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Abstract

Equestrian world is a wide field, which is although not that commonly acknowledged is in demand for efficient design solutions. One of the ongoing necessities is a safe and comfortable accommodation of horses at temporary locations, for instance, fairs and competitions. According to the preliminary research based on the designer's personal involvement and observations, the current situation in the temporary stalls' construction has indicated several aspects for possible improvement.

Further research of the subject has started with a careful analysis of vital requirements for each users' group interacting with portable horse housing. In addition to theoretical studies and on-site observations, a series of interviews with horse riders and holders was held to identify the primary needs and points of focus. Further on, deeper understanding of the weak and strong sides of existing solutions was obtained during the three Case-studies at the large public Equestrian events organized at various locations during the year. Conducted information allowed to form a set of necessary criteria to be met during the design process: safety and strength of the construction, functionality and usability during the installation process, material and aesthetical preferences. At the next stage, a new proposal for the portable stall design has been formed.

Besides being based on the obtained selection of users' demands and successful existing decisions, the design direction aimed to develop an innovative, unconventional approach. First ideas and forms have been polished through fast-prototyping and implementation of users' feedback. Further on, the technical functionality of the structure has been tested through a large scale prototype, while the shape and appearance of the stalls were evaluated through detailed 3D modeling and final scale models.

Main innovation in the final design solution arises from shifting from a traditional square to a hexagon shape in stall layout. Described change allows to locate stalls in different combinations, with a fewer amount of partitions required. Additionally, the chosen shape allows horses to interact socially without the risk of physical damage. Eventually, aiming to satisfy different cases of application, two types of portable housing ‘Stall A’ and ‘Stall B’ were included in the final proposal with slight variations in appearance and functionality. For the outdoors location sets of 4 and 5 stalls were proposed to be equipped with the personal tensile roofing. Based on material studies, observations during study cases, and users' preferences, materials for the execution of the final design were chosen to be galvanized steel and coated plywood sheets.

Generally, the functions of the horse housing appears to be simple and undemanding yet in practice portable stalls’ design is a complex subject. Even though, the safety and strength of the construction comes as a first priority for main users, the other aspects of design eventually play an equally important role. The construction process of the stalls and their durability during installation, demounting, storing and transporting is crucial in the matter of long-term usage. Furthermore, a quite often neglected aesthetic aspect has to be undoubtedly taken into consideration since publicly displayed stalls affect the whole perception of the Equestrian industry. Eventually, even though developed for the narrow purpose of comfortable horse accommodation ideas and solutions created for the portable stalls could be applied in the other design fields and areas of modern life.

Keywords: portable, modular, horse, housing, equestrian, design, partitions
LAURELINDE
Modular System for Portable Horse Housing

Master's Thesis
Smirnova Marina
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ABSTRACT

Equestrian world is a wide field, which is although not that commonly acknowledged, is in demand for efficient design solutions. One of the ongoing necessities is a safe and comfortable accommodation of horses at temporary locations, for instance, fairs and competitions. According to the preliminary research based on the designer's personal involvement and observations current situation in the temporary stalls' construction has indicated several aspects for possible improvement.

Further research of the subject has started with a careful analysis of vital requirements for each users' group interacting with portable horse housing. In addition to theoretical studies and on-site observations a series of interviews with horse riders and holders was held to identify the primary needs and points of focus. Further on, deeper understanding of the weak and strong sides of existing solutions was obtained during the three Case-studies at the large public Equestrian events organized at various locations during the year. Conducted information allowed to form a set of necessary criteria to be met during the design process: safety and strength of the construction, functionality and usability during the installation process, material and aesthetic preferences. At the next stage a new proposal for the portable stall design has been formed.

Besides being based on the obtained selection of users' demands and successful existing decisions, design direction aimed to develop an innovative, unconventional approach. First ideas and forms have been polished through fast-prototyping and implementation of users' feedback. Further on, the technical functionality of the structure has been tested through a large steel prototype, while the shape and appearance of the stalls was evaluated through detailed 3D modeling and final scale models.

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Main innovation in the final design solution arises from shifting from a traditional square to a hexagon shape in stalls' layout. Described change allows to locate stalls in different combinations, with a fewer amount of partitions required. Additionally, the chosen shape allows horses to interact socially without the risk of physical damage.

Eventually, aiming to satisfy different cases of application, two types of portable housing "Stall A" and "Stall B" were included in the final proposal with slight variations in appearance and functionality. For the outdoors location sets of 4 and 5 stalls were proposed to be equipped with the personal tensile roofing. Based on the material studies, observations during study cases, and users' preferences materials for the execution of the final design were chosen to be galvanized steel and coated plywood sheets.

Generally, the functions of the horse housing appears to be simple and undemanding, yet in practice portable stalls' design is a complex subject. Even though, the safety and strength of the construction comes as a first priority for main users, the other aspects of design eventually play an equally important role. The construction process of the stalls and their durability during installation, demounting, storing and transporting is crucial in the matter of long-term usage. Furthermore, a quite often neglected aesthetic aspect has to be undoubtedly taken into consideration since publicly displayed stalls affect the whole perception of Equestrian industry. Eventually, even though developed for the narrow purpose of comfortable horse accommodation, ideas and solutions created for the portable stalls could be applied in the other design fields and areas of modern life.
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INTRODUCTION

Fig 1.1
Mare Laura
in the field
This Master’s Thesis is dedicated to all the wonderful horses and their brave and caring owners, with who I had the pleasure to work, yet above all, to a great mare Laure Linde, who I was fortunate to have in my life from 11.2014 till 10.2015. On the 3rd of October 2015 Laura was put down due to osteoarthritis.

I believe that the grace and the purity of horses is a rich source of inspiration for creativity.

Fig 1.2 Laura and Marina in the September sun
Equestrian world became a part of my life in the autumn 2005, almost simultaneously with the start of my design education. Even for an amateur horse rider, stables are always a special place. Frequently, based on the level of dedication and involvement, stables become for its visitors a second family and home.

To a certain extent, visiting stables can be compared to a meditating experience. The process of leaving the noisy city and reaching the countryside, changing into riding clothes allows to completely switch one's mind of the current problems. The surrounding world transforms into different place, where there is only communication with nature and horses - noble graceful creatures.

While working with the horse on dressage elements, training for show jumping or just hiking in the forest rider gets completely involved in the process, the process that requires full and dedicated attention. The process of finding and reinforcing a communication channel between two partners and friends. This partnership built between a human and an animal is, generally, a constant source of raised spirits and positive emotions. Yet, besides those daily moments of joy and excitement, emerging in training and competitions, horses are able to provide a very deep and pure feeling of happiness, in its finest form. Time spent with horses gives an enormous energy boost.

Besides that, horses teach people patience and persistence, they help developing a strong yet attentive personality. Logically, horse riding has proven its positive therapeutic effects with physically and mentally disabled people.

Thus following my personal emotional attachment for my MA thesis, I have decided to research and develop the topic of portable stall construction, and therefore combine two major passions of my life: equestrian world and creative thinking. I found a strong motivation within myself to design for horses and horse riders - users' groups I can strongly relate too. I hoped that my artistic vision and design education could bring beneficial solutions for the equestrian community.

Naturally, the best projects are executed when the designer is fully informed of the users' needs, when the designer can step in users' shoes and observe the world from their eyes. In this case I served both as a designer and as a user, enhancing my work with relevant connections in the field and ongoing enthusiasm based on personal commitment to the topic.
The Subject of Horse Housing

Initially, a horse in a wild nature does not require specific shelter. Within suitable climate conditions horses are sufficiently comfortable spending major amount of their life in open areas like pastures, hiding if necessary from direct sunlight in the shadows of trees and mountains.

However, with the advent of humans in horse life the situation has changed. Neither agricultural horse breeding farms nor racing stadiums or riding schools could be organized without convenient housing for horses, ensuring their health and safety. Various climate zones require keeping horses indoors, leastwise at night time.

Furthermore, population and interaction of horses can be carefully controlled if horses are observed and housed separately. On the other hand, horses, being herd animals, are ought to be kept in social groups and not isolated from each other. All above mentioned factor resulted in an invention of a simple yet efficient housing for horses: the stalls.

Fig 1.3
Finnish ponies in the paddock
Stall - is a cubicle located in the barn or open area, which is designed to hold an animal without a leash. Inside the stall modern horse spends major part of its time, sleeps, rests and consumes food and water. Stalls are generally located in the stables along a passage or on both sides of it; in case of outdoors stalls, exit from each one of them leads to the open area, passage or riding field.

Nowadays many variations of standard or exclusive stalls are manufactured in different materials: brick, wood, concrete, plastic or metal. Depending on the functional requirements of the stables, stalls are divided into three groups: permanent, transformable and portable. In the current thesis work the focus mainly falls on portable stalls, yet other samples are worth mentioning as well.
Permanent stalls (Fig 1.4 and Fig 1.6) are used in basic stables construction, they show the widest variety of options since their main function is narrowed to providing a suitable housing. Once created for a prolonged use permanent stalls can be executed with different appearance and allow application of stronger and more expensive materials.

Transformable stalls (Fig 1.5) are equipped with rotatable/revolving sections: partitions are fitted with hinges that can be open inside or outside of the stall. This mechanism allows, if necessary, increase the area by combining adjacent stalls, or even facilitate fast stable cleaning with machines and automatic equipment.
Portable stalls (Fig 1.7 and Fig 1.8) carry additional function of re-assembled construction.

They, generally, have light walls made with plastic, fabric or plywood filling. Portable stall can be fitted and fixed with a personal roof or be roofless in a larger covered space, like a stadium or expo-center. These stalls are most often used when temporary placement of horses in tournaments or competitions is needed, as they are quickly and easily installed. Additionally, portable stalls can be used for summer vocations, when horses change their location, to reach more available and rich pastures.
As mentioned before, for the scope of this thesis, temporary horse housing is a research priority.

In general, in their layouts and functions portable stalls in many ways replicate their permanent standard brother. Dimensions, proportions and other necessities for the stall constructions are described in details in the following chapter "Requirements for Horses".

However, the application specifics and collapsible structure of the portable stalls creates a number of extra compulsory necessities for its design.

First of all, stall's design should ensure safety and comfort for all groups of users and for horses especially, due to their unique, active and unpredictable behavior.

From the human point of view convenience and usability of the construction plays vital role: high assembling and demolishing speed along with low weight of the elements is a strong benefit for the stall design. Moreover, the structure should be understandable and should allow simple installation in the absence of unique knowledge, skills, tools and construction machinery.
Conversely, elements must be strong and steady enough to withstand repeated cycles of assembly, impact of indoors or outdoors environment, physical impact of intensive usage and chemical impact of bio-waste. Another key aspect is the ability to install stalls and shelters directly on the ground, without any groundworks.

Finally, great design is one that is sustainable, ecological and with consideration of recycling techniques.

Initially, the functions of the horse housing appear to be simple and un-demanding, yet in practice portable stalls' design is a challenging task. The challenge is to create the structure that is strong enough to accommodate large animal and light and simple enough for only two people to assemble it on a site.

Moreover, existing solutions for portable stables generally neglect the aesthetic aspect of design. Chasing lower costs and treating those stalls as merely temporary buildings, producers consider appearance as unnecessary point of focus.
The Subject of Portable Architecture
From the pre-historical nomadic tribes till nowadays portable architecture has been a part of human residential environment. According to Kronenburg (2002) movable buildings are among the first artifacts created by men.

Humanity needed shelter and protection from dangerous external world. In circumstances of constant migration and tough surviving conditions temporary portable home appeared to be a perfect solution in the early days.

Subsequently, experience that has been gained through mobile homes constructions was implemented in development of fundamental fixed architecture. Generally speaking, movable buildings were the ancestor and source of inspiration for many following architectural findings and masterpieces.

Unexpectedly, today portable architecture is not receiving enough attention, compared to its traditional permanent brother, especially in the matter of thorough design and innovation. Small and often inconspicuous portable and temporary structures are common participants of the modern cities and rural areas.

Movable buildings play their important role in various fields of our life: in commerce and industry, as expo-architecture and accommodation for events, in education and health care, in housing and military engineering, as shelters for refugees and disaster victims.

Usually a need in movable demountable structures arises in the case of temporary change of circumstances or environment, like an exhibition, large event or in worst case as a consequence of natural disaster, for instance, earthquake or flood. Therefore, the strong functionality delivered by the construction of the portable building often derives authors and users attention from the other aspects of its design.

One important side of the movable building design is that temporary construction does not assume temporary usage. Moreover, portable buildings are meant to be build and disassembled multiple times. Therefore, the structure requires thoughtful planning with wise application of strong and durable materials. Innovative thinking and sustainable approach are crucial in the development of demountable constructions, since all the discoveries and achievement acquired in the design process can be eventually widely applied in adjacent fields. Various industries of design and architecture will benefit from innovations raised in the field of portable architecture.
“Movable buildings are a valuable, if comparatively unrecognized, component of the built environment. It has been stated that they fulfill many roles in many different areas of life and work; it must also be acknowledged that many of these functions could not be carried in any other way...”

(Kronenburg, 2002, p.11)
Returning to the possible design omissions, it must be mentioned that created as a temporary helper or necessity-based tool, movable buildings commonly lack harmony and attractiveness in their appearance. The aesthetic balance and artistic approach are often neglected due to major focus on functionality and usability and possibly due to the perception of the whole piece as passing guest in an established landscape.

Meanwhile, whole world is changing towards more and more cosmopolitan and detached lifestyle every day. Our work, education and other aspects of life are no longer tighten to the specific geographical locations.

Modern man is possessing a tremendous amount of freedom in traveling, moving and life planning. Thus, it appears that humanity could benefit once again by one of its first inventions. Residential planning, industrial design and conventional architecture could make a new step forward by reconsidering the value of temporary buildings. For instance, according to Kronenburg (2002) assumptions, paradigm shift in the perception of the movable structures could stimulate even further development of sustainability and ecological awareness.

Thereby, active search for fresh solutions and techniques in portable architecture is crucial today.
Due to the described situation in the field of portable architecture, one of the aims of this thesis work is to change the attitude to the temporary movable structures. According to their importance and frequency of application in our lives they are intended to carry within them an aesthetic beauty and harmony as well as function fulfillment.

Furthermore, the goal is also to increase comfort and satisfaction rates among the users’ groups. Equestrian industry is widely developed all over the world. Horse riding is highly popular even in Finland and other Nordic countries regardless of severe weather conditions. Clearly, successful product design development for horses and riders will have a large audience.

Moreover, inventions created within the equestrian design can be further on applied in other areas, like introduction of a saddle-shaped chair to the office furniture or replication of stalls’ partitions in the exhibition stands construction.

Therefore, the main goal of this thesis is to design a strong solution for portable horse housing: an adjustable modular construction that provides high usability, comfort and safety together with beautiful and balanced aesthetic component.

Final design decisions is ought to be based on research and careful analysis of existing problems and solutions, gathered through observations, interviews and on-site studies.

Fig 1.10 Points of focus
EXISTING PROBLEMS
Approaching the topic of designing temporary stables it is important to first define the main needs of every user group involved in its usage. In the case of portable stalls all users can be divided in the three categories: construction workers - people transporting, assembling and disassembling the stables; horse holders and riders - people using the stalls on a daily basis; horses - main users and inhabitants of the stalls.

Qualified research into specific requirements related to each users' group allows to create balanced design solution which serves in the most advanced way to customers' satisfaction.

In the current thesis an overview of general requirements for each of the three users' segments is conducted, with analysis of possible areas of improvement, compared to existing solutions. First of all, requirements for horses were conducted based on theoretical knowledge and personal practical experience. Preferences of the second users' group: horse holders and riders were defined through the series of interviews and discussions.

Meanwhile, all the important criteria regarding the usability of a design from construction teams' side were gathered during the study-cases observed gradually during spring-autumn 2015.

Users’ Groups

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Requirements for Horses

Horses and their behavioral patterns are one of the main factors that influence the design of stalls and stables.

According to Wheeler (2006) horses have highly developed senses of sight, smell and hearing. A horse's natural defense mechanism is the flight-or-fight instinct. Horses are generally non-aggressive, but when threatened, excited, impatient, scared or in pain they will typically first try to escape by running away. Therefore, first of all, facilities that contain horses need to be sturdy and should not contain any obstacles that would impale a panicking horse.

Apart from an active behavior and strong physical power social needs of horses are likewise an important aspect, which influences stalls and stables design. Horses are highly social animals: "Isolated horses lack the security of a group and often develop undesirable and possibly health-endangering behavior not found when a number of horses live together... If possible, horses should be allowed to see other horses and outside activities to decrease these stereotypes and to reduce anxiety from being isolated" (Wheeler, 2006, p.3)

Therefore, it is crucial in any stalls' design to provide communicating opportunities and visible contact with other horses and surroundings. That rule mainly applies to the stalls' partitions. If they are properly designed and horses can freely communicate with their neighbors, this improves their mental state, they become less aggressive or anxious. However, for safety reasons windows and open parts should have grid or metal bars that will prevent horses from direct physical contact: eliminating any biting or kicking between neighbors. It is equally important that the density of the grid or bars is high enough, in order to ensure that horse is unable to squeeze its hoof or head between them, otherwise an animal can get stuck and seriously hurt.

Proper size of the stall is one of the main criteria that ensure horses' comfort and wellbeing. The size of the stall may be different depending on the horse's training specifics and its dimensions. For standard size breeds and ponies stall with dimensions 3 by 3 meters is sufficient enough. Heavy working cargo horses and warm-blooded breeds need a more spacious place, about 4 by 4 meters, stallion or mare with foal should be provided with stall area of not less than 20 square meters. Experts recommend that stall walls would have the height equal to 1,5 heights of the horse. However, if it is possible they could be designed even higher, this will provide a certain additional comfort and freedom for the animal.
Understandably, sufficient ceiling height affects physical and mental comfort and safety of the horse.

Moreover, it plays a vital role in stall’s ventilation. High ceiling improves air circulation and helps to minimize the risk of head injury for a horse, in case the animal gets scared and raises on back legs. Minimum height of the ceiling should be 2.5 meters for a standard horse, traditionally, however, it is 3 meters high.

... If possible, horses should be allowed to see other horses and outside activities to decrease these stereotypes and to reduce anxiety from being isolated”

In general, the construction of the stall is simple and does not include complicated details. However, one element – the door requires special attention, due to its importance in stall’s usability and various methods of execution.

Usually, door size should be equal to at least 2.4 meters high and 1.2 meters wide to ensure that the horse does not hurt its hip or shoulder. There exist various designs and constructions for the stall’s doors (Fig 2.4). However they usually belong to one of two types: sliding door on rollers, or swinging door opening outside of the stall space.

The swinging door could cause some inconvenience by blocking a passage and increasing the risk of injuring the horses that are in the aisle, therefore sliding models are preferable, if possible.

Sliding models are fitted within lower and upper edges of the stall wall with special slots, which allows the movement. These doors are generally more expensive, but they are likewise more comfortable since they do not block the aisle and give more room for maneuver. In construction of these doors, importance should be given to the presence of the blocker, which would prevent the door from opening too wide.

Fig 2.3
Curious horse Anetty in a wooden stall
Stall doors can be barred, solid or combination of both. It is better to give preference to the combined version, as they provide good ventilation, an excellent overview of the surroundings for the horse, in addition to preventing injury, as horse legs will not get stuck in the bottom of the lattice.

Some of the stationary stalls are equipped with versions where the bottom-sealed and top-barred parts of the door can be opened separately. It provides certain convenience for the stable staff, when feeding the horses and cleaning the boxes. During those processes worker is able to open solely the bottom part, eliminating therefore the risk of the horse leaving the stall unattended.

Moreover, the top barred part can be kept open for calm and social horses, allowing them to look out freely in the passage or to outside area. For same benefits, some doors have an open void in the top part, wider at the top and smoothly narrowing down to the middle of the door (Fig 2.5).
In this case, as mentioned, horses can look out in the passage, yet they are still unable to touch or bite their neighbors. This solution, although very sympathetic for the horse, provides additional risks for general safety at the stables, especially when dealing with active aggressive horses.

In the realms of locks design latches and clasps that can be operated with one hand have a clear benefit for riders and staff, who generally approach stall door with either leashed 400kg animal or with a bucket of food or water supply.

...the door requires special attention, due to its importance in stall’s usability and various methods of execution.

Fig 2.5
Stall doors with a void
Materials Requirements

According to the specifics of horse behavior safe and strong materials are the priority in the design. Those are important, yet not singular criteria that has to be fulfilled in the construction of the horses' housing.

The choice of material for the stall depends on several criteria like: the budget of the construction, taste of the owner or climatic zone. In the stationary stables wood, naturally, is the most commonly used material. Application of timber in stable construction brings various benefits and is relatively affordable. On the other hand, unfortunately, wood cannot be considered as a strongly sustainable material. Especially if the timber was not disinfected properly. The most durable type of wood is oak, yet it is generally highly expensive. On the contrary fir or spruce, which are more accessible in price, quickly become damaged under continues stress that a stall has to withstand.

A convenient and therefore common solution is to use timber, covered with galvanized metal. This will enhance the strength of the surfaces and will prevent animals from nibbling the timber. Galvanized steel is protected from rust if the galvanizing process was made after cutting.

Selecting the flooring material for the stall should be also a thorough process. Obviously stall floor has to fulfill several important requirements. It is important for the floor to be dry and do not absorb smells and odors. It needs to be safe, durable, strong, and yet obtain acceptable density, since as experience has shown, extremely hard flooring can damage horse's tendons. As Wheeler (2006) underlines the health of a horse's legs and feet can be greatly affected by the type of stall flooring chosen. Furthermore it has to be easily cleaned, safe and not slippery.
There are two main categories of flooring for stalls: water-resistant and porous. Porous flooring is usually made out of sand or gravel. This materials allow water transitory into the ground, therefore they tend to accumulate the smell of urine and feces. However for the horse legs they are generally more comfortable and safe, unlike the more hygienic water-resistant surfaces. A common example of water-resistant flooring is concrete base covered with a rubber mat.

For stationary stables, mixture of clay and stone dust, clay and gravel became especially popular for coating stalls bottom. Such floors are considered comfortable for horse physics and have a porous structure. However, they are difficult to maintain. This flooring requires to be leveled once a year and to be completely renewed once in a few years.

As for the concrete and cement floors, they are more durable, yet are often particularly hard and cold.

Therefore, the ideal solution for flooring is a combination of a rubber mat or rug on a soft surface, such as sand or mixture of substances described above. These coating for the stall ground will not slip, absorb smells or moisture and it is easy to clean. Additionally, some types of rubber provide antibacterial and anti-fungal additive. Recently there were developed special rubber mats with a locking-puzzle system. Although they are more expensive than usual ones, it appears to be a great solution when modularity and mobility is required; working as a puzzle they fit tightly in the space - preventing sawdust and manure from clogging under the edge of the flooring.
Horse Vision and Color Perception

In order to define which color scheme would be the most beneficial for a stall design it is important to understand how a horse sees the world. Identifying specifics of horse's vision is a relevant and moreover, an interesting topic for the research.

According to the information that has been conducted, horses, unlike other domestic animals have rather strong visual acuity, stronger than cats and dogs, yet still weaker than human.

"The average horse has a visual acuity of about 20/30 to 20/40, which is much better than the average dog (20/75) or cat (20/100), but slightly worse than the average human (20/20). In humans, 20/20 means that a person can identify the details of an object from 20 feet away. That standard is applied in animals too, so in horses 20/30 vision means that the horse needs to be 20 feet away from the object to see the same details that the normal person can discern from 30 feet." (2008, p.1, Horse Channel.com)

Even though visual acuity is important, for the purpose of stall design, more importantly is to identify how horses perceive colors. According to Jenny Chandler and Mary Foster, it is not yet entirely clear how horses see hues. Some of the experimental exercises have shown that horses see clear difference between blue and grey, yellow and grey, and green and grey. However, defining between red/orange and grey is harder for most of the horses, and occasionally it appears difficult for them to separate green and yellow objects. Generally speaking, horses color perception is in many ways similar to dichromatic "color-blind" human. It can be explained through the fact that horse eyes contain only two types of retinal cells allowing them to differentiate mainly blue and yellow objects. Additionally, an eye of the horse contains less color detecting photo-receptors than human eye which declines the range of nuance shades and tones that horses can distinguish. If the object is located far horses cannot define precisely its color specifics and perceive it as mild grey or as pale version of the hues they comfortable identifying.

"The fact that horses also have many fewer cones in the central retina than humans do also suggests that their perception of color may not be as vivid as that of humans and that colors appear as washed-out pastels or sepia. Nevertheless, this serves the horse's purpose." (2008, p.1, Horse Channel.com)
Following the research and test results we can estimate how horses see the world around us. Therefore, colors applied in stalls design can be arranged in order that would be less noticeable and disturbing to the horse.

A design that would look to a human eye as bright and intense combination of orange, red, blue and grey elements, to a horse would look like an object of a relatively singular solid color if the brightness of the tones is held at one level.

Alternatively, surfaces of stall partitions can be used as canvases displaying landscapes and surroundings the way horses see them. In other words, partition can be a storytelling art piece, allowing to perceive objects through eyes of our riding companions.
Generally speaking, horses color perception is in many ways similar to dichromatic “color-blind” human. It can be explained through the fact that horse eyes contain only two types of retinal cells allowing them to differentiate mainly blue and yellow objects.
Horse Holders and Riders

Another large group that is involved in usage of portable stalls consist of horse holders, horse riders and stables staff. Several important activities including horses and people occur around the stalls: horses are constantly led in and out of the boxes, they have rest, spent night time and wait for the competitions' starts inside the stalls; horses are fed and given water inside the boxes. Moreover, brushing and saddling is held generally inside or near the stalls as well.

With all this actions to be performed and all the experience the horse owners have, they develop their own set of priorities and requirements regarding stall design.

In order to better define those requirements and recommendations a series of personal interviews has been held. Horse grooms, rider and horse owners from Russia, Finland and Poland has been asked a set of questions, revealing their view on the topic.

All the listed questions were kindly answered in person by ten riders and horse owners. Subsequently, their answers and opinions allowed to specify and polish several necessities that are of a crucial importance in stable design.
Users’ Interview. Set of questions:

• Please introduce yourself and tell us shortly about your involvement with horses.
  • For how long have horses been a part of your life?
  • Please briefly describe the stables, where you keep your horse: size, location, specialization.
• What are the 3 most important aspects of stable design and organization for you?
  • What would you improve in your stables design or layout? (2-3 key aspects)
  • Are you satisfied with the stall (box) where your horse(s) is kept?
  What would you improve? (2-3 key aspects)
• If you had an experience staying or working at other stables, were the other stalls better / worse, could you please share your experience (2-3 key aspects).
  • Have you ever been with your horse(s) to an event like competitions, horse shows, fairs?
  • Have you been satisfied with the temporary horse housing at those events?
  Please share your experience. Positive and negative moments (3-4 key aspects)
• Have you ever had a major issue or an accident due to the construction of a horse stall?
  If so, please share your experience.
  • Is appearance and overall design of the stalls and stables important to you?
  • Do color solutions play an important role in stables and stall design?
For majority of the interviewees, safety and comfort of the horse is a top priority. Therefore, for overall stable design as key compulsory features they listed wide passages, sufficient ventilation and proper fire safety; presence of large paddocks and appropriate riding arena footing also occasionally appeared to be of a high importance.

Concerning the stall design in particular, generally riders and staff are satisfied with their boxes, if boxes are within or more than 9 m² in area and if they are made out of durable materials.

The most controversial issue, however, was construction of stalls’ doors. That is one element, which has provoked the most of the accidents and difficulties during horses’ handling.

If the doors are not wide enough it increases the risk of a human to get hurt, while being led out an impatient young horse or a stallion can force its way out, leaving the rider behind or oppress him to the box wall. Swinging doors in case of narrow passages and alleys are strongly undesirable solution – since they can bock the passage; additionally swinging doors are easier for horses to open on its own, therefore in that case proper locking system should be installed.

Regarding temporary accommodation riders and horse owners provided special recommendations and feedback.

Firstly, if the stalls are located outdoors, equipment and food supplies has to be equally protected from rain, as well as the horses. Poor tent roof design has resulted in the past in unfortunate accu-

Fig 2.8
Team is getting ready for the training
mulation of water on the roof, leading to wetting the bedding and increased tension of the horse.

Secondly, it is vital to have safe and strong materials in the partitions, and a variety of partially or fully isolated stalls along with standard ones. Horses at events are placed in unfamiliar environment side to side with the animals they have never met – all this factors lead to raise of curiosity, spontaneous behavior and aggression among them.

Finally, from the matter of social interactions, it is preferable that although visual contact with surrounding or neighbors is maintained, horses are unable to reach in any way other horses physically. Events provide only temporary accommodation, therefore in short term, safety is of higher priority compared to horses’ social needs.

Raising the topic of appearance and coloring solutions in stable and stall design users have not expressed serious demands. For the majority of the riders and grooms function and comfort is a beauty in itself. Practical traditional colors and natural materials are in favor. Additional exuberant decor elements like forged metal parts only result in higher damage risks and therefore are unreasonable to use.

However, many of the horse holders and riders treat stables as second home and come their nearly every day. Therefore they admit, that it is noticeably more pleasant to use attractive stalls, to see how your favorite horse is looking out from a beautiful door with shiny metal bars and freshly lacquered wooden planks.
CASE-STUDIES

Hevosmessut, Helsinki
Hipposphere, Saint Petersburg
International Horse Show, Tallinn
7th-8th of March 2015
21st-23rd of May 2015
2nd-4th of October 2015

Fig 3.1 Jumping in motion
Hevosmessut, Helsinki

Horse Fair 2015 "Hevosmessut" took place in Messukeskus in Helsinki between 7th and 8th of March 2015.

Hevosmessut 2015 was the first horse fair held in the Capital of Finland, historically all the previous Exhibition were located in Tampere or other Finnish cities. Finally, in March 2015 the Horse Fair was organized in the main exhibition center "Messukeskus", at Pasila Railway Station in Helsinki, together with the Fitness and Tourism Fair "Go-Expo".

For the visitors fair facilities offered various coaching programs and lectures, exhibition of breeds, jumping show and vast amount of retailing spots, selling everything a rider or a horse might need.
Horse Fair 2015 showed a strong interest and attention from Finnish society towards the Equestrian world. Fair halls were constantly full with visitors: young riders, families with kids and all types of professionals from the field. One of the main attractions of the Fair was the Jumping Show, where riders from various countries competed in jumping skills.

Additionally, there were organized educating playgrounds for children and an opportunity to test your riding skills on an iron horse – computer-controlled simulator of horse moving dynamics.

Horse Fair 2015 in Helsinki fulfilled its purpose of connecting industry people, providing family entertainment and popularizing the Equestrian activities.
Fig 3.3 Starbox stalls at Messukeskus, Helsinki
Housing for the horses at the fair was organized by the company HorseEvent Oy, Hallahuhta. In the main fair hall, several portable stalls Starbox® by Cheval Liberte were located, accessible for the visitors, displaying various horses from traditional Finnish breed to extravagant islandic ponies.

Horses were mainly privately owned, belonging to different individuals and riding clubs. Brief interviews with the horse owners showed that generally, people are pleased with the horse housing and the horses remained safe. All the jumping horses and their teams were accommodated in a separate hall, with temporary housing and equipment storage organized.

In total the fair accommodated around eighty horses together with their owners and grooms during two days.
Interview of Kari Tuominen, the representative of HorseEvent Oy at the Hevosmessut 2015 has lifted the veil of secrecy concerning accommodation of more than eighty horses at the fair.

All the housing was constructed by the means of foldable stalls Starbox®, by Cheval Liberte. Kari Tuominen and his company have been leasing and constructing this portable stalls at multiple events, for over five years. He is truly pleased with the functionality of the Starbox® stalls.

Nevertheless, he admitted that new, more sustainable and affordable solutions are at the highest interest of their company. The strongest advantage of the foldable Cheval Liberte stalls is their constructing and disassembling speed. According to Tuominen, his team of 3-4 workers is able to disassemble and store 88 stalls in 6 hours only, with the help of a loading crane and a van.

This quality appears a strong advantage in situation when manual labor force is the highest expense.
However, even though Starbox® housing works well to serve horses’ and constructors’ needs, it is clearly lacking attractive aesthetic appearance to match with the whole spirit of the fair.

Fair is a public event, meant to evoke joyful emotions and increase attention to the field's subject. Therefore, it appears wise to reflect those intentions in horse housing as well, considering that part of it is displayed to the visitors.

Finally, from the point of view of leasing and maintain company, in this case HorseEven Oy, the strict patenting system of the Starbox® solution creates several obstacles in matters of purchasing, sub-renting and using this stalls. Although the manufacture company Cheval Liberte allows to buy the stalls, they additionally include the Royalties fees to be paid for every month of the stalls usage.
Hipposphere, Saint Petersburg

Hipposphere is a large and multidirectional exhibition dedicated to Equestrian world, held every year in Saint Petersburg, Russia. Each year more than 17 thousand people attend the fair.

This time it was hosted by new exhibition facility "Expoforum", offering up to 13 thousand square meters of space for the fair disposal. Hipposphere 2015 gathered representatives of various sport clubs, horse breeders, veterinarians, riders, governmental agricultural institutions and anyone passionate about horses, from Russia, UAE, Oman, Slovenia and Commonwealth of Independent States.

Likewise the Hevosmessut in Helsinki, Hipposphere contained valuable seminars and lectures, horse shows, presentation of over 25 various horse breeds along with numerous equipment selling points. It has also provided entertainment and engagement for kids and families with a small pony zoo, presence of camels and even a reindeer with summer-sledge.

However, this year Hipposphere was above all strongly focused on horse-therapy and its impact on human well-being.

A separate campaign called "Share your summer" was held. It was a charity event organized in cooperation with Non-Profitable Organization "Center of mutual integration - Accord", aimed to help people with different disabilities to integrate in the society and spread the awareness about advantages of hippo-therapy.

On Friday, the 22nd of May 2015 the open area of Expoforum was welcoming guests from all over the country offering free of charge horse-therapy session, socializing and educational seminars dedicated to the impact of horses on rehabilitation.

Hippotherapy has proven to provide significant improvement for kids and adults with mental and physical disabilities like: cerebral palsy, developmental delay, Down syndrome, decreased mobility etc.

Ultimately, multi-directional character of the Horse Fair in Saint Petersburg showed amount of value that horses can bring to human lives. Clearly, Equestrian world similar to other industries requires development of new solutions and technologies to serve each of its participants.
Olga Anatolyevna Vorojtsova the leading administrator and CEO of KSK Istok, a horse riding sport center in Yanino, St. Petersburg, Russia – provided valuable and sufficient information regarding accommodation of horses at Hipposphere 2015. The exhibition was hosting over hundred horses, housing for all of them was provided inside the main exhibition hall. All the stalls were assembled on site from parts, by a team of 4 construction workers; two types of portable stalls were used: set of a brand new housing and a set of old, well-tested structures. Both types of stalls had same simple process of assembling from four separate partitions – two sidewalls, backside partition wall and front partition wall with the door (Fig 3.7).

The new batch of stalls has recently been designed and produced by Group of Companies "Karkas", Saint Petersburg, and it has been applied for the horses' accommodation only several times. The older set of stalls has been in use already for 14 years.

Fig 3.7
Construction of the stalls from the new batch
Even though at a first glance both stalls appear to be of a similar design, detailed investigation in their usage and assembly process revealed their noticeable difference, strong and weak points. Freshly and thoroughly made new stalls are impressive in matter of appearance and strength (Fig 3.8).

They have thick, covered with polished black paint metal structure, thick window grids and more than reliable, beautiful solid wooden planks serving as filling for the walls. They look very attractive and are comfortable for horses and grooms. However, they are very demanding in the matters of constructing, disassembling and storing.

Although the old set of stalls applies a similar design concept, it was made with several small but crucial differences. Structure was likewise made with square-section steel frame, welded together, bottom half of the partitions and all back walls were covered with sheets of plywood, windows equipped with narrow steel rods.
Fig 3.8 The new set of temporary stalls
This set of stalls obtained poor appearance, paint has worn out on some parts from steel frames, plywood absorbed dirt and cracked in few places, yet these stalls have proven to work well and possessed several advantages compared to the new ones. Each partition of the old stalls had relatively light weight of 60 kg – compared to 120-130 kg partition weight in the new batch.

The weight was lighter due to the thickness of the metal frame that was thinner in the old construction, however that thickness was sufficient enough to withstand the pressure that stalls receive. Metal rods in the window grid were also of a smaller diameter – what has contributed to the lightness of the whole item.

Additionally, application of plywood in the sealed parts of the partition was a wiser choice, compared to the implementation of solid wooden planks in the new stalls design. Plywood is strong enough to resist the impact of kicking, yet it is more affordable and light weighted than solid wood. Sheets of plywood are less likely to be cracked or broken during loading, unloading and storing, due to its higher flexibility and bending qualities.

Moreover, plywood has noticeably simpler maintaining and repairing process. In case of damage, a new piece of the plywood can be easily purchased, cut according to the size and fixed with screws in matter of hours. On the other hand, application of solid wood planks makes repairing process dramatically more complex. If one of the planks is broken, regardless of its position, the whole row has to be demounted, plank replaced and subsequently the row is re-assembled again.

Furthermore, apart from noticeably easier assembling and maintaining process older set of stall has proved higher durability in storing. Unexpected additional problems appeared with the new batch of stalls after first storing experience (Fig 3.9).
New construction obtains bigger square-shaped hinges, allowing to joint two neighboring partitions with a square metal lock. Unlike the small cylindrical hinges in the old structure new ones get seriously damaged and even completely squeezed and flattened under the weight of above stored partitions.

Therefore when a new event has to be organized construction works spend extra working hours simply fixing and straightening the locks. On the contrary, when the smaller cylindrical hinges were used this problem never occurred (Fig 3.10).

Moreover, the round bolt used as a lock with cylindrical hinges is easily replaceable, while the square lock of the particular dimensions has to be separately manufactured if lost or damaged. These and other observations reveal the importance of details in any design, especially in a deceptively simple objects as horse stalls.

As it has been mentioned above, that the new batch of Stalls had a very pleasant and attractive appearance, it created an impression of a strong, stable and expensive structure, as opposed to seemingly weak and dilapidated look of the old set. However, actually, it should be noted that restoring and refreshing the appearance of the old structures would consume presumably a smaller amount of effort than has been put for dealing with functional defects of the new stalls.

Finally, it is worth stating that even though stalls applied at Hipposphere 2015 all required manual assembly it did not affect majorly the construction duration. According to Olga Vorojtsova, administrator of the event, experienced team of workers are able to install 70 stalls in approximately 6 hours. Declared numbers are surprisingly close to the ones performed by usage of foldable stalls at Hevomessut in Helsinki.
In the beginning of October 2015 an International Horse Show was organized in Tallinn, Estonia. The show gathered hundreds of sportsmen, experts, excited visitors and 180 horses in one location. Therefore, the Show appeared to be likewise a suitable case-study for the thesis research to compliment the data gathered from the Hipposphere in Saint Petersburg and Hevosmessut in Helsinki.

The event was hosted in the large modern facility, Saku Suurihall, located at the edge of the city. Case-study included visiting the site during construction period before the Show and brief staff interview, kindly organized and provided by the main manager of the event - Siim Nõmмоja.

Even though Saku Suurihall is a large spacious building, stables for horses were arranged outside, on the parking area behind the hall. Most of the stalls were located inside large white tents, installed temporary by a subcontractor company, preliminary to the stall construction. Created from rigid metal support system and canvas covering tents served as a shelter from wind and rain. Moreover, tents were spacious with sufficient ceiling height – a quality always beneficial for public spaces. However, these tents were general function tents and could be applied in various exhibitions, concerts and events, therefore their structure and design were not relevant to the focus of research.
Fig 3.11
Saku Suurhall hosting
Tallinn International Horse Show
Main purpose of the case-study was investigation of the stalls constructed at the event, analysis of their strong and weak points. All the construction work for horses' accommodation started a week before horses' arrival, assembly of the stalls in particular, lasted approximately 4 working days. The Show organizer used two types of stalls to locate 180 horses in total. One type was the famously patented Starbox® by Cheval Liberte, identical to the ones used at Hevosmessut in March 2015 in Helsinki.

Second type was a simple stall manually assembled from 4 separate partitions, with standard dimensions 3 by 3 meters. Weak and strong points of the Starbox® stall were described in detail in the previous study-case chapter "Hevosmessut. Helsinki", therefore will not be mentioned here. The strongest advantage of the Starbox® stalls in this occasion was ability to install them outside the white tents area, due to the fact that all the Cheval Liberte stalls are equipped with personal roofs, erectable with the help of hydraulic pumps.

The other type of stalls even though lacked the roofs, yet clearly had a noticeably simpler structure (Fig 3.12). Mainframe was made of approximately 25 by 15 mm hollow metal rods. Dark laminated plywood sheets filled the gaps between the frame structure, forming cheerless yet strong partitions. The back and side partitions were divided into 9 uneven parts with metal bar support in the middle of each partition.

Probably, this technique was applied in order to increase the stiffness and strength of a partition. Additionally, division of the whole surface into 9 smaller segments simplifies replacement of a plywood segment in case of damage.
The only part, allowing visual access inside this stalls, was present in the top half of the stall door, where a plywood sheet was replaced by a row of vertically mounted round metal bars approximately 15 mm in diameter. The space next to the door, in the front partition, which generally serves as a full window, in these stalls was sealed with a plywood sheet as well. This detail is an obvious disadvantage in design, considering the social needs of horses as well as safety requirements. Lack of visibility when dealing with horses is a strong problem that increases risk of damage. Riders and stable staff should be able to see horse condition inside the stall, when passing by or entering the box.

Even though some thoughtful decision have been made in the construction, over all this set of stalls looked very rapidly designed with no consideration of appearance or additional functionality. Stall doors had a singular spring latch lock, mounted within the door surface.

Locks were very stiff and hard to use, opening the door required high physical effort almost impossible to be performed with one hand.

Additionally, application of laminated dark brown plywood displayed low durability of laminate and unsuccessful color choice. This choices had been made, possibly, based on the functional grounds. The area where stables were assembled was restricted for staff attendance only and stalls were not meant to be publicly exposed. Once again, according to the main stable manager at the event, most important criteria for a horse housing design is its safety and functionality.

*Fig 3.12 Basic partition based stalls*
As the observation during case-studies and additional research has shown, current market has a variety of stalls design and stables equipment to offer. Detailed market analysis allows to allocate three groups of existing solutions that are valuable for current MA thesis work. Each of the group examples combine strong and weak points in their design.

Fig 3.13 Stalls assembled on site
Group 1

Group 1 includes portable stalls made from prefabricated partition elements, executed in mainly light, common and affordable materials like steel or aluminum welded frames combined with PVC fabrics, or sheets of plastic or plywood.

These stalls are assembled on site manually, they require skilled construction team, basic tools and possible additional hardware. Transportation can be held by a van, which allows to store items with 3x3m dimensions. Loading parts in the van can be performed both with the help of the loading machines or manually, due to the fact that structure is disassembled in 4 separate comparatively light partitions.

This group examples require noticeable amount of manual labor during installation and show weak durability and aesthetic component, however it is affordable in price and accessible to purchase from various manufactures.

There are multiple companies offering solutions similar to the one created by "Barn 2 GO", it is available worldwide within range of different prices, colors and materials. Stalls can be ordered online directly from manufacture, and exclude any patent technology or licensing to be obtained for further usage or sub-rent.

Examples:

Showplace Stalls by “Barn 2 go®”, USA.

Pricing: 440-730 €/partition; ~ 1750–2930 €/stall*

** Based on the currency rates from 22.12.2012
Group 2

Group 2 contains modular prefabricated stalls assembled inside the barn. This stalls require a thorough and labor consuming installing process, and are more applicable for fixed permanent constructions inside the stables.

However, for the scope of this thesis prefabricated solutions for permanent stalls appear as well to be an interesting point of research. Both temporary and permanent stables have similar user needs – therefore solutions and achievements from one field can benefit development of another.

Group 2 examples are made of more durable and attractive materials, compared to Group 1, like hot-dip galvanizing painted steel bars and wooden planks. They usually consist of prefabricated wall sections which can be easily set in place without additional support posts.

Displayed example, by CMI Horse Stalls & Equipment is a modular system that is relatively easy to build. One stall takes roughly an hour and fifteen minutes to assemble and join with the whole set. This modular system allows you to easily add and remove stall walls and vary the

Fig 3.15 Prefabricated stalls by CMI Horse Stalls & Equipment
amount of horse houses, according to changing necessities.

Therefore, these horse stalls can be used as both permanent stalls and as portable units. Set of stalls can be fixed against wood, steel and concrete – in that case fewer of the prefabricated partitions are used, as existing walls of the space will serve as stall boundaries.

However, in many cases, when the existing barn walls are not suitable for use, stalls can be installed independently, in an open space. Separate partitions are locked together with connection brackets, coming along within the stall-set purchase. Front wall panels are equipped with sliding doors – pre-mounted and adjusted by manufacturer. The strongest advantage of this system is the strength and durability of construction. Additionally, usage of more traditional materials provides an attractive appearance for the stalls.

On the other side, strong structure and material choice has a drawback in its application: this construction requires noticeable amount of time and labor to be build, and therefore is inefficient for short-term temporary horse accommodation.

Fig 3.16
Stalls’ installation options

Examples:
Basic Horse Stall (Modular Build)
by CMI Horse Stalls & Equipment, USA
Pricing: 376-700 €/partition; ~2096 €/stall*

** Based on the currency rates from 22.12.2012
Group 3

This group represents stalls-transformers, - a more technologically advanced version of a temporary stall, which is simply folded for storing and saves a vast amount of time, by excluding the assembling process.

Portable foldable stalls “Starbox®" by British manufacture Cheval Liberte were used at Helsinki Horse Fair 2015, in Messukeskus, that allowed a detailed investigation of their structure and installation system.

Starbox® is a patent design of a portable stall that can be instantly installed. Starbox® consists of a galvanized steel frame, joined by welding and screw fittings. The metal structure has outside frame, and diagonal support in case of outside walls. PVC canvas or plastic sheet is fixed within the frame, creating the main area of the wall.

Front walls or facades are open from top half and equipped with a metal grid protecting horses from hurting themselves and each other. Grid is welded to the structure and is made from round metal bars. Doors are basic swinging doors, with a spring-based locks, and additional shutter in the bottom part, ensuring that door will not be open by accident. Stalls have standard size of 3x3 meters. They can be equipped with two options of PVC roof. In the first option the roof is flat and is simply covering the area of the stall.

In the second option, designed for outdoors event, roof is forming a two-slope shape. The centeral part of the PVC roof canvas is lifted from beneath with gas spring, fixed on the diagonal frames above the center of the stall. The main patent point of the Starbox® structure is that partitions are joined by metal hinges which allow to fold the 3x3 meter cubical piece into a flat-pack.
After folding stalls are stored on the van with the help of the loading crane and can be transported to the new location or storage facility. One stall is folded and packed within 5 min.

The clear advantage of this solution is the assembling and demolishing speed. Although Starbox® appears to be a convenient solution, it is crucial to notice, that the construction process requires a small loading crane and cannot be performed by means of purely manual labor. Additionally, assembly process has to be held in an open space or big enough area with high ceilings – that will allow entrance of the large van and a loading crane.

From the point of view of the construction workers Starbox® is sufficiently comfortable in use, however the difficulties arise if one of the sides starts to bend during the folding process, due to its large size – in that case, folding process is complicated and slowed down.

Starbox® shows a good durability – stalls used at Helsinki Horse Fair were by current moment from 5- to 10 years in use. They require few maintenance activities like cleaning and oiling the hinges. Broken parts both in metal or PVC components can be replaced and fixed with welding techniques.

Regardless of a strong technological benefits of this solution, there is still an opportunity for developing more functional and more importantly aesthetically more balanced designs. Design that would have a thoughtful approach to the proportions and shapes of stall elements like doors, grids and partition joints.

Examples:
Starbox® by Cheval Liberte.
Pricing: 2 stalls - 3039 €; 4 stalls - 5030 €; 6 stalls – 7118 €
DESIGN PROCESS
Sources of Inspiration

Frei Otto

In terms of art design and architecture approaches and inspiration can migrate from one area to another. For instance, complex large-scale structures contain a unique set of solutions that can be applied separately in different small projects, like portable stall design.

Consequently, a great source of inspiration are the leaders and world's icons of architecture, art and design. One great encouraging example is the work of German architect, Pritzker Architecture Prize winner 2015, Frei Otto (1925-2015).

Frei Otto is a pioneer and a true master of tensile architecture. His works serve as an endless source of inspiration due to their graceful appearance and strong social value. Tensile structures designed by Frei Otto are light, highly sustainable and environmentally friendly, they make least possible impact on the surroundings and gently place themselves in the landscape, almost as they are part of nature itself.

This result was achieved due to a comprehensive multi-disciplinary work process, organized by the architect. Frei Otto, actively collaborated with scientists, biologists, engineers and naturalists. Methodology and creative thinking that Frei Otto has applied through his career is a separate strong inspiration point for next generations of designers and architects.

He investigated nature self-formation processes, and took his inspiration and knowledge from various shapes and structures that are self-created in macro and micro environments: from huge rock and ice arches formation to the bubbles and foams of pneumatics processes.

Moreover, another point of admiration is attitude and motivation of Frei Otto's work, his primary intention was to make a world a better place, through sustainable, affordable and beautiful architecture. He aimed to create easily constructed structures for benefits of poor society layers and victims of natural disasters.

Above all, it is interesting to mention, that in certain cases Frei Otto work were created as temporary constructions. Such gorgeous examples of temporary structures, perceived as purely natural, elegant form, are opening, possibly, a new era of temporary architecture and design.
“Frei Otto was the first to examine the link between form and structure and thus discovered the significance of the self-forming minimal surface for design and shape for tent structures.”

(Otto and others, p.74, 1995)
Moduli
Further on, another rewarding source of inspiration and ideas for temporary stalls construction is modular, prefabricated and portable architecture. Modular solutions present various opportunities for enlarging or shrinking the space according to user's needs. Moreover, modular prefabricated buildings are assembled on site, have low environment impact and can be assembled within few days, saving effort and time.

A strong example of rapidly constructed residential housing is - Moduli 225, project created by Kristian Gullichsen and Juhani Pallasmaa in Finland in 1970s.

Moduli was a prefabricated summer cottage designed to solve the need in rental housing, the whole house could be assembled on site within two days only. It was build from a set of pre-executed elements, fixed on the structural grid; Moduli had balanced Scandinavian aesthetics, clean proportions, simplicity of form and natural colors.

The range of prefabricated elements allowed to create different variations of the cottage layout. Unfortunately, despite beautiful aesthetics and innovative thinking project has not became profitable and has not been developed any further.

Fig 4.2
Moduli System by Kristian Gullichsen and Juhani Pallasmaa
Likewise Gullichsen and Pallasmaa, Kieran Timberlake Architects have chosen a similar method of assembly process in the Loblolly House. Loblolly House is a gorgeous modern construction located on the edge of a pine forest in Taylor Island, Maryland.

This modern building displays a new approach to architecture: more sustainable, flexible and environmentally friendly. As the masterpieces of Frei Otto, Loblolly house has minimal impact on the environment – it is fixed as a tree house on strong piles lifting it from the ground. Above that, the construction process does not require major machinery application and interruption of the environment.

House structure consists of several prefabricated elements and integrated assemblies, which can be joined together by means of simple hand tools. All the elements and ready-made blocks like bathrooms and toilets are fixed on an aluminum scaffold which provides connection and support to the elements.
More importantly, all described components of the house maintain their integrity when disassembled, allowing if necessary re-install the building in a different location. The whole Loblolly house has been constructed on the site in less than 6 weeks. The house has stunning appearance due to wooden-panneled outside walls. It perfectly co-exists in the environment, raising between the rows of beautiful pine trees at the sea shore.

As expected, Loblolly House has been awarded with various prizes, like EPA Lifecycle Building Challenge and AIA Housing Award etc.

It is one of the successful examples of new off-site fabrication techniques in architecture which shows that attention of the industry is switching towards more sustainable and efficient methods.
DESIGN MOVEMENTS

Bauhaus

Fig 4.4
Set B9 by Marcel Breuer
Alongside with inspirational sources regarding functionality and design approach that was retrieved from works of Frei Otto, Moduli and Loblolly House, the project required an aesthetic concept, a set of guidelines, assisting in making design decisions.

In order to target various user categories two design movements were selected to serve as a basis for stall appearance. For the purpose of the stalls kept within the restricted staff areas and applied for more technical use the inspiration lied within the ideology of Bauhaus. In contrast, for the stalls displayed publicly at the events like exhibitions, fairs, open-air horse shows the inspiration lied in the grounds of more exuberant Art Nouveau. Those two, seemingly opposite role-models have been chosen according to the slight difference in functionality of the public and concealed stalls and, moreover, to test the effect of how different guidelines affect the design and design process as well.

Bauhaus school representatives had their strong believes that even though evolving from functional form and appearance of an industrially produced object ought to be beautiful and balanced. They fought against the soullessness of mass-production, which although seized in the modern design policy, has remained at certain level in the niche of portable structures.

Simultaneously with directing attention towards importance of visual component of a mass-produced product Bauhaus promoted clean and ascetic aesthetics. Especially, in the field of architecture new young school eliminated all national and historical decoration elements, and praised clear lines of balanced geometrical forms. The described approach suits perfectly for guiding a portable stall design, where the highest priority will always be safety and functionality.

Finally, Bauhaus leaders taught to use materials in their most honest, original form. They also encouraged displaying inner metal structure, following the general idea that in a designed object everything should be beautiful. The thoughtful and focused approach of Bauhaus school and its iconic design items served as a major inspiration source for the portable stalls design.
However, for the special occasions and publicly displayed stalls another movement was chosen for inspiration: fluid and mysterious Art Nouveau; this choice has been made based on a more emotional than rational judgement.

The Art Nouveau movement aimed to unify the previously developed historical styles and revive high-end craftsmanship work that has been losing its value on the background of industrialization. The Art Nouveau movement evolved under different names in numerous countries and nations, known across the world as Modern, Jugendstill, Modernisme, Secession or Stile Liberty. Moreover, it declared its presence in many industry sections.

Escritt (2000) remarks that as well as being aesthetically varied and genuinely international, Art Nouveau was also an incredibly versatile style. Nothing within architecture and decorative arts escaped its influence, from door handles to chairs, chandeliers to apartment blocks, from wallpaper to shop fronts.

Fig 4.5
Ceiling details of the Sagrada Familia, by Antoni Gaudi
Art Nouveau has taken several forms and directions across Europe and has produced numerous masterpieces. Undoubtedly, the most admirable examples of the Art Nouveau movement like the architecture of Antoni Gaudí, interior designs by Victor Horta and jewelry by René Jules Lalique will always remain unique treasures in the design history collection.

However, besides its memorable aesthetic components, Art Nouveau creations quite often obtained additional benefits in terms of their functionality and production process. For instance, in France, according to Escritt (2000) Hector Guimard, has introduced a more sustainable and efficient approach to public space decoration through his metro gates design.

In Finland, the Art Nouveau movement was presented in furniture design through the work of Akseli Gallen-Kallela and in architecture through the immortal masterpieces of Eliel Saarinen, Herman Gesellius and Armas Lindgren.

Finnish architecture of the period, as for instance the building of the National Museum opened in 1916, was a merge between multi-directional foreign influence and the emerging specific Finnish architectural style. National Museum of Finland was built out of natural stone according to the winning project by Gesellius, Lindren and Saarinen office, picked throughout a long completion process.

Yet, the most remarkable creation within the Art Nouveau period in Finland is undoubtedly the Helsinki Railway Station, designed by Eliel Saarinen in 1904. This magnificent building combined rational and cosmopolitan architecture with romantic motifs of a medieval church.
By and large, designers and architects of Art Nouveau acquired their inspiration from nature, applying in their work floral and geometrical shapes, herbal and animal motifs.

Nevertheless, according to Robert Schmutzler (1977) activists of Art Nouveau, never directed their intentions towards simple replicating of nature in its common perception. They have rather aimed to represent in their work the basic natural forces, like the power of organic world to transform eternally.

Even more discreet geometrical and linear directions of the movement were created based on natural proportions and guided by the laws of organic life

“All the swinging, swirling, throbbing, sprouting and blossoming is intended to be an unequivocal sign of organic life, of living form.” (Schmutzler, 1977, p.207)

According to the aspects mentioned above, ideological and aesthetic basics of Art Nouveau appeared strongly suitable for the purpose of stall design. Generally, horse holders and riders feel themselves more connected to the magnificent word of wild life, forests, valleys and lakes, due to their riding experience and ongoing interaction with horses. Therefore for publicly displayed stall appearance which resembles natural environment is an appropriate concept.

Throughout this approach, establishing an atmosphere of natural environment interlaced with fantasy, perception of the equestrian world can be brought to a new level. For the purpose of this thesis following characteristics of Art Nouveau were taken in consideration: softness of lines merging in the construction, virtue of visual arts and connection with natural shapes.
CONCEPT DEVELOPMENT

Sketches & Modeling

Actual design process took place alongside with ongoing research and on-site observation and has started with ideation and sketching.

First ideas and shapes were sought through searching scale models, preliminary 3D modeling and, further on, were approved by users' feedback.

Fig 4.7 First models and prototyping
The Steel Prototype

Subsequently, the functionality of the chosen construction has been tested in a large-scale steel prototype (Fig 4.9). Three steel frames were welded with cylindrical hinges and equipped with a door and plywood filling, in order to test-proof the technical side of assembling 3 partitions in one joint with simple locking rods. The structure has proven to be functional, stable and easy to operate.

Frame dimensions (1000 mm by 400 mm) in this prototype were chosen for practical reasons according to the length of applied steel tubes, in order to eliminate material waste and decrease production costs.

For the purpose of the final thesis presentation the frames were coated with white paint, however in case of mass production, as going to be explained further on, the most recommended coating of the steel frame would be hot-dipped galvanizing.

It is important to state, that the whole prototype was created for technical testing only. Meanwhile, design decisions regarding, for instance, the final thickness of the frames were made later, according to deliberate 3D modeling and analysis of existing solutions.

Fig 4.9
Functionality testing through the steel prototype
The Final Scale Model

The appearance of the stalls and final proportions have been defined through multiple searching models, advanced 3D modeling and, finally, approved by the means of final scale model. Precise and functioning model of a modular portable stall in scale of 1 to 10 was created from cardboard and plastics (Fig 4.10).
Finally, small scale-models were created for sets of 4 and 5 stalls with personal roofing. Even though the shape of the roof and its structure had been studied and approved by an experienced practitioner of tensile architecture, Roy Mänttäri, the scale models allowed to carefully evaluate the aesthetic aspects. For instance, to foresee how curved shapes of the roofs will correspond with strict geometry of the stalls. For the purpose of these scale models intricate canvas shapes were recreated by the means of modern 3D printers, available at Aalto University ADD Lab and FAB Lab.
Fig 5.1
Galvanized steel profiles
Clearly, the choice of materials applied in a product design crucially affects the usability and appearance of the whole item.

Materials chosen for the industrial manufacturing of the Laurelinde stalls are galvanized or painted steel frames, plywood sheets with optional coating and PVC canvas membranes for the tensile roof structures.

Following chapters explain certain details and discoveries obtained regarding those materials within the research and design phases.
Fig 5.2
Steel galvanizing process
Galvanized steel

Based on the analysis of existing solution and functional necessities steel was chosen as the most suitable material for the frame design. Portable horse housing above all should be strong and durable, therefore steel appears to be a perfect choice. Steel profiles and hollow tubes are resistant to pressure yet still light in weight.

For instance, 1 meter of 20mm by 40 mm steel tube has weight of 1,07 kg, therefore a L-shaped tube of the same length would be only 0,535 kg per meter. The whole steel frame structure of one sealed stall partition S would weight: 4,9 kg.

For even higher durability of the portable stalls, galvanizing of the steel frames is strongly suggested. Hot-dipped galvanizing process covers the metal with thick layer of zinc, protecting construction from corrosion and rusting. As Garga (2015) explain "...Zinc's natural corrosion resistance provides the steel a long-term protection from various environmental hazards".

Currently galvanizing process is done through immersion of iron or steel in molten zinc (GSA, 2015) and includes three phases. First of all, the surface has to be properly cleaned which according to the Mooregalvanizing (2015) includes caustic cleaning, acid pickling and fluxing.

Secondly, the structure is placed in a bath with molten zink, the time of galvanizing itself depends on the dimensions of the processed structure.

Thirdly, final result has to pass inspection and test-proof of following qualities: uniformity of the coating, adherence of the coating and appearance.

As has been claimed by Mooregalvanizing (2015) - for over 250 years, hot-dip galvanizing has proven to be a high quality and cost effective corrosion protection coating. In most applications hot-dip galvanizing is superior to paint.

Clearly, galvanizing suits perfectly for the portable stalls construction. Stalls' frames have to withstand heavy physical impact, during the assembly, usage and demounting. In this conditions ability of zinc coating to protect steel surface, even when scratched, improves durability and lengthens the partitions' service time.
Fig 5.3
Plywood samples with glass-fiber coating
As surveys among users have shown – plywood is the most preferable material for the partition surfaces, when it comes to portable stalls design. Unlike its more sophisticated brother, solid wood, which serves as a perfect material for permanent solution, plywood is lighter and more flexible, and therefore works great for the portable structures. Fortunately, lightness and flexibility does not bring weakness. On the contrary, due to the combination of an ability to resist a stress over-load received from the solid wood and its laminated structure plywood shows very strong impact resistance.

"Plywood's laminated structure distributes loads from impact over a larger area on the opposite face, which effectively reduces the tensile stress." (Wood Solution, 2013)

Moreover, plywood is more effective in resisting temperature and moisture fluctuations, layers of veneer located in alternative grain position reduce the climate influence on the material.

Plywood is generally resistant to chemical corrosion and has double higher panel shear strength than solid wood equivalent. However, plywood has its weak sides, the edge, in particular, which has to be located within minimum exposure to moisture and dirt. Edge is usually uncovered with coating and therefore can absorb water or other liquids affecting the quality and the color of abutment surface area, which leads to a faster routing and damaging of the whole sheet.

Nevertheless, plywood still appears as most beneficial construction for portable horse housing, bringing together with its structural advantages the pleasant aesthetic and tactile properties of solid wood. Sufficient safety and high usability of plywood has been proved during interviews at study-case Hipposphere 2015.

In order to investigate all the range of opportunities provided by plywood collaboration was established with one of the leaders in plywood manufacturing, Koskisen Oy.
Koskisen Oy is a Finnish company that has over 50 years of history in plywood producing. Consultants and experts from their main office and plant in Järvelä have helped to define which type of plywood would fit the needs of the stall design. Koskisen Oy has prolonged experience in executing plywood partitions for the horse transporting vehicles. Through that experience we can define the acceptable thickness of a plywood sheet suitable for application in equestrian industries, generally it is 15-17 mm. The tests of physical strength were conducted at the Koskisen Plant allowing to ensure durability of the products.

However, for the stall design treatment of the plywood and coating of the surface is of a crucial importance. Variety of coatings provided by Koskisen Oy is impressive. The most suitable options appeared to be a polypropylene coating and glass-fiber coating.

Polypropylene coating provides strong protection from moisture and mild physical damage like scratches and low-power kicks. It has mildly grain rough surface and several colors are available. However, the color palette is limited to the versions offered by coating supplier. Polypropylene coating has a thickness of only 0.8mm and hardly adds any weight to the partition. However, its strength is still limited and it might not withstand a strong physical impact, coming from a sharp metal objects or a horseshoe if applied directly to the surface.

Fortunately, a second option of coating exists: glass-fiber, a more impressive in the appearance and protection qualities material. Glass-fiber mixture applied to plywood forms a thick 1.3 mm surface, which will certainly tolerate all expected physical influence. Glass-fiber is water and fire-resistant, moreover, it creates a slick shiny surface and can be executed in any custom color. Due to its absolutely even and polished exterior glass-fiber coating will also hold better than its polypropylene analog any stickers and branding posters that have to be attached to partitions, for instance for navigation or advertisements.

Naturally, all the benefits come at a certain price. First and foremost, application of glass-fiber on both sides of the plywood will significantly increase the manufacturing costs. Secondly, the coating is noticeably thicker and more dense (1300 kg/m3) than polypropylene, which results in higher weight numbers for each partition.

However, the coating itself is strong enough, which allows usage of only 9-12mm plywood sheets with coating is applied on both sides, compared to 15mm plywood in case of polypropylene option.
Membranes

Hans-Joachim Schock in his book Soft Shells opens up enormous possibilities offered to the architecture and design by the usage of membranes, foils and sails.

Clearly, application of membranes in temporary constructions provides multiple advantages due to its light weight, accessibility, attractive appearance and other sustainable advantages. History of tensile architecture with membranes offers a wide range of shapes and constructions. However, stall structure does not generally require a shape differentiation apart from traditional four-point sail surface. It is the simplest fixation of a membrane or a sail, when a fabric is stretched and fixed in a square or rectangular plan with four corners located in one plane. Both cable and stiff edges are applicable.

Therefore, for the scope of this thesis material’s qualities and characteristics are more important points of research.

World of architectural membranes consists of coated fabric, uncoated fabric, foils and their variations. However, considering the whole set of requirements coated fabric appears to be the most preferable solution for membrane component in temporary stable construction.

Coated glass-fiber fabrics have proved their durability and can be executed with high water and fire resistance rates. PVC-coated polyester fabrics provide high strength and long-lasting service life. Special variations of the membranes are designed to exert various qualities of the material. For instance, silicon-coated glass fiber fabric shows improved flexibility, while Aramide and PTFE-coated fabric ensure highest strength and damage resistance.

Schock presents multiple inspiring examples of gorgeous tensile architecture within his book.

Fig 5.5
Drawing of the Festival Theatre for the International Eisteddfod in Llangollen, Wales
“There are a number of good, solid and practical reasons for using a textile structure, i.e a. membrane structure made from a modern, coated fabric material, apart from its appealing shape:
  - a short construction period and quick erection
  - their capability to form large column free spaces
  - their relative economy together with the additional bonus of an attractive form
  - good heat protection during summer or in hot climates due to high reflectivity of, for example, PT-FE-coated glass fiber fabric
  - good earthquake resistance through their small mass”

(Hans-Joachim Schlock, 1997, p.8)
For instance, the Festival Theater for the international Eisteddfod, Llangollen, in Wales, with brilliant example membrane roof. The building is gradually incorporated in the surroundings, beautiful membrane roof is placed between two main natural stone walls rising on the side from the main entrance.

Combination of raw natural materials like wood, slate and stone with modern tensile technology is what makes this architectural creation admirable.

Another wonderful example of membranes application is in the Butterfly House in Berlin, Germany. The Butterfly house was created based on the old
structure of the "church in the green", constructed previously in 1982, in 1993 it was converted into a functional and impressive in its shape new facility.

Only rear foundation and two out of three original glue-lam arches were used for the new construction.

Even though, Butterfly house is a stunning example of tensile architecture due to its unique double-sided saddle-shaped roof, it is important that if fulfills its main function properly: providing suitable climate and humidity rates ensuring perfect conditions for animals and plants located inside.
Fig 6.1 Sets of 5 stalls under personal roofing
FINAL SOLUTION
Fig 6.2 Stalls' installation variations
According to analysis of existing solutions, users' requirements and observations during the study-cases the direction in design was chosen to be conservative in matter of material and construction yet innovative in the matters of shapes and appearance.

As a main innovation in design, stalls were decided to be of a hexagon shape in the layout with one door and two windows.

Each stall is meant to be assembled manually from 6 separate partitions by means of standard hinge-and-rod system.

When located individually, one stall, naturally, requires 6 different partitions, 3 sealed ones (Partition S), two partitions with windows (Partition W) and one partition with installed swinging door (Partition D).

However, when located in groups each new stall would require only 5 or 4 new partitions to be completed.

For instance, a set of 3 stalls joint together needs only 15-16 partitions, depending on composition, 4 stalls are made from 19 partitions total, composition of 5 stalls with the equipment storage in the center consists from 26 partitions only.
Fig 6.3 Partitions of the Stall B

Fig 6.4 Partitions of the Stall A
In order to make the structure modular and flexible Partitions S has two modifications: Partition S1 – with lower location of cylindrical hinges, and Partition S2 – with a higher location of hinges, ensuring the possibility of joining three partitions together. (Fig 6.5)

Whenever there are 3 elements joint together only one of the partitions is with a window or a door installed, therefore manufacturing those partitions with a different hinges' height is not required.

Overall, portable stalls main purpose is safe and convenient accommodation for horses. However, occasionally there appears a side-requirement to this temporary constructions. In most cases portable stalls are located in areas accessible for staff only, in the backyards or behind the doors. Yet when it comes to an exhibition or open-air events those portable stalls can be displayed to public. In this case, appearance of the stall plays an important role, since it affects the perception and general image of the event.

Considering this aspect, two different types of stalls have been developed within this thesis work: Stall B and Stall A. (Figures: 6.3, 6.4, 6.6-6.9)
STALL B

Stall B – designed to be used by staff in restricted areas, is a simple yet functional model, inspired by the ideology of Bauhaus movement. It applies the most sustainable and practical materials: galvanized steel frame and standard plywood sheets covered with waterproof coating.

As a more practical solution, Stall B is equipped with a two-sectioned swinging door. The top and the bottom part of the door can be opened separately.

For instance, the top can be opened to allow the horse to lean its head out, while opening the bottom part simplifies the process of providing food and water to the horse, without additional risks.

Windows and doors are protected with steel net. The door net has a functional opening in the bottom corner of the top door, ensuring the access to the locking system for a rider from inside the stall.

< Fig 6.6
A Set of 3 Stalls B, installed together

Fig 6.7 >
Basic Stalls B in a restricted area for staff
STALL A

Stall A – designed for public exposure, is a more elegant model, with unconventional doors and windows shape inspired by the Art Nouveau. It applies more expensive yet attractive materials. Metal frame can be either galvanized or painted according to the preferable color.

Plywood sheets are covered with polypropylene or glass-fiber coating. Coated plywood is heavier and does not allow instant replacement, yet it is more resistant to a physical damage and can be executed in various colors.

Smooth coated surface also allows application of printed taping and stickers, which can be used in purpose of team identification, advertisement or infographics.

In case of Stall A, swinging door has one section with curved void in the top part, allowing horses to lean their heads outside the stall. Importantly, the construction of stalls and their placement along each other still eliminates the danger of physical contact between neighboring horses.

< Fig 6.8
A Set of 3 Stalls A with coated plywood installed together

Fig 6.9 >
A range of Stalls A with teams’ identity applied to the surfaces
OUTDOORS SOLUTION

Fig 6.10
Personal roofing for the sets of 5 and 4 Stalls
Generally, stalls at the events are located within the large barns, exhibition halls or in temporary installed shelters. In those cases, stalls do not necessitate personal roofing.

However, in case of outside location, exhibition and shows, where stalls are displayed in public, an attractive and functional roof construction is needed.

Therefore, for Stalls A arranged in groups of 4 and 5, separate tensile roof structure was designed.

For a group of 4 stalls the tensile roof is created from rectangular PVC-coated polyester canvas and for a group of 5 stalls from hexagon shape canvas. In both cases polyester canvases are fixed on 4 or 6 compressed aluminum poles with stretching ropes attached to the ground behind the poles.

Amount of ropes alternates form 1 to 2 per each pole, since this amount is efficient enough to withstand the stress. Bottom edge of the ropes is fixed to the ground or floor through the small platforms with 2 fasteners. Tensile structures of this shape are impressive in the appearance and highly functional in temporary constructions. They are strong enough to withstand impact of the wind and rain. However, those roofs are not meant to sustain a heavy load of several snow layers.

Fortunately, majority of the Eques-trian events, located outside, take place in the spring or summer period. Even more, generally, temporary stalls, arranged outside the buildings are only used in the warm climate conditions since sport horses, as many domestic animals, are not used to be kept in the cold temperatures for prolonged periods.
Fig 6.11
Dimensions
of the tensile
6-corners roofing
Fig 6.12
Dimensions of the tensile 4-corners roofing
Functionality & Application

First of all, for the purpose of accommodating a horse - hexagon shape of the stall is, in fact, more suitable than the traditional square one. It is crucial to provide the horse with an ability to make 360-degree movements in the stall and have rest, yet it is not recommended to locate horses in extensively spacious spaces since it can cause unnecessary anxiety and obsessive-compulsive behavior. Domestic horses used in sports activities are meant to receive their daily movement from exercising and walking in paddocks and summer fields. Stalls, on the contrary, are meant for resting.

Additionally, 6 corner shape of the stalls allows to create for the horses required semi-private conditions. When assembled in group this stalls allow neighboring horses to see and smell each other, yet they eliminate the risk of unnecessary physical contact.

Further on, an effort has been made to implement in the final design all recommendations and demand from riders and stable staff perspective. Stall door is 1600 mm wide and comfortable in operation. Locking system can be opened and closed with one hand. In the open position the door can be fixed to the ground, to ensure safe passing, by the means of the lock rod, coming all the way down to the bottom of the frame.

Windows bars and nets are dense enough to ensure safety. Unnecessary decorative elements were avoided. Hinges and locks are sealed within the surface of the frame wherever possible. (Fig 6.13-6-17)
Fig 6.13 Stall A, top of the locking system and hinges
Fig 6.14
Variations of the locking rod dimensions

Fig 6.15
Bottom part of the locking system
Fig 6.16
Top part of the locking system, Stall B

Fig 6.17
Top part of the locking system, Stall A
Moreover, expectedly, the process of assembling and demounting stalls has affected their final design. Hexagon shape of the stall allowed to decrease the weight and width of one singular partition.

The total weight of the heaviest partition: Partition S is estimated to be around 52 kg (Fig 6.19), which is noticeably less than average weight of a partition in rectangular stalls (75-100 kg, depending on frame thickness).

In the decided proportions one partition can be carried and installed by two adult men, while in traditional square stalls one partition could only be lifted by an effort of 4 workers.

Joints' hinges have cylindrical shape and are equal in their diameter to the thickness of the frame, preventing squeezing and damaging of the hinges during transportation and storing. (Fig 6.14)

The frame profile in the partitions is mainly L-shaped, with few rectangular exceptions in the door structure. Dimensions of the profile were selected according to study-case observation. The goal was to find balance between strength and lightness of the structure.

Plywood is attached to the frame with nuts and bolts – allowing simple and painless replacement of a plywood part in case of damage (Fig 6.18). L-shape of the frame simultaneously allows almost seamless installation of plywood sheets and, additionally, protects vulnerable plywood edge from moisture and dirt.
Section C-C. Partition D

Section B-B. Partition D

Section A-A. Partition S

Fig 6.18
Plywood joints sections*
**To be watched together with Fig 6.3, p. 108

- Plywood
- Metal. Galvanized steel
Partition S
Stalls A & B

Plywood area: 5m²
Metal profile length: 10,9m
Plywood weight - 48 KG
Metal profile weight - 4,9 KG
Bolts & Nuts x 20 - 0,8 KG
Hinges & Rods x 8 - 0,4 KG

Total weight:
~ 52 KG

Bolts & Nuts M10x30mm
0,04 KG

Hinges 20x110mm
0,05 KG

Partition W
Stalls A / Stall B

Plywood area: 2,7m²
Metal profile length: 10,9m
Plywood weight - 29 KG
Metal profile weight - 4,9 KG
Bolts & Nuts x 12 - 0,5 KG
Hinges & Rods x 8 - 0,4 KG
Metal Bars Weight - 9,9 KG /
Metal Mesh Weight - 1,1 KG

Total weight:
~ 45 KG 36 KG
1 meter - 0.39 KG
Round metal bar D 8mm - Stall A
windows & doors

1 meter - 0.45 KG
L-shaped steel profile, 40x20x1000 mm,
thickness 1 mm

Partition D
Stalls A / Stall B

Plywood area: 2.5m²
Metal profile length: 21 m /
Metal profile length: 22.6 m
Plywood weight - 27 KG
Metal profile weight - 9.5 KG /
Metal profile weight - 10.2 KG
Bolts & Nuts x 12 - 0.5 KG
Hinges & Rods x 8 - 0.4 KG
Metal Bars Weight - 8.5 KG /
Metal Mesh Weight - 1.1 KG

Total weight:
~ 46 KG
39 KG

Displayed numbers
are with the help of:
Plywood weight calculator
Steel tube weight calculator
Hot galvanized mesh calculator
Steel tubes calculator
Bolts and nuts specification*

** sources listed in the Bibliography section
(Accessed on 25.10.2015)
As a flooring solution interlocking rubber mats has been chosen. Thick rubber mats will protect horses’ hoofs from damage and joints from overloading. The flooring for each portable stall is hexagon shape assembled from 7 separated pieces. Interlocking system allows to fix rubber mats within each other, hexagon shape of the floor will serve as a support for the whole stall structure.

Modular structure simplifies logistics and replacements between the elements.
Overall, the main goal of this thesis work was to create a convenient and attractive design proposal for temporary horses' accommodation, improving the drawbacks of the existing solutions.

Developed design of modular stalls is aiming to change the general approach to portable temporary constructions on several levels, including functionality, usability and appearance.

As it is widely known in the design society, the most beautiful solutions are commonly the simplest ones, therefore mainly traditional materials and structures
have been preferred over extreme and controversial solutions.

Additional value was intended to be retrieved from attention to the aesthetic aspect which is generally neglected in the temporary constructions.

Suggested color palettes and prints are meant to create cheerful and positive atmosphere, reminding to the participants and guests of Equestrian world the joy of horse-human interaction.
Thank You!

Helsinki
2016
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