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Beef Cattle Barn Design for Cold Climates; Case of Van Province

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HIGHLIGHTS

- The main consideration in the planning of beef cattle barns is to protect the animals from strong winds in winter and extreme heat in summer.
- Since 30% genetics and 70% environmental conditions are effective on animal productivity, animal barns should be planned to provide comfort areas for animals.

Abstract

Livestock operations generally deal with dairy or beef cattle. Although sufficient attention is paid in design and construction of dairy barns since modern technology, mechanization and labor are used intensively in dairy barns, beef cattle barns are still constructed in traditional styles. However, in cattle barns planned for meat production, which is one of the most important protein sources of human beings, desired conditions should be provided at optimum levels. Working conditions of the workers should be improved, physical, chemical and biological characteristics of animal rations should be improved and hygienic production environment should be provided. Therefore, beef cattle barns should be designed and constructed in accordance with modern technologies and technical standards and regional conditions should be taken into consideration. In this study, planning and design criteria of beef cattle barns for cold climate regions were determined and 100 and 200-head capacity beef cattle barns were developed and designed for Van Province conditions. The designed beef cattle barn project, was submitted to the Agricultural-Specialized Organized Industrial Zone Project Commission and it was deemed appropriate to carry out the exercise.

Keywords: Agricultural Structures; Barn; Beef Cattle; Biosystems; Cold Climate

1. Introduction

The primary objective of livestock operations is to increase profit margins. For this, quality product outputs must be achieved at the highest levels. Quality and quantity of animal products are largely

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designated by genetic structure of the animal at a rate of 30% and environmental conditions at a rate of 70% (Ekmekyapar 2001). Indoor environmental conditions play a great role in animal housings. Therefore, livestock operations should provide optimum environmental conditions for each species.

Animal housings are mostly constructed for cattle, ovine and poultry. Cattle operations usually deal with dairy or beef cattle. Small, medium and large business owners unfortunately do not pay a special attention on physical characteristics and environmental conditions of housing systems. Proper or optimum environmental conditions may reduce animal diseases by about 70% and increase animal performance and product quality (Zhong et al. 2020). In recent years, it has been seen that only large-scale enterprises give partial importance to housing design since construction of modern buildings is the primary criteria for state incentives provided to livestock operations. Such supports are limited only to dairy cattle barns. Small and medium-sized enterprises still house their animals in barns with traditional primitive conditions.

Beef cattle barns are built in 4 different styles as; closed fixed stall, closed free, semi-open free and open free barns. Open barns, semi-open barns and closed barns are built in regions where hot, warm and cold climatic conditions are prominent, respectively (Shouse et al. 2004). In closed cattle barns, animal stalls built in dairy barns may not be needed (Okuroğlu and Yağanoğlu 2015).

Beef cattle breeding is done for meat production and beef cattle barns should have features that will increase the yield and meat quality of beef cattle (Agus and Widi 2018). However, even in large-scale enterprises that have partially switched to modern barn planning, beef cattle barns are converted from barns designed by considering the planning criteria of dairy cattle barns.

In this research; beef cattle barns with a capacity of 100 and 200 heads were designed and presented for the beef cattle barns that are planned to be built in the region within the scope of the Agricultural-Specialized Organized Industrial Zone Project, which was approved and gained legal personality by the Ministry of Agriculture and Forestry in the province of Van. The developed beef cattle barn projects will also set an example and be applicable for the beef cattle enterprises that are planned to be built in other regions with cold climate conditions.

2. Materials and Methods

Present research area is located between Gürpınar, Edremit and Gevaş districts of Van province. Nearly 400 ha of approximately 1700 ha idle land of the province, most of which has been used as pasture for many years, were included in the scope of the Agricultural-Specialized Organized Industrial Zone Project under the leadership of Van Governorship (Anonymous 2019). The stakeholders of the project are Metropolitan Municipality, Chamber of Commerce and Industry, Eastern Anatolia Development Agency, Provincial Directorate of Agriculture and Forestry, Van Investment Monitoring and Coordination Department, Ipekyolu, Tusba, Gevaş, Gurpinar Municipalities, Van Commodity Exchange, Red Meat Producers and Cattle Breeders Associations. About 186 beef cattle enterprises with a capacity of 40 thousand cattle, industrial, treatment and biomethane facilities, emergency slaughter units and administrative and social units will be built within the scope of the project (Anonymous 2021). In Cattle Breeding units of the project, it was aimed to operate 100 enterprises (50 units of 100, 50 units of 200 heads) in the first stage, to raise a total of 11750 beef cattle and to produce 4000 tons of red meat annually. Another objective of the project is to reach out to livestock enterprises operating in the Central Districts of Van Province with the clustering model (VATSO 2013).

Livestock businesses operating in Central Districts of Van Province, plans and projects of 100 and 200-head beef cattle barns, which will serve as a model for beef cattle enterprises, one of the independent units of the facilities to be built in the region within the scope of the Agricultural-Specialized Organized Industrial Zone Project constituted the primary materials of the study.

2.1. Geographical and climate characteristics of the region where beef cattle enterprises will be built

Within the scope of the project, 4 alternatives were considered in the selection of places for the construction of beef cattle barns, taking into account criteria such as the presence of pasture in the region, topographic conditions, proximity and distance to settlements and climate characteristics. The characteristics of these places are given in Table 1 and Figure 1.

Table 1. Places where beef cattle barns will be built.

No	District	Neighborhood	Type	Total Area (Decare)
1	Gevas Gurpinar Edremit	Gundogan Sakalar Kopruler	Pasture	8620
2	Gurpinar	Kiziltas	Pasture + Government	1304
3	Tusba	Gollu/Tabanli	Pasture	2408
4	Tusba	Yumurtatepe/Yeni	Pasture	2515

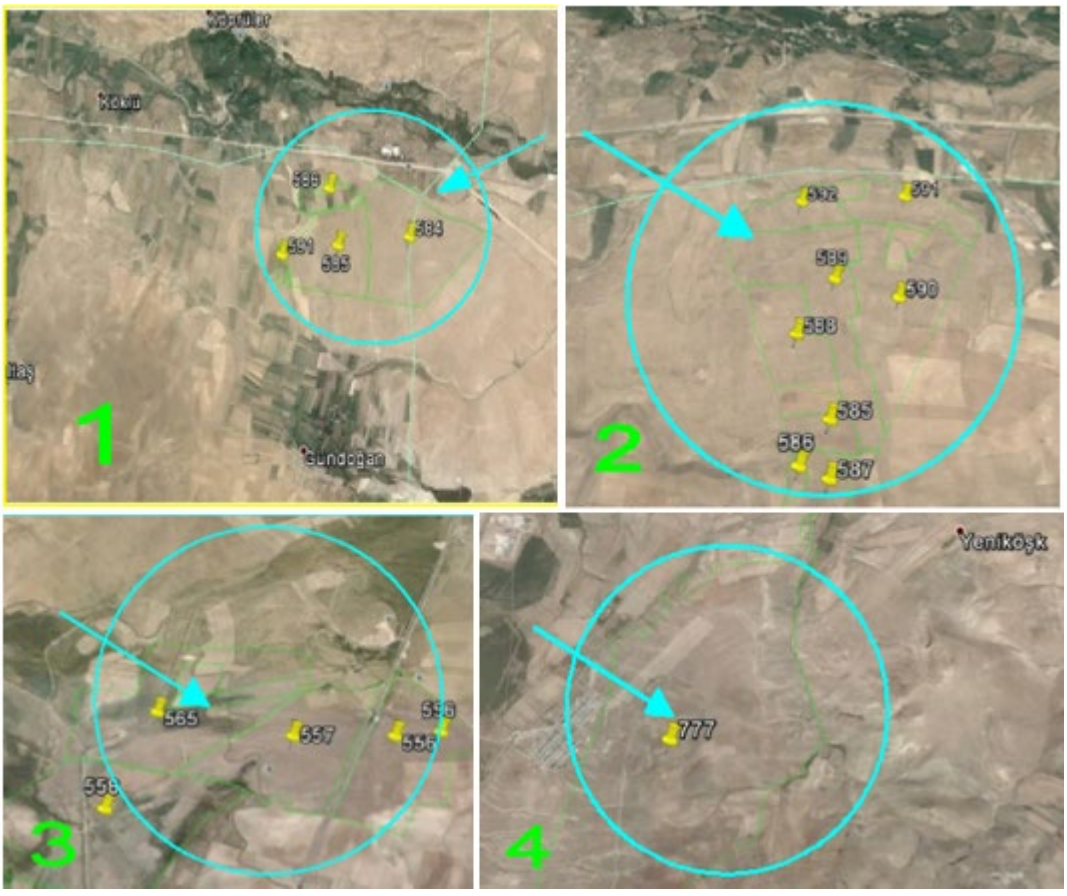


Figure 1. Topography of the places where the cattle barns will be built.

When the climate conditions of the regions where the lands are evaluated for the places where the cattle barns will be built are examined (Anonymous 2022), it was seen that they had the same climate characteristics since all of these alternatives are located in the same geographical area. These regions are classified as regions with cold climate conditions (Yılmaz and Çiçek 2018).

2.2. Livestock businesses operating in central districts of Van province

In the Central Districts of Van Province, there are a total of 1 567 livestock enterprises and 1 341 of them were actively operating. The enterprises mostly deal with small scale production with 20 heads on average. Animal assets of 124 enterprises with a capacity of 21 and above, which constitute 19% of cattle breeding establishments, have 81% of the total cattle stock (VATSO, 2013). All of these enterprises were breeding in barns with traditional primitive conditions (Figure 2).

Figure 2. Examples of beef cattle farms operating in Central District of Van Province.

2.3. Beef cattle barn planning criteria

Before the planning of cattle barns suitable for the region, the region where the barns will be built was examined on site in order for the study to serve the purpose. In this process; topographical conditions of the region, whether it is suitable for barn construction, soil characteristics, transportation and product marketing status were determined by considering climatic conditions.

Since cold climate conditions are dominant in Van Province, beef cattle barns were designed in closed fashion. To reduce construction costs and to have an economical production, animal stalls were not included and free style was adapted.

Present beef cattle barns are composed of a resting place, feeding and fodder storage area and a promenade. Providing the necessary space for each animal is one of the most important parameters when planning a resting place. The areas needed for each animal in closed free beef cattle barns are given in Table 2 (Koçak et al. 2015).

Table 2. Required area dimensions in closed free beef cattle barns.

Animal breed	Required area (m²/per animal)
Calf	2.0-2.5
Heifer	2.7-3.0
Cattle	3.0-3.6
Bull	4.0-6.0

Feeders are the most important equipment in beef cattle barns. It should be placed in the resting place and in the promenade. They can be made of wood or masonry and can be fixed or portable. Feeders should be considered as 45-55 cm for calves, 55-65 cm for beef cattle, 70-80 cm for adult cows and bull. The height of the part where the animal sticks its head and eats from the ground should not be higher than 45 cm for calves and 55 cm for adult animals (Achmad et al. 2019). It should have a width 120 cm for mangers feeding from both sides, lower width 45 cm, upper width 75 cm for one-sided ones. It is recommended that the lower part of portable mangers should be made at a height of 20-25 cm from the ground. The front of the mangers should be covered with 3-3.6 m wide and 10-15 cm wide concrete or 15 cm thick sand and gravel. The inclination of this part outward from the mangers by 6-8% makes it easier for animals to eat feed (Ekmekyapar 2001) (Figure 3).

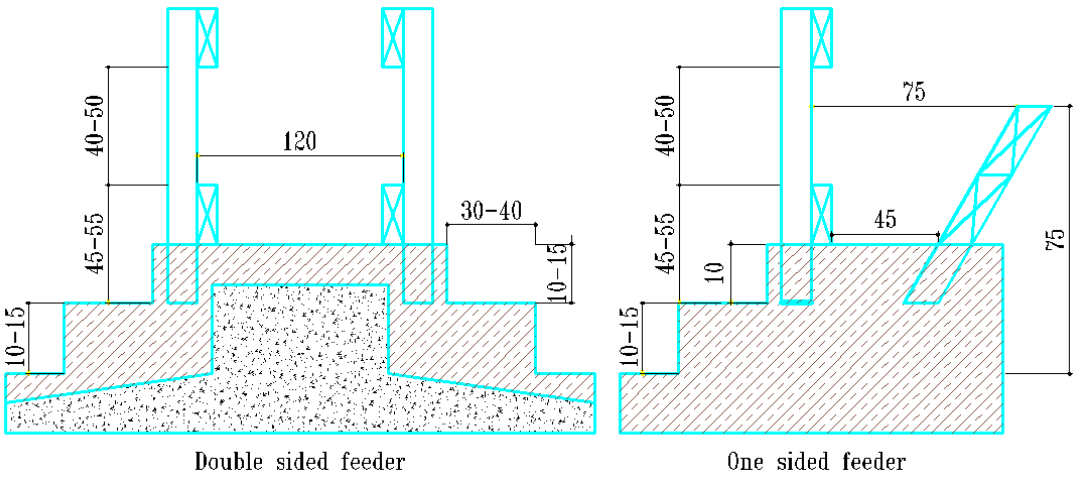


Figure 3. Single and double-sided fixed feeder dimensions.

In order to meet the water needs of the animals, automatically controlled water tanks should be built and precautions should be taken against the danger of freezing in winter (Karaman and Ekmekyapar 1996).

The resting place base can be concrete or compacted soil. It is considered appropriate to make the barn height between 2.8-3.6 m depending on the climate conditions in closed free barns applied in beef cattle breeding in Kapuinen (2001). The height of the beef cattle barns suggested in this study was 3.5 m.

Heat and moisture balance calculations for the developed beef barns were made in accordance with the principles specified in Ekmekyapar (2001), Beatty et al. (2006) and Okuroğlu and Yağanoğlu (2015). The amount of heat and moisture releases by the animals to the environment was taken from Okuroğlu and Yağanoğlu (2015). In the selection of structural members of the proposed closed free beef cattle barn, in the ground arrangement of the barns and in the design and preparation of sample barn plans, principles given in Rosina and Robison (2002), Shouse et al. (2004), Olgun (2016), Sirin and Kocaman (2016), Gozener and Sayili (2011), Ekmekyapar (2012) were used.

While designing agricultural structures, foundation members should be considered first. Foundations can be made in 4 different ways as under-wall, single, continuous and raft foundations. Foundation of single-story buildings is generally built as a single foundation using tie girders (Ekmekyapar 2012).

3. Results

Structural and technical features of closed free-breeding barns with a capacity of 100 and 200 head, which were thought to be suitable for cold climate conditions, and sections and plans showing these features were given as the results of this study.

A single foundation was chosen and it was suggested to be connected to each other with tie girders in order to prevent horizontal displacements (Figure 4). The foundation depth was taken as 0.90 m (KTMMOB 2009).

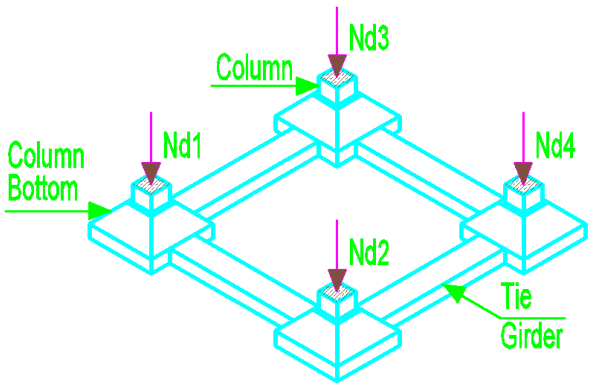


Figure 4. Single foundation section connected by tie girder.

To protect animals from northerly winds and rains, long axis of 100-head barns was closed with a wall and promenade was placed on the south face. The 200-head barn is formed by placing two separate 100-head barns facing each other. Width of the barn, except for the wall thicknesses, is 18.85 m, including 3.20 m service path, 0.75 m single-sided feeder, 12.50 m rest area, 2.40 m manure bed. The barn is composed of 8 paddocks, each of which is 8.00 m long and a 3.00 m service road left in the middle to facilitate herd management. Total length inside is 67.00 m excluding wall thicknesses. Paddocks are separated from each other by iron profiles with a diameter of 8.00 mm, a height of 120 cm from the floor. Each paddock (100.00 m2) is planned to accommodate 20 animals. Resting areas separated from feeders by manger irons was envisaged to planning of a 2% slope to facilitate maintenance and cleaning. A promenade of 8x20 m, with an area of 160.00 m2 and an outward slope of 5% is planned for each paddock in the barn. Shades have been made in the promenade to protect feeders and waterers from precipitations and for animals to be able to rest in the shade. A urine channel with a width of 30 cm and along the length of the barn, through which rain water and animal urine can be evacuated is considered in the promenade.

Masonry and wooden-framed walls are used in agricultural buildings. Masonry walls can be built with 5 different building elements: stone, brick, breeze-block, pumice block and adobe (Rosina and Robison 2002). In present beef cattle barns, it was deemed appropriate to be used long-lasting, easy to use, economical and light-weight pumice blocks. Side wall heights of the barns are designed as 3.5 m in order to provide adequate ventilation. No wall was considered on the long axis facing the promenade. Instead, a curtain wall with transparent insulation, which can be opened and closed, is planned separately for each paddock from the floor to the soffit level. Depending on the seasonal conditions, the curtain walls can be turned into semi-open barn models by opening fully and it can be turned into closed barn models with completely shut down. Or, since the curtain walls are adjustable, they can be left partially open as desired. Such a case allows animals to walk freely in the promenade without animal traffic. Desired level of ventilation can also be achieved and accumulation of harmful gases is prevented. Wall surfaces was covered with 2 cm thick interior and 3 cm thick exterior plaster and a light color paint should be applied on plasters.

About 10 cm blockage, 250 dose 15 cm lean-concrete, 10 cm floor covering and 3 cm screed-concrete should be placed on compacted soil on the floor of the barns. In order to increase the ventilation efficiency and reduce the cost, headlining is not considered.

Steel construction was chosen as the roof frame members. Insulated, corrugated sandwich panel was chosen as the covering material. A minimum slope of 33% was selected (Alptekin et al. 2014).

On the short sides of the barn; 3.00x3.20 m metal doors where tractors and other tools and equipment can enter have been placed at the start and end points of the service path and in the middle of its long walls. In addition, 1.60x1.20m portable doors that enable transition between paddocks and can be opened and closed in both directions were placed both in the resting areas and in the promenade. A total of 16 2.20x0.60m transom lightings were planned to be installed. Ventilation windows, 2 of which are in each paddock with the upper edge 60 cm below the soffit level on long pumice blocks wall were designed. A total of 8 1.00x0.60 m transom windows with the upper edge 60 cm below the soffit level (4 on each short walls) were also projected. No window was used on insulated transparent curtain wall.

Adjustable ventilation opening that can be opened and closed with automation system is built along the roof ridge of the beef cattle barns. In addition, to be used when the ventilation openings are closed, 8 ventilation chimneys with dimensions of 1.00x1.00 m were placed along the ridge and they were 50 cm high from the ridge (Şirin 2017).

4. Discussion

4.1. Barn height and barn building elements

The barn height is the clearance between the service road and the lower beam of the roof or roof truss (Ekmekyapar 2001). The height of the designed barn was determined as 3.5 m by considering the criteria for determining the barn height specified in Şirin and Kocaman (2016) and Olgun (2016).

The barn foundation floor must be able to safely bear the load coming on it through the foundation. Foundation width varies according to the foundation wall material to be used. Foundation depth varies between 80-120 cm (Okuroğlu and Yağanoğlu 2015). The barn was prepared with a foundation depth of 90 cm, which is in accordance with the foundation depth recommended in Okuroğlu and Yağanoğlu (2015).

It is proposed to use 30 cm wide bricks in the walls of the barn. The recommendation of Karaman and Ekmekyapar (1996) that "the wall thickness of barns planned in cold regions should be 1.5 bricks thick for brick walls" was taken into consideration.

The roof of the barn was planned as an asymmetric gable roof considering the barn roof planning principles stated in Alptekin et al. (2014).

According to Agus and Widi 2018, windows were placed on the long walls of the barns to ensure adequate lighting and ventilation.

4.2. Barn compartments

In beef barns, the barn compartments consist of a resting place, a feeding place and a promenade yard. In beef cattle barns, should be allocated an area of 2.0-2.5 m² for each calf, 2.7-3.0 m² for each heifers, and 3.0-3.6 m² for each beef cattle (Ekmekyapar 2012; Şirin and Kocaman 2016). In the planned beef cattle barn projects, the size of the resting area was adjusted according to these criteria.

The most important equipment needed in beef barns are feeders. The width of the feeder should be 120 cm for feeders with feeding from both sides, and the lower width of the feeder should be 45 cm and the upper width should be 75 cm for feeders with feeding from one side. Feeders placed in the promenade yard should be double-sided (Ekmekyapar 2001; Olgun 2016; Achmad et al. 2019). In the fattening cattle barn projects prepared, the planning of the feeders is in compliance with the specified rules. In order to meet the water needs of the animals, drinkers have been installed with precautions taken against the dangers of frost in winter.

The promenade yard is a place where animals can roam freely in order to benefit from daylight and sunlight. The promenade yard, which is at least the size of the resting place, is one of the most important compartments to be planned in beef cattle barns (Ekmekyapar 2012; Okuroğlu and Yağanoğlu 2015). It should be planned on the south side of the barn and at a slope of 1.5-2% towards the outside for easy cleaning (Karaman and Ekmekyapar 1996; Şirin and Kocaman 2016). The promenade yard compartments organized in the beef cattle barn projects meet the literature data. The beef cattle barn design projects proposed in our study set an example for the barn enterprises to be built in the region with these features.

5. Conclusions

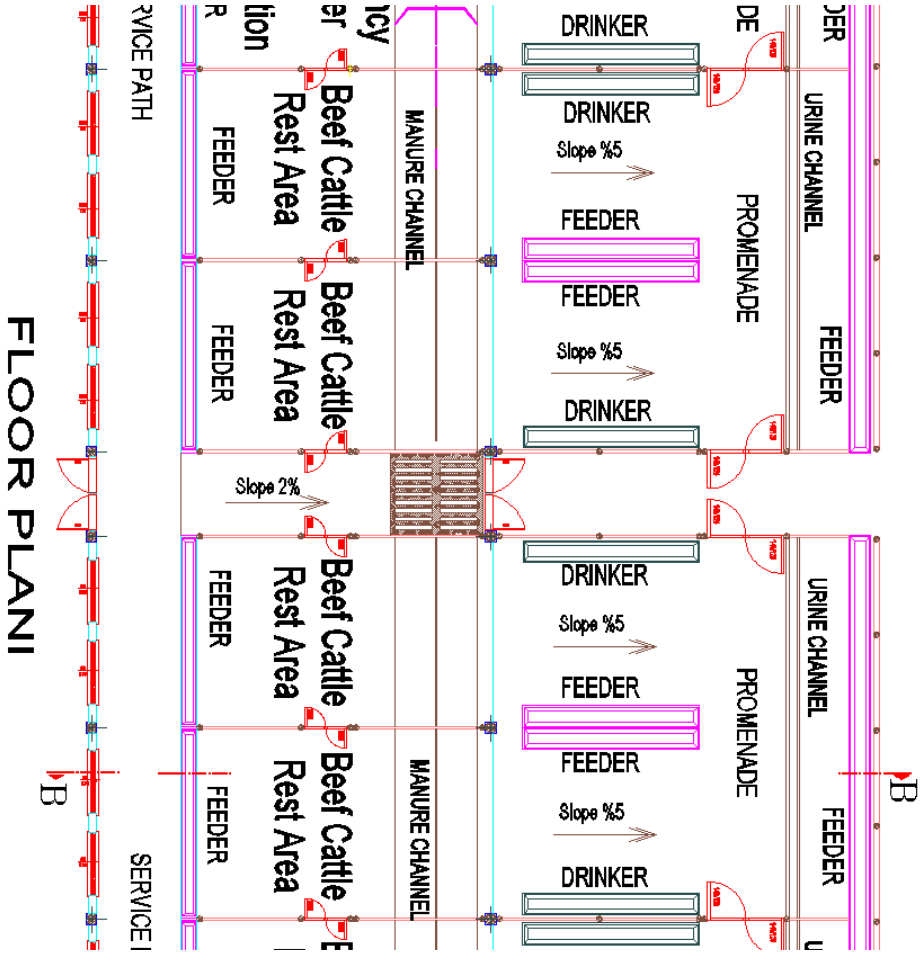
As a result; beef cattle barns do not need to be as protected and expensive as dairy barns. The main consideration in the planning of beef cattle barns is to protect the animals from strong winds in winter and extreme heat in summer. Different types of housing are applied in beef cattle breeding. However, plans and projects of beef cattle barns were developed according to the planning principles of closed barns, which are one of the forms of housing applied in beef cattle breeding, especially considering the trend in recent years and its suitability for local conditions.

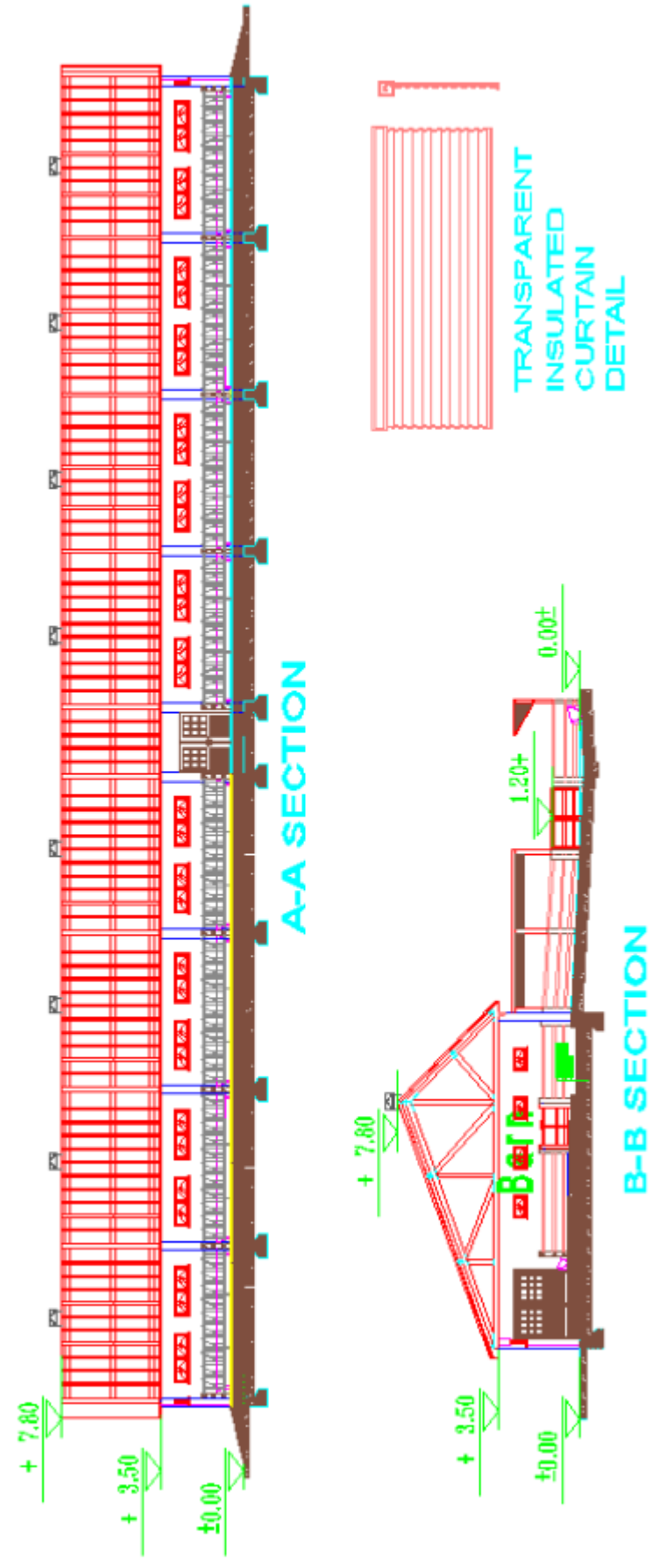
In this section, drawings of 100 and 200-head capacity closed free cattle barn projects prepared in accordance with cold climate conditions are included.

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: : The authors declare no conflict of interest.

5.1. 100-head capacity closed free cattle barn projects

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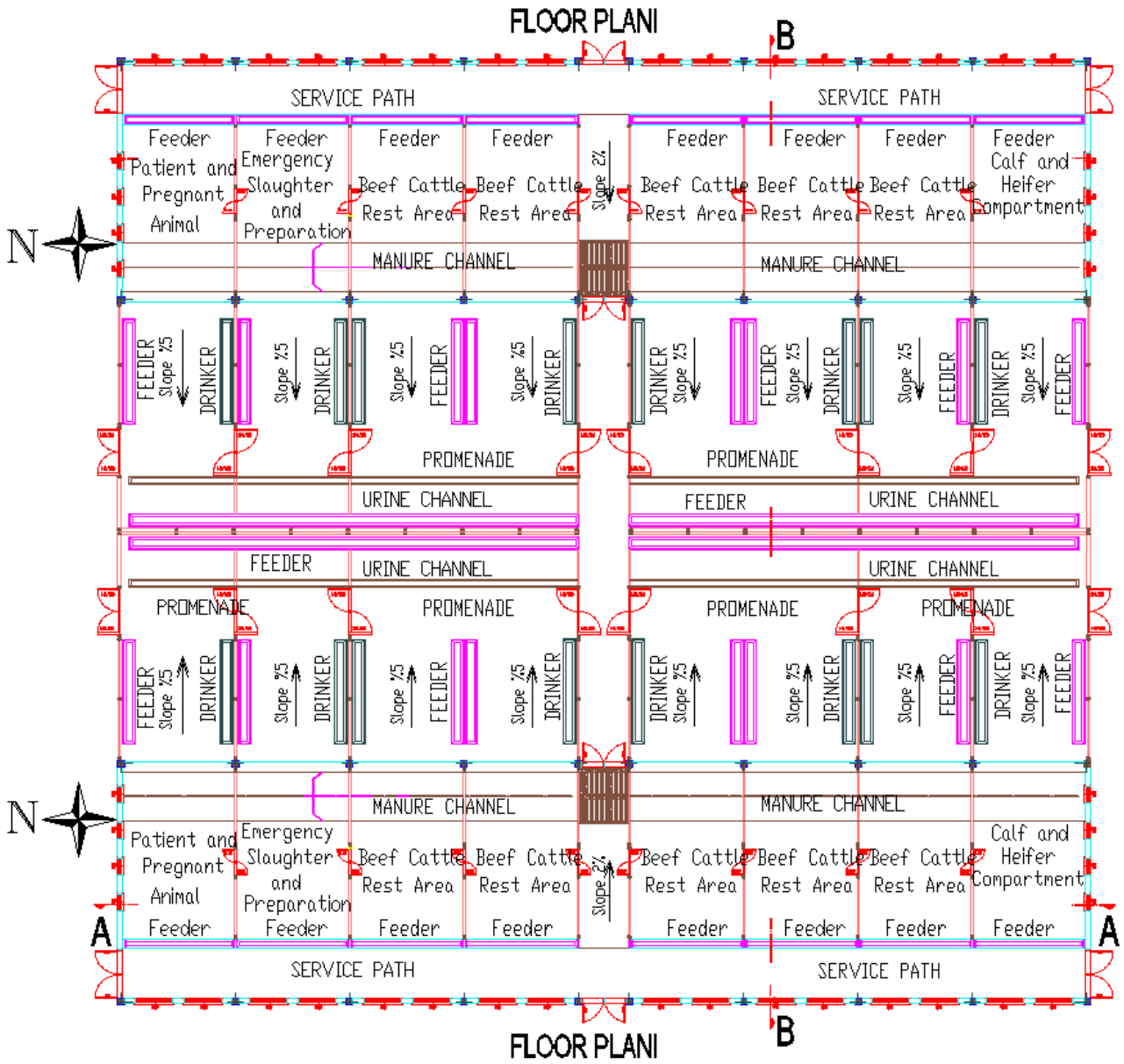
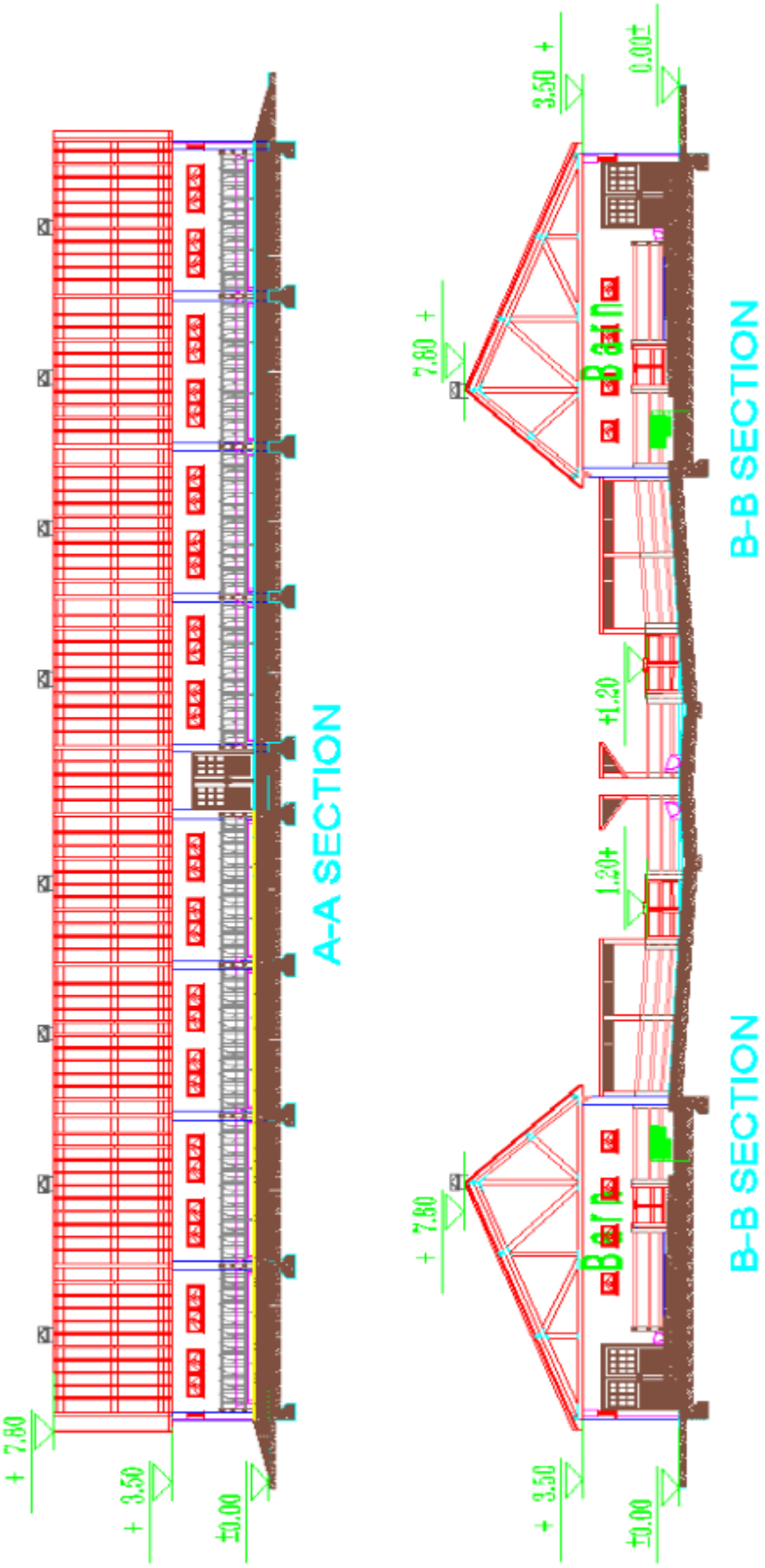
5.2. 200-head capacity closed free cattle barn projects

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