Integration of sustainability issues into the design process of a temporary event infrastructure

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ABSTRACT: Within the frame of temporary events, having recourse to the model of the tent corresponds to usual experiences. When the model offers advantages of fast assembly and certain flexibility, it has some significant disadvantages at the same time, especially regarding comfort (thermal and acoustic) and sustainability. Additionally, the transports induced and the materials used aren't subject to special verifications, especially regarding the necessary energy and the influences on the environment. In this context, the present article explains in detail the objectives of this project "ON STAGE", which consists of developing an alternative to the current practice, by showing the same advantages of the tent, but by offering an increase in term of sustainability. Not only verified on architectural, constructive and technical basis, but also regarding regulations and efficiency, the feasibility of the model this research is about will allow the arrangement of reliable bases for the next realisation of the infrastructure, which will have the importance of an applicable prototype. From the point of view of an increased sustainability, the project aims particularly at obtaining the following matters: quality of architectural expression, flexibility of the infrastructure, response to acoustic requirements, optimisation of the thermal comfort by bioclimatic principles, ideal utilisation of renewable resources and efficient utilisation of the infrastructure.
Keywords: sustainable architecture, temporary architecture, integrated design, bioclimatic principles

1. INTRODUCTION

Subsequently to the verification of certain limits in the general practice of tents for events, the project "On STAGE" (sustainable temporary arenas for gigs and events) entails developing an integrated alternative regarding improved characteristics of sustainability. This article presents a composition of elements, issued in the first phase of the project, referring to the development of architectural and technical concepts. For the background, the article shows at first some exploratory information regarding the boom in the event branch, in order to clarify the context of the increasing demand, where the project is positioned. The presentation of the results of an analysis of a temporary event infrastructure corresponding to the common practice, allows the expression of the objective principles for the project "On STAGE", both from point of view of urban integration and architecture and from point of view of the criteria for sustainability. Finally, the article presents a conceptual vision of the future infrastructure, a light construction that integrates likewise principles of the bioclimatic architecture, wooden modular construction and active use of solar energy [1].

This constitutes the basis of a process for integrated design which is still under development and which will allow the repetitive optimisation of the different dimensions of the project and the subsequent realisation of an infrastructure having the importance of an applicable prototype [2].

2. INCREASING DEMAND REGARDING TEMPORARY EVENT INFRASTRUCTURES

In consideration of the especially significant number of cultural manifestations (festivals, shows, exhibitions), commercial (trade fairs, fairs, exchanges), sportive or political festivals, where the assembly of temporary infrastructures is necessary, a tangible need regarding the material is manifested. Nevertheless, the consultation of all regional, national or international agendas, which appear on the media, induces an impression of the real growth in the event branch.

Some explanatory information on the growth in the cultural sector, and additionally especially in the area of performative arts allows the clarification of the increasing demand for materials for temporary event infrastructure [3]. By a global measure, the importance of this area is officially acknowledged nowadays, as the structure, determined by UNESCO, underlines, which defines 6 extensive cultural, dynamic areas and in which this one was precisely named "Performance and celebration" [4].

The specific analysis of this area, as measured by a country like Switzerland, shows this importance: the revenues generated by the event industry in its entirety (summing up commercial, cultural, festive, sportive and political forms) have increased regularly since 2003 by 6% per year on average [5]. The Federal Statistical Office (OFS) adds a completion in the field of the analysis of the frequentation linked to cultural practices.

2008, in terms of musicals, 67 % of the Swiss population attended at least one concert or another music event. It is interesting that the music world brings together almost every age group of the population and does so in a very strong way (between 63 % of the 60–74 years old and more than 74 % of the 15–29 years old). At the same age, more than one third of the population attends at least one festival, varying between about 20 % for the 60 to 74 years old people and more than 55 % for the 15 – 29 years old ones [6].

In terms of the entirety of the European countries, the average of the population attending a "live" performance in 2006 (including the Swiss category "music or other musical events") was around a little bit more than 40 % of the population [7]. These different figures accentuate the high potential of developments in this branch and consequently the essentially increasing demand for temporary event infrastructures. Following the lead of other constructive systems, it seems to be interesting consequently, to research regarding the level of consideration of criteria concerning the sustainability.

3. LIMITS OF THE COMMON PRACTICE

In order to comprehend more precisely the advantages and the disadvantages of the usual practice of material for the temporary event infrastructure, a case study has been conducted on a representative model of this type of temporary model. A tent of classical fabrication had been specifically chosen, which harbored the main stage at the Cully Jazz Festival (Switzerland), destined for about 1000 viewers. The results of these analyses are summarized below, focusing on the most significant aspects for the project "On STAGE".

3.1.Thermal comfort

In order to evaluate the climate inside more precisely, four data loggers had been place inside and outside the tent during the whole festival, namely one week (fig. 1). The results obtained and presented in figure 2 clearly show the characteristics of the light construction of the analyzed model. In fact, the tent had neither any insulation nor any thermal sealing, which made it susceptible for the different temperatures outside, but especially for the influences of the direct solar radiation. In that way, you can note the important variation of the monitored temperatures, at the beginning of the afternoon, on a sunny day (March 30) and on a very cloudy day (March 31), which expresses the strong dependence of the inner climate on the direct solar radiation. A second peak in inner temperature had been monitored at the end of the evening of the concert. In fact, the presence of one thousand visitors represents an energy input inside which may not be neglected, and it is recommended to consider the users (viewers, musicians and technicians) in the objective for the improvement of the thermal comfort.

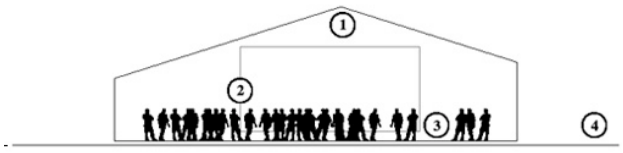

Figure 1: Cross section of the analysed tent with position of the data loggers.

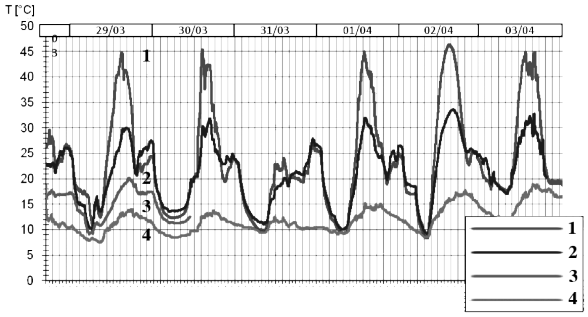

Figure 2: Measuring of the temperatures during the period of utilisation during the Cully Jazz Festival (March – April 2011).

These two factors influencing the climate inside, which are the direct solar radiation and the internal heat gains, are furthermore not or hardly controllable by the operators. In case of the analysed construction and despite making recourse to some simple devices for heating and aeration, it remains difficult to compensate the climatic variations inside and however reach satisfactory thermal comfort for the users (fig. 3).

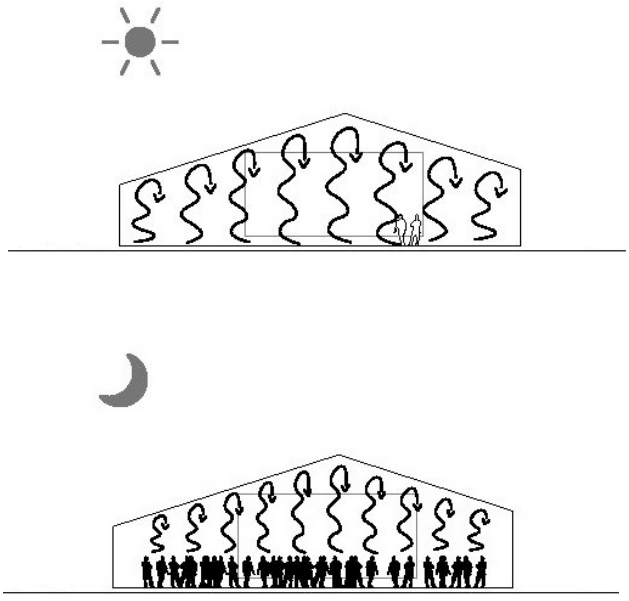

Figure 3: Basic drawing of the principle of overheating at daytime and at night determined during the phase of analysis. This situation results from the difficulty to react on two main factors that influence the climate inside (direct solar radiation, internal heat gain)

As a consequence, we notice that thermal discomfort significantly influences the sustainability of the infrastructure. In fact, to reach an acceptable inner climate during cooler periods, it would be necessary to compensate the thermal losses of the casing of the tent by temporary heating oil devices, but their efficiency is very bad, the influences on the environment are not to neglect and their results are very quickly dispersed due to the light construction.

3.2. Acoustic comfort

The acoustic comfort is also influenced by the light construction, the more acoustic quality you have inside the more emissions sound to the neighborhood. In order to evaluate the acoustic quality inside, the times of reverberation had been measured during a concert. The results, illustrated in figure 4, show that it is possible to stay within the optimum area for jazz, but with one time measuring around the limits for the bass frequencies as a consequence of the light construction of the model. A model with big awnings made of cloth tensed across the ceiling of the tent, contributes to improve the periods of reverberation in order to reach a satisfactory level for the jazz. This is not necessarily valid for other acoustic requirements that are more pointed, referring to classical music for example.

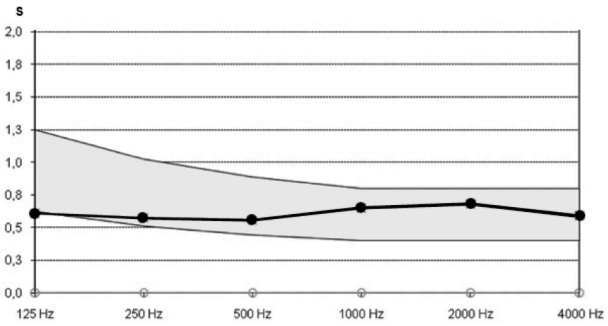

Figure 4: Measurement of the time of reverberation during a concert on the occasion of the Cully Jazz Festival (2011) – it is possible to stay within the optimum area for jazz but with one time measuring around the limits for the bass frequencies, as a consequence of the light construction of the model.

During the analysis, a different type of noise pollution, especially annoying for the users (viewers and musicians) had been detected. It is a disturbing noise due to the constructive modalities of the infrastructure. Above all, it is about vibrations of the base plates and of the structure of the seating rows for the placement of the viewers. This acoustic discomfort also results from the base plates. In fact, the ones mentioned are composed of wooden elements surrounded by a metal belt, which surely protects them from manipulation but which are only a source for disturbing noise in case of repetitive vibration. In case of strong wind you can also note additional noise resulting from the movement of the construction and the ceilings, especially when the sound volume of the concert is low.

One last aspect is concerning the sound emissions outwards, which are very important and which generate significant noise in the neighborhood. However, as illustrated in picture 1, values far above the legal limits for permanent construction have been detected on the occasion of the measurements. Even if this type of temporary use often benefits from a certain tolerance on the part of the neighborhood, a level that is so high constrains the area of hourly use as well as the possibilities of implementation on certain sites.

	Noise outdoor dB(A)				
	Leq,e	Lr max,e	Leq10,max	Lr,m	
POINT 1	64.5	68.9	75.5	75.5	Above legal limits
POINT 2	68.0	70.9	79.0	79.0	Above legal limits
POINT 3	67.2	70.1	78.2	78.2	Above legal limits
POINT A	64.3	67.2	75.3	75.3	Above legal limits
POINT B	62.0	64.9	73.0	73.0	Above legal limits
POINT C	67.2	70.1	78.2	78.2	Above legal limits

Tableau 1: Measures of the medium noise level at several points in the neighborhood of the tent during a concert at the Cully Jazz Festival (2011). The measurements show values far above the legal limits for permanent constructions.

3.3. Architectural quality and durability

Finally, it is to be noticed that the used model accords only little importance to architectural characteristics of the infrastructure, whereof the first aim is to comply with the functional requirements without caring for the expression of the object. Even if the implementation of such an infrastructure is temporary, it represents a spatial impact that is important for the site and, seen from the perspective of global quality, this aspect must be handled carefully. This has been done in the case of the object under study as the site of the festival is in the historic village Cully, on the waterfront of Leman Lake and in the heart of the Lavaux territory, which has been classified by UNESCO as World Cultural Heritage.

Furthermore, another aspect is the development of current practical limits considering criteria of sustainability. The transports induced and the materials used aren't subject to special verifications, especially regarding the necessary energy and the influences on the environment. The aluminum is the main material used for the structure, as it offers interesting characteristics of lightness and hardiness, but it although requests a lot of energy during its production. Furthermore, the transports for the different parts of the tent could be optimized from the point of view of the consumption of non-renewable energy by a better planning regarding the material.

4. TARGETED OBJECTIVES OF THE PROJECT

Regarding the analysis and the significant points mentioned, the following targeted objectives are formulated for the development of the project "On STAGE", from point of view of planning an alternative infrastructure for the usual practice.

4.1. Flexibility and adaptability

The first objective of the project is being able to offer adequate advantages for the classic tent, especially regarding the aspects of flexibility and assembly, which are the most important points in the current practice. With this in mind, the constructive system will be based on the aggregation of simple elements that are easy to transport and fast to disassemble. A configuration and constructive modalities by elements, which have to offer an important level of modularity, permit an implementation at different sites and for multiple usages. The assembly of the whole or of parts of the systems must be possible, in order to adjust the size of the infrastructure to the required usages. Furthermore, from the aspect of reducing the impacts, the model is meant to minimize the impact on the soil.

4.2. Optimization of comfort

The concept of the planned infrastructure must permit the users the optimal management of the thermal and acoustic comfort, as well as a reduction of the unsolicited noise toward the neighborhood. In this sense, the project must offer a certain mass, regarding thermal and acoustic, in order to minimize the variations in temperature and to control more precisely the acoustic aspects of the model. The objective is to keep the inner climate in a comfortable zone, which is the same condition as outside and the occupancy rate [8].

4.3. Optimal use of resources

For an objective that takes into consideration the increase of the sustainability, the model will include architectural bioclimatic principles, especially regarding the thermal insulation, the protection from the sun, natural ventilation and passive refection, which allow the reduction of its energetic demand (warmth and cold) and the prior valorisation of resources that are locally disposable [9]. For the demand proportion, the integration of models working with renewable resources will be researched, especially with reference to solar energy (solar roofing including moveable photovoltaic cells) and the production of warmth (thermal heat pump). It is especially about evaluating the modalities of a neutral balance between consumed energy during a period of utilisation and renewable energy captured by the infrastructure during the same period.

4.4. Efficient exploitation

Parallel to technical models the project aims at establishing a basis of a concept of efficient economic exploitation of the infrastructure, especially by enabling valorization of the model and by optimizing the possible complementarities of usage. By rationalizing the process of assembly, disassembly and stocking, the project has to reach an economic feasibility for the operator of the model whilst ensuring favorable operation conditions. The project aims at establishing bases of a financially balanced concept, regarding its lifecycle including an optimization of production costs and exploitation [10].

4.5. Architectural expression

The concept and the realization of the new infrastructure, likewise temporary and permanent, will include a special care for the architectural expression. The system will be well conceived in a way that it will contribute to the expression of a spatial coherence and offer a harmonic integration of the object in the different contexts where it will finally take place.

5. ARCHITECTURAL AND TECHNICAL CONCEPTS

Subsequent to the definition of the objectives of the project, a conceptual vision had been developed in order to set the basis of the constructive system and to specify the components that have to be developed in detail regarding the specific objectives mentioned. This conceptual vision is the basis of an iterative process of integrated design in the course of which the interdisciplinary competences of the different partners of the project (civil engineers, experts for thermal and acoustic, carpenters, specialists for photovoltaic and operators) have to optimize the infrastructure in terms of the objectives stated. Turning these principles resulted in the development of solutions and complex systems based on several overlapping effects and integration with overall architectural design [11].

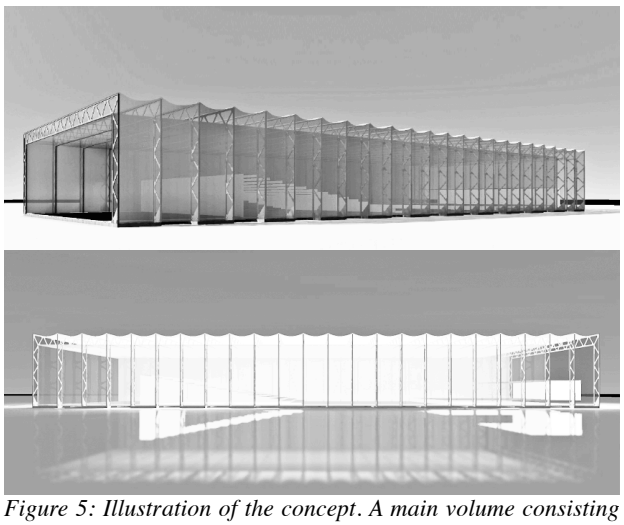

Figure 5: Illustration of the concept. A main volume consisting of modular wooden elements for the structure and the walls

inside encased by a sheer cloth and supported by a photo-voltaic system.

Such as shown in figure 5, the conceptual vision is based on the idea of a volume principal consisting of wooden modular elements. These elements are based on metal rails and reduce the impact on the soil and enable to adjust the level of the soil, depending on the specifications of any terrain situation one might find. The walls inside in the form of panels allow the optimal control of the environmental interior by ensuring a thermal and acoustic sealing. All this is surrounded by a sheer cloth, support of the photovoltaic technology, which generates concurrently some sealed thermal space, at the same time also useful from the climatic point of view by preferring an assembly of natural ventilation and from the acoustic point of view as well, as it dampens the noise emission.

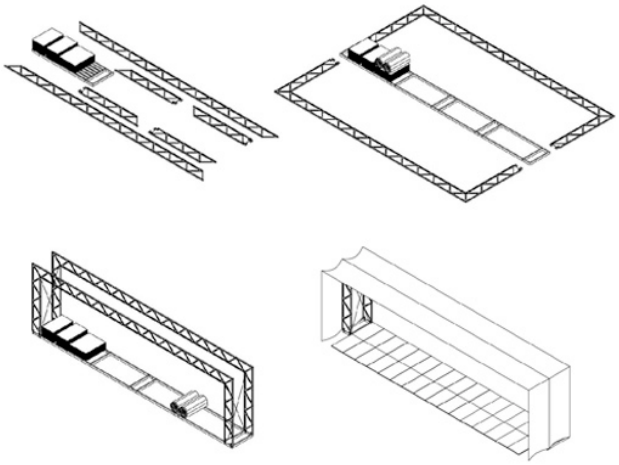

Figure 6: Illustration of the modularity of the system, shown constructively. The construction is based on the simple aggregation of elements easy to transport and fast to disassemble.

As shown in figure 6, a series of triangulated frames, compounds of wooden elements, prefabricated in the workshop and assembled on site, compose the structure of the building. On this structure, an inner casing is fixed consisting of wooden panels by means of which the mass is reduced in order to facilitate the operation, but sufficient to comply with the acoustic requirements and to offer a certain thermal insulation. Finally, an outer casing in form of a sheer cloth including the moveable photovoltaic system on the roof completes the model.

In order to avoid overheating due to the solar radiation during the day and due the internal heat gains by the users during the night, the project uses the given space between the two layers of the casing as a sealed space that helps to deflect the warm air by providing a tempered layer, which contributes to the thermal insulation for the stability of the temperature inside even in cooler periods. The scheme of figure 7 shows the planned principles for the management of the different situations of overheating at night and at daytime.

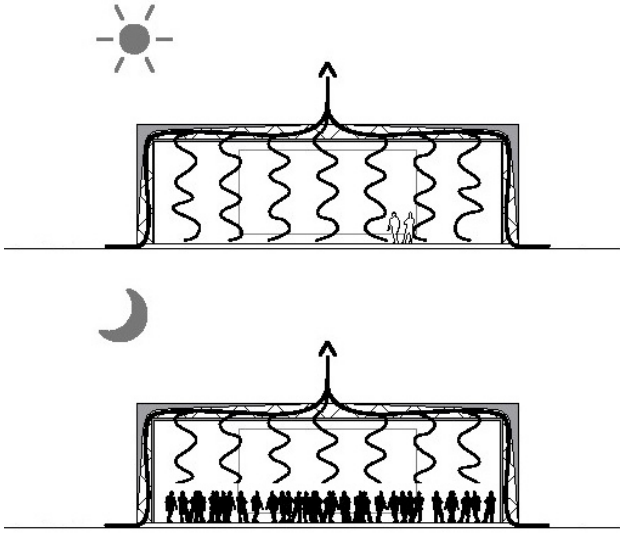

Figure 7: Scheme of the natural ventilation principle to control the situations of overheating at night and at daytime.

Regarding the acoustic, the additional mass which is filled inside the acoustic panels will help to control the acoustic of the room better and to reduce the noise toward outside. The different layers – panels, inside, sealed space and photovoltaic cloth – are shown by cross-section in figure 8 below.

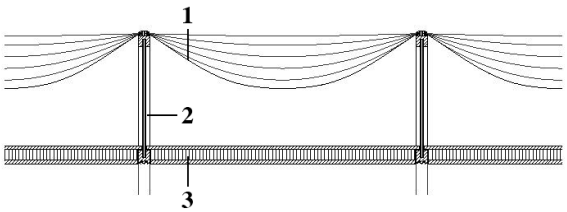

Figure 8: Cross-section of the projected casing. The project uses the space between the two layers of the casing as a sealed space assisting the bioclimatic control of comfort (1-photovoltaic cloth, 2-wood structure, 3-acoustic panels).

The assembly of this double casing allows the reduction of the amplitude of variations in temperature and the optimization of controlling the internal output by allowing at the same time the reduction of further energy input, determined on the occasion of the analysis of the current practice. For the energetic demand balance, the integration of models working with renewable resources will be researched especially regarding solar energy (roofing out of photovoltaic cloth) and the production of heat (thermal heat pump) in order to aim at a neutral balance between consumed energy and renewable energy captured by the model during the period of assembly,

exploitation and disassembly. A comparative analysis of the life cycle (LCA) between the current practice and the new infrastructure will likewise be realized for taking into consideration the energy needed and the impacts on the environment during the process of the optimization of the concept.

6. PROSPECTS

One of the originalities of the project "On STAGE" is to deal with the challenges of permanent architecture in the area of a temporary and transportable construction. From that results a confrontation between the objectives of a longer sustainability and the time of amortisation – environmental and economic – especially short and having the necessity to reach an optimisation of improved performances of buildings. This type of objective leads to experimentation with constructive, innovative solutions, potentially applicable to permanent constructions.

From this point of view, the first conceptual phase constitutes a working basis for a process in integrated design, currently in progress, which implies in a repetitive way the interdisciplinary competences of many partners (civil engineers, specialist for thermal and acoustic, carpenters, specialists for photo-voltaic technology and operators). Such workflows can be characterized by iteration loops involving actors in each rough phase [12].

The objective of the next stages of the strategy is to arrange a reliable basis in the long run for the realization of a first infrastructure, which will have the importance of an applicable prototype, verified not only on the architectural, constructive and technical level, but also regarding regulations and efficiency. The results of these next phases of the research will be presented in future papers.

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