it is absent or does not exceed 5 cm.
- Type II - subsidence of the soil's own weight exceeds 5 cm.

SUBSIDENCE



Deformations and development of cracks in the walls of buildings with different forms of soil subsidence:

a - along the edges of the building;

b - along the entire length of the building with a maximum in the middle;

c - partial subsidence of the soil on the length l_0 , the shorter length and height of the building



Destruction of the foundation during the subsidence of the underlying loess strata

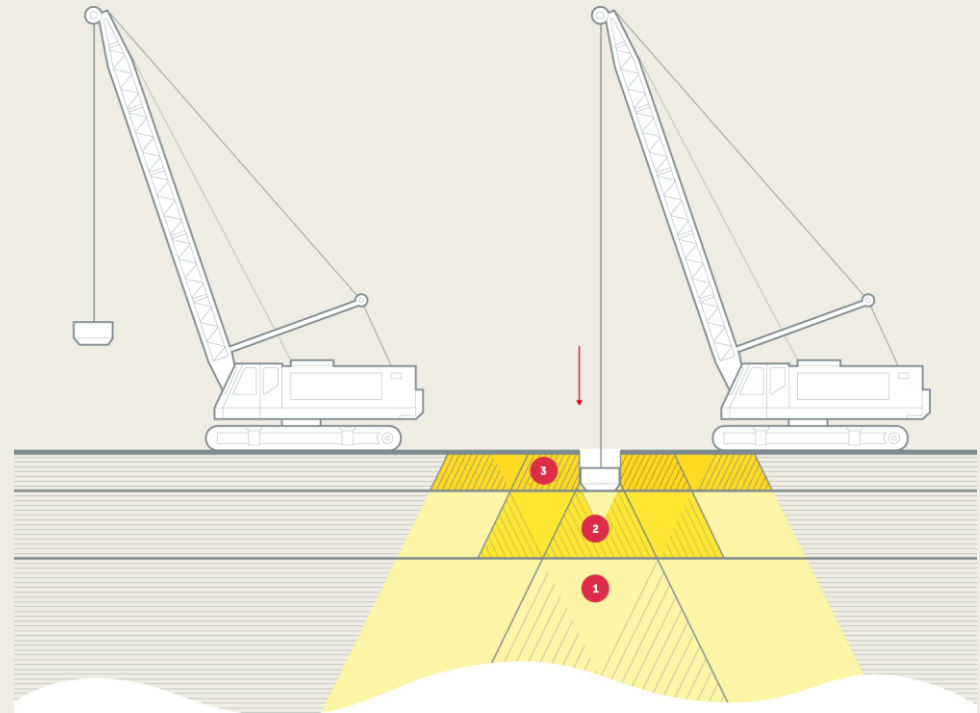
Destruction of the school building as a result of subsidence of the loess layer in the middle of the building



SURFACE COMPACTION



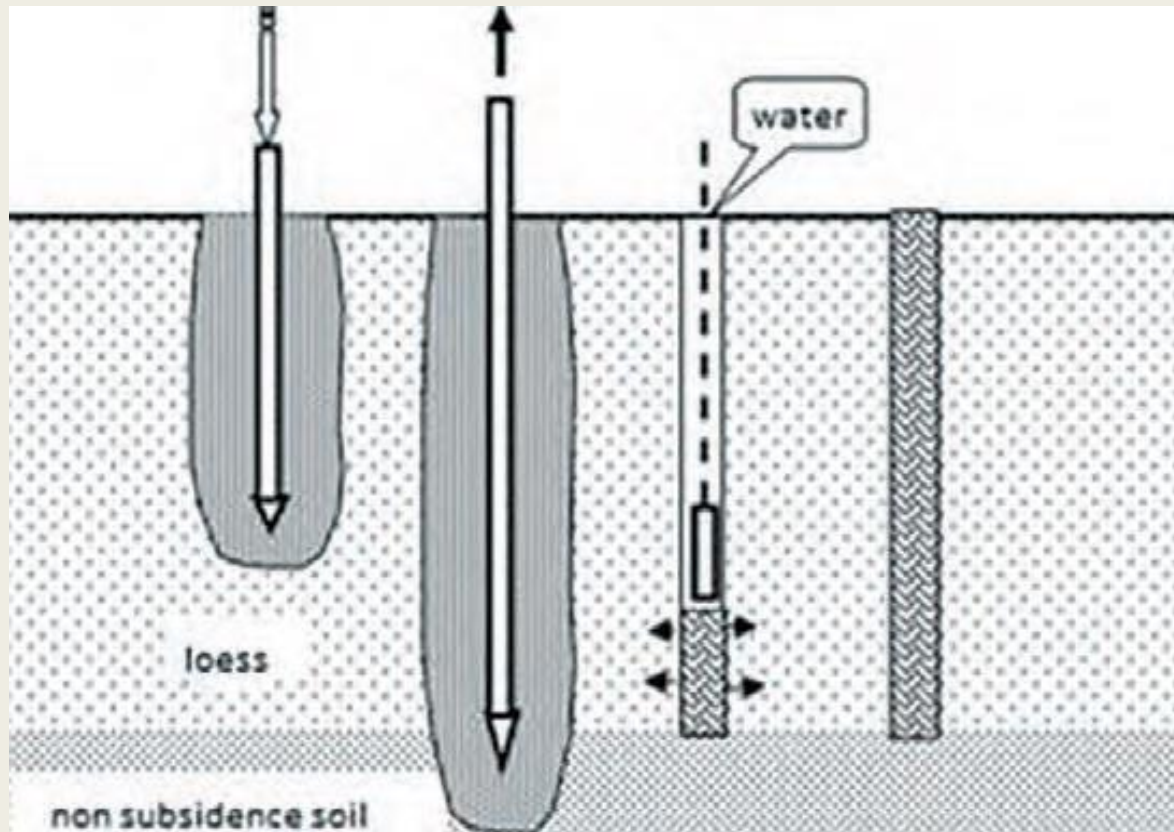
Compaction of subsidence soil with a hand vibrating compactor



Surface compaction of subsiding soils with heavy tampers.

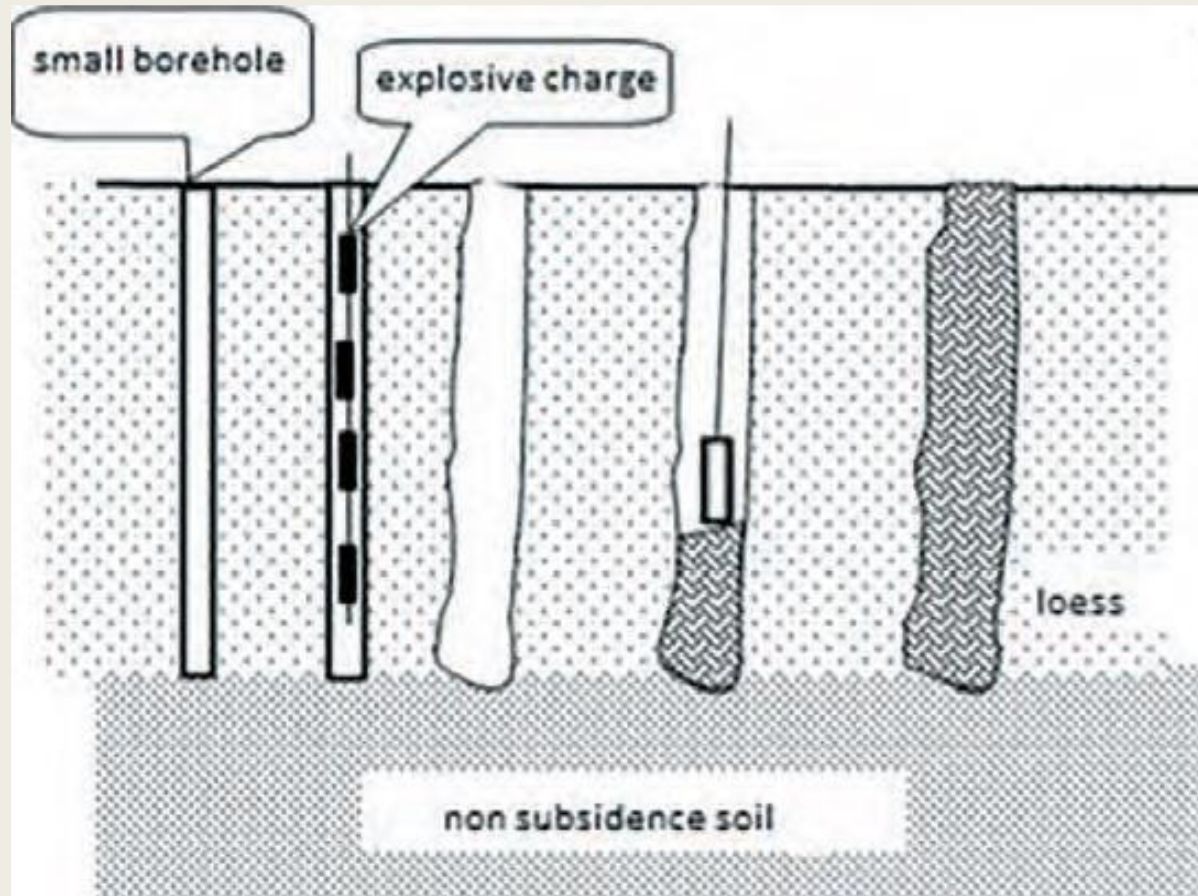
Legend: **1** – tamping with maximum impact energy on a given grid; **2** – tamping with lower impact energy on the grid between the primary grid; **3** – levelling, performed after the ramming of the site

SOIL PILES



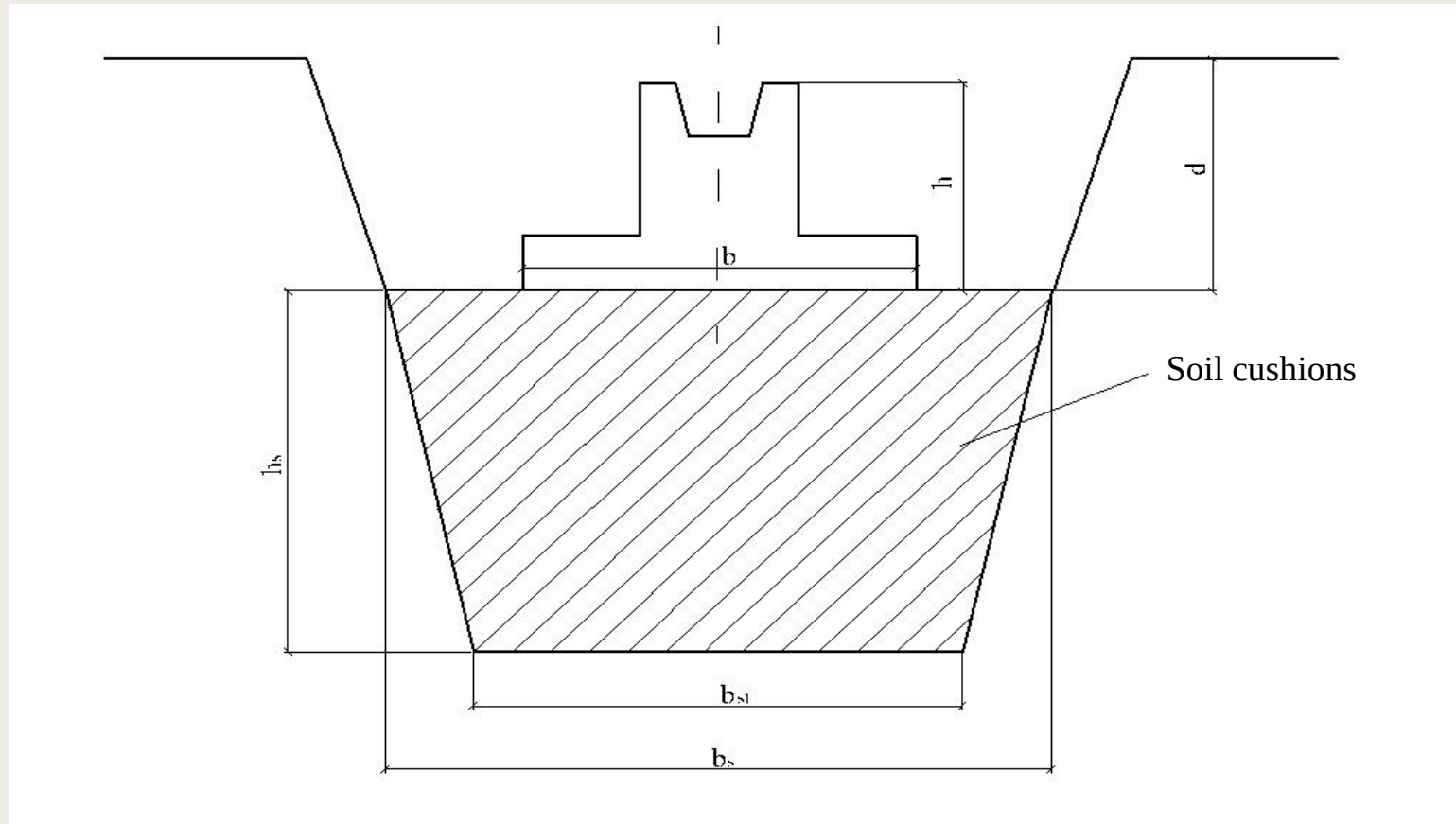
Technological sequence of creating soil piles in the loess base

COMPACTION OF THE LOESS BASE USING EXPLOSIVES



Implementation of soil piles for compaction of the loess base using explosives

SOIL CUSHIONS



SILICATIZATION



Odessa Opera House, built on loess soils, fortified with silicatization

CUTTING THROUGH SUBSIDENCE SOIL WITH PILES

Piles based on the bearing capacity of the base soils in subsidence soils should be calculated from the condition :

$$N \leq \left(\frac{F_d}{\gamma_k} \right) - \gamma_c \cdot P_n$$

where N is the calculated load, kN, on one pile;

F_d is the calculated bearing capacity of the soil of the foundation of a single pile,

γ_k - reliability factor (1.4 is assumed if the bearing capacity of the pile F_d is determined by calculation);

γ_c is the coefficient of working conditions, which depends on the subsidence of the soil:

at $S_{sl} = 5 \text{ cm}$ — $\gamma_c = 0$, at $S_{sl} \geq 2 S_u$ — $\gamma_c = 0.8$ for intermediate values S_{sl} — γ_c is determined by interpolation;

P_n — additional frictional force.

$$P_n = u \sum_0^{h_{sl}} \tau_i \cdot h_i$$

$$\tau_i = \xi \sigma_{zg,i} \operatorname{tg} \varphi_i + c_i$$

u — pile perimeter, m;

h_{sl} — calculated depth, m, within which summation of the forces of lateral friction of the subsiding soil layers is performed, which is equal to the depth of the sole of the subsiding layer of the soil under the action of its own weight;

τ_i — estimated soil resistance, kPa,