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Research paper

Formation of Small-Volumetric Livestock Buildings on the Principles of Cooperation and Blocking

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Abstract

The features of livestock buildings functional organization and planning were investigated, the factors forming the building for different livestock maintenance were established. Proposals and recommendations for the design of small-volumetric cattle-breeding cooperative and blocked buildings have been developed. The formation of new types and the nomenclature of livestock cooperative buildings with various types of animals, the pattern of possibility such buildings cooperation and blocking was proposed. The possibility of model objects formation, based on the main optimization criterions was found theoretically. The buildings arrangement planning modelling and determination have become possible to computerize due to compound algorithms for calculation of small-volumetric cattle-breeding building, block-schemes and developed functional and technological blocks.

Keywords: *cattle-breeding small-volumetric cooperative buildings, planning methods, principles of cooperating and blocking, the algorithm of program composition, unification of volumetric-planning decision and modeling planning structure.*

1. Introduction

Cattle-breeding small-volumetric cooperated and blocked buildings are new types of buildings that have begun to spread recently [1]. The main feature of small-volumetric cattle-breeding buildings is their small capacity and small size. To ensure the effectiveness of their design decisions, several different functions (areas of specialization) such as cooperated or blocked should be combined. The design of such buildings requires the development and implementation of a methodology that considers their particularities and differences and promotes the acquisition of the most appropriate options.

2. Page layout

Cattle-breeding buildings and structures design should be based on general provisions of agricultural production, accurate calculations of the natural and economic characteristics of a particular farm and the prospects for its development [2]. Cattle husbandry is formed on the basis of factors combination (Fig. 1) and design decisions.

In practice, indicated above factors determine the type of cattle-breeding building. The design decision of buildings is dictated by technology, sanitary and veterinary requirements, environmental protection requirements, economic criteria and aesthetics. Planning should consider the technological requirements the utmost with the best economic indicators and buildings architectural treatment [3].

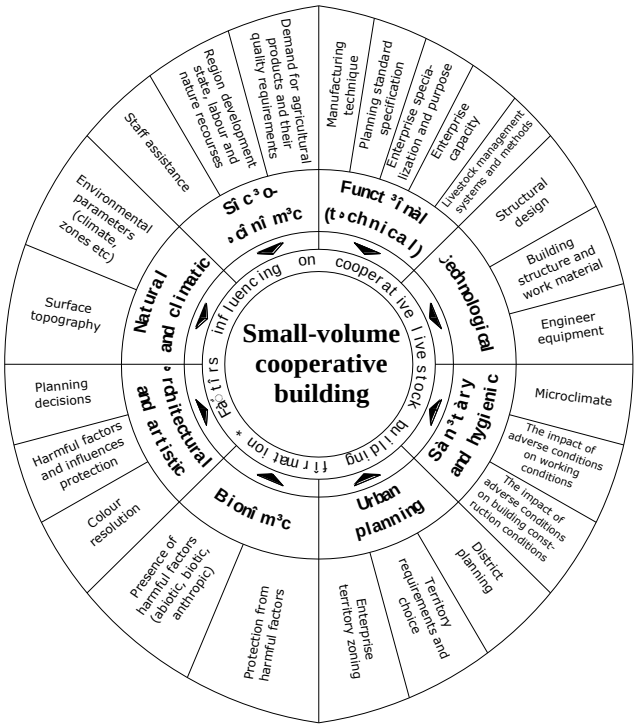


Fig. 1: Factors influencing on cooperative livestock building formation

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When developing layout draws for production zones of small agricultural enterprises and husbandry farms, it is necessary to provide for economically efficient the main agricultural buildings and structures cooperation and blocking on one land plot and organization of common facilities for service and maintenance purposes (Fig. 2).

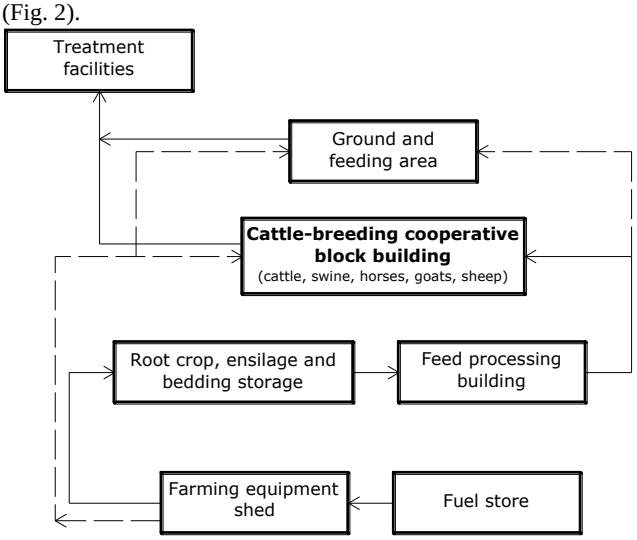


Fig. 2: Process scheme of farm production area functional links

The rational formation of cooperative buildings is in the both occupied area and the functional and technological links reduction to the technically possible minimum. Thus the following basic principles should be considered (Fig. 3): 1) the principle of functionality: the buildings of one purpose can be cooperated or blocked; herewith it is necessary to achieve the minimum possible functional and technological links; 2) compactness, when located closely buildings with the same space-planning decisions are blocked; in addition, it is necessary to achieve minimum compactness ratio (the ratio of the outer walls perimeter to the usable area); 3) zoning, when blocked buildings located in one functional zone can be separated into separate subzones; 4) considering the microclimate, when buildings with different cattle are combined, but with close parameters of the internal microclimate.

Therewith, the following principles are considered: blocking is possible on the basis of the identified blocking elements and due to the construction technological design or blocking is impossible due to constructive inexpediency, according to veterinary, fire and sanitary requirements. [4, 5, 8].

The cooperative building of the main purpose should be formed, considering the internal climate of the houses, necessary for the normal life of grouped cattle. For example, adult livestock can be kept with horses, since the basic regulatory parameters of the microclimate for these animals are in the same range of values [5, 11, 13].

There are two types of blocking: horizontal, when groups of buildings are grouped in a horizontal direction; vertical, when individual buildings are combined into one multi-storey building. For the short-term, the block-section type is the most rational among the horizontal types of blocking when the planning sections are cooperated by a flexible space-planning structure to create a blocked building.

The matrix of cattle-breeding buildings possible blocking and possible blocking of auxiliary premises was developed based on the above mentioned principals, considering zootechnical, sanitary, fire and technological requirements, and conducted experimental and theoretical studies (Fig. 4). Veterinary buildings can be blocked to each other, except for quarantine. The hospital and dispensary can be blocked to some of the main production buildings. Buildings or premises for veterinary purposes, combined in one block, as a rule, should have separate entrances, while the veterinary point can be blocked with any production building, with the exception of the milking room or milk storage room. The isolator, when it is blocked with other veterinary objects, should be fenced and have a separate entrance to its yard.

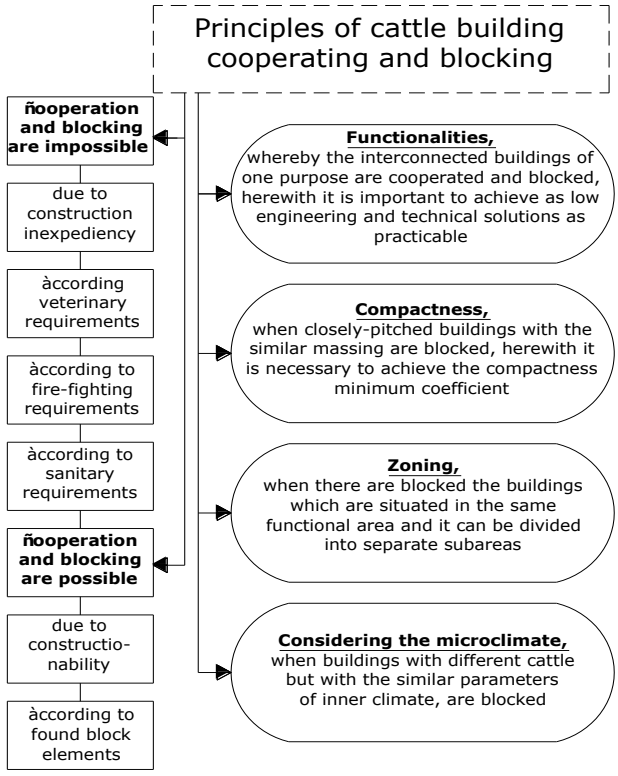


Fig. 3: Principles of cattle buildings cooperating and blocking

The second subgroup of service premises can be combined with, for example, the economic-energy unit (boiler room, maintenance point, agricultural equipment shed, disinfection facilities, transformer substation).

Premises for cattle artificial insemination can be cooperated with buildings of the main production purpose.

Most of the storage buildings and structures (root house, feedstuff store, sheds etc.) tend to be blocked with the feed room. When designing such a room, it is necessary to adhere to technological and fire safety requirements [5].

Objects of auxiliary purpose (administrative-economic, household premises, food, municipal services, etc.) can be blocked with the construction of the main production purpose. It is possible to block them with a dairy department, a maintenance point, a warm parking for tractors and cars, that is, with most service, storage and auxiliary buildings of the livestock enterprise. The choice of an option depends on the general layout, the terrain, architectural and building requirements, the position of the main entrance to the enterprise, etc. It is important to consider that the buildings architectural proposals should be organically combined with the overall composition of the enterprise, with its urban design features and the functional purpose of each building and structure individually and combined.

Cooperation and blocking of small-sized live-stock buildings of the main purpose (cowsheds, pigsties, stables, goat sheds, sheepfolds) and with auxiliary facilities (feed room, root house, service depot, agricultural machines shed etc.) have been considered for the first time. The capacities of livestock farms have been determined and unified nomenclature of cattle-breeding cooperative buildings has been proposed. The formation of new livestock cooperative buildings has been carried out based on analysis of state design standards, technological design norms (GSN and Departmental Norms of Production Engineering), design experience and construction. The design of a cooperative and blocked main production building should be carried out on the basis of the proposed typology of cooperated buildings (Fig. 5).

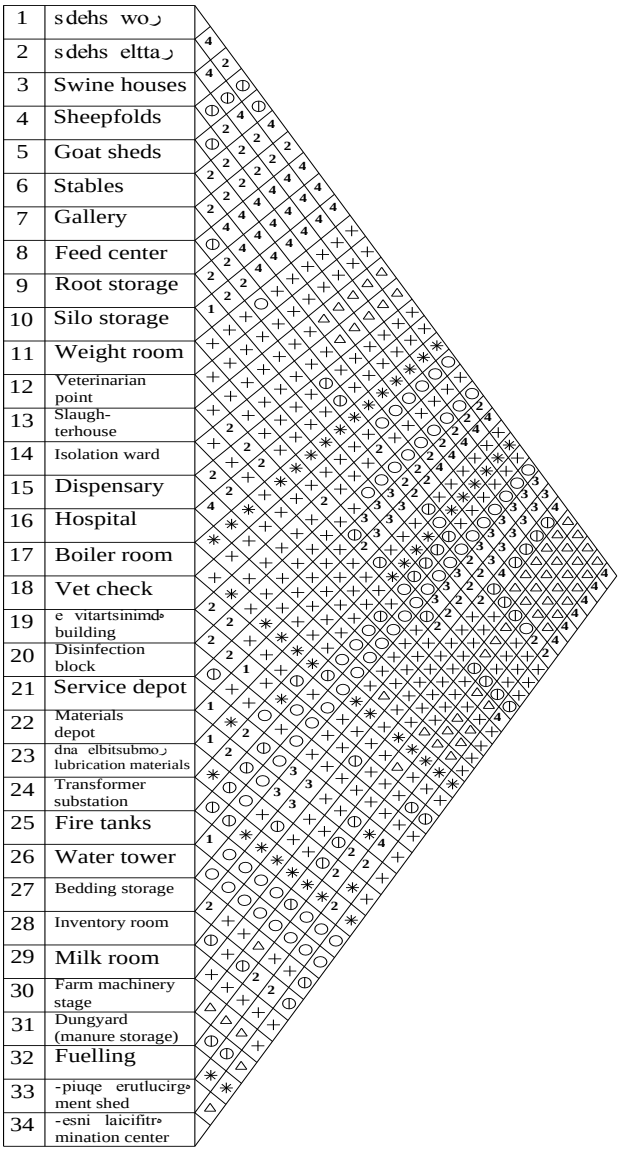


Fig. 4: Principles of cooperation and blocking of buildings and structures matrix:

1 – blocking is possible according to constructionability; 2 – the same on the basis of the detected blocking elements; 3 – cooperation is possible on the basis of zoning; 4 – the same for functional and technological expediency; O, Ø – blocking is impossible because of the constructive and technological inexpediency; Δ, *, + – cooperation is impossible according to veterinary, fire-fighting and sanitary requirements

In forming the typology, the enterprise production requirements were considered primarily. For example, if a farm specializes in the dairy production, then livestock is managed properly: cows – for milk, swine – for meat, horse – for in-farm transportation. All these animals are in the appropriate ratio [5].

The maximum number of livestock, which can be combined, was determined according to the engineering design code, based on both the normative and measured microclimate indicators standards of cattle-breeding small-volumetric cooperative buildings. Increasing the livestock number in the room significantly affects the deterioration of the room internal climate, and therefore, in the entire building as a whole [8]. In this case, livestock buildings blocking is impractical.

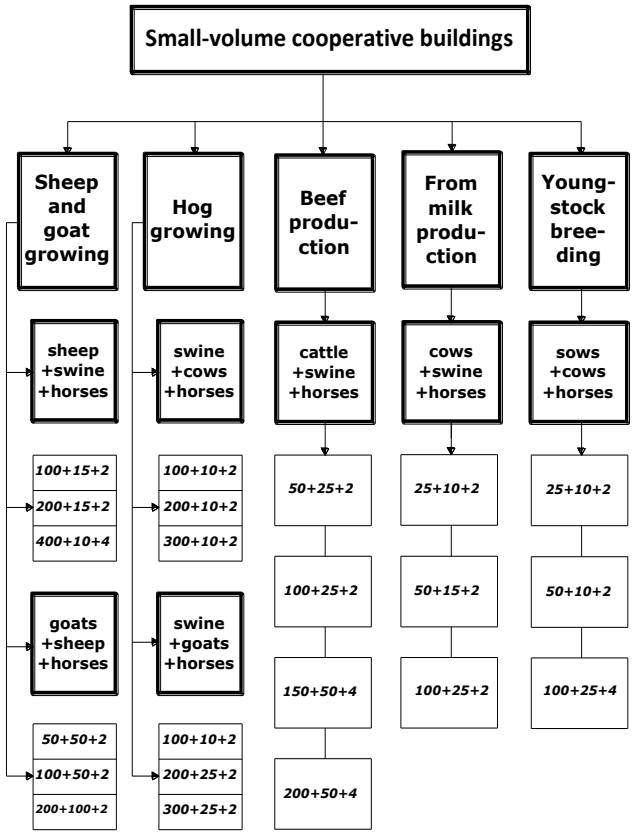


Fig. 5: Typology of livestock small-volumetric cooperative cattle-breeding buildings for farms

Unification of massing for livestock buildings, that is, cooperating a large number of such planning elements, such as a horse stable, a horse stall, to one cooperative functional-technological block was based on the building rational planning, planning elements placement, their capacity, ensuring sufficient feeding area, normal passageways and driveways for maximum mechanization of feed distribution and cattle manure removal.

On the basis of functional-technological units, it is possible to form cattle-breeding building design decision, but as the task is multifunctional, the layout may be different, therefore it is better to use computer technology.

To determine the parameters of the service premises of the cooperative and blocked building, the algorithm for calculating the total area and production area of the livestock building and the block diagram of the SPACE program (Fig. 6) was developed. With the help of compiled algorithms for calculating the parameters of a low-volumetric cattle-breeding building and control-flowcharts, it became possible to simulate and determine the planning structure of rooms on a PC [15].

It is proposed to form the model of the cooperative livestock building object on the basis of dividing the “building block” system into components of types B (space-planning organization) and F (functional-technological structure). When creating quality standards models, the separate livestock buildings design process analysis was carried out, then objects properties hierarchical scheme was constructed and its research was carried out. The main criteria for the blocked buildings planning decisions optimality include: "livestock and human flows", "functional relationships" and "compatibility".

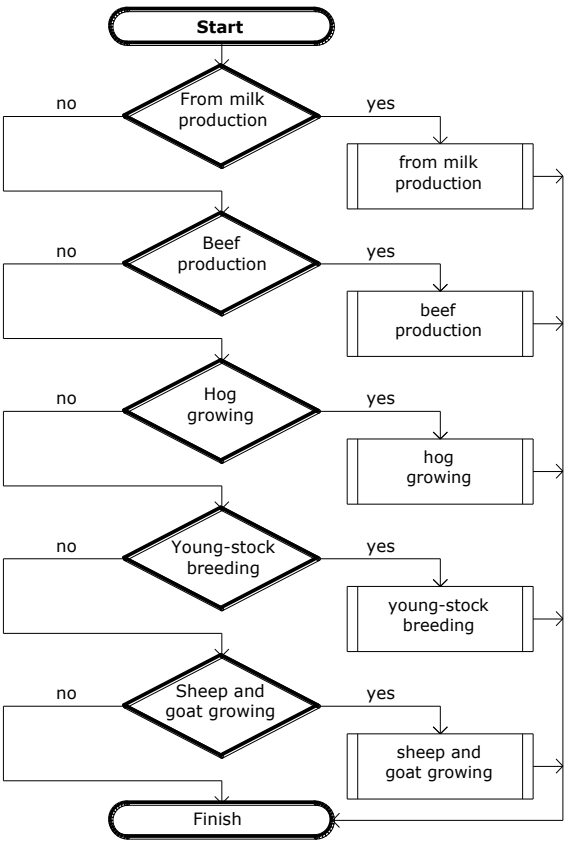


Fig. 6: Block diagram for cooperative and blocked buildings determining planning parameters using PC

The criterion "livestock and human flows" describes the function

$$F_{1ij} = \sum r_{ij}^n k^n ,$$

where r_{ij}^n –is the movement frequency of a type "n" user between rooms i and j;

k^n – the relative importance of the building type "n" user.

The criterion "functional relationships" describes the function

$$F_{2ij} = \sum \Phi_{ij}^l k^l ,$$

where $\Phi_{ij}^l = 1$, if the relationship exists, $\Phi_{ij}^l = 0$ if the relationship does not exist;

k^l – weighting factor for assessing the relative importance of type "l" links.

The criterion "compatibility" describes the function

$$F_{3ij} = \sum s_{ij}^m k^m ,$$

where S_{ij}^m – is the value (1 or 0) to determine buildings compatibility according to the type of obstacle "m"; k^m – a weight value to assess the relative importance of an obstacle such as "m" [7, 9, 14].

Functional and technological links of separated livestock buildings with auxiliary buildings and premises were considered in the final layout design. In the cooperative livestock building reference layout developing process, a variant selection of the space-planning decision was carried out considering the areas and significant values of connections and all the building components relative position were determined (Fig. 7).

The formation of the space-planning decision of live-stock buildings is determined by the farm direction and specialization, the production processes technology, the biological type and size of animals, the system of their maintenance, feeding methods, watering, manure removal, etc. At the same time, the climatic conditions of the construction area, the internal climate parameters production facilities, the ensuring maximum efficiency in the use of investment, the possibility of enterprise further development and specialization, the maximum use of the enterprise capacity by means of buildings reconstruction and modernization should be considered.

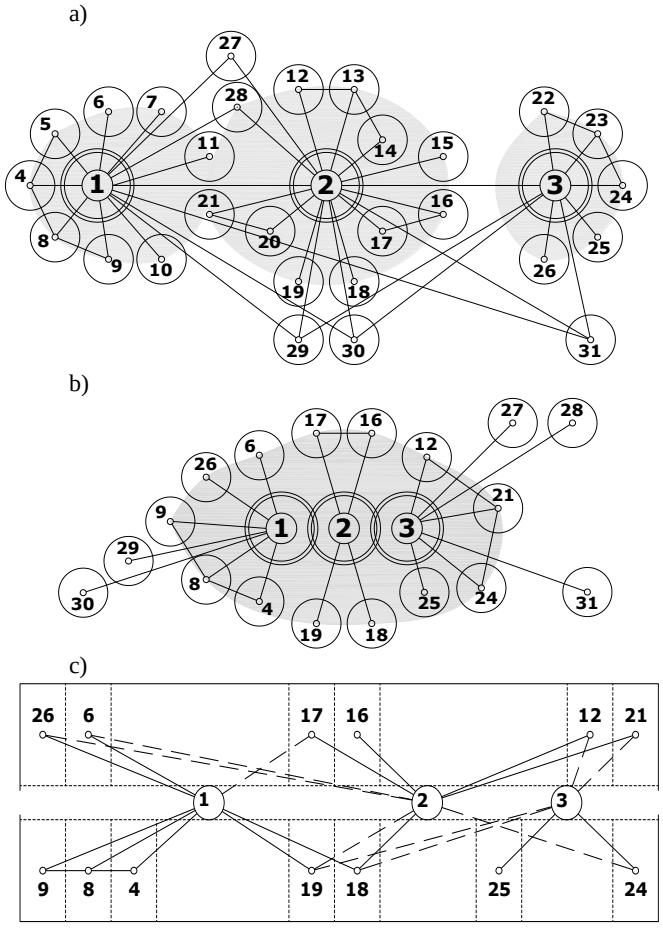


Fig. 7: Layout of the livestock buildings planning structure:
a – the scheme of output configuration; b – reference layout diagram;
c – the planning scheme of the cooperated cattle-breeding building;
1 – pigsty; 2 – cow shed; 3 – stable; 4, 14, 24 – farm equipment;
5, 12, 23 – bedding storage; 6 – artificial insemination point;
7, 15, 26 – staff room; 8, 20 – feed processing room; 9 – compound feed storage; 10, 18 – ventilation chambers; 11, 19 – switchboard room;
13, 22 – forage storage; 16 – milk storage and milk equipment washing room; 17 – hay storage; 21 – root storage; 25 – harness room;
27 – weight room; 28 – service point; 29 – fire tanks; 30 – water tower;
31 – manure storage

Floor area should be calculated depending on the rational planning and placement of individual functional and technological elements (stalls, boxes, sections, boar pens, box stalls, passages, canals, feeding troughs, drink troughs, etc.).

When choosing a space-planning decision for the pigsty, age of animals should be considered, and therefore it is necessary to divide them into gender and age groups, to change feeding methods, to increase the boar pens size. Therefore, premises rational planning, machines placement, their capacity, ensuring sufficient feeding area, normal passages for maximum mechanization of feed distribution and manure removal are of great importance.

Blocking of buildings for reproduction of livestock and young-stock breeding is acceptable. Blocked rooms, insulated by walls, should have separate exits to the outside.

The choice of livestock space-planning decisions depends on the cattle system, the placement of individual technological elements (stalls, boxes, cages, feeding troughs, water troughs, passages, manure removal trays, etc.), as well as a milking system for cows.

Design and construction of buildings for keeping sheep is carried out considering the systems of their keeping in accordance with in-house process engineering standards-agro-industrial complex. When pasture-stall system, lightweight three walled sheds are built for keeping cattle on winter pastures. Sheepfolds, roofs, or lightweight vaulted sheepfolds with low walls without garret

floors are built for youngsters and for caraculs in areas with long winters and in areas with an estimated outside air temperature not lower than –20 ° C, but with large fluctuations and strong winds. The lambing part of sheepfolds is closed.

The choice of space-planning decisions of goat sheds depends on the age and sex characteristics of the animals.

The space-planning decision of stables is determined by the sex, age, size and purpose of the animals [5].

When designing cooperative livestock buildings, it should be focused on the plan compactness, functional zoning clarity and premises interconnection, architectural and planning design flexibility that allows to transform the room for its multifunctional use, periodic capacity and redevelopment increase due to changes in function, the possibility of new forms of maintenance organizing and developing, availability of summer space for seasonal expansion and interaction with the environment. These qualities provide the building space-planning structure optimality, its work high efficiency, convenient maintenance of animals. Space-planning decisions of buildings and structures should be carried out considering the possibility of their easily refocusing as for new technologies according to market requirements [10].

3. Conclusions

On the basis of the conducted research, the farm functional planning organization features were established; the factors forming the livestock buildings were determined. Proposals and recommendations for the design of low-volumetric livestock cooperative and blocked buildings were developed. It is proved that the cooperation and blocking of low-volumetric buildings is possible if it does not contradict the technological process conditions, constructive decision, safety, veterinary and zootechnical, sanitary and fire safety rules and it is relevant for technical and economic considerations. In general, the cooperation and blocking of livestock buildings should ensure: rational interchangeable arrangement, individual premises connection and insolation, paths reduction for both animals and service personnel; work organization advanced technologies and methods introduction; planning decisions flexibility that allows to change the premises structure considering the operating conditions and ease of use; labor costs reduction for the buildings construction and operating costs per unit volume; improvement in both construction and performance. On the basis of the conducted research, the formation of new types and the nomenclature of livestock cooperative buildings with various types of animals, the pattern of possibility such buildings cooperation and blocking.

The proposed method of cooperated and blocked livestock buildings modeling and planning structure on the basis of the main optimization criteria are defined that allows to form the space-planning decisions of such buildings with the functional and technological connections maximum reduction.

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