PLEA 2015
BOLOGNA, ITALY
09 -11 September 2015

POETICS OF AIRFLOW IN ARCHITECTURAL DESIGN: THE CASE OF BAMIYAN CULTURAL CENTRE PROPOSAL

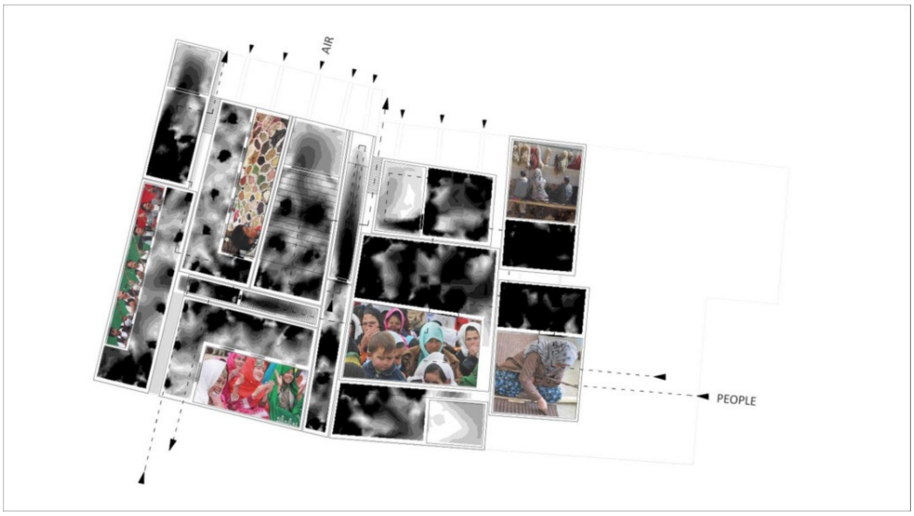

Fig 1: Bamiyan Cultural Centre proposal: air flow patterns

Research summary

This research explores air as a primary carrier of the atmospheric spatial qualities, such as heat, vapour and odour, and as a mediator between human body and the environment. With the assumption that patterns of air flow within a building are inextricably linked to the subjective experience of space, we investigate the hidden poetics of aerial processes in architecture, on an example of a project proposal for a Cultural Centre in Bamiyan Valley, Afghanistan. In response to the existing hot and arid climate conditions on one side, and a long history of political conflicts, poverty and fear on the other, we chose a traditional Afghanistan courtyard house as a vernacular model to further build upon. We pursued an economic structure that provides locally familiar ambiances and a sense of safety and identity. The investigations of air flow characteristics of this sofisticated, locally developed, climatic device led us to a series of conclusions on the relations between physical structure and aerial behaviour of the courtyard house, which we further implemented in our conceptual design of the centre. Multiple courtyard system was developed as a complex *atmospheric mechanism* that modulates the existing natural processes to construct specific atmospheric conditions inside in relation to the proposed cultural programme. In this way, architecture becomes an integral part of the local ecosystem. Carefully orchestrated aerial behaviour significantly contributes to a humane design approach, one based on people needs and their immediate experience of space. Our aim is to transcend the common discrepancy between the bioclimatic strategies and *atmospheric* - sensorial - design, aiming towards a holistic approach that considers both equally important.

Keywords: air flow, architectural atmosphere, atmospheric design, courtyard house, multiple courtyard system

1. Introduction

In his book *Housing, Climate and Comfort*, Martin Evans (1980) illustrates a connection between air flow velocity and the effects it has on human beings. For example, he notes that velocity of 0.25mps is only consciously noticeable at low air temperatures, wheres one of 0.50mps feels ''fresh at comfortable air temperatures, but drafty at cool temperatures''. This association of air velocity to environmental behaviour and corporeal feeling might in theory be generalized by saying that *air circulation affects our spatial experience*. Sensorial stimuli such as heat, odour, vapour, draft and air pressure result from aerial behaviour and are carried on or in the air, meaning that air flow patterns are important for architectural practice in terms than go beyond the issues of bioclimatic design, towards the construction of spatial qualities and human emotions. The work reported in this paper is a part of a larger research agenda based on the hypothesis that invisible aerial processes are potentially a scientific basis for precise construction of architectural atmospheres. On a case study of our project proposal for a Cultural Centre in Bamiyan Valley, Afghanistan, we investigate the potential of air flow patterns in the conceptual phase of the *atmospheric* design process.

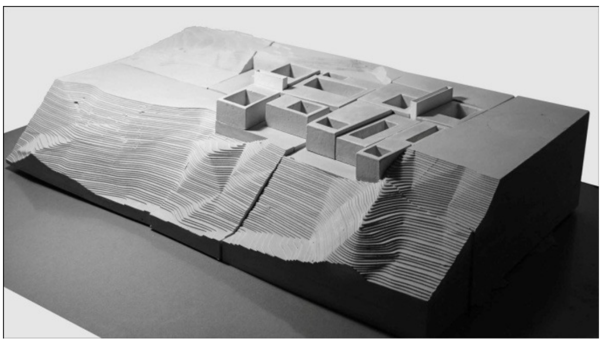

Fig 2: Bamiyan Cultural Centre, plaster model

2. Project aspirations

Bamiyan Valley is located at 2.500m altitude, central Afghanistan, surrounded by mountainous terrain, with little rainfall and exposed to strong sunshine during the summer. Over the course of a year, the temperature typically varies from 5°C to 34°C and daily temperature swings are quite drastic, up to the difference of 17°C. Typical wind speeds vary from 0 mps to 10 mps (calm to fresh breeze), rarely exceeding 22 mps (strong gale), and the wind is most often out of the north during the summer months, and north west during the winter (''Average Weather,''2015). Primary infrastructure, such as public electricity, water, sewerage systems, and gas are not available, meaning that the Cultural Centre building needs to obtain its own self-sustained infrastructure system. Due to dry and arid climate, diurnal variations of temperature and local lack of infrastructure, efficient natural ventilation system has proven to be crucial for building in this location. We aspired to design a structure that *breathes*, constantly providing cool fresh air during the hot sunny day, and releasing accumulated warmth during the chilly nights. Equally important, Bamiyan Cultural Centre needed to unite a variety of local cultures, and provide fertile ground for succesfull cultivation of new thoughts and ideas. In the land with a long history of political conflicts, poverty and fear, we needed to create a familiar atmosphere, one of safety and tranquility. Our proposed solution is based on local vernacular principles of Afghanistan courtyard houses. We interpreted courtyards as architectural manifestation of traditional Afghanistan lifestyle. These are spaces of community gatherings, and climatic retreats, as they are traditionally designed to maximize light, warmth and fresh air supply in all seasons around the year. The familiarity and safety of the traditional courtyard house atmosphere was an important local quality we decided to build upon.

3. Courtyard house as an element of atmospheric design

Cultural Centre's programme required a system that allows individual functioning of several separate spaces simultaneously, while at the same time intermingling these events into one living organism - an incubator for contemporary cultural production. We proposed a conglomeration of courtyard houses, each house for one of the eleven major programmes: (1) reception/ lobby area with (2) tea house, (3) permanent and (4) temporary exhibition spaces, (5) performance hall, (6) workshop studio, (7) research centre and library, (8) classrooms, (9) administration offices, (10) artworks storage and (11) service/ communication areas. Traditional courtyard house, being a highly sofisticated climatic device (Weber & Yannas, 2014), offered us a mechanism for precise control of architectural atmospheres - each of the eleven programmes can offer unique microclimate conditions for its visitors. Following Lisa Heschong's (1979) observations on characteristic thermal association and fondness developed for the refreshing air flow of an American porch swing or a Victorian gazebo, we expect people to form unconscious attachments to each microclimate, and in this way stregthen their individual sense of place and local identity.

3.1 Variations of air flow

The first phase of the research process involved testing the influence of varying courtyards' properties (spatial volumetry, orientation, proportion of open and closed areas) on characteristic air flow patterns and attained air flow velocities.

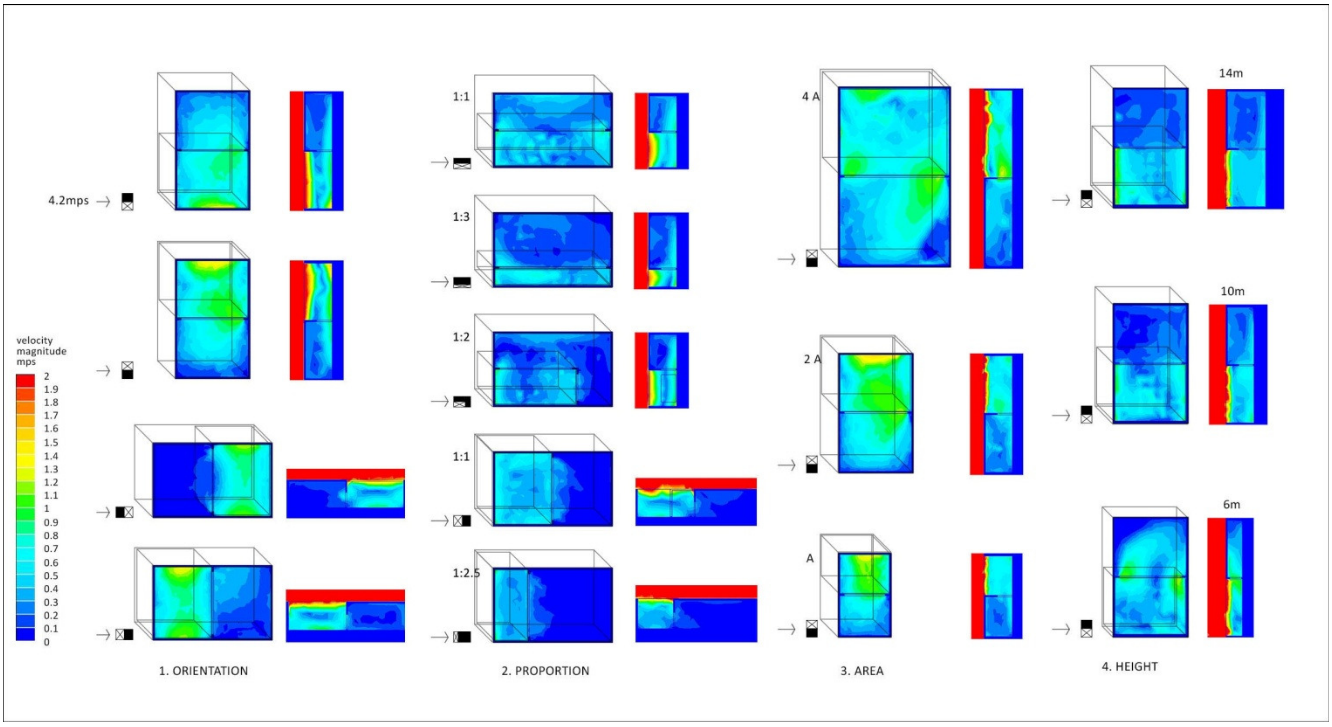

Fig 3: CFD simulations I (dark blue - stagnant air, red - air velocity >= 2mps)

The testing was performed via CFD simulations for various types of courtyards with simplified boundary conditions: 4.2 mps air flow velocity from one direction (average wind speed for Bamiyan Valley) and locally available material, concrete for the entire structure. Since each element consists of one courtyard and one enclosed space, in this phase we were only testing single side natural ventilation, or the ability of the courtyard to capture the incoming air and direct it towards the interior space in a variety of patterns. These analysis, illustrated in figure 3, led us to several significant conclusions that might be implemented in further design process: (1) if the element is positioned parallel to the wind direction, meaning that the wind encounters first the courtyard and then the closed space or vice versa, the air velocity will be drastically reduced and the interior will be supplied with much less amount of fresh air than if the case is opposite, the house being orthogonal to the direction of the incoming wind; (2) the smaller the courtyard is, in relation to the enclosed space, the lesser the amount of air is to enter the room; (3) the smaller the area of the courtyard is, the incoming air will enter the enclosed room with higher velocity; (4) the deeper (higher) the entire element is, the air flow in lower zones, within human heights, will be slower; and (5) stagnant air areas and air flow patterns in general, are influenced by orientation of the courtyard house, its height and surface area, and the proportion of the closed and open space.

3.2 Atmospheric design

Our next step was to determine the value of each of these parameters for each of the eleven elements according to their programme specific requirements. For example, exhibition spaces, due to the possible fragility of the artworks, need more uniform air flow patterns and lower velocities, than office spaces, where sometimes the circulation of air is crucial to maintain concentration levels high. The tea-house overlooking the landscape should be open to sudden blasts of brisk air that infuse the building with the surrounding atmosphere of the valley. Storage area should have enough air supply, but the least possible fluctuations of flow velocity. Classrooms should have different air flow patterns among each other, to provoke a dinamic learning experience altogether - one might study about Afghanistan history in a more still-air, calm atmosphere, and about native handcraft and arts in a more vibrant, drafty spaces.

4. Conglomeration of elements and complexity of flows

With the conclusions gained from the previous phase of CFD simulations, we set the initial parameter values. However, we noticed that, once the eleven elements are brought together they influence each other and form a complex system of flows - an advanced atmospheric mechanism. We performed another phase of CFD simulations, this time testing the whole building, and taking into acount its position within the context - with its two sides it is built into the terrain and with the other two directly exposed to the prevailing north and northwestern winds.

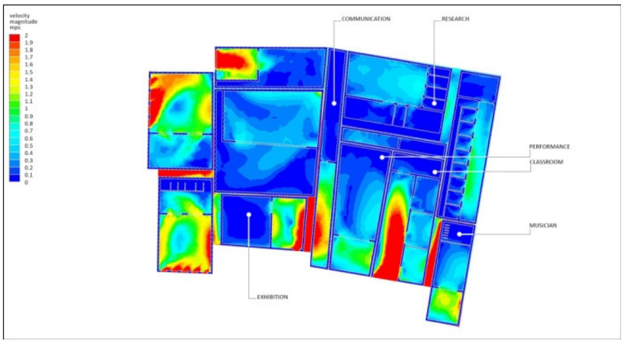

Fig 4: CFD simulation II (dark blue - stagnant air)

We conceived the roof of the Centre as a continuation of the surrounding landscape, so that the courtyards, carved into the hill, are to capture the incoming winds and form eleven cool air pools within the structure bellow. Our main goals were to achieve: (1) efficient natural ventilation - supplies of fresh air throughout the whole building, and (2) varieties of air flow patterns to gain a spectre of different atmospheric conditions inside. The second phase of CFD simulations, illustrated in figure 4, has shown significant amounts of stagnant air areas, specifically in the research spaces, musician's studio, some of the classrooms, in temporary exhibition rooms and partly in the performance hall. This is why, from the initial single side ventilation, we moved onto much more efficient cross ventilation system (Tablada et al., 2005.), by introducing underground air channels that capture the air from the incoming winds, distribute it to the spaces above to be released through the courtyards. During the day, floor surfaces of the courtyards are heated in the sun: the hot air in lower areas moves upwards,

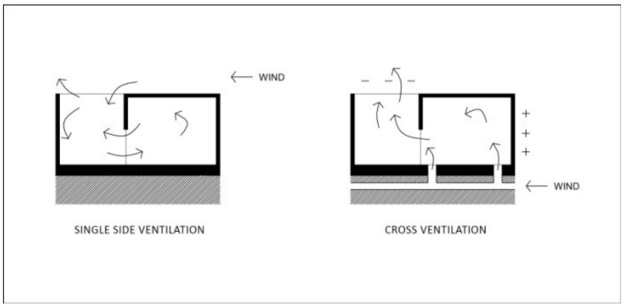

Fig 5: a) single sided and b) cross ventilation

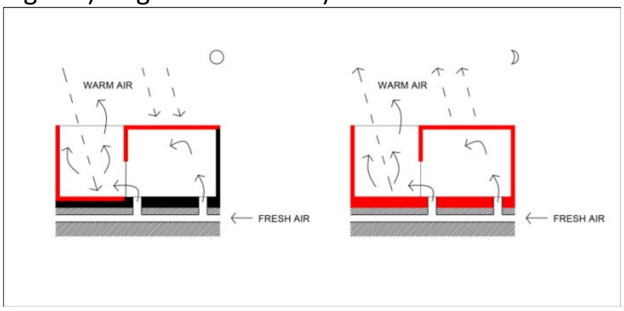

Fig 6: natural convection a) day and b) night

sucking colder air from the underground channels to replace it. During the night, concrete thermal mass releases the accumulated heat - warm air moves into the sky, and chilly night air is sucked into the building through the channels. The Cultural Centre becomes a complex wind catcher that literally breathes, evaporates and dries on dynamic flows of Bamiyan air (Fig. 5, 6 and 7).

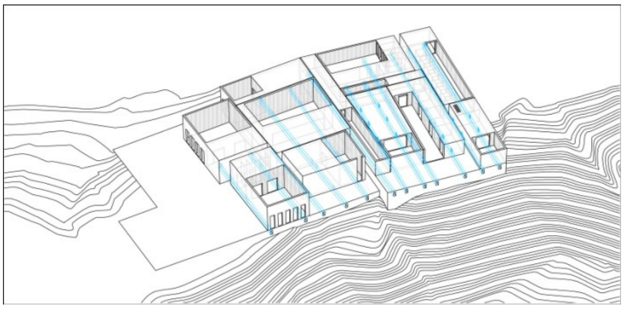

Fig 7: underground air channels (marked blue)

5. Results and future implementation

Once we introduced the underground air channels, the patterns of air flow had significantly changed. We had reduced the stagnant air areas, due to the improved cross ventilation and natural convection processes. Air velocities in enclosed areas mostly did not go over 0.3mps, except for zones close to the courtyards and air channels' outlets, where the incoming fresh air obtained velocities from 0.6 up to 2mps, depending on the distance from the exposed facade. These fluctuations responded to our initial goals towards a variety of atmospheric conditions within the Centre. However, since the variations are quite drastic, we retained the possibility of manual control of the channel outlets. Thus, the air of each room remains within a scope of flow patterns and velocities, to be tuned in relation to the current needs. Cultural Centre became a musical instrument on air- an aerophone for the production of architectural atmospheres.

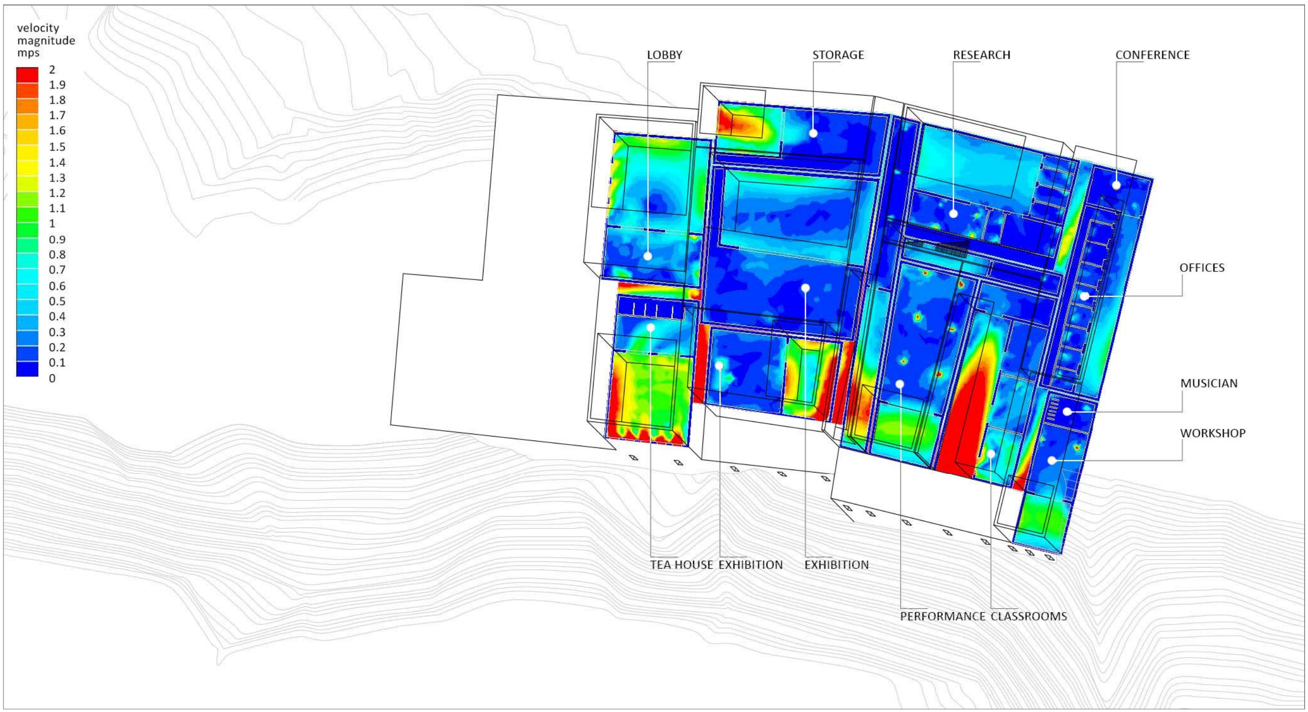

Fig 8: CFD simulation III (with air-channels)

By investigating air flow patterns via CFD simulations in the conceptual design phase, we managed to design an adaptable system for future, more detailed developments of this project, as the configuration of the courtyards and the position of the underground air channels can be further modified, according to the results attained in earlier phases. The airflow patterns, in this way, form an integral part of the Centre's architectural design, as basis of its constructed atmospheres and spatial experiences. More broadly, we believe to have developed one of the models for precise atmospheric design in the future, one that is based on comprehension and further innovation of the existing air flow patterns of vernacular architecture. These patterns should be approached environmentally and economically - as locally developed strategies for climate control, as well as culturally - concerning the character of air flow, or air as a carrier of spatial qualities - and thus of local identity and a sense of place and belonging.

6. Conclusions

This research project has significantly improved our understanding of aerial behaviors in relation to a variety of spatial configurations. Firstly, we have acquired invaluable knowledge on the physiology of the courtyard house - the relation between its configuration and the attained airflow patterns. These have resulted in a number of conclusions to be applied in any future research concerning this building typology. Secondly, we have demonstrated how the investigation into the air flow patterns can inform and influence the design process from its early phases, towards the profound understanding of the mutual relationship between the building and its air, and as we have also stated, it constructed atmospheres. Thirdly, we believe to have accentuated the importance of profound architectural, technological and cultural understanding of local vernacular traditions, that moulds architectural design in any context and for any specific lifestyle. Locally constructed patterns of air, its poetics and produced atmospheres offer an invaluable insight into the traditions and lifestyles of the community, and thus present a source of immense new knowledge for comprehension of the existing, and the construction of new types of living. Most importantly, we argue that the attained knowledge and experience contributes to the formation of the scientific basis for comprehension and construction of architectural atmospheres. That being so, we believe it will greatly influence our future investigations into atmospheric design processes.

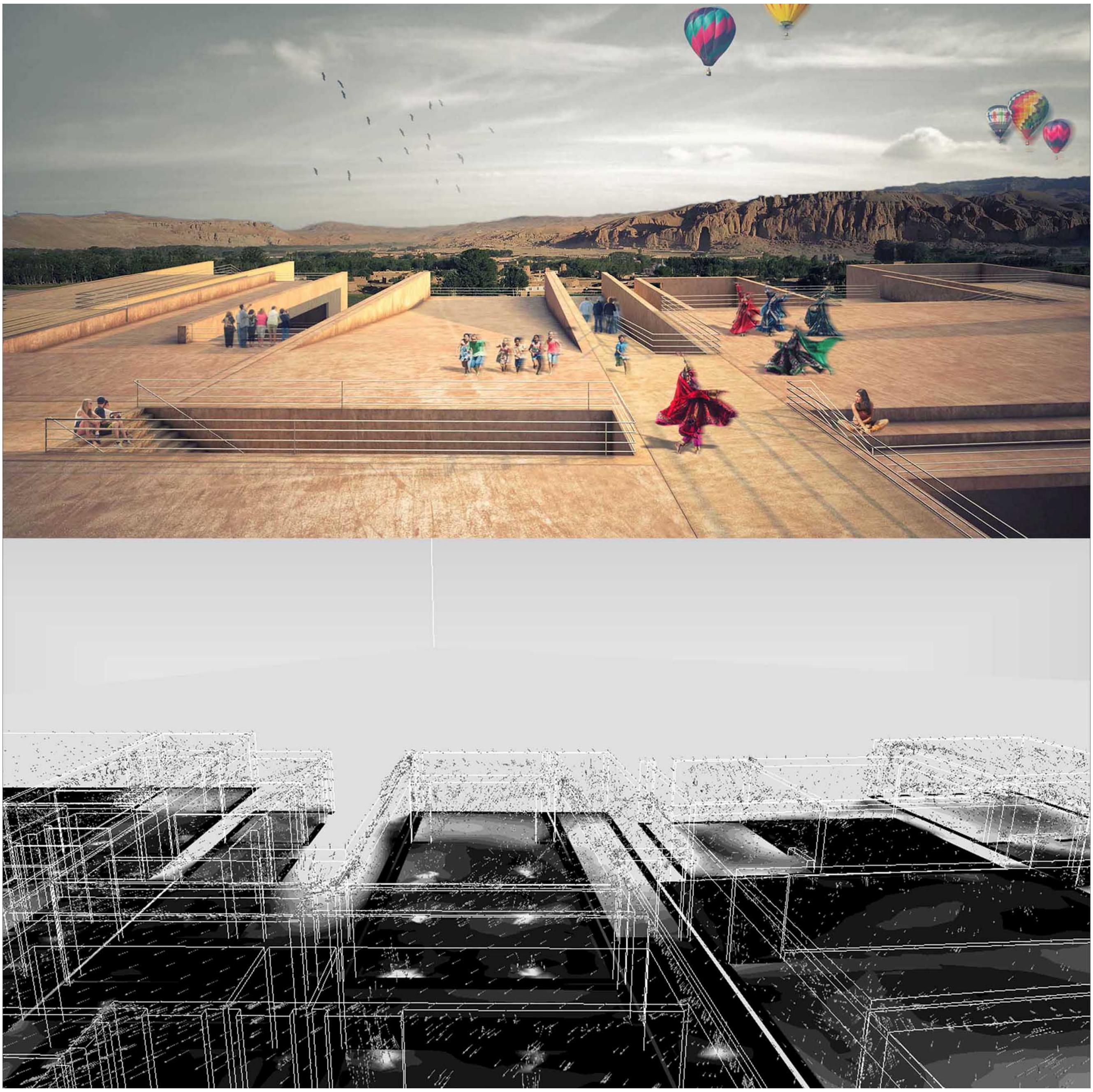
Fig 9: Bamiyan Cultural Centre: towards *atmospheric design*

7. Acknowledgments

The author of this paper is supported by the PhD student scholarship of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

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