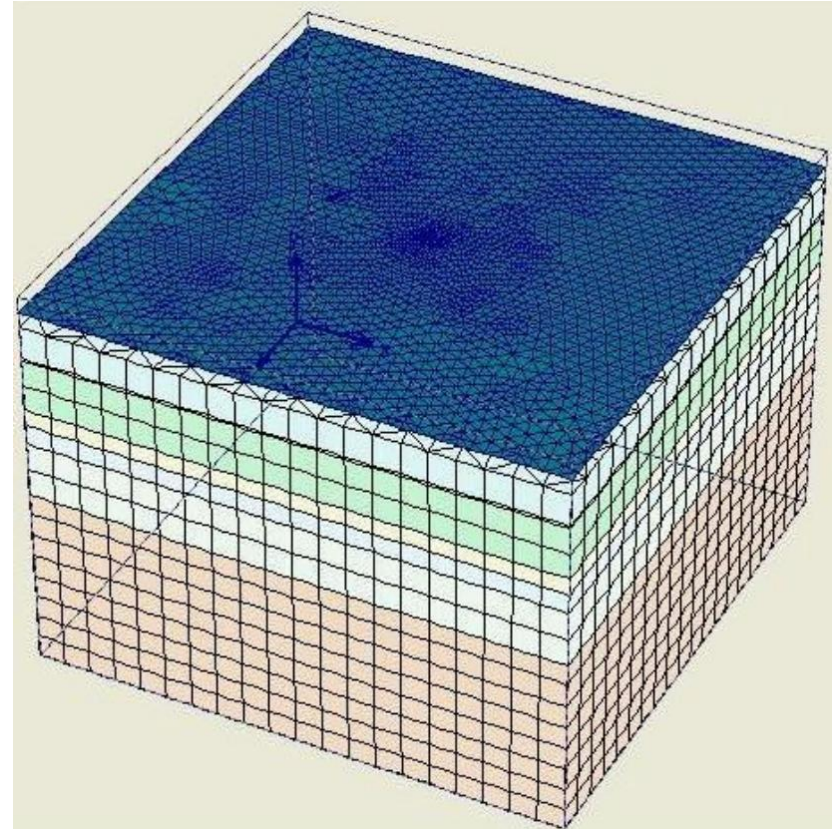
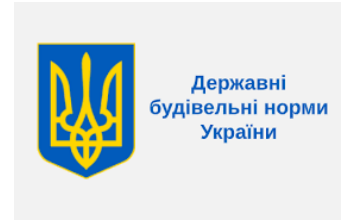


Topic 3. Selection of a Soil Base Model



Criteria for choosing a design model of the soil base



According to DBN B.1.2-14:2018:

- The calculation of structures should reflect as reliably as possible the actual operating conditions of the object and its stress-strain state by taking into account the relevant design situations.

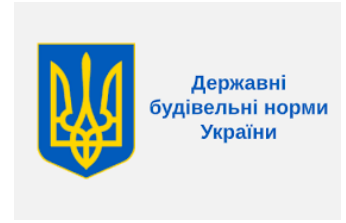
The calculation is carried out on the basis of the design model, which should take into account the factors that have a significant impact on the stress and deformed state of structures. When forming a design model, as a rule, it is advisable to take into account nonlinear effects (geometric and physical nonlinearity of elements and the system as a whole, the influence of structural deformations on changing the values of loads acting on it)

Requirements and recommendations for the choice of design models are established in the design standards and in the norms regulating loads and impacts. Building codes can also determine possible design solutions that ensure the implementation of certain design prerequisites.

Structures for which the design standards do not establish mandatory requirements for the use of nonlinear design models are calculated under the assumption of the linear dependence of load effects on the parameters in proportion to which the load value changes. At the same time, checking the bearing capacity of the cross-sections of the elements can be carried out taking into account the nonlinear properties of the material.

Calculations can be performed on the basis of experimental data. In this case, the conditions of the experiment must correspond to the operating conditions of the structure, and the conditions that cannot be simulated must be taken into account using additional reliability factors.

Criteria for choosing a design model of the soil base



Also according to DBN B.1.2-14:2018:

- For objects of the CC3 class of consequences (liability), it is necessary to perform calculations of load-bearing structures twice — using different design schemes and different computer programs. The run-up of the results of such calculations by the main factors (efforts in the elements of the category of responsibility A, periods of intrinsic fluctuations in the first three forms, coefficients of the safety margin) should not exceed 10 %."

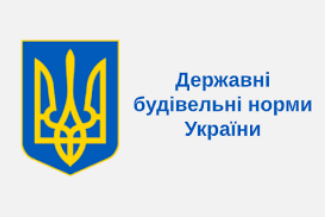
When designing buildings and structures of the class of consequences (liability) CC3 and CC2 in territories with special conditions and soils with special properties at their basis, the provisions of DBN A. should be observed. 2.1-1, DBN V.1.1-12, DBN V.1.1-24, DBN V.1.1-25, DBN V.1.1-45, DBN V.1.1-46, DBN V.1.2-6, DBN V.1.2-12, DBN V.2.1-10, DBN V.2.2-15, DBN V.2.2-24, DBN V.2.4-3, DSTU-N B V.1.1-39, DSTU-N B V.1.1-40, DSTU-N B V.1.1-41, DSTU-N B V.1.1-42, DSTU-N B V.1.1-44 and perform detailed calculation according to the spatial model and scientific support in accordance with DBN V.1.2-5-2007.

It is necessary to distinguish between cases when structures, their elements, assemblies, etc., for which the requirements are established by the relevant building codes, and cases that are not covered by building codes.

For the first group of cases, the restrictions established by the relevant building codes should be observed. (Paragraph 6.1.10 added, Amendment No. 1) 6.1.11

For the second group of cases, strength testing is performed by comparing the stresses obtained by the finite element method in the linear formulation of the problem with the design resistance of the corresponding material. For isotropic materials in a flat or spatial stressed state, it is recommended to use stresses according to the Mises criterion. Other inspections are carried out within the framework of scientific and technical support in accordance with DBN B.1.2-5.

Criteria for choosing a design model of the soil base



Calculation situations should also be taken into account, in particular:

The requirements of design standards must take into account the conditions in which the boundary state is realized.

For this, characteristic situations are established, which are called calculated and are determined:

- design scheme;

- a list of boundary states that should be considered;

- types of actions that can be implemented in a given calculation situation;

- the value of the allowable probability of failure.

When calculating structures, the following types of design situations should be considered:

- established, for which the typical duration of Tsit implementation is comparable to the established service life of the Tef object (for example, the period of operation between two overhauls or changes in the technological process);

- transitional, which are characterized by the duration of Tsit implementation less than the estimated service life of Tsit (the period of construction of the object, overhaul, reconstruction);

- emergency, which are characterized by a low probability of Psit and a short duration of Tsit implementation $\ll T_{ef}$, but which will lead to possible failures that are significant in terms of consequences.

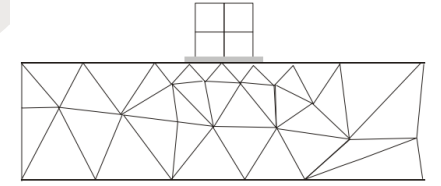
And also, some logical limitations:

In most cases, the designer has a general-purpose product in his hands that allows the calculation to be carried out in a linear-elastic installation.

When conducting engineering and geological surveys, there are inaccuracies in determining the characteristics of the foundation, which makes it impossible to perform accurate nonlinear calculations based on inaccurate data.

In the process of construction and subsequent operation of the building, the properties of the base soils may change.

Soil Base Modeling



SCAD Office provides an opportunity to ensure that the joint operation of the ground part of the structure with the soil mass is taken into account, forming a common finite-element model. In this analysis model, soil can be described by flat or volumetric finite soil elements. This approach to solving the problem is the most general, and the result of its solution is the closest to reality. It should be borne in mind that the soil mass is a non-linearly deformable medium consisting of layers with different properties. It should also be taken into account that the dimensions of the considered soil mass should be such that the nature of the boundary conditions in the zone limiting this array does not have a significant impact on the stress-strain state of the entire model. The need to take into account these factors leads to a significant increase in the volume of calculations, which can be at the limit of capabilities even in modern computers. The large size of the problem and its nonlinearity greatly increase the time for its solution.

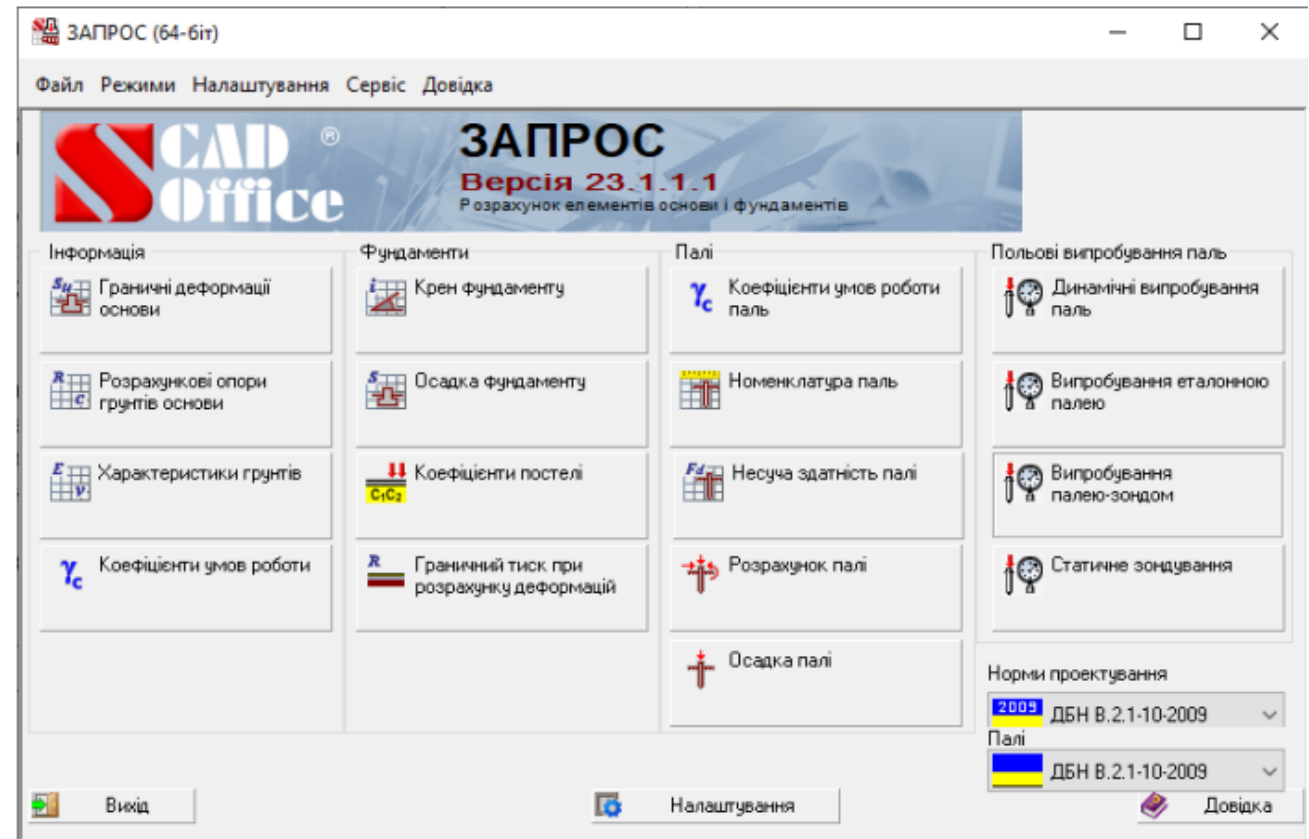
In this regard, the calculation models of the soil base are still relevant, which provide the correct connection between the methods of soil mechanics and the methods of structural mechanics and allow you to replace a large soil mass with a limited number of parameters reflecting its properties. The possibility of such a replacement is provided by the model of linearly elastic half-space, which is used in the calculation of the subsidence of the base, as well as the models of the base proposed by Winkler and Pasternak.

In the Winkler model, the distributive properties of the soil are described using the bed coefficient C_1 , which reflects the compression work of the soil and correlates the vertical resistance of the soil with the subsidence of the base under the foundation sole.

Pasternak's model is based on two independent bed coefficients, one of which is the compression coefficient C_1 (analogous to the Winkler bed coefficient) and the other is the C_2 shear coefficient, which relates the intensity of vertical shear resulting from internal friction between soil particles to soil subsidence under the foundation sole.

Program REQUEST

- The program implements the modes of calculation of foundations by deformations of rectangular foundations, determination of the slope of foundations of this type, calculation of bed coefficients and maximum pressure in the calculation of deformations (design resistance of the foundation soil).



Program REQUEST

The calculation and information functions implemented in the program are combined into groups in the following sections:

Foundations

Piles

Field tests of piles, Information.

- In the Foundations section, the following operations are performed: determination of the rectangular roll in the plan of the foundation from the loads acting on it; calculation of the base by deformations of rectangular columnar and strip foundations, as well as rigid slabs; determination of the stiffness coefficients of the substrate, which consists of a finite number of layers, each of which is linearly deformed and constant in thickness; calculation of the limit under the sole of the foundation (calculated soil resistance).
- The Piles section includes two information modes – Coefficients of pile operating conditions and Nomenclature of piles, as well as the following design modes: determination of the bearing capacity of the pile that works for vertical load; determination of the coefficient of the stability margin of the warp, the minimum and maximum bending moment and the transverse force in the cross-section of the pile, as well as a number of other characteristics of the pile; determination of the subsidence of a pile that works for a vertical load.

ЗАПРОС (64-6it) - Осадка фундамента

Файл Режими Налаштування Сервіс Довідка

Загальні дані Навантаження на підлогу Грунти Результати

Перевірка для рівня підлоги задовільняється

Розрахунковий опір ґрунту в рівні підлоги фундаменту	9,306	T/m ²
Середній тиск від навантажень (включаючи вагу тіла фундаменту, ґрунту і підлоги) в рівні підлоги фундаменту	0	T/m ²

Осадка визначена для основи у вигляді пружного напівпростору

Осадка основи	61,401	мм
Просадка від навантаження	0	мм
Просадка від ваги ґрунту	0	мм
Сума осадки і просадки	61,401	мм
Глибина стисливої товщі	0	м
Вінклерівський коефіцієнт постелі	0	T/m ³

ЗАПРОС (64-6it) - Граничний тиск при розрахунку деформацій

Файл Режими Налаштування Сервіс Довідка

Загальні дані

Розрахункові характеристики ґрунту

☐ Прийняті за таблицями ДБН

☒ Визначено безпосередніми випробуваннями

Фундамент

Ширина підлоги фундаменту b 1,3 м

Глибина залягання фундаменту від рівня планування d_f 1,5 м

Характеристики ґрунту

Розрахункове значення питомого зчеплення ґрунту, що залягає безпосередньо під підлогою фундаменту c_u 2,243 T/m²

Кут внутрішнього тертя ϕ_u 22 град

Товщина шару ґрунту вище підлоги фундаменту зі сторони підвалу h_s 0 м

Осереднене розрахункове значення питомої ваги ґрунту, що залягають нижче підлоги фундаменту γ_u 1,77 T/m³

Осереднене розрахункове значення питомої ваги ґрунту, що залягають вище підлоги фундаменту γ'_u 1,69 T/m³

Коефіцієнти умов роботи

γ_{c1} 1,25 γ_{c2} 1,1

☐ Підвал

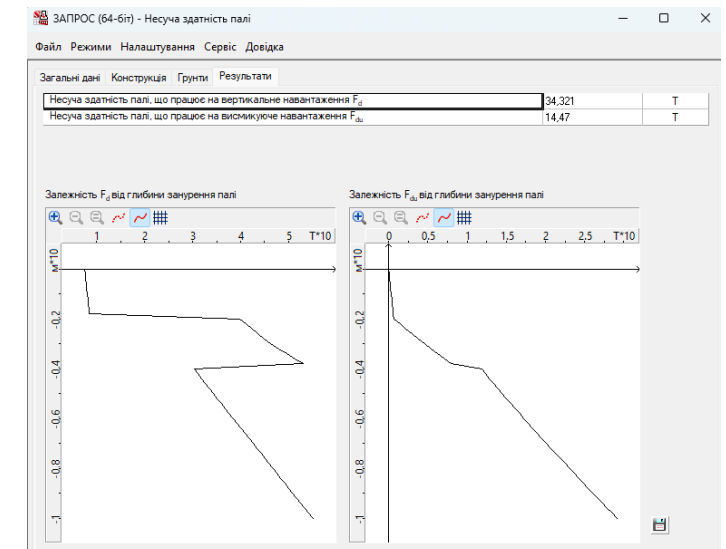
Глибина підвалу h_d 0 м

Товщина конструкції підлоги підвалу h_{cd} 0 м

Розрахункове значення питомої ваги конструкції підлоги підвалу γ_{cd} 0 T/m³

Результат

Розрахунковий опір ґрунту основи R 32,545 T/m²



Program REQUEST

The calculation and information functions implemented in the program are combined into groups in the following sections:

Foundations

Piles

Field tests of piles, Information.

- The section Field tests of piles contains a calculation for determining the bearing capacity of piles based on the results of their dynamic tests; determination of the bearing capacity of a driven (full-scale) hanging pile operating for a compressive load, based on the results of soil tests with a reference pile; determination of the bearing capacity of a driven (full-scale) hanging pile that works for a compressive load, based on the results of soil tests with a probe pile; determination of the bearing capacity of a driven (full-scale) hanging pile operating under compressive load, based on the results of soil tests by static sensing.
- Reference modes provide revision of the limit values of the relative difference of subsidence, roll and average or maximum subsidence for structures of various types; provide information about: design supports of soils of various types, given in regulatory documents; soil characteristics given in the DBN, as well as coefficients of working conditions.

ЗАПРОС (64-bit) - Статичне зондування

Файл Режим Налаштування Сервіс Довідка

Загальні дані

Глибина зондування нижнього кінця натрної палі: 5 м

Тип зонду: I - зона з наконечником із конуса і ковзка

Коефіцієнт умов роботи палі в ґрунті γ_c : 1

Число точок зондування: 1

Грунт по боковій поверхні палі: піщаний ґрунт

Обчислити всі окремі значення

Переріз натрної палі

D: 400 мм

Діаграма: Круг з діаметром D та висотою L.

Меню Обчислити Звіт Довідка

ЗАПРОС (64-bit) - Граничні деформації основи

Файл Режим Налаштування Сервіс Довідка

Граничні деформації основи

Споруди	Відносна різниця осідань (D_s/L)	Крен	Середнє (в ділянках максимальної осідання, см)
те саме, збірної конструкції	-	0,004	30
окремо розташований силосний корпус монолітної конструкції	-	0,004	40
те саме, збірної конструкції	-	0,004	30
окремо розташований робочий будинок	-	0,004	25
5. Динамі завантаження Н, кН			
$N \leq 100$	-	0,005	40
$100 < N \leq 200$	-	$1/(2H)$	30
$200 < N \leq 300$	-	$1/(2H)$	20
$N > 300$	-	$1/(2H)$	10
6. Жорсткі споруди завантаження до 100 кН, крім зазначеного у поз. 4 і 5	-	0,004	20
7. Антени споруди зв'язки:			
стовбур шогі заземлені	-	0,002	20
те саме, електрично ізольовані	-	0,001	10
вежі радіо	0,002	-	-
вежі короткохвильових радіостанцій	0,0025	-	-
вежі (окремі блоки)	0,001	-	-
8. Площі постійних дій електротехніки			

Примітки:

1. Граничні значення відносного прогину будинків, зазначених у поз. 3, приймають $0.5(D_s/L)$, а відносного вигину — $0.25(D_s/L)$.
2. При визначенні відносної різниці осідань (D_s/L) у поз. 8 за L приймають відстань між осями блоків фундаментів у напрямку горизонтальних навантажень, а в опорах з відтяжками — відстань між осями списнутого фундаменту й анкера.
3. Якщо основа складена горизонтальними (з ухилом не більше 0,1), витриманими по товщині шарами ґрунту, граничні значення максимальних і середніх осідань допускається збільшувати на 20 %.
4. Граничні значення підйому основи, складеної набухаючими ґрунтами, допускається приймати: максимальний і середній підйом у розмірі 25 % і відносну різницю осідань у розмірі 50 % відповідних граничних значень деформацій.

Меню 2003 Довідка

CROSS Program

The CROSS program is designed to determine the coefficients of bedding for the calculation of foundation structures on an elastic winkler base based on modeling the work of a multilayer soil mass. The geological structure of the soil mass is assumed to be arbitrary and is restored according to engineering and geological explorations.

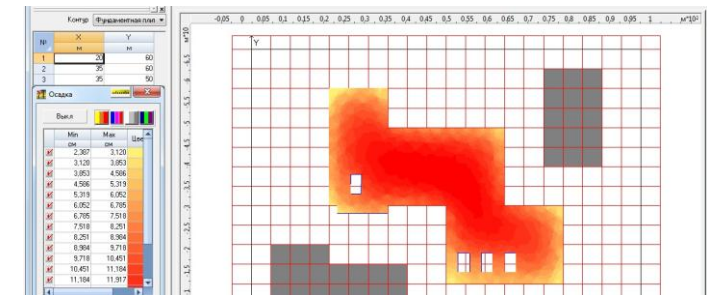
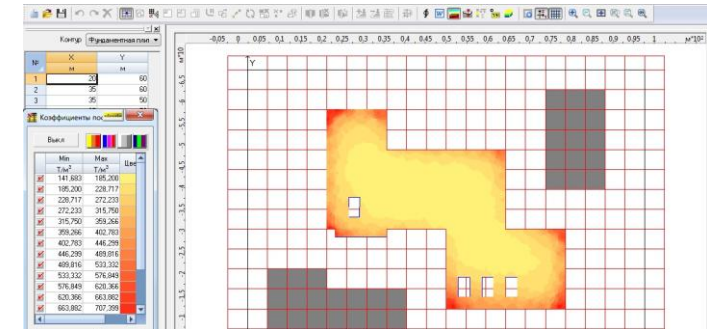
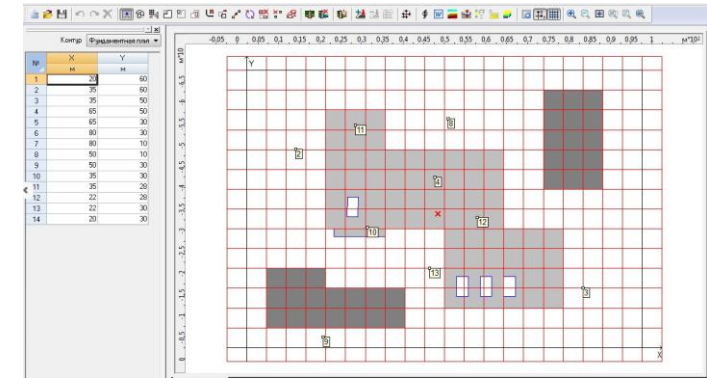
The model takes into account the fact that the soil does not react in the same way at all points, and its modulus of deformation increases with increasing depth and load. Thus, it allows you to describe the realistic operation of foundations in a heterogeneous environment.

The construction site on which the designed structure is located and other objects (existing buildings, pits) that affect it are considered in the sense that the soil loads transferred by these objects can lead to subsidence of the designed foundation. In addition, it is believed that the results of geological exploration are known, which are presented in the form of information on the characteristics of the soil in drilled wells.

Graphical interactive tools provide the formation of arbitrary configurations of buildings at the construction site.

Information about the location of wells and soil characteristics allows you to build a section of the soil mass on the screen.

The result of the program is the values of the bed coefficients at any point on the base of the designed structure and transfer them to SCAD for iteration.



Creating a Foundation Slab Model

Forming a grid of finite elements on a plane

Automatic triangulation of a closed region of arbitrary shape on a plane is one of the most versatile ways to form a mesh of finite elements. The complex provides for the possibility of triangulation both when creating a new circuit and triangulation of a fragment of the finished circuit.

General provisions

The Generate Freeform Mesh on the Foundation Slab Model Plane operation is called from the Diagram section of the toolbar. Triangulation is controlled using the buttons that are combined in the toolbar of the task window and appear after the initiation of triangulation.



To triangulate a given area, you need to perform operations in the following sequence:

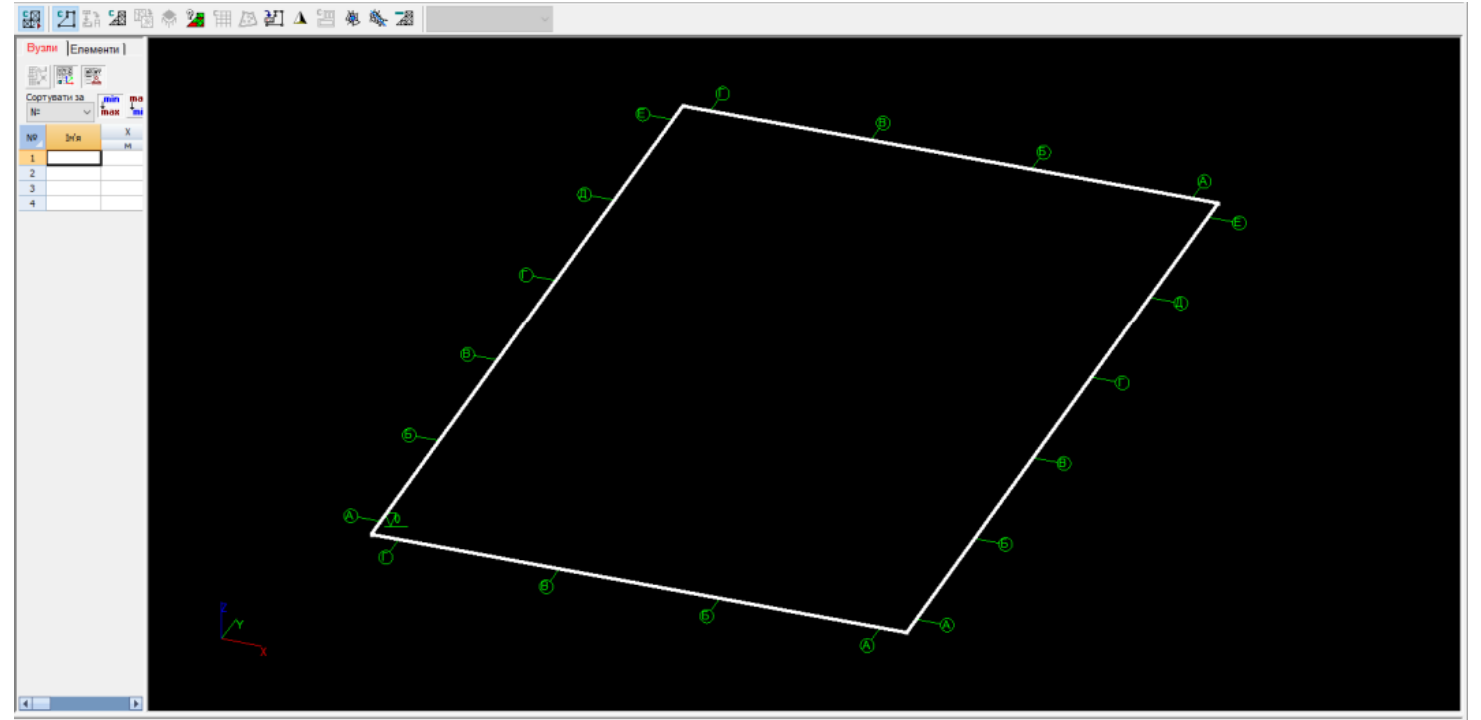
press the Set Path button and circle the reference nodes of the outer contour with a "rubber thread" ("reference" means nodes lying at the corner points of the contour);

- repeat the previous operation for all internal circuits;
- click the Generate Triangular Grid FE button on the plane and assign triangulation parameters in the Automatic Triangulation dialog box;
- after exiting the dialog box, pressing OK splits the specified area into finite elements of three and/or four nodes;
- set the area in place in the circuit by pressing the appropriate button, and/or write it as a subcircuit.

Once the triangulation area is split, the path is not reset and you can reassign the new triangulation parameters, and so on until you get a satisfactory result. The outline will only be reset after the area has been placed in place on the diagram and/or written as a subcircuit.

Forming a grid of finite elements on a plane

Before starting triangulation, it is necessary to define the contour that delimits the triangulation area. The contour is defined using a closed polyline passing through pre-inserted support nodes. In addition, elements that lie on the border of the triangulation region can be used as a contour. If the triangulation region contains internal regions in which triangulation is not performed (for example, holes), then each of these regions must be defined using "its own" contour.



Triangulation options

Before triangulation is carried out, the triangulation method is selected in the "Automatic Triangulation" window, parameters are set, and (if necessary) the characteristics of the stiffness of the finite elements are set (the "Rigidity" button is used).

According to the chosen technique, triangulation can be performed:

A – Only on specified nodes – new nodes are not formed, triangulation is performed in such a way that only existing nodes on the loop and in the triangulation area participate in it;

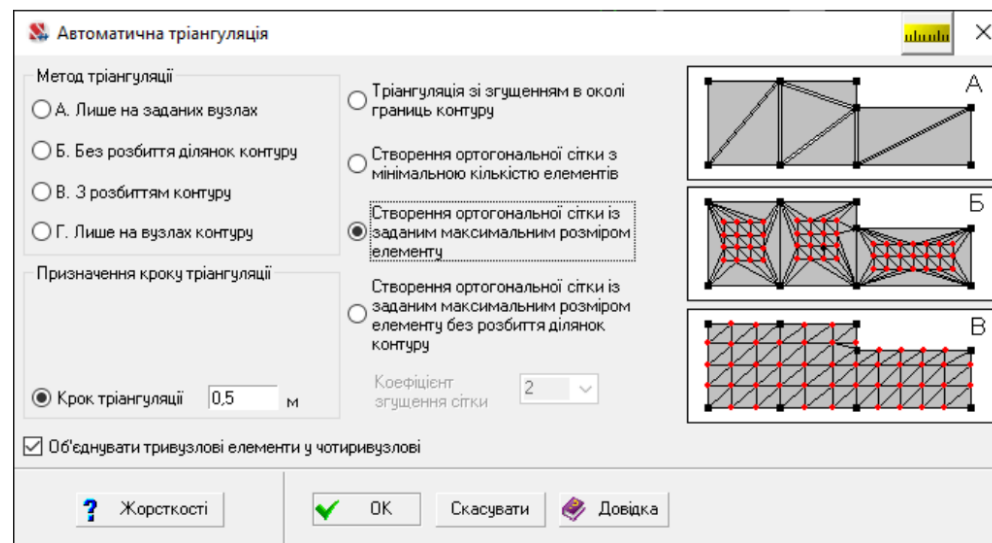
B - no polygon partitioning - the triangulation region is divided into finite elements with a given maximum edge size (triangulation step), but no additional nodes are introduced in the sections of the contour;

B – With a contour stem – the triangulation area and the contour are divided according to a given step;

D - Polygonal nodes only - Finite elements are mesh only on polygonal nodes, nodes in the triangulation region are not used in the mesh (even if they fall in the region).

If the Automatic Triangulation dialog box is configured to combine three-node elements into four-node elements, then during the schema generation process, such a combination will be performed for all valid pairs of triangles.

Additionally, you can establish the features of the mesh formation.



When entering the circuit, the following rules should be observed:

- when entering a section of the contour, you can lower the nodes that lie on the line connecting the support nodes. They will be entered into the circuit automatically. The exception is triangulation "only by circuit nodes", which takes into account only support nodes;

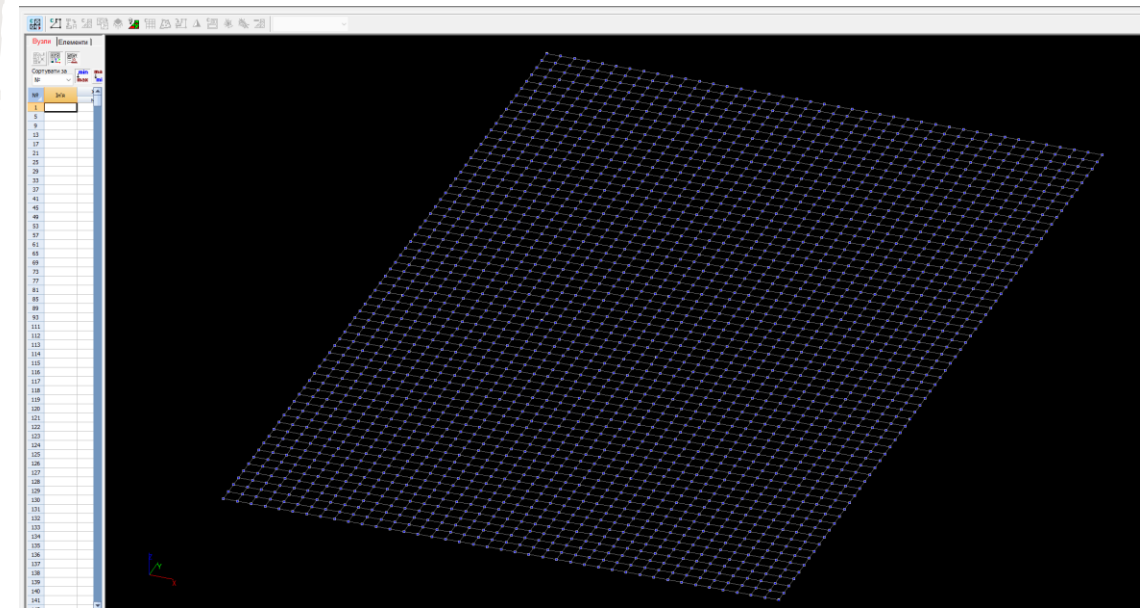
- the circuit is closed by double-clicking after entering the last node or pointing to the first node;

- the presence of matching nodes, both supporting and intermediate, is not allowed. Hereinafter, "matching" will be understood as nodes that have the same coordinates or are separated from each other by a distance that is less than or equal to the value of the accuracy of estimating the matching nodes. This value is set in the "Settings of Environment Settings" dialog box, which can be accessed from the "Options" section of the menu of the same name;

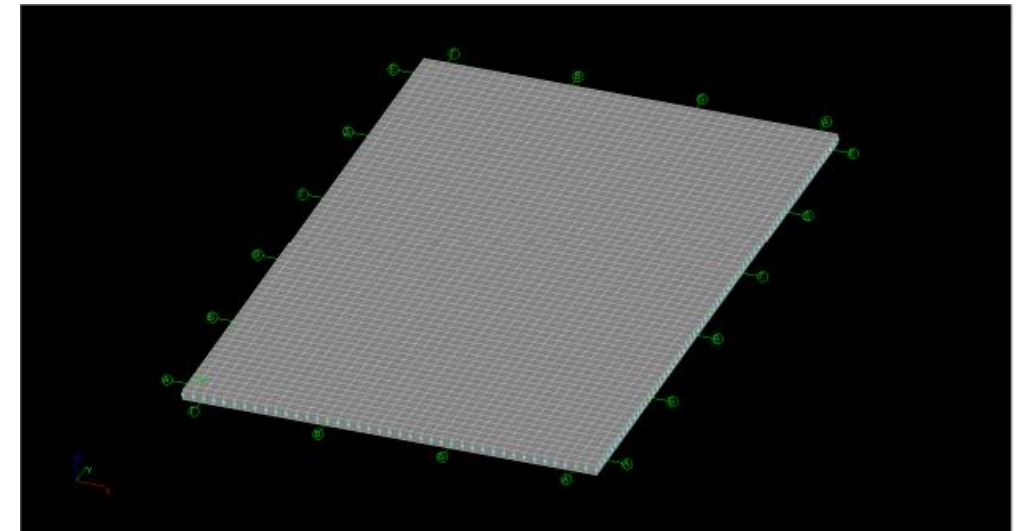
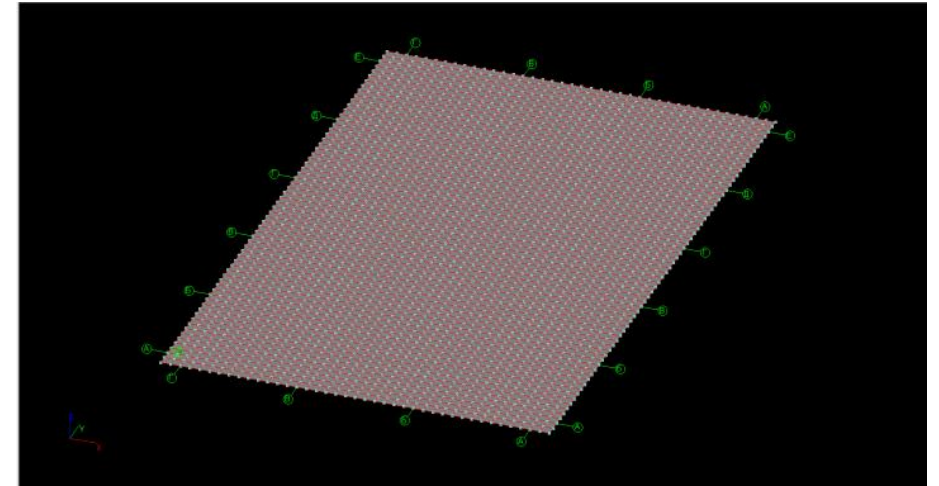
- it is not allowed that matching nodes get inside the chain;
- it is not allowed to have nodes inside the circuit (including those belonging to other circuits) lying from the circuit at a distance of less than 0.15 from the specified triangulation step. The presence of such nodes leads to the interruption of the triangulation process due to the appearance of degenerate triangles;

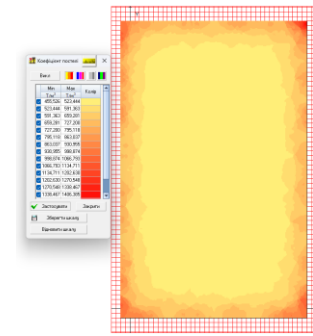
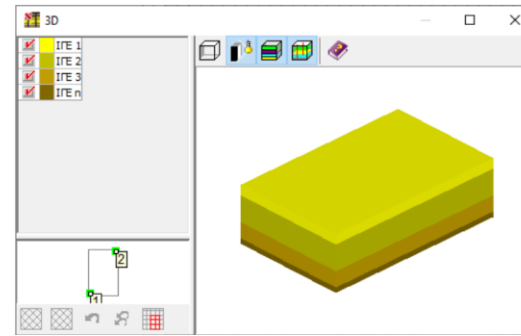
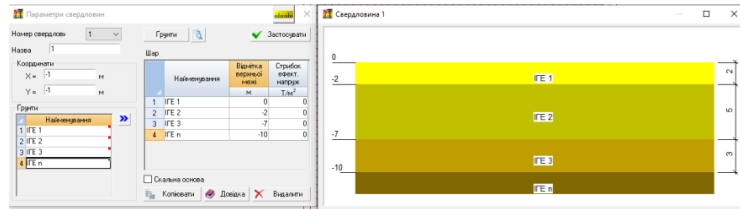
- internal contours should not intersect or touch each other;

- the presence of contours lying outside the contour, limiting the triangulation zone, is not allowed.



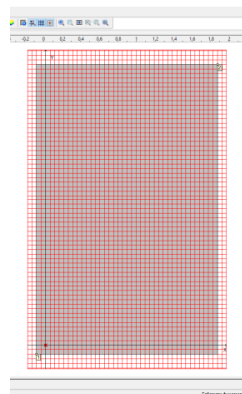
- The created contour must be assigned a rigidity that will correspond to the rigidity of the foundation slab for the first iteration.
- In the Plate Stiffeners dialog box, you must assign the slab stiffness settings and assign a name to it.
- Select all created plate finite elements with a rectangle and press the confirm button.
- For the created foundation slab, you can assign preliminary reinforcement using the tool "Setting the reinforcement scheme..." on the "Assignment" tab.
- Select all finite elements of the created slab and press the confirm button to assign the specified reinforcement.
- The next step is to assign to the plate the previous coefficients of the elastic base, obtained from the results of the calculation in the REQUEST program. The assignment of the previous coefficients is necessary for the first iteration of the calculation
- The created foundation slab can be downloaded and transferred to the KROSS program to calculate the coefficients of the bed, taking into account their variability.





Наименование	Плотность Т/м³	Модуль деформации Т/м²	Модуль пружкости Т/м²	Коэффициент Пуассона	Коэффициент переувлажнения	Тиск переувлажнения Т/м²	Колр
1 IPE 1	1.85	2400	20000	0.3	1	0	
2 IPE 2	1.87	2600	21666.667	0.3	1	0	
3 IPE 3	1.90	2500	20633.333	0.35	1	0	
4 IPE n	1.92	3000	25000	0.4	1	0	

- In the CROSS program, the engineering and geological structure of the construction site is simulated and the coefficients of the bed are calculated, taking into account the load from the foundation slab and the actual layering of IHE on the construction site.
- The calculation is performed iteratively, by transferring the calculation data to SCAD, recalculating the stress-strain state taking into account the updated bed coefficients, recalculating the bed coefficients in the CROSS to a convergence $< 10\%$.



Formation of design schemes from volumetric elements

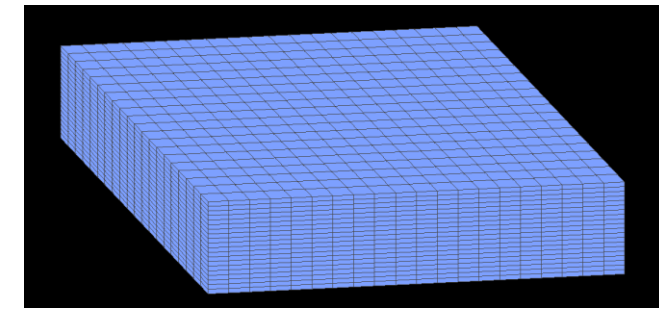
Creating volumetric elements can be performed both by directly entering volumetric elements at nodal points, and by using the "Copy Scheme" tool from plate elements.

To create a model of the soil base in the form of a volumetric soil massif, it is necessary to select the slab using the "Mark Elements" tool.

On the "Diagram" tab, select the "Copy Diagram" tool, and activate the "Copy the visible part of the diagram" mode from the drop-down menu.

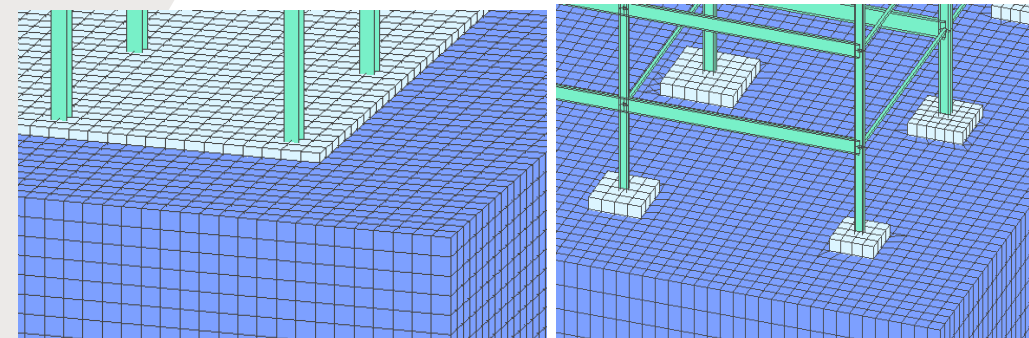
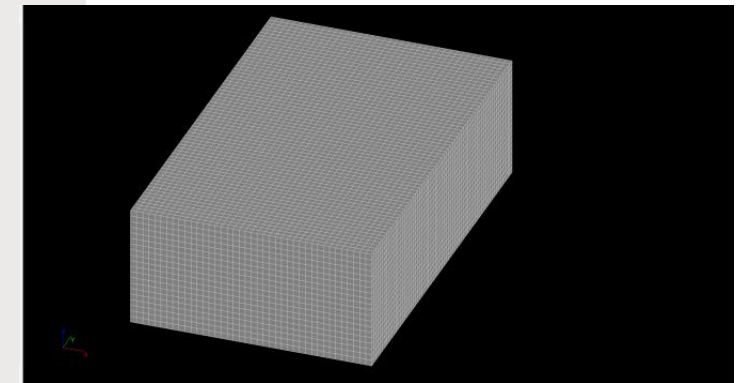
After configuring the copying parameters, a soil mass will be created with the binding of the nodes of the soil mass to the nodes of the previously created foundation slab.

When creating a volumetric soil mass for individual foundations, it is necessary to ensure the connection of the nodes of the foundation elements with the volumetric elements of the soil mass, for the correct calculation.



Копіювання схеми

Копіювання видимої частини схеми



Formation of design schemes from volumetric elements

For the created soil mass, it is necessary to assign the stiffness parameters: the power of the IGE, the volumetric weight, the modulus of elasticity and the Poisson's coefficient, we take from the engineering and geological arcs (similar to those assigned in the CROSS program).

Жорсткість об'ємних елементів

Ізотропія

Матеріал

Інші...

Об'ємна вага 1.85 Т/м³

Параметри

Модуль пружності 2400 Т/м²

Коефіцієнт Пуассона 0.3

Коеф. лінійного розширення 1.2e-005 1/°C

Параметр загасання (у частках від критичного) 0

Ім'я типу жорсткості

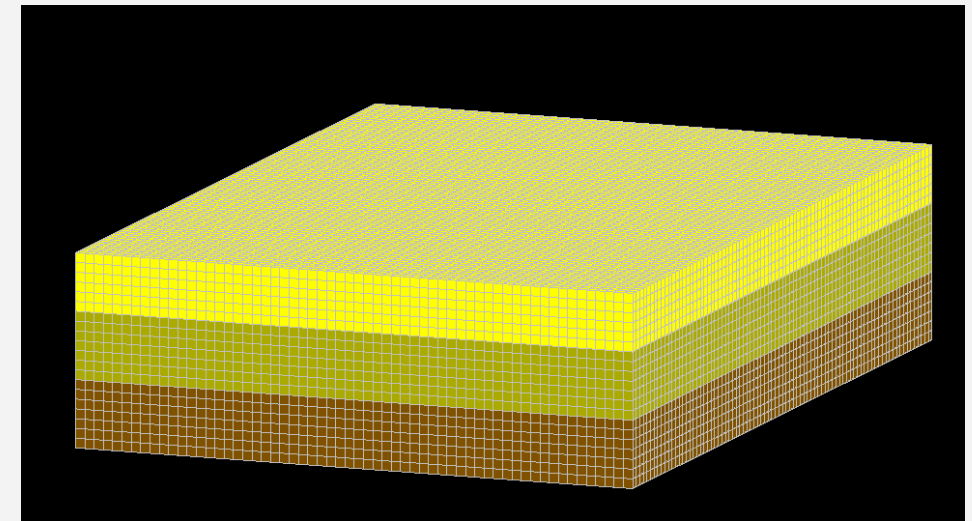
Грунт

☐ Використати опис як ім'я

Типи жорсткості

Модуль пружності	Ім'я типу жорсткості
7 2400 Т/м ²	Грунт

Замінити та вийти Замінити та продовжити OK Скасувати Довідка



Afterword

«... of all the mistakes that can be made during construction, the most dangerous are those made in the foundation, because they immediately cause the destruction of the entire structure, and it is extremely difficult to correct them."

Andrea Palladio (1508–1580)