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IMPROVING DESIGN OF DAIRY COWS HOUSING IN BOSNIA AND HERZEGOVINA

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Abstract:

Agriculture represents a very important economic field in Bosnia and Herzegovina (BH). The construction and architectural design of dairy cow facilities depend on many factors, primarily the economic and technological conditions, and the geoclimatic features of the area where construction of the agricultural facility is planned. The agricultural facilities must provide proper accommodation for animals, their good production, adequate microclimatic conditions and their presence must not disturb ecological and aesthetic quality of the environment in which they are located. Therefore, special attention should be paid to the design of facades and the design og agricultural facilities. This paper puts an emphasis on clarifying the approaches used in the design of dairy cow facilities in Bosnia and Herzegovina, as well as contemporary approaches of the European Union (EU). The aim of this paper is to indicate how the new approaches apply to design of these types of objects.

Keywords: dairy cow (cattle) facilities, architectural design, Bosnia and Herzegovina

UNAPREĐENJE OBLIKOVANJA OBJEKATA ZA UZGOJ MUZNIH KRAVA U BIH

Rezime:

Poljoprivreda je veoma značajna privredna oblast u Bosni i Hercegovini. Način izgradnje i arhitektonsko oblikovanje staja za muzne krave zavise od mnogih faktora, ali prije svega od ekonomsko-tehnoloških uslova i geografsko-klimatskih karakteristika područja na kojem se planira izgradnja staje. Stajski objekti moraju obezbijediti kvalitetan smještaj životinjama, njihovu dobru proizvodnju, adekvatne mikroklimatske uslove i svojim prisustvom ne smiju narušiti ekološki i estetski kvalitet okruženja u kojem se nalaze. Stoga je posebnu pažnju potrebno posvetiti projektovanju fasada i oblikovanju stajskih objekata. U ovom radu akcenat je stavljen na pojašnjenje dosadašnjih pristupa u oblikovanju staja za muzne krave u Bosni i Hercegovini kao i savremenih pristupa u Evropskoj Uniji. Cilj je ukazati na nove pristupe oblikovanja ovog tipa objekata.

Ključne riječi: staje za muzne krave, arhitektonsko oblikovanje, Bosna i Hercegovina

1. INTRODUCTION

Architectural design can be seen as an eternal quest for an appropriate concept in the infinite richness of the variants offered by a space. The aesthetic level encourages open interpretation and affects stimulatingly to the viewer of architecture (Trkulja, 2013). However, the architectural design of most agricultural facilities is not a dominant trend, as opposed to other 'more attractive typologies'. The reason for this is not that it does not have anything attractive to offer than what is specific: quality animal housing and good production are important, whereas the aesthetics represent a 'tertiary category'.

Animals placed in cattle facilities must feel leisurely. Housing facilities should be comfortable enough for animals to develop and grow normally, to contribute to good production and achieve production capability. In addition, when planning and building agricultural facilities, special attention shall be paid to the application of modern technologies and equipment, as a well-designed and well-structured building and built-in equipment enable high productivity and rationalization of individual work operations (feeding, milking, manure collection).

In order to achieve the best welfare of animals, agricultural facilities must be planned and constructed very carefully and thoughtfully since these types of facilities are expensive, and will prove profitable only if they are used for 25 to 30 years. Modern cattle housing facilities are designed mainly as similar or typical objects, primarily needing to satisfy the economic and technological conditions and principles of design. Manufacturers offer to sell incredible construction, materials and equipment for efficient maintenance and management of these specific buildings. In addition, agricultural facilities must fit the environmental conditions of the space and their presence must not harm their environment either environmentally or aesthetically. Therefore, special attention should be paid to the design of facades and the design of agricultural facilities.

2. OBJECTIVES AND METHODOLOGY OF THIS PAPER

The objective of this paper is to point out to new approaches in designing of dairy cow facilities in Bosnia and Herzegovina. The applied methodology puts an emphasis on field research, i.e. analysis of agricultural facilities in the BH territory, and processing of collected data offered in this paper, providing the narrative and the photo documentation. The method of content analysis encompassed the use of textual and visual sources in order to present contemporary EU approaches to building of agricultural facilities. The conclusions of this paper were assembled and systematized by means of synthesizing method which was applied to all the results of the research.

The principal objective is to clarify the current approaches in the design of these types of facilities. Research issues are related to the development of architectural discourse: the construction and architectural design of dairy cows housing facilities, appropriate microclimatic conditions and ecological and aesthetic quality. The research outputs certainly contribute to understanding of existing approaches in design of these facilities in Bosnia and Herzegovina, as well as contemporary approaches in the European Union. The focus is on the fact that this issue in Bosnia and Herzegovina has not been studied so far, at least not to the extent that would initiate a new approach in designing of agricultural facilities and defining important principles of design. This research is an attempt to use an example of a small country, such as Bosnia and Herzegovina, to point to further development and the evolution of the design concept of milking cattle stalls.

3. ARCHITECTURAL DESIGN OF DIARY COW FACILITIES IN BOSNIA AND HERZEGOVINA

Bosnia and Herzegovina is one of the constituent republics of the former Yugoslavia. It is located in the western part of the Balkan peninsula (Fig. 1). Agriculture represents a very important economic field in Bosnia and Herzegovina. The surface of BH is 51209 km², agricultural land making about 2.5 million ha and 0.7 hectares per capita (FAO, 2012). Cow accommodation and the construction of agricultural objects in BH depend on geographical and climatic characteristics of the area where the construction of these objects is planned. In the south of BH is characterized by a prevailing mild submediterranean climate, with long warm summers and mild winters. The central part of BH is characterized by a mountain-continental climate. In the north, there is a typical continental climate. The various climate and topography of the terrain in BH represent highly favorable conditions for the farming of livestock and breeding food of animal origin (Indigenous dairy products industry in Bosnia and Herzegovina, date unknown).

Figure 1. Administrative division of Bosnia and Herzegovina (Source: FAO, 2012)

The most intensive agricultural production takes place the lowlands, with the biggest farms located there, whereas in the mountains the farms are mostly smaller. Lowlands are more competitive in milk production, primarily due to higher food yield per unit area, dense population and a higher demand for agricultural land. Therefore, the agricultural objects and farms are larger so the cows are more often in loose housing system. On the other hand, agricultural facilities in BH mountains are generally smaller, cows are most often accommodated in tie-stall system. Cows are released to grazing during the spring, summer, and autumn due to abundant pastures in this area (Jovović et al., 2014). The estimated numbers and shares of farms, cattle and cows, for all of Bosnia and Herzegovina, after combining together data from the Pilot Agricultural Census, Master Sample, and statistics on Legal Units, are shown in the Fig. 2.

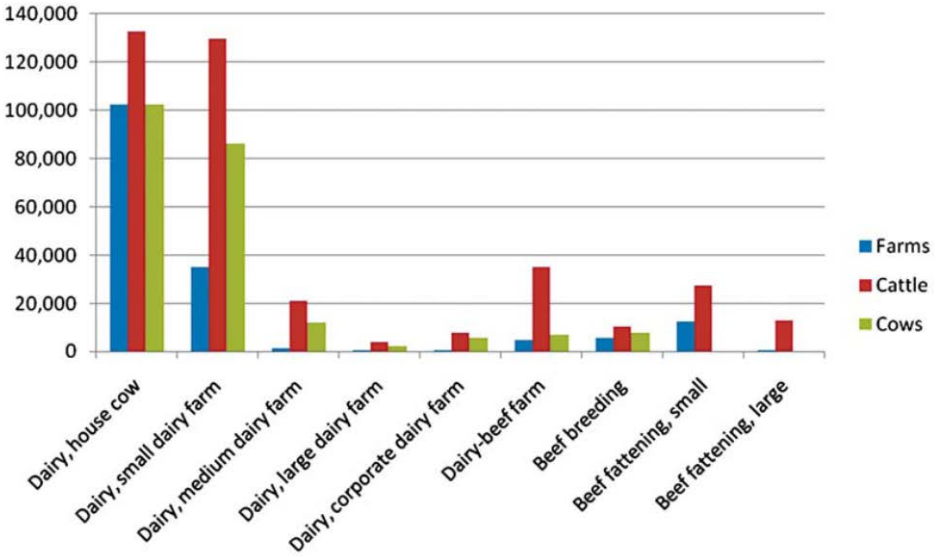

Figure 2. Cattle farms in Bosnia and Herzegovina (Source: FAO, 2012)

In Bosnia and Herzegovina, family farms are the most frequent types of farms. Thus, for example, the total number of households in Republika Srpska (RS) is 414847, and 131586, that is 31.72% categorized as agricultural households (Vaško et al., 2016). The same authors state that over 50% of the milk purchases in the RS comes from small farms holding up to five dairy cows, and that the smallest number of farms have over 200 dairy cows, or a 0.1% of total number. About 1.2% of the total purchased milk is obtained from the large farms (Fig. 3).

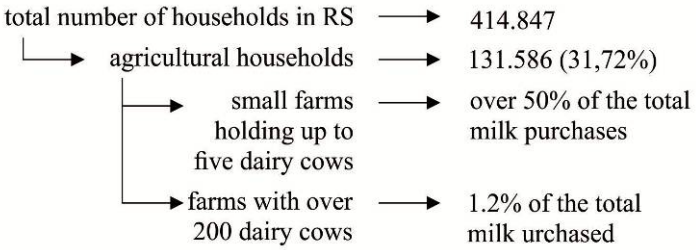

Figure 3. Milk purchases in the RS (Source: Authors according to Vaško et al., 2016)

Different systems of materialization of the objects for farming dairy cows are used for the construction of agricultural facilities. They are mostly prefabricated in order to have the construction of objects as quick and as cheap as possible. The materialization of the milking cattle facilities depends directly on the production and the needs of cattle for its healthy growth. In addition to their functionality, cost/effectiveness, durability, quality of materials used and comfort for animals, the milking cattle facilities should also provide certain aesthetic qualities, which make an integral part of architecture. In addition to architectural design, they are also influenced by the materialization of individual elements of the object.

Masonry farm buildings are widespread in Bosnia and Herzegovina. This method of construction is traditional and recognizable in smaller agricultural facilities, for the

farming up to 10 dairy cattle. The usual roof covering, used in the territory of Bosnia and Herzegovina, is roofing tile (Fig. 4, left). However, it is a characteristic roof covering of old agricultural objects. Lately, sheet metal is the most commonly used roof covering in reconstruction of old roofs and putting up of new roofs (Fig. 4, right).

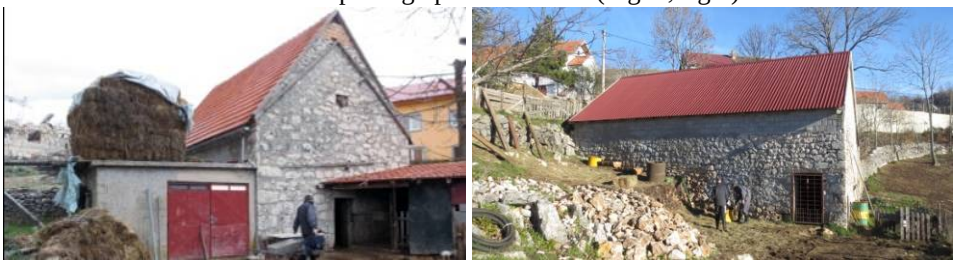

Figure 4. Objects for farming dairy cows in Gacko, BH, 2013 (Source: Authors)

The disadvantages of the smaller objects in Bosnia and Herzegovina are mainly the poor ventilation, insufficient light and poor microclimatic status. Šoch (1998) considers that the microclimate is the basic existential and productive factor in the cattle farming business. The composition of the air in agriculture facilities certainly plays an important role. Cows are adversely affected by the concentration of gases in the stalls. Hazardous gases in the air are carbon dioxide (CO2), ammonia (NH3) and hydrogen sulfide (H2S). Animals produce these gases when breathing or they are formed by decomposition or process of fermentation of organic matter from food, manure and urine. Bad ventilation and poor quality of air in many agriculture facilities in Bosnia and Herzegovina are affected, above all, by closed facades with small windows (Fig. 5) (Jovović, 2015). Buildings with poor ventilation and stagnant air present an unhealthy environment not only for the dairy cattle, but also for the man working in them. Namely, the unfavorable environmental conditions lead to various diseases of cows, and reduce the production and (hygienic) quality of milk (Havranek and Rupić, 2003 in Ostović et al., 2008).

Figure 5. Objects for farming dairy cows in Novi Grad, BH, 2011; Bileća, BH, 2013 and Brčko, BH, 2017 (Source: R. Grubešić, left; B. Rogić, middle; S. Osmanagić, right)

Due to the above mentioned shortcomings, contemporary agricultural facilities have a different design concept. It primarily includes semi-open and open facades, and this is enabled with the use of skeleton instead of masonry construction system. Namely, according to the construction design of the peripheral walls, and taking into consideration the agro-ecological zone and the microclimatic characteristics of the environment where erecting of the building is planned, the facility can be designed with closed, semi-open or open facades (Fig. 6).

Figure 6. Construction of the peripheral walls of objects for farming dairy cows: closed object, Prnjavor, BH, 2014; semi-open object, Trnopolje, BH, 2014 and open object, Prijedor, BH, 2014 (Source: Authors, left and middle; B. Rogić, right)

A closed facility implies a fully enclosed cattle housing space with walls and windows. This type of facilities is foreseen in moderate and colder climatic zones, since it provides ideal protection of cattle against bad weather conditions, but it also requires good ventilation inside the facility. Namely, insufficient amount of fresh air in the agricultural facility leads to increasing of microbiological and pathogenic organisms, which has adverse effects to general health status and productivity of cattle. Full-scale facade construction also entailing investments in ventilation systems, make it the most uneconomical of all.

The semi-open facility includes semi-open space for cows with a facade wall in the shape of a high parapet. The semi-open system is the optimal choice between open and closed systems, but it is closer to the closed system in relation to economic investments. Its advantage entails natural ventilation and good thermal abilities. The semi-open agricultural facility is ideal in Mediterranean and dry climatic conditions.

An open facility implies a completely open space for cows on one, two or all four sides of facade, i.e. covered space with no walls. This type of construction is suitable in dry, warm and Mediterranean climates, with a small number of rainy days per year. It is the closest to the cow's natural environment. Also, such construction system of agricultural facility is the most economical, as it only requires the construction of canopy, so the total expenditures are reduced by approximately 50%.

Areas with lower average annual temperatures are more suitable for the cattle (Erbez et al., 2015; Jovović, 2015), as cows can tolerate low temperatures only if the environment is dry, with no draft. Also, the temperature difference between the outer and inner space of the agricultural facility should not be higher than 10°C during the cold days. Otherwise, warm and humid air will condense in the cold parts of the building. Excessive condensation creates an unhealthy environment for cows (Gay, 1995). High temperatures cause a decrease in milk production and reduction in reproductive capacity of cows. Therefore, in order to obtain desirable production capabilities, cows should not be exposed to direct sunlight during the summer, especially in the afternoon. The metal or white aluminum roof can reduce thermal stress, since it maximizes the reflection of sunlight (Mijić and Bobić, 2012).

Facade walls play a major role in the formation of microclimate inside the facility because their construction is connected with ventilation and lighting inside the object. When planning the system of horizontal ventilation, holes for transverse ventilation are built-in in the facade walls. At the same time, this provides an additional lighting. Facade walls can be constructed of wooden, concrete or brick elements, masonry or may be prefabricated. Mostly masonry stasis are built, because they are long-lasting, and make it easier to maintain hygiene and disinfection (Matarugić and Budimir, 2004).

However, the stalls can be completely open, with birds and other animals' protective netting set up.

Nowadays, experts recommend a horizontal ventilation system with openings on the walls that can be regulated by slotted plastic curtains (Fig. 7). In this case, the height of the hole is up to 3 meters, thus regulating the air supply and transverse ventilation. Protective film, resistant to strong wind, protects animals from draft that can have a negative effect on animals (Matarugić and Budimir, 2004). The drive is controlled by a manual shaft, or by electric drive.

The type of ventilation system depends on the climatic conditions, therefore it is good to combine natural and mechanical ventilation in the areas with high temperatures. In areas with moderate climate, it is good to leave the stall walls open, with windproof nets that allow sufficient ventilation. Tunnel ventilation is best to use in the areas with cold winters and hot summers. Construction of stalls with one open wall (best on the southern side of facility) with windproof net, allows optimal transverse ventilation and precise regulation of the air supply. Alternatively, the longitudinal walls of the stalls have solid parapets and open upper parts of the walls with windproof net set up (Fig. 7). The windproof net is made of special, highly resistant, synthetic materials, which are interconnected in several layers with small perforations. It is resistant to strong winds and can withstand wind blows up to 150 kilometers per hour and almost completely stop it before entering the building (even up to 93%). Also, the windproof net allows constant air flow during the summer and its reduced flow during the winter, thus preventing the draft to which cows are very sensitive. If perforated materials are used, during the year they allow to accumulate particles (because of gases released by cattle) that reduce the open surface of the net and the airflow during the winter. In the spring the net is simply cleaned, enabling the cycle to start over. The system is easily controlled by manual or automatic opening and closing of the net. The use of wind protection nets reduces construction spending (Ivanović et al., 2008).

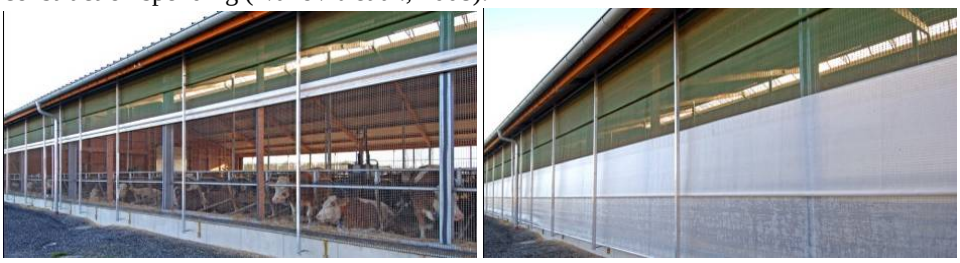

Figure 7. Wind protection net placed on a stall (Source: WolfSystem)

In the geographical region of Bosnia and Herzegovina, summer months represent a period in which may create conditions that can lead to the heat stress. On the other hand, when it comes to low temperatures, the best way to protect cattle is to adjust the housing facility to the weather conditions. The stall should not be drafty. On the other hand, ventilation should lead to sufficient fresh air and drain the air pollution (Erbez et al., 2015). Due to poor economic conditions, farmers in Bosnia and Herzegovina use a plain nylon or tarpaulin instead of a wind protection net, to cover the open parts of facade in the low winter and high summer temperatures, and thus create a better microclimate (Fig. 8).

Figure 8. Tarpaulins installed during winter to the open parts of the facade in Bijeljina, BH, 2014 (left); Gradiška, BH, 2014 (middle); and Prijedor, BH, 2014 (right) (Source: Authors)

The light coming through transparent roof elements increases the temperature inside the stall, thus creating negative effects. Additionally, in areas with high precipitation, the roofs are covered with snow for several months, disabling the illumination through transparent roof elements. Therefore, this type of roof lighting is not widespread in BH, especially in the mountain regions of BH. It is possible to provide cascading roof lighting by skimming the roof level. Roof cascades are made in order to allow adequate illumination throughout the year (WolfSystem). Triangular and rectangular lanterns are used also for roof lighting, most often placed along the longer side of the stall (Fig. 9).

Figure 9. Zenital lighting through: transparent roof elements, Czech Republic, 2009; openings created by the skimming the roof level, Kozarska Dubica, BH, 2014 and lantern, Trnopolje, BH, 2014, left (Source: Authors)

Facade lighting is allowed by facade openings created on the building, which can be placed on one longitudinal facade (lateral illumination) or on both longitudinal facades (bilateral illumination). Facade openings are shaped in the form of windows, as a continuous opening above the parapet walls or completely open facades (Fig. 10). Nordlund (2003) states that at least 50% of the surfaces of the longitudinal walls must be movable, so they can be removed as needed, which is essential for adequate ventilation inside the facility.

Figure 10. Facade lighting in BH: in the form of windows, Kozarska Dubica, 2014; continuous openings above the parapet walls, Trnopolje, 2014 and completely open facades, Prijedor, 2014 (Source: Authors)

All of the above shows a gradual evolution and development of the design concept of dairy cow facilities in BH, and approximation to EU design concepts. This "design evolution" is initiated by the economic and technological conditions that need to be provided in the stall, as well as by the geographical and climatic characteristics of the area where the facility it is located. However, defining the design concept of facilities is at a very low level, because facilities of similar layout and design solutions are built without the modern design, which should be in line with the local architectural form. Therefore, one can say that in BH these facilities need a new identity, that lays upon the traditional architectural elements and the context needed. Since the objective of this paper is to point to new approaches to the design of dairy cattle housing facilities, the further elaborations provided in the below text provide an overview of several attractive solutions.

4. MODERN TENDENCIES IN DESIGNING DAIRY CATTLE HOUSING FACILITIES

Modern trends in designing dairy cows housing facilities are very much different from the current situation in BH. Design concepts evolved: from classical smaller agricultural facilities (for farming up to 10 cows) to modern concepts of vertical forms. Modern agricultural facilities apply a different design concept which primarily refers to the utilization of different façade materials, but still on the same closed, semi-open or open types of objects (Fig. 11).

Figure 11. Construction and materialization of the facade walls of modern stalles for dairy cows (Source: WolfSystem)

Unlike masonry objects that are widespread in BH, the developed countries mainly use prefabricated skeleton construction systems of laminated wood or steel. They enable fast and quality construction. Additionally, the prefabricated skeleton construction systems offer to designers an unlimited opportunity in architectural design of dairy cows housing (Fig. 12).

Figure 12. Modern agricultural objects with classic steel construction and construction of prefabricated reinforced concrete columns and laminated wood primary beams (Source: Brueninghoff)

More attention is also paid to the ventilation of facilities and facade illumination. Facade openings are formed in the same way as in BH: as windows, as a continuous opening above high parapet or completely open facades (covered space without walls). However, the use of facade materials and architectural shaping of the stalls are incomparable. The EU insists on the use of ecological materials (primarily wood) and mobile wall elements (Fig. 13), just recently being acknowledged in BH, still being in the initial development phase.

Figure 13. Ventilation and facade lighting in stalls in the EU: in the form of windows, continuous opening above high parapet and completely open facades (Source: WolfSystem)

Defining the conceptual solution for the cattle housing in BH and EU cannot be compared. This is best shown by an insight into design solutions of the modern stall facades. For example, a free-stall barn for 30 cows was built in 2005, at the heart of an idyllic landscape of fields, pastures, forests and mountain valleys in Lignières in northwestern Switzerland, (Fig. 14). The client wanted a modern design which meets organic production standards. Architectural studio Localarchitecture was supposed to project a cattle housing facility near the existing farm. In order to design a project that would abide by the development of local architectural form, architects did a detailed analysis of the farm typologies present in the region. By combining typologies, architects synthesized different traditions, thus giving them a new identity. Commitment to sustainable development is reflected in the choice and application of materials, whereas dimensions of wooden elements are adapted to the dimensions of timber available in the nearby forest. In addition to environmental advantages, wooden elements also allow natural ventilation. Stall architecture recognizes the area and the place where it is built and face opens the valley (ArchDaily).

Figure 14. Free-stall barn for 30 cows, Lignières (Switzerland), Localarchitecture (Source: HIC et NUNC)

Integration with the surrounding landscape, without expensive planning, budget and building materials, was the concept of the Agricultural Social Care Project „Grote Heklaantje“, implemented in Bergen, Netherlands (Fig. 15). The design of this wooden

cube, created by the architectural studio Negen Graden Architectuur, confined to simple needs, with the region recognizable construction. The social healthcare farm for mentally and physically handicapped people is built to accommodate eight residents who require the care and the family providing care. In addition to a deep litter for young cattle inside the stable building, there is an educational area where those interested may acquire information regarding the special qualities of this project and the environment. The house and stable have a sturdy wooden facade. Object design and materials are in harmony and create a recognizable unity (Architizer).

Figure 15. Project „Grote Heklaantje", Bergen (Netherlands), Negen Graden Architectuur (Source: Architizer)

The cattle farm in Pratteln (Switzerland) is characterized by the architectural concept aimed to integrate the building into its hilly green surroundings, using natural materials in construction of the wall and installing the greening of the roof. Namely, the designers Georg Schmid and Jonas Wuest used Bauder greenroof system and local hazelnut branches set into concrete as screening around the entire structure instead of the classic wall. The grass on the roof is mown twice a year (Fig. 16).

Figure 16. Cattle farm in Pratteln (Switzerland), Georg Schmid and Jonas Wuest (Source: Greenroofs.com)

At the top of a low ridge, alongside the old forest, there is a barn that represents the entrance to the Cornell campus and a testing ground for students of agriculture. It is the first object that students and visitors get to see, so it is therefore given an aesthetic function. The barn provides an elegant, modern look to the traditional design of cattle barns (Fig. 17). On the other hand, guided by the slogan that a happy cow is a productive cow, priority in a functional organization was given to the comfortability of cows. The cows can move and eat as much as they like. They bed down on sand, a natural deposit that does not support the growth of bacteria. Installed automatic brushes increase the

comfortability of cattle. All this influences that each cow produces an average of 95 pounds of milk per day, so the cattle are milked three times daily (Cerio, 2013).

Figure 17. Dairy barn (exterior and interior) and the experience the magic of automatic brushes (Source: Cerio, 2013)

In the past few years, vertical farming projects are being popular, thus representing modern concepts of a vertical farm. However, the Circular Symbiosis Tower, designed by Lee Dongjin, Park Jinkyu and Lee Jeongwoo for the 2011 Skyscraper Competition, is the first skyscraper that proposes a vertical farm for actual livestock (Fig. 18). The main concept was to create a new habitat to raise cattle within the city. The skyscraper consists of a central tower that carries spiral grazing lawns, enabling free movement of cattle. Healthy and sustainable farm work relies on the symbiosis between cows, chickens and pastures. Namely, after 30 days of habiting the same pasture, the cows move to a higher platform, while chickens use the previous platform (the grass are not the primary source of food for chickens) until the grass is grown again. Chickens feed on worms that grow in the cow feces and thus improve the biodegradation of the feces and growth of pastures. This enables the grass surfaces to which the cows return again after some time to restore, and the whole cycle is repeated again (eVolo, 2011). Vertical farms are a modern concept adapted to areas facing the issue of developing farms in horizontal areas, which is not a problem in BH. The concept of a vertical farm is far from the standards and needs of BH. Also, this concept is far from the proper accommodation for animals and their good production.

Figure 18. Circular Symbiosis Tower, 2011 eVolo Skyscraper Competition (Source: eVolo, 2011)

5. CONCLUSION

In order to enable good production and animal welfare, agriculture facilities must be carefully planned and thoughtfully constructed. Primarily, they must satisfy the economic and technological conditions and design principles, but they also must fit into the environmental conditions of the area and their presence, must not harm their environment, either ecologically or aesthetically speaking. Therefore, the special attention is paid to both the design of agricultural facilities and the design of their facades. This paper, explored the approaches used in the design of cattle barns in Bosnia and Herzegovina, as well as contemporary approaches to this issue applied in the European Union.

The survey showed that family farms (with up to 5 dairy cows) and masonry buildings (for the farming up to 10 dairy cows) are by far the most represented in Bosnia and Herzegovina. Inadequate ventilation, poor illumination and, hence, the bad microclimatic status of these smaller agriculture facilities are being recognized as disadvantageous. Facade walls play a major role in the forming a microclimate in a barn and the poor microclimate conditions are influenced above all by closed facades with small windows. Therefore, newly built cattle barns apply a different design concept: semi-open and open facades with continuous openings above high parapet or with completely open facades.

The study has shown a gradual evolution and development of the design concept diary barns in BH and approximation to the EU design concepts, but only in a domain that initiates economic and technological conditions and geographic and climatic characteristics of the barn's surrounding environment. On the other hand, defining the design concept of barns in BH is at a very low level, with facilities with facilities of similar layout and design solutions, without application of modern design methods. Primarily, this refers to the use of façade materials and architectural design of barns. The EU insists on the use of ecological materials (primarily wood) and mobile wall elements, just recently being acknowledged in BH, still being in the initial development phase. Therefore, one can say that a new identity must be given to the diary barns in BH, respecting the traditional architectural elements and the natural context, and putting into the forefront a natural way of care for and breeding of animals. Adequate design and materialization of the diary barns (objects built from natural materials) undoubtedly contribute to the increase in the comfort ability of cattle and the milk production, as well as to the improvement of the ecological and aesthetic quality of the barn environment.

In relation to all of the above, it is clear that the objective of this research paper has been reached: clarification of existing and pointing to the new approaches for in designing diary barns in Bosnia and Herzegovina. EU approaches are applicable in BH. Therefore, BH should learn from the EU and harmonize its regulations with EU regulations, what was achieved in Republic of Srpska with Rulebook on spatial and technical conditions for housing of farmed animals, buildings and equipment in animal husbandry (Official Gazette Republic of Srpska, No. 100/15) which certainly contributes to the improvement of the design of the housing facilities of dairy cows. The trend of increasing the number of animals per farm and the construction of larger housing facilities is already up to date. Also, reconstruction of existing and construction of new facilities is expected to be in accordance with standards that prescribe the conditions for the accommodation of dairy cows and generally domestic animals.

Well-designed barn serves not only to ensure better animal welfare, but also to facilitate the work of farmers, make systems more applicable for controlling of critical points and with it to improve food security (milk, meat).

LITERATURE

[1] Trkulja, T. (2013). Prostor stvaralaštva – između percepcije i doživljaja. AGG+ časopis za arhitekturu, građevinarstvo, geodeziju i srodne naučne oblasti 1(1): 84-93.

[2] FAO. (2012). Meat and Dairy Sector study for the IPARD programme in Bosnia and Herzegovina. FAO, Rome.

[3] Indigenous dairy products industry in Bosnia and Herzegovina. developed within the Project Value Chains for Employment of the United Nations Development Programme in Bosnia and Herzegovina, with the expert assistance from the Federal Institute for Agriculture, and for the purposes of the Export Promotion Agency of BiH (BHEPA) and the Foreign Trade Chamber of BiH (FTCBiH).

[4] Jovović, V., Važić, B., Rogić, B., Bøe, K.E., Ruud, L.E., Marić A., Erbez, M. (2014). „Examination of certain parameters affecting dairy cows welfare in Bosnia and Herzegovina“. In: Proceeding of Fifth International Scientific Agricultural Symposium “Agrosym 2014” (854-857).

[5] Vaško, Ž., Ostojić, A., Rokvić, G., Drinić, Lj., Mrdalj, V., Figurek, A., Brković, D. (2016). Poljoprivreda i ruralni razvoj u Republici Srpskoj do 2020. godine. Banja Luka: Univerzitet u Banjoj Luci, Poljoprivredni fakultet.

[6] Šoch, M. (1998). „Dynamika výskytu lehkých aeroiontů ve vzduchu v teletníku a vzduchu venkovním a jejich vliv na sledované fyziologické hodnoty u telat“. In: Sborník zemědělské fakulty Jihočeské univerzity v Českých Budějovicích řada zootechnická, číslo 2 (91-97). České Budějovice: JUZF.

[7] Jovović, V. (2015). Analiza mikroklimatskih parametara u stajama za smještaj muznih krava u Bosni i Hercegovini. Master teza. Istočno Sarajevo: Poljoprivredni fakultet.

[8] Ostović, M., Pavičić, Ž., Balenović, T., Sušić, V., Kabalin, A.E. (2008). Dobrobit mliječnih krava. Stočarstvo 62(6): 479-494

[9] Erbez, M., Važić, B., Rogid, B., Jovović, V., Marić, A. (2015). Effect of certain barn construction characteristics on indoor climate status in dairy barns in Bosnia and Herzegovina. Journal of Animal Science of Bosnia and Herzegovina - “special issue” Livestock Housing 2: 31-36.

[10] Gay, S.W. (1995). Natural Ventilation for Freestall Dairy Barns. Virginia Cooperative Extension, Publication 442-763. Website: http://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/442/442-763/442-763_pdf.pdf

[11] Mijić, P., Bobić, T. (2012). „Značajke toplotnog stresa kod krava na mliječnim farmama“. U: Zbornik radova VIII Savjetovanje uzgajivača goveda u RH (43-47). Osijek: Hrvatska poljoprivredna agencija.

[12] Matarugić, D., Budimir, D. (2004). Uzgoj krava. Banja Luka: Caritas Italiana, Lorenzo Meneghini.

[13] Ivanović, S., Radivojević, D., Pajić, M. (2008). Ekonomska efikasnost investicija u proizvodnji mleka na porodičnim gazdinstvima. Poljoprivredna tehnika 33(4): 87-95.

[14] WolfSystem. Website: http://www.wolfsystem.com/

[15] Nordlund, K. (2003). Ventilating existing buildings. Preconvention Seminar 7: Dairy Herd Problem Investigation Strategies. American association of bovine practitioners. 36th Annual Conference, Columbus, OH., 1-10.

[16] Brueninghoff. Website: https:// www.brueninghoff.de/
[17] ArchDaily. Etable De Stabulation Libre / LOCALARCHITECTURE. Website: http://www.archdaily.com/442813/ etable-de-stabulation-libre-localarchitecture
[18] HIC et NUNC. Local Architecture > Etable a Lignieres. Website: http://hi-carquitectura.com/wp-content/uploads/2013/07/w.jpg
[19] Architizer. Agricultural Social Care Project „Grote Heklaantje“, Bergen, The Netherlands. Website: http://architizer.com/projects/agricultural-social-care-project-grote-heklaantje/
[20] Greenroofs.com. Viehscheune (Cattle Barn) Burgain, AG. Website: http://www.greenroofs.com/projects/ pview.php?id=143
[21] Cerio, G. (2013). The Dairy Barn, Redesigned: Cornell’s new barn makes cows (and humans) happy. Website: https://modernfarmer.com/2013/09/dairy-redesigned-cornells-barn-innovation-makes-cows-humans-happy/
[22] eVolo. (2011). Vertical Farm. Website: http://www.evolo.us/architecture/vertical-farm-2/
[23] Official Gazette Republic of Srpska, No. 100/15. Rulebook on spatial and technical conditions for housing of farmed animals, buildings and equipment in animal husbandry.