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School of Architecture Urban Planning Construction Engineering

Master of Science in Architecture

OUT OF EARTH, INTO THE NATURE

A RESEARCH ON LANDFORM SPORTS ARCHITECTURE DESIGN

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Abstract

Based on the phenomenon that many sports buildings have similar, closed and isolated forms which are not in line with the urban context, this research starts from a new discussion on the relationship between sports architecture and the environment (both the natural environment and the urban environment) from the perspectives of regionalism, public fitness concept and ecological protection. Under this background, landform sports architecture is a special form of sports architecture. Its most important characteristic is that the building and the landform environment are integrated by applying landform design techniques. The analysis in this research relies on existing typical landform sports architecture. By summing up the specific influence factors of determining landform design techniques for sports architecture in three aspects (environmental conditions, architectural characteristics and objective supports), the applicability of landform sports architecture in various environments is proved. Meanwhile, based on the principle that landform sports architecture has a humble gesture which is harmonious with the surrounding environment, a form design strategy and a technique lexicon are proposed. Together with key points of the functional space design, they provide references for future practices. On the occasion of Milan's successful bidding for hosting the 2026 Winter Olympic Games, based on the development background of sports facilities and urban landscape system in Milan, this thesis proposes a sports-landscape integrated system composed with landform sports buildings as nodes and urban greenways as connections. Corresponding proposals on specific sites demonstrate the possibility of constructing landform sports architecture in the urban environment with the landscape system. Through the analysis and research of landform sports architecture, the whole thesis calls for an integrated relationship among sports architecture, the urban environment and nature from the perspective of architectural design.

Astratto

Partendo dal fatto che molti edifici sportivi hanno forme simili, chiuse e isolate che non sono in linea con l'attuale contesto urbano, questa ricerca parte da una nuova discussione sul rapporto tra architettura sportiva e ambiente (sia l'ambiente naturale sia l'ambiente urbano) dalle prospettive del regionalismo, del concetto di fitness pubblico e della protezione ecologica. In questo contesto, la landform sports architecture è una forma speciale di architettura sportiva. La sua caratteristica più importante è che l'edificio e l'ambiente di landform sono integrati applicando tecniche di progettazione landform. L'analisi si basa sulla tipica landform sports architecture esistente. Sommando i fattori di influenza specifici per determinare le tecniche di progettazione delle forme di terreno per l'architettura dello sport in tre aspetti (condizioni ambientali, caratteristiche architettoniche e supporti oggettivi), viene dimostrata l'applicabilità della landform sports architecture in vari ambienti. Nel frattempo, sulla base del principio secondo cui la landform sports architecture ha un umile gesto che è in armonia con l'ambiente circostante, vengono proposte una strategia di progettazione della forma e un lessico della tecnica. Insieme ai punti chiave della progettazione dello spazio funzionale, si forniscono riferimenti per le pratiche future. In occasione dell'affermazione promossa da Milano per ospitare i Giochi Olimpici Invernali del 2026, sulla base dello sviluppo delle infrastrutture sportive e del sistema di paesaggio urbano di Milano, questa tesi propone un sistema integrato sport-paesaggio composto da landform sports architecture come nodi e strade urbane come connessioni. E le proposte corrispondenti in siti specifici dimostrano la possibilità di costruire una landform sports architecture nell'ambiente urbano con il sistema del paesaggio. Attraverso l'analisi e la ricerca dell'architettura sportiva landform, l'intera tesi elabora una relazione integrata tra l'architettura dello sport, l'ambiente urbano e la natura dal punto di vista del progetto dell'architettura.

Acknowledgement

I would like to express my gratitude to all those who helped me during the research. First of all, I gratefully acknowledge the help of my supervisor, Prof. Fabris, who has patiently offered me valuable suggestions in the academic study and helped me to improve my final thesis. I also thank other professors in Politecnico di Milano and Prof. Qian in Tongji University who gave me some instructions. Moreover, I thank my friends in Italy and China who offered me technical and spiritual support. My most important gratitude belongs to my family who encourage and support me in all aspects all the time. Last but not the least, I thank myself, a girl who always works hard and never gives up.

Qiu Rongrong

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CHAPTER 1

Introduction

1.1 Research Background and Significance

1.1.1 Issue Statement

In recent years, with the continuous improvement of people's consciousness about health, the emphasis on sports career has not only been reflected in professional and competitive sports, but also been expanded to the public fitness concept. The increasing demand for sports activities has brought about abundant and rapid construction of stadiums, sports facilities and sports fields with different scales, types and grades. As the form innovation of sports architecture is always an attracting topic, sports buildings with various styles are emerging in the wave. Based on this background, landform sports architecture which applies the landform technique to sports architecture breaks through the iconic image brought by the large volume, promotes echo to the environmental context, and thus becomes a new possibility for sports architecture design and construction.

In fact, there are already some built-up landform sports buildings all over the world which show advantages in particular geographical environments. However, practices in urban environments meet some problems. On one hand, landform sports architecture is unable to react to urban environment appropriately due to designers' misunderstanding of the term "landform technique". On the other hand, its form particularity causes economic problems, construction difficulties and technical challenges, which make it difficult to put landform sports architecture into practice. Therefore, in order to create comfortable and diverse new sports

space for users, when applying this possible form into sports architecture design, we need to face challenges like re-understanding the definition and advantages of landform sports architecture, selecting suitable landform design strategies for different conditions, and overcoming technical problems related to function and space design.

1.1.2 Background of the Topic

From the perspective of architectural regionalism, due to the urgent development and improper positioning of sports architecture, many sports buildings under rapid construction emphasize too much on being landmarks and the buildings themselves do not conform to the historical urban context. The phenomenon of formalism and sports architecture's similarity lead to its disconnection with environmental conditions. The resulting drawbacks now are pushing developers and designers to pay more attention to the concept of regionalism.

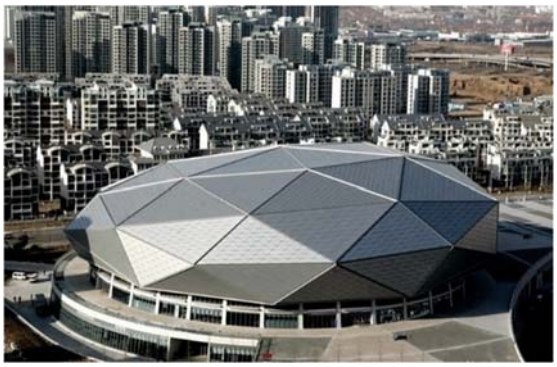


Fig. 1-1-1: Guoxin Stadium in Qingdao
Fig. 1-1-2: 2022 World Cup Stadium Proposal in Qatar
Description: They seem strange and exaggerated in the background of such a really distinct urban texture.
Source: www.shensuofeng.cc/a/gongchenganli/58.html; bbs.zhulong.com/101010_group_201810/detail10123744

Fig. 1-1-3 & 1-1-4: Two Similar Stadiums in China
Source: www.image.baidu.com

Fig. 1-1-5: Universiade Sports Center in Shenzhen, China

Fig. 1-1-6: Baku Crystal Hall in Azerbaijan

Description: The two stadiums are both designed by GMP Architekten and have similar facade forms.

Source: www.image.baidu.com; bbs.zhulong.com/101010_group_201810/detail10119761

From the perspective of sports and fitness, under the guidance of the public fitness concept, sports have gradually turned from professionally competitive activities to media for public leisure, entertainment and socialization. The positioning of sports architecture tends to become the supporter and carrier of the public activity media. Thus, under this background, more ideas and practices of sports architecture design which pay attention to the relationship with community, landscape and daily life should be proposed and tried.

From the perspective of environmental and ecological protection, because sports architecture usually has a relatively large volume and a high energy consumption, neglecting distinct local landform conditions when designing and constructing it may cause damage to the ecological environment, especially the land resources. Therefore, the land use strategy of sports architecture is worth studying with the purpose of sustainable development.

The above background points to a new discussion on the relationship between sports architecture and the environment. As a form design technique that directly emphasizes this relationship, applying the landform technique in sports architecture design will provide possibilities for dealing with above issues. In reality, some existing landform sports buildings located in natural environments interact well with geographical conditions while lacking of comfortable and pleasant spatial atmosphere. Some ones located in urban environments emphasize too much on the special form. They aim at landscaping but ignore the ecological significance of the landform technique. Based on the advantages and disadvantages of existing projects, discussing the applicability of landform sports architecture in different environments as well as studying corresponding design strategies and techniques will provide theoretical references for rational practices of landform sports architecture in the future.

1.1.3 Significance of the Research

1.1.3.1 Theoretical Significance

Since landform sports architecture projects are relatively few in the sports architecture field and the relevant theoretical research is fragmented because it is usually based on individual projects, this type of sports architecture does not have its own systematic theory. In addition, the contradictions between its particularity and public long-term perception, and between the economic condition and construction cost, have further hindered the theoretical development of landform sports architecture. However, the existing projects prove that the design and construction of landform sports architecture are feasible and necessary although some of them lack of proper consideration on specific environmental conditions. Therefore, discussing theoretically on the form applicability and design strategies respectively in natural and urban context not only improve persuasiveness in practical construction of landform sports architecture, but also help to establish a broader view of sports architecture design.

1.1.3.2 Practical Significance

Today, when resource scarcity and globalization are becoming more and more serious, regionalism, openness and ecology are constantly emphasized in the new discussion about the relationship between architecture and the environment. The design of sports architecture should change its similarity, closure and independence under the background of rapid and massive construction. Instead, to produce various forms, to try possibilities suitable for the new era and new requirements, and to seek a sustainable development path. The landform sports architecture, as an uncommon form of sports architecture, may echo the above trends in different regional environments. On one hand, its application is an innovative attempt; on the other hand, design and construction problems can be further found and solved in practices, which will help complete the theoretical system. Meanwhile, the technical problems brought about by its particularity can further promote the development of related technologies for sports architecture.

1.2 Research Status and Literature Review

The main object of this research is landform sports architecture. The core concerns are: 1) Influence factors of applying the landform technique in sports architecture design. 2) Challenges and strategies of landform sports architecture design in terms of the form, function and space in different environments. 3) Possibility and Significance of applying landform sports architecture in a specific city.

Because the research topic has clear directionality and specificity, although there are some projects all over the world, theoretical researches have not formed a corresponding system, and there are few directly relevant literatures. Therefore, during the beginning period of researching, it is better to collect theoretical data about “landform sports architecture” as well as “landform architecture”, “regional sports architecture”, “mountainous sports architecture (it has a great correlation with the special geographical environment)” and “landform exhibition architecture (it has a similar scale with large sports architecture)” for reference.

1.2.1 Landform Architecture and Landform Sports Architecture

The concept of “landform architecture” was formally proposed by an architectural theorist Charles Jencks. The international research has developed for a period from the emergence of “mat-building” which was the result of the interplay of Team X and Le Corbusier in the modern architecture time. The theoretical study of landform architecture has always been closely integrated with the discussion of topography and environmental relations. In the mid to late 20th century, *Design with Nature* written by Ian McHarg expressed the idea of combining natural environment with architectural design. John Ormsbee Simonds proposed to create a “new landscape” in farmlands, urban vegetation and urban land frameworks in his book *Earthscape: A Manual of Environmental Planning and Design*. *Site Planning* written by Kevin Lynch stated that the site design should base on environmental conditions.

In recent years, urban environmental issues have become more and more serious, which promotes the integrated design of architecture and landscape. *Topographical Stories* written by David Leatherbarrow started from the relationship between architecture and land to show the new thinking way of architecture and landscape architecture in a single framework of cultural meaning. The book *Landform Building: architecture's new terrain* edited by Stan Allen

introduced the development status of landform building from aspects of form, scale, atmosphere and process. The landform building has become a new trend in the development of contemporary architecture as mentioned in this book. *Landform architecture: emergent in the nineties* written by Charles Jencks interpreted “landform” as a pioneering design idea combining the urban design with earth art.

In terms of architectural projects, landform buildings like Water Temple designed by Tadao Ando, Yokohama Port Terminal designed by FOA Office, Pavilion LFone designed by Zaha Hadid and Oslo Opera House designed by Snøhetta are famous works and successful attempts on landform architecture. More and more good landform building works are coming out by the new generation of young architects now.

Fig. 1-2-1: Water Temple (Tadao Ando)
Fig. 1-2-2: Yokohama Port Terminal (FOA Office)
Source: m.focus.cn/home/news/index/newsDetail/421561c3; www.archdaily.com/554132

Fig. 1-2-3: Pavilion LFone (Zaha Hadid)
Fig. 1-2-4: Oslo Opera House (Snøhetta)
Source: www.artwave.it/architettura/buildings/; www.scandinaviastandard.com/take-a-tour-of-the-oslo-opera-house/

In China, Chinese traditional philosophy about the combination of people and nature started to guide artificial construction from an ancient time. Cave dwellings and grottoes which combine with topography in the northern Shanxi area appeared very early. However, there have been no books specially devoted to the theory of landform architecture over the years, but only some

relevant articles in journals and academic papers appeared. For example, *A Theoretical Study on the Landscape Planning in Ancient China* written by Tong Yuzhe and Liu Hui published in *Chinese Garden* in August 2003 presented related traditional theories and practices of landform architecture in Chinese history. It emphasized the organic combination and mutual utilization of architecture and natural or artificial environment. It was more about the inspiration of landscape and garden design. Master degree thesis *The Study on Form Generation of Contemporary Landform Architecture* written by Chen Yubin in 2010 discussed the form generation of landform architecture from perspectives of the historical origin, theoretical support, morphological classification, design method, construction problem and local practice. Master degree thesis *Research on Landform Building of the Urban Environment Based on the Spirit of Place* written by Tang Kai in 2013 analyzed macroscopic design strategies about urban relations as well as microscopic design strategies about the material, structure and space through practical cases under the background of genius loci. Master degree thesis *Research of Contemporary Urban Landform Architecture Design* written by Wang Jing in 2012 described features of landform architecture and design strategies of its relationship with city. In addition, there are some articles that contain similar keywords such as "landscape architecture", "topographical architecture" and so on. What they discussed about are closely related to landform architecture.

Correspondingly, contemporary Chinese architects also created some landform buildings. For instance, Wenchuan Earthquake Memorial Hall in Yingxiu Town designed by He Jingtang's team, Exchange Center in Chengdu Tianfu Software Park designed by Liu Jiakun, Public Art Plaza in Shenzhen Luohu District designed by URBANUS and Shanghai Qingpu Library designed by Ma Qingyun respectively applied landform techniques in architectural design in aspects of combining with nature, simulating topographical elements, respecting context and creating open space for the public.

Fig. 1-2-5: Wenchuan Earthquake Memorial Hall (He Jingtang)

Fig. 1-2-6: Chengdu Tianfu Software Park (Liu Jiakun)

Source: www.archcollege.com/archcollege/2016/7/27233.html; www.ikuku.cn/post/52821


Fig. 1-2-7: Public Art Plaza in Shenzhen Luohu District (URBANUS)
Fig. 1-2-8: Shanghai Qingpu Library (Ma Qingyun)
Source: bbs.zhulong.com/101010_group_201808/; www.ikuku.cn/project/qingpu-puyangge-tushuguan-maqingyun

Comprehensively, most analysis of landform architecture are related to characteristics, significance and form generation, while there are few theories about technical problems existing in practices of landform architecture. From the perspective of the architectural environment, the research domain of landform architecture has been transited from the natural environment to the urban environment. From the perspective of architectural types, the research objects of landform architecture are mostly public buildings, including large-scale public buildings. For instance, Master degree thesis *Research on the Design of Landform Architecture in the Horticultural Exhibition—A case study of the 2019 Beijing World Expo International Exhibition* written by Sun Ruochen in 2017 and master degree thesis *Research on Disappearing Design of Contemporary Museum Architectural Form* written by Li Mingxing in 2015 researched on the landform exhibition architecture. However, the research on landform sports architecture which also has a large scale is always scarce. The rare domestic literatures on landform sports architecture only stay in analyzing the significance of landform as a form design element but lacking consideration on specific design techniques. For example, master degree thesis *Research on the Form Design of Long-span Sport Architectural Landform Disappearing* written by Cheng Zheng in 2012 proposed strategies and methods of form disappearing in terms of landform sports architecture without involving functional and spatial strategies, which cannot form a multi-faceted reference for the practice of landform sports architecture. The above omissions are also the reasons and inspirations for doing this research.

1.2.2 Regional Sports Architecture and Landform Sports Architecture

Research on regionalism has always been favored by architectural theory researchers. For regional sports architecture, international researches carried out with practical projects. Since

the 1980s, there have been many outstanding works. For example, some Japanese modern long-span sports buildings like Yoyogi National Gymnasium reflect the perfect combination of science, technology, national aesthetic taste and traditional architectural forms as Suo Jian mentioned in his article *Presentational Traits of Regional Culture of Japanese Contemporary Architecture with Huge-space Forms* which was published in *Huazhong Architecture* in 2003. The design of the ten venues for the 2002 World Cup in Korea also imitated core symbols of the national traditional context, which reflects various possibilities of expressing regionalism in sports architecture.

In China, researches on regionalism of sports architecture mainly focused on the angle of energy conservation and ecological technology. For example, master degree thesis *Building Energy Efficiency and Performance Simulation Analysis of Large Space Gymnasium* written by Yang Jin in 2002 presented theoretical analysis and software simulation in terms of shape, orientation, lighting and ventilation of sports architecture. Doctor degree thesis *Research on Ecological Overall Design of Contemporary Sports Architecture* written by Yue Yin in 2005 referred to the regionalism from an ecological perspective. However, the theoretical research on regionalism of sports architecture from aspects of spatial design and cultural expression is relatively few. Doctor degree thesis *Effective Critical Regionalism Text Research on Long-span Sports Facilities* written by Lian Xu in 2010 abstractly discussed effective critical regionalism text in aspects of history, communication, expression and design strategies of sports architecture by combining with theories of other disciplines. Mater degree thesis *The Regional Design Strategy of The Stadium and Gymnasium* written by Wu Yingang in 2013 discussed the current status and strategies of the regional design of sports architecture with the author's design practice.

In addition to researches on spatial and technical characteristics mentioned above, in the field of regionalism, there are a few researches on sports architecture concerning about ecology and culture in certain environments (mountainous, icy and snowy environments, campus, etc.). Among them, the research on sports architecture in special geographical environments has strong theoretical reference value for this topic, especially mountainous sports architecture and underground (or sinking) sports architecture. As for mountainous sports architecture, master degree thesis *Design & Technology of The Mountainous Stadium* written by Lu Ting in 2008 and master degree thesis *Study on the Adaption of the Stadium Space in Mountainous Area* written by Wang Xiaofang in 2008 considered about principles and strategies of designing

stadiums in mountainous environments from aspects of planning, site selection, shape adaptation, spatial organization, structure, topographic relationship, regulation, facility technology, sustainability and so on, which formed guidance for sports architecture design in particular topographic environments. As for underground (or sinking) sports architecture, there is few theoretical literatures, but only a small number of journal articles and some practical projects are presented. Article *Embedment and Development—Research on Sports Architecture Design Based on the Sinking Mode* written by Lu Shiliang, Zhang Chunyu and Ju Xi published in *Journal of Human Settlements in West China* in 2017 discussed about the pros and cons of sinking sports architecture. Berlin Olympic Velodrome and Swimming Pool in Germany whose volumes are almost completely sinking, Chofu City Gymnasium in Japanese which has a sinking courtyard, Helsinki underground swimming pool in Finland which combines with the function of shelter, Jorvik Cave Speed Skating Hall for Winter Olympics in Lillehammer which is good at insulation are all typical examples of reflecting regionalism by combining geographical and functional characteristics. In addition, Japanese magazine *Shin-Kenchiku* also includes several Japanese sports buildings that are closely integrated with underground space. They demonstrate the feasibility of sports architecture reacting to the characteristics of local environments through spatial relationships between the volume and environment.

In summary, as a special form of sports architecture, although landform sports architecture has not formed a complete theoretical system with comprehensive researches, it links to many related concepts and there are some practical cases as support. The research of this topic, with the help of relevant concepts and theories, is an analytic summary of typical projects and also a dialectical supplement to the theoretical research part.

1.3 Research Content and Method

1.3.1 Research Content

Through the study of existing landform sports architecture, related landform architecture proposals and theoretical methods, this research aims to discuss dialectically on the influence factors of applying landform techniques in sports architecture design in different environments, and to summarize and analyze basic form, function and space design strategies as references for the design and construction of landform sports architecture in accordance with local conditions. Finally, based on the urban development background of Milan, to discuss about the significance and possibility of constructing landform sports architecture in Milan as an example of applying it in the urban environment.

Chapter 1: Introduction. To briefly explain the research background, significance and research status of this topic. To clarify the research content, methods and logical framework.

Chapter 2: Overview of Landform Sports Architecture. To illustrate related theories of landform architecture. To clarify the definition of landform sports architecture. To explain characteristics of the object from three aspects: necessity, feasibility and particularity of landform sports architecture design.

Chapter 3: Applicability of the Landform Technique in Sports Architecture Design. By analyzing the causes and effects of existing landform sports buildings' form generation, to dialectically discuss on the applicability of the landform technique in sports architecture design in different environments and conditions, and to summarize relevant factors that affect the applicability.

Chapter 4: Design Strategies of Landform Sports Architecture. Through the analysis of key points of landform sports architecture design, to pertinently analyze and extract design strategies and techniques in relevant projects to form a corresponding design graphic lexicon of landform sports architecture form, function and space design strategies.

Chapter 5: Idea and Significance of Landform Sports Architecture in Milan. Based on the background of Milan's successful bidding for hosting the 2026 Winter Olympics and Milan's urban planning for the landscape system, to state the possibility and significance of applying landform sports architecture by discussing proposals on relevant sites in Milan.

Chapter 6: Conclusion and Outlook. To Summarize results of the research on landform sports

architecture. To point out its enlightenment to current architectural activities and to Propose possible development trend of this topic in the future.

1.3.2 Research Method

a) Literature Research Method

It is mainly used in the early stage of the research. To read relevant literatures on keywords such as “landform” and “sports architecture” to summarize historical development process, various design strategies (form, function, space, etc.) about landform sports architecture, which aims to accumulate basic theoretical knowledge for this research.

b) Case Study Method

Through the inductive analysis of relevant projects, to summarize design strategies and techniques generally and pertinently, which serves as the practical support for the theoretical discussion.

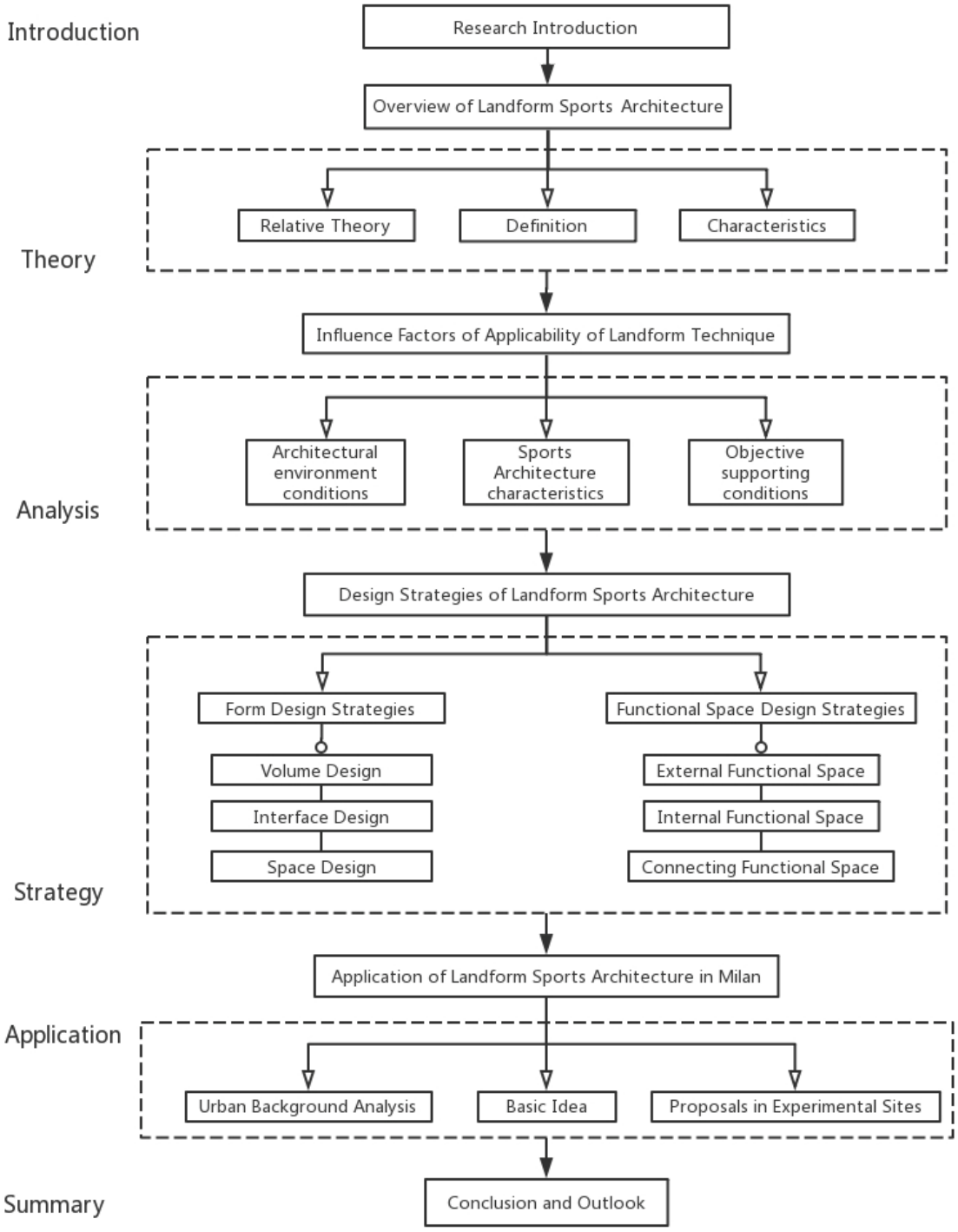
c) Qualitative Analysis Method

On the basis of literature and case support, from the perspective of qualitative analysis, to put forward ideas of morphological applicability and design strategy, which could be practiced and verified in the future.

d) Design Graphic Method

Through the targeted analysis and extraction of design methods in relevant projects, forming a graphic lexicon of landform sports architecture design techniques.

1.4 Research Framework



CHAPTER 2

Overview of Landform Sports Architecture

2.1 Relative Theories of Landform Architecture

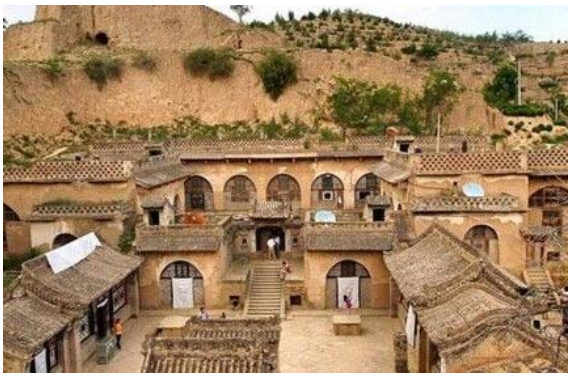
As Wikipedia shows, a landform is a natural feature of the solid surface of the Earth or other planetary body. Landforms together make up a given terrain, and their arrangement in the landscape is known as topography. Landform architecture closely combines architecture with landform to create a type of architectural form that integrates architectural functions and artificial landscapes. Therefore, its theoretical development relates to multiple disciplines like architecture, landscape and topography, and they have gradually become integrated in the field of landform architecture.

2.1.1 Early Forms of Landform Architecture

(1) Earth Shelter

Earth Shelter is a structure (usually a house) with earth (soil) against the walls, in the roof, or that is entirely buried underground. As an early form of combination of architecture and land, it aims at adapting to the climate and topography. It has become relatively popular after the mid-1970s, especially among environmentalists. However, the practice has been around for nearly as long as humans have been constructing their own shelters. Earth sheltered building is one of the most ancient forms of building. It is thought that from about 15,000 BC, migratory hunters in Europe were using turf and earth to insulate simple round huts that were also sunk into the

ground.[1] Such buildings covered by soil adapt to geographical conditions in a passive way as they are friendly to nature. They have been appeared in many countries because of advantages such as passive heating and cooling, humidity control, wind and earthquake protection, fire protection, soundproof and so on. For example, Chinese Yaodong (cave house) is a particular form of earth shelter dwelling which is common in the loess Plateau in the north district of China. Local people creatively make use of the plateau terrain to build artificial living caves and also to create a special architectural culture. Matmata, an underground village in Tunisia, was built by Berbers for adapting to the harsh and hot climate in the region. The Nordic sod house enhances buildings' capability of keeping warm by plating turf on the roof. So to speak, many cases show that early traditional landform architecture is the crystallization of human beings adapting to nature.



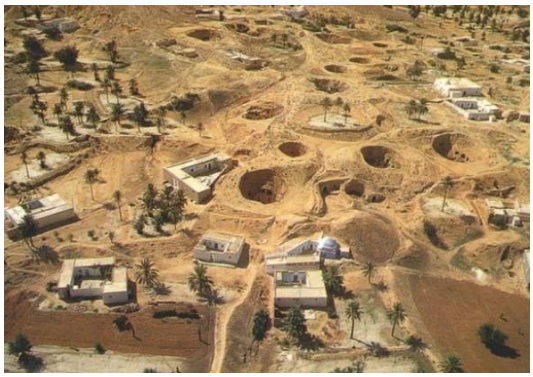


Fig. 2-1-1: Chinese Yaodong
Fig. 2-1-2: Matmata in Tunisia
Source: sns.91ddcc.com/t/21361; www.testmylife.com/en/offer/djerba/matmata-douz-QjAtXXaz.html

(2) Mat-building

Mat-building emerged in the late 1950s as a consequence of the debates within CIAM over principles of the functional zoning. Alison Smithson[2] described the mat concept and defined mat-building as follows: "mat-building can be said to epitomize the anonymous collective, where the functions come to enrich the fabric, and the individual gains new freedoms of action through a new shuffled order, based on interconnection, close knit patterns of association and

[1] Partly excerpted from Wikipedia "Earth Shelter".

[2] Alison Margaret Smithson: English architects who is often associated with the New Brutalism.

possibilities for growth, diminution and change.[3]" It is an architectural prototype put forward by Team X's young architects. From the individual and the whole relationships between architecture and city, they have carried out many practices about this concept by means of urbanization of buildings and urban networking, such as Amsterdam Orphanage designed by Van Eyck in 1995, Noah's Ark Proposal designed by Brom in 1962, Bihir office building designed by Herzberg in 1968 and so on. This type of building used a spatial weave and infiltration technique to show a horizontally stretched texture of physical space. Unfortunately, the construction of The Free University of Berlin in 1970s showed many problems caused by designer's over-concern about its form rather than structural relationship, which leads to the silence of mat-building concept. However, it soon revived with the popularity of high-density low-rise buildings. The development of landform architecture in the 21st century, driven by industrial technology, continues the horizontally extended form of mat-building and unfolds the interaction between architecture and the earth's landscape.

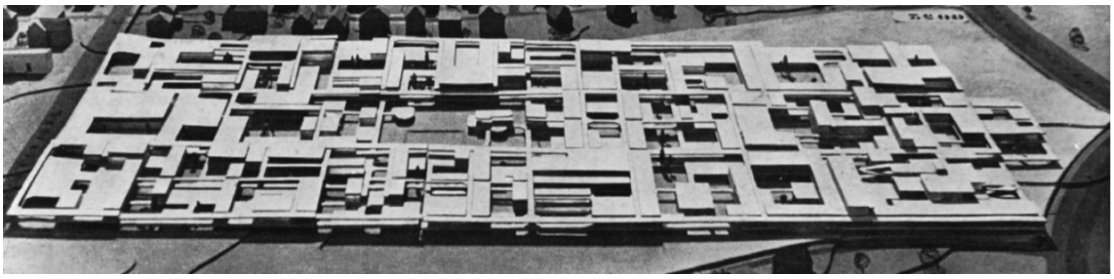


Fig. 2-1-3: Mat-building Example (Competition Design for the Free University, Berlin, 1963)
Source: dusp.mit.edu/sites/dusp.mit.edu/files/attachments/project/projections_10_b.pdf

2.1.2 Basic Theories of Landform Architecture

(1) Genius Loci (Spirit of Place)

According to Norwegian architect Christian Norberg-Schulz, a place refers to a whole consisting of nature, form, texture and color of a specific substance. It is not only an embodiment of existing space, but also have characteristics. He believes that orientation and identification are manifestations of existing space of a place. People establish relationships with places through orientation and identification to confirm their emotional communication with places. The

[3] Alison Smithson's article *How to Recognize and Read Mat-Building- Mainstream Architecture as it has Developed Towards the Mat-Building* in *Architectural Design* of September 1974

establishment of genius loci is closely related to the relationship between the place, the natural environment and the formation of characteristics of the place itself. This theory also emphasizes the interaction of people, architecture and nature by the architectural form. Due to the direct relationship between buildings and local environments, the design of landform architecture and environments are simultaneously developed. Compared with buildings that have relatively independent forms, the creation and presentation of genius loci are very significant to landform architecture.

(2) Field Condition

Field Condition is a concept put forward by Stan Allen who is an American architect, theorist and former dean of Princeton University School of Architecture in his book *Points+ Lines*. It emphasizes the difference of architectural form between buildings as experience fields and buildings as traditional visual objects. The concern about locality is particularly important for the former ones because it is a bottom-up factor in the system. One of the characteristics of buildings as experience fields is that the field is fundamentally a horizontal phenomenon. Different from the visual impact brought about by vertical cities and buildings, what these field combinations seem to promise in this context is a thickening and intensification of experience at specified moments within the extended field of the city.[4] This theory coincides with British architect Frampton's concept of megaform which points to buildings with horizontal features that can influence the landscape in metropolitan. From the angle of field, landform architecture redetermines the relationship between the architectural form and the land. In this way, buildings join in the surface to show a thickened two-dimensional plane.

(3) Landscape Urbanism

Landscape urbanism is a theory of urban planning arguing that the best way to organize cities is through the design of the city's landscape, rather than the design of its buildings.[5] The core is to emphasize that landscape is the carrier of all natural and human civilization processes. This theory was formally put forward by Charles Waldheim in the mid-1990s, and it is an

[4] Partly excepted from book *Points +Lines* written by Stan Allen.

[5] Excerpted from Wikipedia "landscape urbanism".

important view and methodology for urban construction today. It is worth mentioning that landscape architect and theorist James Corner's general idea for using landscape urbanism points out the emphasis on horizontality and environmental fluidity, which lays the foundation for the interaction between urban space and the land environment. As Tom Turner summarizes his book *Landscape Design History and Theory: Landscape Architecture and Garden Design Origins*, landscape is a context which contains architecture and civil engineering. Landscape urbanism will break the boundary between the landscape and the city by organizing them as one. From this point of view, landform architecture in the urban environment can be regarded as a part of the urban landscape while being integrated into the city, and becomes a means of realizing the integration of city and landscape.

(4) Integrated Design of City, Architecture and Landscape

The Beijing Charter which was adopted by Wu Liangyong[6] in 1999 proposed the architectural system in the 21st century – general architecture, namely the integration of architecture, landscape architecture and urban planning. At the same time, it emphasized the concern for the human settlement environment which should adapt to local conditions sustainably. Whether from the perspective of ecology or discipline integration, the introduction of this concept provides an opportunity for the development of landform architecture in the new era.

[6] Wu Liangyong: an academician of the Chinese Academy of Sciences and the Chinese Academy of Engineering, urban and rural planner and educator, founder of human settlements environmental science.

2.2 Definition of Landform Sports Architecture

2.2.1 Definition Interpretation

Although landform architecture has developed for a period of time, it does not have a very clear and fixed definition. In the general understanding, landform architecture reacts to or simulates natural environmental elements. In terms of architectural form, natural landscape elements such as mountains, rocks, landforms and rivers are inspirations for creating landform architecture, and the buildings show similar features with the natural landscape. However, with the acceleration of the urbanization process, landform architecture should have a more inclusive meaning in the urban environment, especially for landform sports architecture. Because of the particularity of its function, the interactions among the environment, people and city are more intense. It is not reasonable enough for landform sports buildings in urban environments to focus on simulating natural landscape without taking urban factors into consideration. Therefore, besides the relationship with the nature, there must be other factors which promote realization of landform sports architecture. For instance, to achieve energy-saving and land-saving from the angle of ecological effects, or to comply with the site dynamics and urban elements from the angle of morphological characteristics. Undeniably, the understanding of the meaning and reference range of the word “landform” largely determines the scope of landform sports architecture discussed in this research. Even though it cannot be accurately delineated, it must be basically clarified.

Firstly, the landform sports architecture discussed in this research is determined in terms of its main function. It is a type of public architecture containing sports activities, a space for educational sports, athletic sports, physical exercise and sports entertainment. The composition of various types of sports buildings varies greatly depending on the use, scale and construction condition. Usually, sports fields, athletes’ rooms (rest room, changing room, bathroom, toilet) and management rooms (office room, facility room, equipment room) are the basic spaces in sports buildings.

Secondly, the landform technique is essentially a form design method used to promote the connection between sports architecture and landform environments (both the urban environment and the natural environment) by sports architecture reacting to or simulating the environmental characteristics around it accordingly. These environments include not only natural landform elements such as mountains and rivers, but also special urban textures formed

by parks, buildings, squares, roads and blocks. This technique connects buildings to the earth, and weakens the boundary between buildings and environments or creates spatial transitions, in order to integrate buildings into the environments and further make them become part of the urban landscape and context. In this way, the protection, continuity and creation of genius loci can be achieved. What is worth mentioning is that this kind of integration concerns much about the relationship between forms of sports architecture and the land. Generally, the building seems like growing out of the earth and then being naturally integrated into the environment.

2.2.2 Changes of the Perception of Sports Architecture

Currently, the number of landform sports buildings is relevant small. In addition to technical and economic constraints, the reason also relates to the public's inherent perception of sports architecture. Although groups with different roles have different understandings of sports architecture's status and significance, generally speaking, on one hand, the humble gesture of its form does not obey people's perception that a large-scale building should be iconic visually; on the other hand, people would not like to enter the land to participate activities because of cultural habits. Together with other similar reasons, the development of landform sports architecture is limited. Therefore, understanding and accepting landform sports architecture need people to adjust the solidified perception of sports architecture. Correspondingly, whether a landform sports building can lead to positive perception change is also an important criterion for judging whether the design strategies of landform sports architecture are good.

(1) The Dimension of Environment: From Iconic to Humble.

Apart from the large-scale sports buildings that really need to show the power and image of the country or the city through the unique tension of the form, sports buildings which are built for the public's everyday use could change their gestures into humble ones instead of iconic ones. Because by doing this, architecture and the environment can be integrated, which plays an active role in urban space connection and natural environment protection.

(2) The Dimension of Value: From Monumental to Experiencing.

Sports buildings usually have monumental significance because they are often linked to

important sport events, thus guiding the architectural form to be designed with monumental features. However, in order to serve for citizens in daily life, landform sports architecture pays much attention on function and space experience. Moreover, by integrated design of the city, landscape and architecture, sports architecture with the landform technique can have internal functions as well as external spaces which will connect and carry public activities better. As a result, by changing itself from monumental to experiencing, landform sports buildings could bring positive effects to the whole sites.

(3) The Dimension of Aesthetics: From Grand to Suitable.

The large scale always contributes much to the popularity of sports buildings. It is also an indicator that some local governments blindly focus on. Especially in China, since China's reform and opening, the fast expansion and the competition of construction speed and scale have caused an arbitrary aesthetic standard which regards bigness as beauty. As sustainable development is becoming important, the concept of grand form of sports architecture should be changed. Instead, it is correct to adapt it to the regional context. This is not only the premise of accepting landform sports architecture, but also the development trend of contemporary architecture.

2.3 Necessity of the Landform Technique in Sports Architecture Design

(1) An Exploration of the Relationship Between Sports Architecture and the Environment

As mentioned above, the discussion on the relationship between architecture and the environment emphasizes the coordination of them. As for sports architecture, firstly it is necessary to clarify possible contradictions between its particularity and the integration with the environment. In terms of the form, first, sports buildings inherently have long span and great height due to the special needs of sports activities inside. And with the concept of concentrated construction of sports facilities appears, sports centers and sports parks within affiliated outdoor sports fields and facilities occupy more areas and become an independent block in the city. Second, the internal function organization of sports buildings determines the spatial layout that sports fields are in the center surrounded by auxiliary space. Regular geometrical sports fields and surrounding stands together form a relatively fixed spatial volume. Third, the relatively fixed and complete volume leads to flexibility of the interface form design, then special form of the roof and facade has become one characteristic of many sports landmarks.

Therefore, the large volume of sports buildings has an impact on the urban spatial context and landscape texture because the independent form occupies a relatively large land. Undeniably, the large-scale landmark buildings can reflect the city's power and become an important node in the urban structure because they are easy to be recognized visually. However, they also face the risk of becoming a huge weird invasion in cities with a small-scale texture or becoming artificial voids in the continuous landscape.

Fig. 2-3-1: Shanghai Yuanshen Sports Center in China

Fig. 2-3-2: Jalisco Stadium in Mexico

Description: The independent construction of the plot makes the stadiums lack coordination with the surrounding high-density urban environment., which makes them too conspicuous.

Source: Google Map


Fig. 2-3-3: Kyocera Dome Osaka in Japan

Fig. 2-3-4: Berlin Olympic Stadium in Germany

Description: Kyocera Dome looks like a prominent and independent pearl left in the tight urban environment. The transitional state of the boundary between nature and the city is directly broken by large-scale Berlin Olympic Stadium.

Source: Google Map

Aiming at above problems, through the form hidden effect caused by the landform technique, the solidification of the sports architecture's huge image can be broken. Therefore, it can be integrated into the landform, and create a closer and natural connection and interaction with the environment.

(2) An Attempt on Open Form of Sports Architecture

The openness of sports architecture is reasonable because it is based on the traditional relationship between sports and natural environments as well as the change of the significance of sports nowadays.

Firstly, about the relationship between sports and natural environments. In primitive society, sports activities originated from human beings adapting to nature. People use limbs as tools to acquire living materials and to resist threats in natural environments, which lays the foundation of the relationship between sports and the nature. Afterwards, in the era with developing infrastructure, people exercise in open spaces, grasslands, squares and parks. Then, with the improvement of living standards, professional sports facilities start to provide professional and comfortable environment for sports activities. But the advantages of an outdoor environment filled with sunlight and fresh air are irreplaceable. Although current cities are difficult to provide large, free and open natural environments, from the perspective of health and landscape, the pursuit of nature always reminds designers to create more open sports buildings.

Secondly, about the change of the significance of sports in contemporary time. The concept of public fitness and new lifestyle of social sports are becoming popular. Daily sports activities are

not a platform for professional athletes to compete with each other, but a part of vivid social life. With more and more community sports facilities are built, sports as a recreational and social medium should be presented in a freer and more natural style. Therefore, instead of keeping the sense of imprisonment and distance brought about by closed sports buildings, openness should be one of the contemporary themes of sports architecture design and construction.

However, in reality, some national and municipal stadiums are hardly open to the public due to the management and maintenance of the sports fields. Except being used in formal events, closed sports buildings are isolated from the daily life in the prosperous city, which is not ideal in terms of space efficiency. Some large-scale sports buildings want to be catalysts of districts' development to promote vitality of surrounding urban space. But the closed image does not welcome people to participate in activities spontaneously. Finally, the lack of popularity limits the further development of the whole area.

Fig. 2-3-5 & 2-3-6: Pancho Arena in Hungary (Tamás Dobrosi, Doparum Architects)
Description: The arena with a beautiful and special form does not open to the public because of the preservation of the field grassland. Moreover, the arena is very far from main city while the transportation is not convenient. Thus, the arena neither serves for residents around it nor attracts tourists to come, which causes it to be usually vacant.
Source: www.archdaily.com/538826

Fig. 2-3-7: Capital Stadium in China
Fig. 2-3-8: Beijing Workers Stadium in China
Description: The images of the stadiums themselves are closed and solemn, which do not attract the public to play sports, communicate and enjoy social life with each other in the places.
Source: Google Map; www.piaocn.com/changguan/47.html

To enhance the openness of sports buildings, in addition to the flexible management, improving openness of the architectural form and space can improve the building's connection to urban space, attract people and has a positive effect on interaction. The landform technique can help achieve openness. To be more specific, first, the landform technique can weaken the boundary to promote integration among spaces; Second, it can create spatial transition to promote communication among people; Third, it can reshape the place to promote interaction between people and space.

(3) An Approach for Sustainability in Sports Architecture Design

The destruction of natural environment by artificial construction is a persistent issue. In recent years, the phenomenon of "de-greening" and the emphasis on sustainability have further promoted attention on resource shortage and ecological protection in the architectural field.

As far as ecological protection is concerned, firstly, landform sports architecture design makes buildings integrated into environments by strategies like embedding them into the land and covering them with plants. Using artificial terrain with sports space to compensate for the mountain and soil damage can not only add new functions to the original environment but also maintain its natural state as much as possible. Secondly, landform sports architecture can enhance its internal natural light and ventilation by good form design and use passive energy-saving strategies to reduce energy consumption and pollution emission produced by mechanical heating and cooling.

As far as rational use of resources is concerned, in high-density cities, the shortage of land resources brings challenges to the construction of large-scale sports buildings. The vertical integration of landscape and buildings commonly used in landform architecture is conducive to the intensive use of limited land, which can meet diverse needs of public space and landscape space at the same time.

2.4 Feasibility of the Landform Technique in Sports Architecture Design

(1) The Horizontal Land as an Expansive Site for the Large-scale Sports Architecture

Whether from the expansive form of mat-buildings or from landscape urbanism theory which states architecture should base on the landscape substrate, it is clear that the discussion of the symbiosis of buildings and the land is common in the development of landform architecture with the support of topography. Kenneth Frampton once explained in his book *Modern Architecture—A Critical History*, megaform is not an isolated form but a continuation of the environment. Horizontality is one of its typical characteristics. It tends to integrate with the overall landscape form in a wide visual filed and to merge with the site to become a virtual landscape. This kind of megaform is more common in contemporary architecture projects with large-scale such as sports buildings, universities, transportation buildings, shopping centers and so on. It can be inferred that as sports architecture has a relatively large volume, compared to small-size buildings, the combination with the landform can produce the effect of symbiosis with the land in a more powerful way. When the architectural form is integrated into the environment, it further promotes the organic integration of architecture, landscape and city. Meanwhile, the horizontal characteristic of the land provides a substrate for large-scale landform sports architecture.

(2) Multi-height Interfaces Connect with the Three-dimensional City

The concept of three-dimensional city appeared after the World War II when Le Corbusier proposed his idea that the city must be concentrated because only the concentrated city had vitality. In recent years, with the rapid economic growth and urbanization, the concept of compact city has gradually changed the urban development model from “two-dimension spreading” to “three-dimension accumulation”. For example: 1) Vertical space development represented by high-rise buildings; 2) Three-dimensional integration of on-ground and underground transportation systems; 3) Centralization of related functions in urban planning. Especially in metropolis, the transportation system and the functional structure have been complex. They are multi-layered with open interfaces. Under such a background, landform buildings enhance the relationship between the building and the earth by design strategies such as elevation, embedding, juxtaposition, superposition and so on. Making full use of the top,

medium and bottom interfaces of the building to interact with multi-height interfaces of the city can form a three-dimensional connecting system. Meanwhile, because sports buildings usually hold gathering events, the multi-direction and multi-level evacuation systems are needed, so they could be connected to the three-dimensional urban systems mentioned before. Therefore, the construction of landform sports architecture in three-dimensional cities is feasible and reasonable. It is worth mentioning that for cities with special topography such as mountainous cities, urban development follows the topography to form three-dimensional spaces naturally. The construction of landform sports architecture in such environments can simultaneously conform to the topographical features and the development trend of urban space.

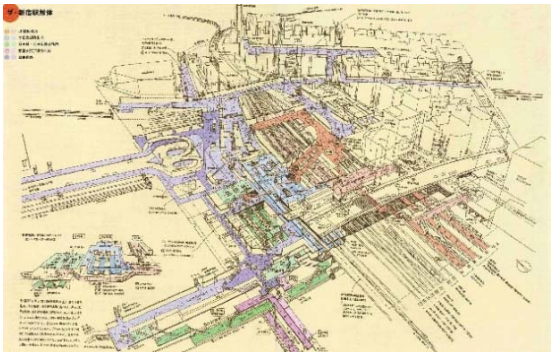


Fig. 2-4-1: Underground System around Shinjuku Station in Tokyo

Fig. 2-4-2: Shinjuku Bus Terminal

Description: In high-density city like Tokyo in Japan, complex infrastructure systems connect the city in different levels. Large-scale buildings like a bus terminal connects with the city in different directions on different levels. The building interacts with the city's interfaces and is integrated into the contemporary urban landform.

Source: i.stack.imgur.com/Opgp7.jpg; zh.wikipedia.org/wiki/%E6%96%B0%E5%AE%BF%E7%AB%99

(3) The Flexible Exterior Interface Form Interacts with the Landform

As mentioned in the part "Necessity of Landform Technique in Sports Architecture Design", one characteristic of the sports architecture is that its internal space and functions are relatively fixed. The concentrated internal functional space brings the possibility and flexibility of the facade design. Sometimes this feature brings about strange and exaggerated facade design, but for landform sports architecture, little constraints on facades are helpful to the flexibility of external interface design. Interfaces of buildings, terrains and cities are more possible to be connected. Meanwhile, while realizing the complete internal functions, the released free interface is also helpful to connect internal and external functional space around the site. The connecting interface itself can also be added with related open functions to improve the

efficiency of land use.

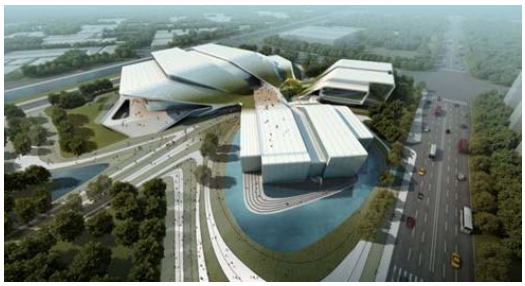


Fig. 2-4-3: Guangzhou Gymnasium for the Asian Games (GDAD)

Fig. 2-4-4: Beijiao Sports Center Project in China (Decode Urbanism Office)

Description: Two sports buildings with different schemes for architectural interfaces. The left one uses streamline to interact with the land while the right one connects interfaces to create external activity space on a new level.

Source: image.baidu.com; www.archdaily.cn/cn/600337

2.5 Particularity of the Landform Technique in Sports Architecture Design

(1) Targeted Designs React to Diverse Environmental Conditions

Though project practice and experience accumulation for many years, conventional sports architecture has formed some relatively fixed paradigms. The same design approaches can be used in different sites to meet basic requirements. For instance, many stadiums have large platforms as buffer zones on an upper level to organize the circulation, strip-type windows on the skin are popular for enhancing natural light inside, lots of sports buildings have commercial function on the ground floor to serve for audiences, etc. There are many widely used and highly efficient design strategies and techniques. However, a landform sports building is closely related to its environment, so the design of different landform sports buildings should not be generalized and copied because diverse environments brings different influence and consequences. Some conventional design strategies are not well suited for this type. Therefore, various environmental conditions and unconventional forms bring particularity to the design of landform sports architecture. Special and “customized” strategies help to create individual features for each landform sports architecture.

(2) Integrated Design Helps Solve Technical Difficulties

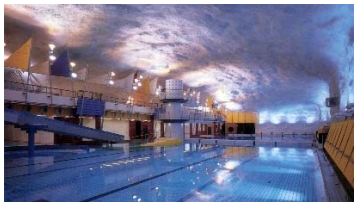
For landform sports architecture, the need for integrated design of architecture, landscape and city has been explained in previous parts. Compared with conventional sports architecture, the design of landform sports architecture should not be limited to the single building itself, but the surrounding environment needs to be taken into consideration. Seeking possible contacts and establishing the relationship between them are crucial.

Moreover, solving the technical difficulty of landform sports architecture also needs integration of various professional knowledge and cooperation of various specialties. It is self-evident that the special form of landform sports architecture brings technical difficulties. For example, compared with conventional sports architecture, there are more interactions between landform sports buildings and environments, especially the earth. So, in the process of construction, earth excavation and filling ask for more concerns about the land quality and the workload. In the early stage of the design process, the investigation of environmental conditions should pay more attention on the geological conditions and the development limitation of underground

space. In the middle stage of the design process, according to actual situations, the weight of the building, the layout of functions and so on should be adjusted by optimizing materials, structures and architectural forms for adapting to particular environments and reducing negative impacts. Meanwhile, although problems about natural lighting, ventilation and drainage inside caused by the special architectural form and difficulties like evacuating people from the underground space can be solved by applying new equipment and technologies, considering about above issues also from the perspective of the architectural form may save time and money. Therefore, the design of landform sports architecture needs to cooperate and coordinate with various specialties at an early stage. In this way, the feasibility of the architectural form can be determined from various aspects of techniques, and the design can be adjusted and optimized in time. In all, the integrated thinking of various technical difficulties is a challenge to the form designer under the background of the particularity of landform sports architecture.

2.6 Basic Information of Typical Landform Sports Architecture Projects

(Ordered by year)

No.	Project	Information
1		**Munich Olympia Stadium** Location: Munich, Germany Designer: Frei Otto and Gunther Behnisch Year: 1972 Seats: 69250 (used to be 8000) Structure: Tensile and membrane structure
2		**Osaka Castle Hall** Location: Osaka, Japan Designer: Nikken Sekkei Year: 1983 Seats: 16000 (fixed seats: 8956) Gross Floor Area: 36174 sqm Site Area: 36351 sqm Cost: 10.6 billion JYP
3		**Palais Omnisports de Paris-Bercy Omnisports** Location: France (12th arrondissement) Designer: Michel Andrault, Pierre Parat, Jean Prouvé (Renovated by DVVD Architects) Year: 1984 (Renovated in 2015) Floor Area: before 59100 sqm / after 62000 sqm Cost: 110 million euros for renovation
4		**Chofu City Gymnasium** Location: Tokyo, Japan Designer: Kume Sekkei Co., Ltd. Year: 1985 Gross Floor Area: 6057 sqm
5		**Helsinki Underground Swimming Pool** Location: Helsinki, Finland Designer: Hkp Architects Year: 1993 Gross Area: 11000 sqm Main Function: 4 pools, gyms and a fitness center.
6		**Gjovik Olympiske Fjellhall** Location: Norway Designer: Moe-Levorsen AS Architects Year: 1993 Seats: 5830 Net Area: 10010 sqm Gross Area: 14910 sqm Cost: 135 million NOK

7

Osaka Municipal Central Gymnasium
Location: Osaka, Japan
Designer: Nikken Sekkei
Year: 1996
Seats: 10000 for the main hall, 188 for the small hall
Gross Floor Area: 38425 sqm
Cost: 48.3 billion JYP

8

Max-Schmeling-Halle
Location: Berlin, Germany
Designer: Jörg Joppien, Albert Dietz and Annette Maud-Joppien
Year: 1997
Seats: 11900 (fixed seats: 7491)
Gross Floor Area: 48800 sqm
Land Area: 38565 sqm
Cost: 105 million Euros

9

Berlin Olympic Velodrome and Swimming Pool
Location: Berlin, Germany
Designer: Dominique Perrault
Year: 1997
Seats in Velodrome: 12000 (fixed seats: 5668)
Gross Floor Area: 93320 sqm
Plot Area: 100000 sqm for cycling and swimming

10

Vizcaya Indoor Swimming Hall
Location: Vizcaya, Spain
Designer: ACXT, SA Grupo IDOM
Year: 2001

11

Estádio Municipal de Braga
Location: Braga, Portugal
Designer: Eduardo Souto de Moura
Year: 2003
Support Space: 10071 sqm
Seats: over 30000
Cost: over 161 million euros

12

City of Jaca Hockey Arena
Location: Jaca, Aragon, Spain
Designer: Coll-Barreu Arquitectos
Year: 2005
Gross Floor Area: 18123 sqm
Cost: 24418000 euros

13

Langreo Sports Center
Location: Langreo, Asturias, Spain
Designer: ACXT
Year: 2006
Main Function: sports hall, swimming pools, rhythmic gymnastics area, services

14

Insular Athletics Stadium in Santa Cruz de Tenerife
Location: Tincer, Santa Cruz de Tenerife, Canary Islands, Spain
Designer: AMP Arquitectos
Year: 2007
Sears: 4000

15

Zamet Center
Location: Rijeka, Croatia
Designer: 3LHD Architects
Year: 2008
Site Area: 12289 sqm
Gross Floor Area: 16830 sqm
Seats: 2380 seats in the sports hall
Main Function: a sports hall, local community offices, library, retail and service spaces, a garage
Cost: 20 million euros

16

Municipal Pool of Povoacão
Location: Acores São Migue, Portugal
Designer: Barbosa & Guimarães Architects
Year: 2008

17

Slowtecture M Gymnasium
Location: Hyogo Prefecture, Japan
Designer: Shuhei Endo
Year: 2008
Seats: 1500 seats for center court
Courts: 9 tennis courts
Structure System: Steel truss

18

Dalian Shide Stadium
Location: Dalian, Liaoning, China
Designer: NBBJ
Year: designed in 2009

19

Medellín Sports Coliseum
Location: Medellín, Colombia
Designer: Mazzanti Arquitectos
Year: 2010
Seats: 9000
Main Function: 5 sports arenas (martial arts, handball, gymnastics, basketball, volleyball)
Cost: CO$50 million

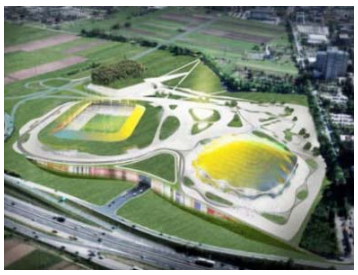
20

Guadalajara Volcano Stadium
Location: Mexico
Designer: Jean-Marie Massaud and Daniel Pouzet
Year: 2010
Seats: 45000

21

Sport Center ETH Honggerberg
Location: Zurich, Switzerland
Designer: Dietrich | Untertrifaller Architekten
Year: 2010
Gross Floor Area: 10374 sqm

22



Stožice Sports Park
Location: Slovenia
Designer: Sadar Vuga d.o.o. Architects
Year: 2010
Seats: 16038 for stadium, 12480 for sports hall
Footprint: 182000 sqm
Gross Floor Area: 460720 sqm
Main Function: a stadium, a sports hall, a shopping center
Cost: 119 million euros

23

Yangzhou Stadium
Location: Yangzhou, China
Designer: TUS-DESIGN Group
Year: 2011
Gross Floor Area: 24840 sqm
Seats: 6000

24

Ice Hockey Rink Proposal in Umea
Location: Umea, Sweden
Designer: BIG Architects
Year: Designed in 2011
Area: 4600 sqm
Main Function: Ice hockey rink, amphitheater

25

Mantes-la-Jolie Water Sports Centre
Location: France
Designer: Agence Research
Year: 2012

26

Kofun Stadium Proposal for 2020 Olympics
Location: Tokyo, Japan
Designer: DGT & A+ Architecture
Year: Designed in 2012
Area: 290000 sqm
Budget: 1.3 billion euros

27

Rock Stadium Proposal
Location: Al Ain, United Arab Emirates
Designer: MZ Architects
Year: designed in 2012
Plot area: 563333 sqm
Total Built-up Area: 206300 sqm
Seats: 40000

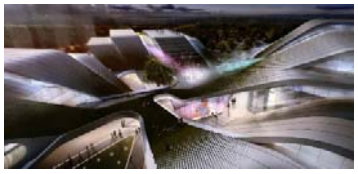
28

Hill of Fame Stadium Proposal
Location: Russia
Designer: Studio 44
Year: designed in 2012
Seats: 33000

29

Gammel Hellerup Gymnasium
Location: Hellerup, Denmark
Designer: BIG Architects
Year: 2013
Floor Area: 1100 sqm
Cost: 50 million DKK

30



Beijiao Sports Center
Location: Foshan, Guangdong, China
Designer: Decode Urbanism Office
Year: Designed in 2013

31

Omiyamae Gymnasium
Location: Tokyo, Japan
Designer: Jun Aoki＆Associates
Year: 2014
Main Function: a main arena, a swimming pool

32

Gymnasium Palais des Sports de Loudéac
Location: France
Designer: Bohuon Bertic Architectes
Year: 2014
Area: 5157 sqm
Seats: 1200
Cost: 5865500 euros

33

Polur Rock Climbing Gymnasium Proposal
Location: Polur, Iran
Designer: New Wave Architecture
Year: designed in 2014
Gross Floor Area: 4500 sqm

34

Vallehermoso Sports Center
Location: Madrid, Spain
Designer: ABM Arquitectos
Year: 2014
Gross Floor Area: 19740 sqm
Footprint: 8400 sqm
Number of Floors: 5

35

Street Dome in Haderslev
Location: Haderslev, Denmark
Designer: CEBRA, Glifberg+Lykke
Year: 2014
Area: 1500 sqm for Street dome, 4500 sqm for skate park

36

Longvic Sports Center
Location: Route de Dijon, 21600 Fénay, France
Designer: Dietrich | Untertrifaller Architekten; Sénéchal-Auclair Architectes
Year: 2015
Gross Floor Area: 3150 sqm

37

Sanwayao Community Sports Center in Chengdu
Location: Chengdu, China
Designer: CSWADI
Year: 2015
Gross Floor Area: 11936 sqm

38

Yangzhou Li Ning Sports Park
Location: Yangzhou, Jiangsu, China
Desiger: Australia PT Design Consultants Limited
Year: 2015
Site Area: 143376 sqm
Gross Floor Area: 51320 sqm (29320 sqm above ground)

39

Aquatic Center in Alps
Location: France
Designer: Auer Weber
Year: 2016

40

Putuo Fitness Center in Zhoushan
Location: Zhoushan, China
Designer: TJAD
Year: 2016
Gross Floor Area: about 30000 sqm

41

Mondorf-les-Bains Sports Complex Proposal
Location: Mondorf-les-bains, Luxembourg
Designer: Mecanoo + Metaform Architects
Year: designed in 2018
Area: 24500 sqm (including the velodrome)
Usable Area: 9000 sqm for velodrome, 2200 sqm for multisport hall, 3200 sqm for aquatic center
Budget: 65 million euros (including the velodrome)

42

Quzhou Sports Campus
Location: Quzhou, Zhejiang, China
Designer: MAD Architects
Year: under construction (designed in 2018)
Site Area: 6999040 sqm
Building Area: 337500 sqm
Seats: 30000 for stadium, 10000 for gymnasium, 2000 for natatorium
Main Function: a stadium, gymnasium, natatorium, national sports complex, outdoor sports venue, science & technology museum, hotel accommodations, youth center and retail programs.

2.7 Summary of the Chapter

This chapter mainly discusses the related theories, the definition and characteristics of landform sports architecture.

For the related theories, this chapter explores the historical origin and theoretical support of landform architecture. The early landform architecture evolved from traditional earth shelters and mat-buildings produced in 20th century. It has been influenced and promoted by theories like genius loci, field condition, landscape urbanism, Integrated design concept of city, architecture and landscape, etc.

For the definition, this chapter pays attention to the meaning and reference range of the word “landform”, as well as states that landform sports architecture is a type of public building for sports activities and it uses landform techniques to react to or simulate characteristics of natural or urban environmental elements. The architectural form is closely connected to the earth. It creates spatial transition and form integration to help create the spirit of place. Understanding landform sports architecture requests changes of fixed perceptions on the form of sports architecture. The integration of sports buildings and environments, the experience in the site and the adaptation of the sports building to particular environments should be emphasized.

In terms of characteristics, firstly, based on the features of form, function and construction of sports architecture, this part points out the necessity of landform techniques in sports architecture design mainly results from the discussion of the relationship between architecture and environments, the contribution to the openness of sports buildings and the significance of ecological protection. Secondly, based on the scale and internal space organization of sports architecture as well as the development trend of cities, this part points out the feasibility of landform techniques in sports architecture design mainly results from the expansion of buildings by the earth environment, the connection of interfaces between three-dimensional cities and landform sports buildings, the flexibility of the external architectural form. Thirdly, based on the technical difficulties of sports buildings, this part points out the particularity of landform techniques in sports architecture design is that it requests environmentally oriented and professionally integrated design process.

Finally, this chapter presents a summary of typical landform sports buildings and their basic information, which will be discussed in detail in the following chapters accordingly.

CHAPTER 3

Applicability of the Landform Technique in Sports Architecture Design

As a special form design method, the landform technique is not the mainstream in sports architecture design. The unconventional results are usually accompanied by controversy. Dialectically, while commending landform sports architecture for strengthening its relationship with the environment, it is also necessary to understand that choosing this type blindly may bring criticisms because of disadvantages like ecological damage, inefficient investment and so on. Therefore, in the early stage of design and construction, judging whether the landform technique is applicable to a specific sports building according to the actual situations is a prerequisite for designing and realizing landform sports architecture reasonably.

The architectural design is always comprehensive, and it is difficult to conclude a direct and quantifiable criterion for the form design strategy. In this Chapter, through analyzing the reasons of applying landform techniques for sports architecture and their advantages and disadvantages based on existing projects, to summarize factors of influencing the applicability of the landform technique for sports architecture. In the future practice, designers can check these influence factors and balance relevant advantages and disadvantages according to conditions of specific projects, as well as use these cases as reference, finally to determine if the landform sports architecture is suitable under specific conditions.

3.1 Factors of Architectural Environment Condition

3.1.1 Terrain Condition

Compared with flat terrains, terrains with the height difference are more likely to trigger the choice of the landform technique for sports architecture design. On one hand, terrains with the height difference often lead to more connecting interfaces with the architecture. Then the architectural design could react to different interfaces on different levels integrally. On the other hand, based on the purpose of ecological protection, the principle of less intervention on original terrains promotes the realization of landform sports architecture in terrains with the height difference. Because instead of cutting the terrain into artificial shapes to match with architectural form, landform sports architecture can comply with the original terrain. Meanwhile, there are also some sports architecture designs that do not actively choose to use landform techniques but naturally strengthen the relationship between the building and the earth in the process of coping with the terrain's height difference. Examples are as follows.

(1) Terrain Conditions Determine the Application of Landform Techniques

a) Sloping Terrain

Sport Center ETH Honggerberg is located in Switzerland and is a university sports facility. The construction site is a slope facing to the campus and is at the boundary of the campus and natural environment. The designer chose to conform to the terrain and retain the feature of this slope. The sports building is inserted into the sloping site with a hayfield. The top surface of the building is connected with outdoor space on the same level above the slope. A ramp entrance connects the top outdoor space and the middle level of the building. In this way, the volume of the building disappears when being looked from the natural site around it on the upper level. At the same time, the ground level of the building connects with the outdoor space below the slope, making the building's main entrance revealed in the campus to attract students to come. In general, it seems that the outdoor space flows through the generous foyer along a green ramp back into the open. This project uses the landform technique to deal with the terrain' height difference and protects the continuity of the overall natural environment on the southeast side of the campus.

Fig. 3-1-1: The Environment Map of Sport Center ETH Honggerberg (Dietrich | Untertrifaller Architekten)
Description: It is located at the boundary of the campus and the nature. As an expansion project for the campus, it is out of the old block of the campus and is placed into the original natural part. Therefore, to coordinate with the environment, it needs to react to the nature and the campus at different direction simultaneously.
Source: Google Map

Fig. 3-1-2: Bird View Image of Sport Center ETH
Fig. 3-1-3: Disappearing Effect of Sport Center ETH
Fig. 3-1-4: The Entrance on the Top Surface
Fig. 3-1-5: The Entrance Facing to the Campus
Description: The sloping terrain determines the form of this landform sports building and helps it create two different images on nature and university sides respectively. When connecting to the nature, what is worth mentioning is that the building does not directly connect to the grassland but is transited spatially by a few outdoor sports fields. In this way, the designer not only changes the border into a space but also creates relevant new functions for the border.
Source: bbs.zhulong.com/101010_group_201810/detail10057377/

b) Hilly Terrain

Yangzhou Stadium is located in Yangzhou City, China. It is one of the main buildings in Yangzhou Sports Park. Due to the uneven hilly terrain of the construction site, the designer chose to use the landform technique as the form strategy to design the stadium in order to preserve and continue the ecological environment of the park. The main space has been sunken into the “valley”, the roof has been designed into a sloping form, and a part of the building envelope has been covered with grass. In this way, the form of the whole building echoes the hilly terrain organically and is integrated into the surrounding environment in the park. Meanwhile, because of the sunken space, the entrance of the building is located above. When audiences go down into the hall, they interact with the retained height difference of the

terrain, which is a special experience. By the way, the swimming hall near the stadium also uses some landform techniques. Since the swimming hall is located near a small hill in the park, its southeast entrance is covered by soil and plants for matching up with the terrain there. Therefore, by coordinating these buildings with corresponding terrains, the whole sports park looks environmentally friendly because the landscape and sports buildings are integrated.

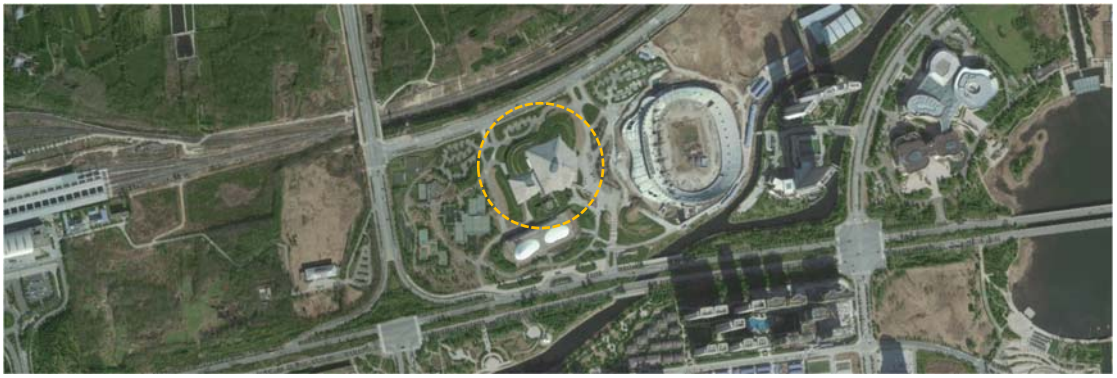


Fig. 3-1-6: The Environment Map of Yangzhou Stadium (TUS-DESIGN Group)
Description: The stadium is in the middle of the sports park which is constructed complying to the hilly terrain. From the map, the stadium looks like two squares but the boundary of the stadium is not totally smooth and regular in order to match up with the natural form of the park. Actually, the shape of the stadium could be more organic such as simulating the contour instead of using rectangle as prototype.
Source: Baidu Map

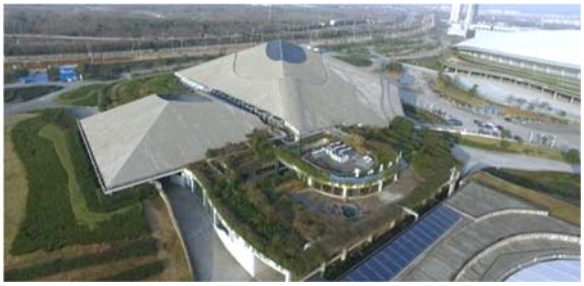


Fig. 3-1-7 & 3-1-8: Bird View Images of Yangzhou Stadium
Description: From the bird view images, the stadium looks like a prominent hill in the park because the material of the roof is different from surrounding environment, while looking from the ground, it is natural because the roof touches the green slopes and hills around it. In this project, the whole form of this landform sports building not only simulates a natural element but also connects with the natural element directly. To make the building and the environment more integrated, the boundary of the roof and surrounding plants could be blurred to form a continuous transition. For example, making more parts of the roof especially the bottom part be covered by plants may be a possible way.
Source: www.baike.baidu.com; www.ourjiangsu.com/a/20180509/1525906379511.shtml

c) Concave Terrain

The concave terrain creates natural condition for hiding buildings in the environment with a

sinking form. Ice Hockey Rink Proposal designed by BIG is located on a bowl-shaped plot in northern Sweden. In order to comply with and accentuate the natural topography of the site, the design extends and continues the shape of the land into its interior space. Half of the site carries the ice hockey rink while the other half is created to be an amphitheater for people to have activities freely. Because the form of the roof has been designed according to the landform, the feature of the original landform has been maintained and the whole sports architecture looks harmonious with the concave terrain. Conversely, Stožice Sports Park is also built on a site where used to be a concave terrain, but the designer chose to use the landscape to fill up the void space and build the sport architecture on the new landform. This project creates a close relationship between the building and the new landform but has already demolished the original context of the site.

Fig. 3-1-9 & 3-1-10: Rendering Images of Ice Hockey Rink Proposal (BIG Architects)
Description: In different seasons, the rink and landscape together present different views. Meanwhile, since the wall of the rink is transparent and light, people who have activities inside and outside in the concave terrain can interact with each other, which creates a special experience for them and the whole site is more like an integrated landscape.
Source: www.designboom.com/architecture/big-architects-ice-hockey-rink-in-umea/

(2) Terrain Conditions Promote the Application of Landform Techniques

a) Straightforward Height Different

City of Jaca Hockey Arena is located in the city of Jaca, Spain. It is the most representative sports facility of the 2007 Jaca European Youth Olympic Festival and the largest event venue in Jaca. As an iconic place, the building was not initially dedicated to present a hidden form. However, because there is a straightforward height difference between the main road and the construction site, in the process of coping with the condition, the designer set tall walls following the outline of the building's plan. The walls reach to the level of the road from the bottom, then the space enclosed by the walls was covered by a mountain-shape elliptical vault to create a complete interior space for sports games. Since the vault directly touches the ground on the

side of the road and connects to the slightly inclined front plaza, the continuity of the roof and the land is visually created. Therefore, even though the color and material of the roof looks different in the environment, when looking from the road, the architectural form has a close relationship with the land. There is not a set of fixed paradigms of landform techniques. In sports architecture design, because of comprehensive influence factors, it is not proper to design every sports building in special terrains into landform sports buildings. However, when dealing with the height difference of the terrain, the landform technique which is good at establishing relationships between the building and landform can help solve specific topographical problems.

Fig. 3-1-11: The Environment Map of City of Jaca Hockey Arena (Coll-Barreu Arquitectos)

Description: The arena is located in the developing district of the city where there are both natural fields and communities. Based on the purpose of building it as a landmark, the arena is distinct from surrounding texture and the elliptical shape is prominent as shown in the map. The whole arena is not a landform sports building which hides its form in the environmental background.

Source: Google Map

Fig. 3-1-12: Image Viewing from the Road

Fig. 3-1-13: Image Viewing from the Western Field

Description: Even though looking from the western and southern field, the arena is very tall and iconic, looking from the road, it is friendly and partly hidden as the roof connects with the ground directly. Meanwhile, the form of the building's roof simulates the mountain to create a relationship with background landscape. By using the landform technique, this project simultaneously meets the need of being a landmark and reducing the sense of distance brought about by such a big volume.

Source: www.archdaily.com/17739

b) Landscape Blocking

Vallehermoso Sports Center is located in Madrid, Spain. There was an old sports facility built in 1950 which has been demolished later, and the new sports center was built on the same site. The designer planned to design it as a gentle building in its architectural expression to embrace and interact with the city. The site presents a very singular situation as it is defined by a slope of trees and plants to be protected that form a hill located at a significantly higher level than the surrounding streets. In order to retain the green slope to keep being the image and character of the urban net in this area of the city, the sports center is buried behind this hill. The sinking form makes it look like a landform sports building which is inserted into the hill when viewing from the street. The preservation of the terrain brings limitation to the building and creates such a hidden appearance. In addition, the facade with steel pipes which simulates forest element reduces the sense of presence of the building by being painted with a low-saturated green color, thus the building is integrated with the environment better. In this project, the designer did not determine to design it as a landform building which establishes a relationship with the land actively, but the surrounding terrain condition changes the image of the building by blocking a part of it and thus makes it look like a landform building. It is worth mentioning that in the actual construction, the facade has been changed into bright green and yellow colors which is very eye-catching. This result not only violates the original intention of the facade effect, but also weakens the importance of retaining the green hill, and the relationship logic of the architectural volume and the site is affected.

Fig. 3-1-14: The Environment Map of Vallehermoso Sports Center (ABM Arquitectos)
Description: The sports center is surrounded by some sports facilities and communities. The slope of plants forms a part of the boundary of the main road and the block. Keeping them shows respect to the urban context and also gives limitation to the site of sports center. Being complied to the limitation and hiding part of the building behind the slope shows the building's humble attitude to the environment.
Source: Google Map

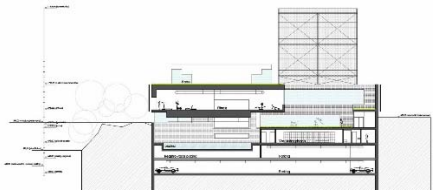


Fig. 3-1-15: Drawing of South Elevation

Fig. 3-1-16: Drawing of Section

Description: The elevation and section drawings show that the bottom part of the building is blocked by the slope and the revealed part is also sheltered by trees on the slope. The project shows respect to the retained urban element.

Source: www.archdaily.com/153705

By contrast, in the flat terrain environment, if applying landform techniques to the sports architecture design, creating sinking or mountain-shape form means large-scale earthworks, which is not proper from both perspectives of economy and ecology. If there is no other ingenious landform technique strategies and methods or it is not supported by more important factors, just from the perspective of terrain conditions, the applicability of landform sports architecture in a normal and flat terrain environment is not persuasive.

3.1.2 Climate Characteristic

The response of landform sports architecture to the climate characteristic is mainly reflected in the energy-saving effect of thermal insulation brought by the earth (or artificial land). Since a sports building has a large spatial scale and lots of gathering events, the control of internal comfort and energy consumption are needed. In order to achieve sustainability, the passive energy-saving design is adopted by concerning about the relationship between the building and landform. In this way, the building's internal physical environment can be adjusted and the energy consumption can be reduced by landform techniques such as soil covering. The landform sports architecture has several significances and effects for dealing with climatic influence factors. Examples are as follows.

a) Physical Environment Adjustment

Slowtecture M Gymnasium located in Japan is a landform sports building whose external wall is covered by the soil to control the internal environment. Specifically, the continuous surface of roof and wall is covered with plants on artificial soil in which the bark of Japanese cedar and cypress are mixed. This plant surface offers a necessary result of insulation at the area of users'

activities. According to the different situations of direct sunlight from the north and south, the area of the soil has been adjusted. Specifically, the plant surface covers the building up to the height of 20m on the south side, while it covers up to the height of 4m in the north side where the direct ray is weak. The result of insulation by this plant surface is effective, so that the temperature of inside of the dome is approximately 30℃ when the temperature of outside is 40℃ during the summer. Meanwhile, the sky window, shading seal which is pasted on the glass and louver openings not only provide mind natural light for the internal space and help reduce artificial lighting inside, but also reduce the temperature which increases by direct rays of sun and produce gravitational ventilation. Facing the requirement of saving energy, this landform sports building is successful by cooperating the form strategy and the envelope design.[7]

Fig. 3-1-17 & 3-1-18 & 3-1-19: Bird View, Plant Surface and Internal Space Images of Slowtecture M (Shuhei Endo)
Description: The physical environment inside is adjusted mainly because of the surface design. Soil covering is common in landform buildings since it is a sustainable approach and integrate the building into the natural environment.
Source: www.archdaily.com/6853/slowtecture-m-shuhei-endo

b) Energy-saving Design Support

In Max-Schmeling-Halle in Germany, the green roof is applied to achieve energy-saving purpose. The designer aim to create an ecologically sustainable stadium. With the concept of “green bridge”, the building is connected to the ground through slopes in a symmetrical form. The slope acts as green roof covered by soil and grass. On one hand, the landform technique creates connections between the building and the land. On the other hand, vegetation on the sloped parts of the roof provides extra insulation and reduces the amount of resources needed to provide a pleasant climate inside the building.

[7] Partly excerpted from www.archdaily.com/6853/slowtecture-m-shuhei-endo/

Fig. 3-1-20: Green Roof of Max-Schmeling-Halle (Jörg Joppien, Albert Dietz and Annette Maud-Joppien)

Fig. 3-1-21: Image Viewing on the Green Roof of Max-Schmeling-Halle

Description: The sloping roof creates the connection between the building and the land. Unlike Slowtecture M Gymnasium, the grassland on the roof does not have the purpose of simulating the surrounding environment. The soil covering here is to support the energy-saving design and to make the building become a landscape. There is space for people to walk and stay on the top of the slope, which gives the roof another definition: a balcony for the top floor.

Source: www.eventundco.com/index.php/eventlocations/max-schmeling-halle; www.max-schmeling-halle.de/en

c) Sports Space Insulation

Gjovik Olympiske Fjellhall located in Lillehammer in Norway is the Ice Hockey Hall for 17th Winter Olympics. It is the world's largest subterranean auditorium which can only be found 120 meters underground. Because it is built in the mountain, the natural rock and soil totally wrap over the building to create a good thermal insulation for the interior, which helps to maintain the ice surface of the sports field when it serves for ice hockey games. It is said that the interior temperature can be maintained at around 8℃ without heating and cooling equipment.

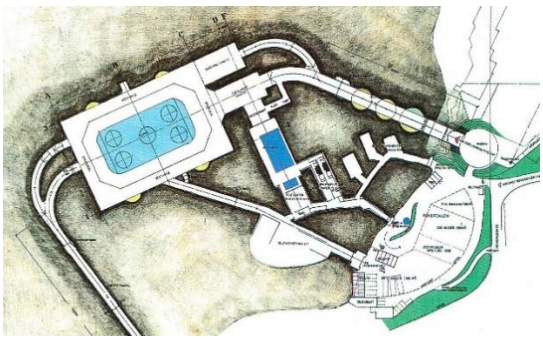


Fig. 3-1-22: Plan Drawing of Gjovik Olympiske Fjellhall (Moe-Levorsen AS Architects)

Fig. 3-1-23: Image of the Ice Hockey Hall in Gjovik Olympiske Fjellhall

Description: Considering that the building is mainly for ice sports, to keep the internal space in a suitable temperature is very important. Being hidden in the hill makes full use of insulating effect of the rock and soil to help reduce the energy consumption for cooling and heating. Although this cave hall balances the architectural function and climatic factors naturally, the landform technique used for this sports building is a little bit extreme since it totally gives up the form design of the building but only takes its function and space into consideration.

Source: www.arkitektur-n.no/prosjekter/gjovik-olympiske-fjellhall?cat=8281

Correspondingly, for districts whose climate is hot perennially, sports buildings for a large number of people to play sports and watch games usually have a higher request for the building's openness. The need for natural ventilation and heat-proof shading determines that the landform technique which is good at insulating is usually not very suitable. But landform sports architecture which is designed by weakening the sense of wrapping and creating connections between open interfaces is still possible to adapt well to the climate. Especially in the design of outdoor stadiums, the open architecture does not need to be insulated well. But adopting the landform technique such as sinking and embedding can create a better shelter when achieving other purposes by this form at the same time. Thus, creating a comfortable sports space can also be the reason for designing landform sports buildings in a hot district.

Even though it is not in a hot district and its architectural form is not for dealing with the climatic factor, the sports facilities in Munich Olympia Park shows an example of landform sports architecture with the open form. The stadium combines the sports field with the external ground to form a smooth and coherent overall terrain. The roof made of tensile and membrane structure help create necessary shelter while ensuring natural ventilation and visually open appearance of the building. When designing a stadium which needs to cope with the hot climate, it is possible to take the open architectural form of Munich Olympia Park as reference, but it is important to enhance the lateral ventilation and the top radiation shielding to create a natural and comfortable sports place.

Fig. 3-1-24: Bird View Image of Munich Olympia Stadium (Frei Otto and Gunther Behnisch)

Fig. 3-1-25: Roof Structure of Munich Olympia Stadium

Description: The structure of the roof creates ventilation space on the back side naturally and the acrylic glass panels that clad the tensile membrane help form an open effect for the building by establishing a relationship to its context and the light exposure that it experiences. The acrylic panels shimmer in the sunlight, reflecting the light, the color of the sky, and the surrounding landscape.

Source: www.a-xun.com/10103.html

3.1.3 Site Environment

As stated in the introduction and overview chapters, in the new discussion on the relationship between sports architecture and environments, landform sports architecture has a special form by establishing a close interaction with the landform environment. According to the analysis and classification of existing projects, the site environment is the most common factor which determines the application of landform techniques in the sports architecture design. The environments which bring influence to buildings can be divided into natural environments and artificial urban environments. Facing to different environments and sites, landform sports architecture generally maintains a humble gesture and uses the landform technique to express respect to the environment by means of cooperation, integration and reaction.

3.1.3.1 Urban Space Requirement

As we know, in a complex and organic urban environment, the construction of new buildings is driven and also restricted by surrounding functions and space. Sports architecture has relatively specific and clear internal functions, but the distinct architectural forms have flexible and various influence on urban environments. When the iconic exaggerated form or introverted simple configuration has a negative effect on the overall environment, or when there are clear environmental restrictions and demands, choosing the landform technique as a form design strategy can react to demands through establishing external spatial relationship and otherwise provides a feasible form design approach for dealing with specific restrictions. Examples are as follows.

(1) Restriction on Spatial Scale

a) Height Restriction

Gammel Hellerup Gymnasium is located in a high school in Denmark. The site of the multi-purpose hall is in a yard enclosed by other main facilities of the school. In order not to block the natural light and good view for the surrounding existing buildings and to keep the yard as an open public social space in the school, the main space of the new hall is buried underground to limit its height above the ground. The roof is bulged to form a hill covered with a wooden

surface that can be used flexibly in the yard. The edge of the roof is designed as a long social bench, and its lattice design ensures the penetration of daylight below. The landform technique used in this sports building aims to deal with the height restriction brought about by surrounding buildings. It also enhances the importance of the place since it creates a new focal point and link between school's existing facilities.

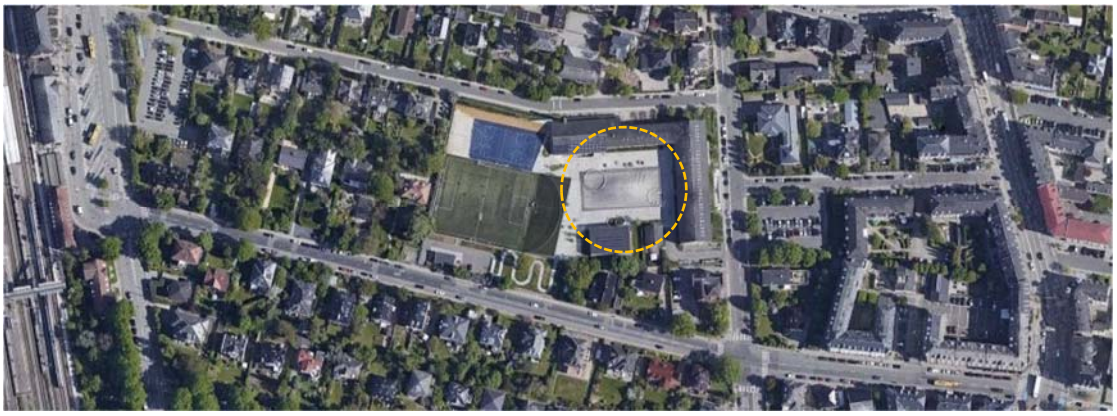


Fig. 3-1-26: The Environment Map of Gammel Hellerup Gymnasium (BIG Architects)
Description: As seen in the map, the original yard is the center space of the school. Views from surrounding school buildings communicate here. By hiding part of the gymnasium underground and connecting its roof to the ground, the yard in the school is kept with social functions and the building does not influence the views.
Source: Google Map

Fig. 3-1-27: Image Viewing from the Yard
Fig. 3-1-28: Interior Image of Gammel Hellerup Gymnasium
Description: As a landform sports building, Gammel Hellerup Gymnasium uses the landform technique to sink the sports field five meters below the ground. Although this architectural form is determined by the height restriction, it finally contributes to the good quality of external and internal space simultaneously.
Source: www.archdaily.com/412908/gammel-hellerup-gymnasium-big

Osaka Castle Hall which is located in the Osaka Castle Park in the center of Osaka is also a sports building with the landform technique due to the restriction of the environment. Osaka Castle is one of the three castles in Japan. It has a long history, the exquisite architecture and the beautiful scenery. It is an important symbol of Osaka City. Located beside such a famous place, Osaka Castle Hall cannot destroy the overall landscape image by its large scale,

especially the conspicuous height. Under this background, the designer chose to sink the main body of the sports building underground to meet the height restriction and to enclose the building with stone walls in order to create a natural image and a hidden effect.

Fig. 3-1-29：The Environment Map of Osaka Castle Hall (Nikken Sekkei)

Description: The hall is in the Northeast side of the ancient castle. There is a river near the site and many modern buildings on the other side of the river. In such a complex urban area, the landform technique makes the sports building humble. The color of the roof is also coordinated with buildings in the castle.

Source: Google Map

Fig. 3-1-30: Bird View Image from Outside the Castle

Fig. 3-1-31: Bird View Image from Osaka Castle

Description: The trigger factor of the hall's sinking form is the height restriction, thus as the bird view image shows, the view of the tallest building in the castle and the overall landscape do not be blocked by the big hall. While looking from the castle, the revealed big roof of the sports hall seems like a part of the modern building group on the other side of the river. It is successfully integrated into the urban background.

Source: www.osaka-johall.com/english/; www.oneworld-osaka.com/en/local_guide/

b) Volume Restriction

Longvic Sports Center is in the suburban district of Dijon in France. Being affected by the surrounding area whose texture is relatively small, it is not suitable for a building with big volume to be built on the site. In order to deal with the sports building's large scale, the designer chose

the landform technique to be a form design strategy of the building for reducing the overall visual impact. The playing field and spectator seats are embedded into the ground, which makes it possible to keep the building at a moderate height while ingeniously placed bend breaks up and modulates its length. As described by the designer, these facets could be continued in the green roof landscape, turning it into an attractive fifth facade which could be particularly well visible from the street access. This building is harmoniously integrated into the fragmented surroundings made up of single-family homes, nurseries, fields and meadows.[8] However, in reality, the green roof is hard to be seen by people standing on the ground. In fact, the green roof of this building is not effective for reducing the presence of the building's large volume but becomes a camouflage for the building in the master plan of this district.

Fig. 3-1-32: The Environment Map of Longvic Sports Center (Dietrich | Untertrifaller Architekten; Sénéchal-Auclair)
Description: The sports center is located in a site which is near a confluence point of roads from different directions. The requirement of reducing the sense of big volume leads to all the landform techniques applied on this building. Among them, the most interesting technique is the bend which is used to adjust its length because the broken line coordinates with the outline of the plan which adapts to the site shape and well reacts to the confluence point.
Source: Google Map

Fig. 3-1-33: Bird View Image of Longvic Sports Center
Fig. 3-1-34: Sunken Interior Space
Description: As seen from the bird view Image, the bend is not only for adjusting the length of the building, but also coordinates with the sloping terrain of the site, which shows the connection between the building and the environment.
Source: www.archdaily.com/801859

[8] Partly excerpted from https://archello.com/project/sports-center-in-longvic-france#stories

(2) Demand for Spatial Connection

a) Connection Reservation

Langreo Sports Center is located in the coal-mining area of Asturias in Spain. The site of the building is in a reconstructing area of the town. Besides the new sports center, the area which is currently occupied by ruined buildings will be changed one after another. A part of the reason of applying the landform technique in the architectural form design is to make the building as an example for reconstruction in this district. The undulating roof surface of the building extends to form plazas and gardens now, and it reserves a father connection with the adjacent area because it can connect to new buildings with the similar form in the future. Thus, this is a good example of establishing relationship between new buildings and existing environment.

Fig. 3-1-35: The Environment Map of Langreo Sports Center (ACXT)
Description: The site half encloses ruined buildings which will be reconstructed in the future. The close relationship between the new building and ruined buildings needs the designer to pay much attention to the future connection.
Source: Google Map

Fig. 3-1-36: Bird View Image of Langreo Sports Center from the East of the building
Fig. 3-1-37: Space Between Langreo Sports Center and adjacent buildings
Description: The continuous roof is also the wall facing to the space between the sports center and ruined buildings. In the future, this curved roof can be extended starting from the in-between space and then creates landform buildings or landscape in the same style. Unlike normal buildings which do not connect their forms to the land naturally, this building designed with landform techniques is more flexible and friendly to the environment because of the potential of continuity, which reserves possibility of integrating the surroundings in a direct way.
Source: www.archdaily.com/7391/sports-facilities-for-colegio-vizcaya-acxt

b) Spatial Transition

Different from the urban planning, to create spatial transition in the urban space from the perspective of architectural design can maintain the integrity and sequence of urban space in a bottom-up way. So, it has become an important factor when determining the form of a building and designing its external space.

For example, Zamet Center which is located in Rijeka makes a good demonstration of spatial transition by applying landform techniques. When designing the building, an important issue is how to fit it into the urban texture of Rijeka. The goal is to minimize the damage to the city and have a positive impact on the surrounding urban environment. Elements such as the uneven terrain, the adjacent school, the park landscape and the busy roads surround the sports center. Under this background, the designer did not choose to establish a sports center with a simple configuration and a big volume, but to use the landform technique as the form design strategy to integrate it into the complex environment by decomposing the volume and sinking the space of the sports center into the ground. Meanwhile, some cultural functions and public services have been added into the undulating volumes between the main sports venue and the front plaza of a school across the road. Thus, their functions are organically connected, and the sports building is integrated into the urban context well because of the transitional form. So to speak, for a sports building whose large scale brings negative influence to the surrounding environment, landform techniques that decompose and conceal the architectural form is highly applicable for the intention of integrating it into the overall texture of the city.

Fig. 3-1-38: The Environment Map of Zamet Center (3LHD Architects)
Description: The north side of the site is a front square of a school and some green lands while the south side of the site is a main road where people usually come from. According to the terrain, the landform technique is used as a spatial transition method to connect the north and south part. The vivid public functions and the artificial landscape also become the transiting functions. This landform sports building, together with the public square, plays the role of cultural center, artificial landscape, public square, urban connection and spatial transition at the same time.
Source: Google Map

Fig. 3-1-39: Bird View Image of Zamet Center

Fig. 3-1-40: Street View Image of Zamet Center

Description: The complete volume of the building has been decomposed into strips which are similar to the scale of the urban texture. In order to coordinate this main volume with the surrounding context, uneven strips with cultural and service functions are added on the square.

Source: www.e-architect.co.uk/croatia/zamet-sportshall-rijeka; Google Map

However, applying the landform technique as the form design strategy to promote the spatial transition of sports architecture and the urban environment also needs to adapt to local conditions and to choose suitable design methods accordingly. For example, in the first construction of Palais Omnisports de Paris-Bercy (The Accorhotels Arena) in France in 1984, in order to coordinate with the nearby park, it was designed as a mountain-shape landform building with soil covering. Although the prominent wide steps surrounding the building were conducive to attract people and create a special architectural form, the design ignored spatial transition with the urban space, which made it lack of touch with the city. In order to help Paris bid for hosting the Olympics in 2024, the arena was renovated in 2015. In this renovation, the connection mode between the building and the site was changed. Some wide steps were demolished, instead, the public space facing the city and filling the gap between the arena and the street has been created, which produces spatial transition between this isolated arena and the surrounding urban space. This arena finally has a more open form and shows a friendly image to welcome people with public activities on the front square. To a certain extent, this building realizes the urban spatial transition by reducing part of the feature related to the landform technique. So to speak, when applying the landform technique and corresponding design methods in a sports building design, the openness of the sports building and its relationship with the urban space must be taken into consideration dialectically, especially in a complex urban area.

Fig. 3-1-41: The Environment Map of The Accorhotels Arena (Michel Andrault, Pierre Parat, Jean Prouve)
Description: The surrounding urban environment of this site is complex. The railway, Bercy Park, the river, the bridge and so on are different elements that the arena needs to pay attention to. In the first construction, building wide steps around the arena was a unified and simple method to react to various urban elements in different directions. The steps also came from the concept of mountain so that this artificially natural form coordinated to the park near it. In the renovation, the designer thought about the importance of different interfaces and determined main entrances and public front squares according to main directions of coming people.
Source: Google Map

Fig. 3-1-42 & 3-1-43: Bird View Images of The Accorhotels Arena Before and After the Renovation
Description: The renovation changed part of the architectural form of the arena and reduced its direct connection with the land. Compared with the original one, with open interfaces, the new arena reacts to the urban context from the perspective of spatial transition. What matters more for the new architectural form is urban spatial relationship.
Source: www.gooood.cn/the-accorhotels-arena-by-dvvd-architects-and-engineers.htm

(3) Demand for Spatial Guidance

a) Direct Guidance

Putuo Fitness Center in Zhoushan and Sanwayao Community Sports Center in Chengdu are both community-level sports buildings located in China. In order to attract and guide residents in communities to come to participate in sports activities, what they have in common is the design strategy of integrating the building and the site with an open form. In the two projects, the ground public space is connected to the top of the building by the sloping roof, and the continuous sloping roof serves as both an open public space and a traffic link, creating a strong

sense of guidance. The overall appearance of the building meets the need of traffic guidance in the site.

The similar form appears in the first-round bidding proposal of Beijing Olympic Shooting Hall. The slope is also used as the feature of the landform technique, but its form has a weak relationship with the environment because there is no clear need of guidance or echo of surrounding landscape. In addition, the angle of slope is relatively small so that the internal space is limited at the edge. This design has not been realized finally. So to speak, the similar landform technique does not necessarily originate from the same influence factor, but the logic of form generation needs to be clear and reasonable.

Fig. 3-1-44: The Environment Map of Putuo Fitness Center (TJAD)
Description: The slope faces to the main entrance of the center, attracting and guiding people with a friendly form.
Source: Baidu Map

Fig. 3-1-45: The Environment Map of Sanwayao Community Sports Center (CSWADI)
Description: The slope faces to the outdoor sports field on the east side, continues the sports atmosphere and guides people from outside to the roof of the building and also to the sports hall inserted in the slope. The slope can also be the viewing stand for audiences of outdoor sports games.
Source: Baidu Map



Fig. 3-1-46: Bird View Image of Putuo Fitness Center

Fig. 3-1-47: Side View Image of Sanwayao Community Sports Center

Fig. 3-1-48: Rendering Image of First-round Bidding Proposal of Beijing Olympic Shooting Hall Design

Source: baike.baidu.com; www.archdaily.cn/cn/769553

b) Indirect Guidance

The two cases that use landform techniques to create the direct guidance mentioned above both focus on one-direction guidance. When it is necessary to create multidirectional openings, the landform technique which is good at producing a sense of flow will be useful. Just as Omiyamae Gymnasium in Tokyo, the guidance it creates is relatively indirect and free. As a sports facility in a residential community, the designer hopes to naturally guide people into the gymnasium by creating continuity of the environment. Therefore, the gymnasium has been divided into two scattered buildings with smooth elliptic outlines which do not have dead corners. The main bodies have been sunken into ground and covered by green roofs to weaken the volume for avoiding overwhelming surrounding residentials and reducing strong occupation of the environmental space. In this way, the openness of the site has been highlighted and the free guidance has been enhanced. The building is not simply assimilated into the community, but its humble charm will be noticed naturally when people get into the site.

Fig. 3-1-49: The Environment Map of Omiyamae Gymnasium (Jun Aoki＆Associates)

Description: The site of the gymnasium is surrounded by communities. By designing it in elliptic shape, there is no clear main entrance for the site, so that residents from various directions are welcomed. Soil covering as the landform technique integrates the building with natural elements, making this site more like a community park.

Source: Google Map

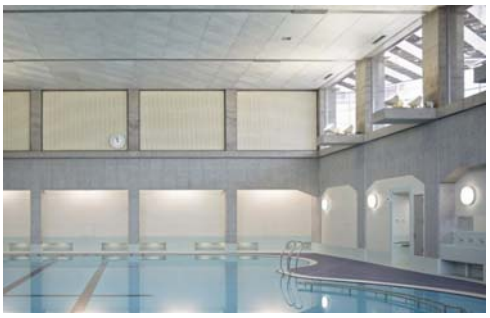


Fig. 3-1-50: Bird View Image of Omiyamae Gymnasium

Fig. 3-1-51: Interior Image of the Swimming Pool

Description: Sinking technique makes sports buildings have a similar height with surrounding buildings. The height of the gymnasium is limited to 5 meters above the ground since the main arena is located at 6.64 meters below and the swimming pool is 2.49 meters under the ground. Their humble forms welcome people friendly.

Source: www.aokijun.com/en/works

3.1.3.2 Preset Positioning of the Building

For sports architecture with few limitations from the site condition, the reason of applying the landform technique is mostly derived from the preset positioning of the specific sports building in the city, like expressing fluidity, naturality or special monumentality in aspects of appearance and external space. these positionings usually come from the government, the designer, the need of citizens and so on. The influence of such factors is relatively subjective and lacks decisiveness. Thus, the landform technique as the form design strategy of sports architecture usually depends on other objective factors while preset positioning of the building is also an importance supporting factor. Examples are as follows.

a) As Fluid Urban Landscape

Because the landform architecture has an advantage in creating fluidity, the landform technique of fluidity is applicable for sports building which is positioned as fluid urban landscape. To take Street Dome located in Denmark as an example, the goal of the building and its site is to create an open and free place for street sports as well as social gathering and leisure activities. The achievement of this goal is attributed to the overall artificial landscape created by the fluidity and continuity of the external ground and the interior floor which are designed with the landform technique.

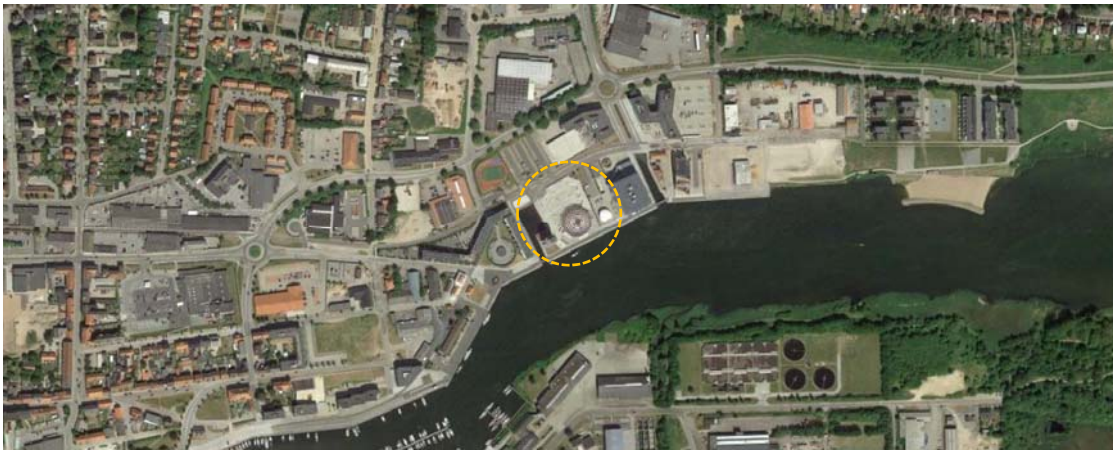


Fig. 3-1-52: The Environment Map of Street Dome (CEBRA, Glifberg+Lykke)
Description: The site is near a river, so it will become one part of the river side landscape. Being positioned as fluid urban landscape, the building coordinates with the river landscape.
Source: Google Map

Fig. 3-1-53: Image Viewing from the Other Side of the River
Fig. 3-1-54 & 3-1-55: External and Internal Space of Street Dome;
Description: The envelope of Street Dome directly connects with the uneven artificial landform which is for street sports on the site, and this external landform is extended into the building. On one hand, it creates slopes for people to take a rest or challenge difficult sports actions on the shell. On the other hand, it creates a seamless flow through the entire park and makes the whole site seem like a fluid urban landscape when looking from the surrounding urban space.
Source: www.archdaily.com/558349

b) As Natural Urban Landscape

Quzhou Sports Campus in China is under construction. It is a very bold attempt. The designer practices his concept “landscape city” and regards the sports campus as a landscape area in the new developing urban district to echo the historical landscape culture of the city. The design embeds the functions of the sports park within natural forms, creating an earth-art landscape in the center of the new city—a poetic landscape that falls somewhere between that of Earth and Mars. Such a large-scale landform sports architecture is unprecedented. The design creates a natural atmosphere, a spiritual environment and a flexible space for sports activities,

which is amazing. The organic form of the buildings and space in the park is powerful to express the city's landscape culture. Meanwhile, the soil-covering building is conducive to energy saving. However, on one hand, the form generation mainly comes from the subjective concept and there are few considerations about the specific environment. Whether the connection between the sports campus and future urban context is reasonable or not remains to be tested. On the other hand, in order to realize this design in such a relatively flat site, the terrain of the site need changing greatly. The artificial height difference on the site is somewhat ecologically unfriendly, and the high construction and maintenance cost is also a challenge it needs to face. This project states again that the applicability of landform sports architecture which is designed mainly because of the preset positioning of the building needs to be proved with other influence factors.

Fig. 3-1-56 & 3-1-57: Rendering Images of Quzhou Sports Campus (MAD Architects)
Description: As a natural urban landscape, the design is successful. The mountain-shape soil-covering buildings and artificial lakes really express the natural atmosphere created by the architectural form and space. However, if the design is practical is still a question. Just take the grassland cover as an example. The grassland's quality needs too many efforts to maintain. Especially in China, the grassland which is open to public usually brings damage to itself. Meanwhile, the hot climate in summer and rainy weather in Quzhou will impact the experience in external space with few trees or artificial shields. Clearly, factors like climate matters less than the landscape concept when applying the landform technique in this project design.
Source: www.gooood.cn/construction-breaks-ground-on-mads-quzhou-sports-campus.htm

Insular Athletics Stadium is a sports facility in Santa Cruz, Spain. As a stadium located in the suburban district, it faces the challenge of establishing relationships with the city and nature at the same time, thus the designer positioned it as an urban landscape with natural attribute. In order to achieve this idea, the designer applied the landform technique from aspects of terrain and material. On one hand, using the slope to dissolute the boundaries between the city and territory as well as to connect the external public space. On the other hand, piling up local stones to simulate the shape of the crater. Thus, ensuring its landmark image while reducing the impact on the environment to realize the fusion of artificial and natural landscape.

Fig. 3-1-58: The Environment Map of Insular Athletics Stadium (AMP Arquitectos)
Source: Google Map

Fig. 3-1-59: Bird View Image of Insular Athletics Stadium
Fig. 3-1-60: Interior Space Under the West Cover
Description: The landform technique is used to design interfaces of the stadium and the environment, promoting this stadium to become a natural urban landscape. The interfaces have been thickened or extended, and they are made of natural stones. In this way, the interface is not just a cold boundary as normal stadiums usually show but is a volume with functions. The unifying petrified mantle covers various functions and integrates them into the ground, which helps to create a pure crater shape.
Source: www.archdaily.com/2822/insular-athletics-stadium-amp-arquitectos-sl

c) As Monument Urban Landscape

Buildings which is monumental usually do not use the landform technique as the form design strategy to make it hidden too much. However, a stadium proposal named Kofun Stadium which is designed by DGT for 2020 Olympics in Tokyo uses an untraditional concept. The designer used mountain-shape landform sports building to create monumentality. This untraditional form is derived from an untraditional concept called Kofun. Today, the stadium has become more about the expression of modern technology, to make a sort of UFO or specific icon that is inevitably exiled to the outskirts of the city due to the large scale of its intervention. Based on this situation, the designer hope to create a monumental building like a grave to express commemoration of ancient Japanese civilization and symbolization of human's hope in the

future, and also to recall the construction means of ancient stadiums which were created by excavating earth to form a gathering space. The stadium is designed as a mountain covered with plants, which creates a monumental and ecological urban space. Regardless of the acceptance of the project's concept and the feasibility of its actual construction, its huge landscape form connected with earth and the purpose of monumentality are in line.



Fig. 3-1-61 & 3-1-62 & 3-1-63: Rendering Images of Kofun Stadium Proposal (DGT & A+ Architecture)
Description: As a mountain-shape building which allows people to climb up, the stadium is not only a monument in the urban context but also becomes a park and a viewing stand for people to have fun in the external space and to enjoy the beautiful urban scenery.
Source: www.gooood.cn/kofun-stadum-by-dgt.htm

3.1.3.3 Natural Environment Influence

The main places where sports buildings and the natural environment are connected are located in a non-urban environment and otherwise a natural landscape area in the city. Due to human's respect to nature and the long-established environmental values in the architecture field, although main activities are usually concentrated in a sports building, it is necessary and significant to think about the external space and coordinate the building with the external natural environment if there is one. In a site with the prominent natural environment, choosing the landform technique as the form design strategy for sports architecture is a good approach to establish a direct and harmonious relationship with the natural environment visually. Through analysis of landform sports architecture projects, it is found that sports buildings which fully cooperate with the natural environment by applying the landform technique have different intentions. For sports buildings that regard "integration, reaction or protection" as main intention of establishing relationships with the natural environment, the application of the landform technique as the form design strategy has a relatively powerful and objective basis. Examples are as follows.

(1) For the Purpose of Integrating with Nature

a) Weakening the Building

There is an aquatic center located in a plateau environment close to valleys and alpine forests in Alps. The grand, complete and natural scenery requires the building to weaken itself and be integrated into the environment with a humble gesture. On the basis of conforming to the contours of the terrain, the designer selects the landform technique as the form design strategy. The sloping roof covered with soil, the entrance with an organic shape and special sky windows together make the building be hidden in the dense mountainous vegetation in the summer and blend with the snowy alpine environment in the winter. Compared to build an independent and outstanding volume there, this landform sports building emphasizes a harmonious and symbiotic relationship with the natural environment.

Fig. 3-1-64: The Environment Map of the Aquatic Center (Auer Weber)
Description: The site shape of the aquatic center is like a triangle. The building occupies nearly the whole site for complying with the terrain. The green roof and the curved outline make it totally integrated into the architectural site and the surrounding natural environment.
Source: Google Map

Fig. 3-1-65 & 3-1-66: Bird View Image and External Image of the Aquatic Center
Description: With snow covering on the sloping roof, the overall form of the building is very similar to snowy mountains. The curved line of entrances and sky windows coordinate with the overall form to help the building be integrated into the environment. Meanwhile, as this is an aquatic center where swimming pools do not need a very high interior space, the building could touch the land with a creeping and lying posture.
Source: www.dezeen.com/2016/01/28

The successful bidding proposal of Mondorf-les-Bains Velodrome and Sports Complex aims to create a new entertainment destination in a rural area on the edge of Mondorf-les-Bains in Luxembourg. The sports complex includes a new national velodrome, an aquatic center, a multisport hall and a climbing wall. Since the project site belongs to the designated restored agricultural land, the building needs to coordinate with the surrounding environment for a harmonious overall landscape. Since the importance of these functions are different and they do not need to be prominent as a whole, the designer chose the landform technique as the form design strategy to weaken part of the architectural volume. The aquatic center and the sports hall are sunken into the ground and absorbed by the sloping green roof. The humble gesture of them highlights the velodrome as a recognizable landmark in the landscape which is visible from the neighboring highway. In this way, the special image of the sports building and its respect to the surrounding landscape are both acquired and balanced. The manipulations of the architectural form and the landscape rationalize the complex program in a clever way.

Fig. 3-1-67: Rendering Image of Mondorf-les-Bains Sports Complex Proposal (Mecanoo + Metaform Architects)
Description: In this project, the purpose for integrating the aquatic center and sports hall into the natural environment is to emphasis the presence of the velodrome. The landform technique helps balance appearing and concealing
Source: www.gooood.cn

b) Strengthening the Integration

Munich Olympia Park is well-known for its combination with the natural landscape. The organic architectural form which is closely integrated with the park site is derived from the intention of expressing anti-monumentality in the design. Unlike the 1936 Berlin Olympics which showed off the Nazi regime, the organizers of the Munich Olympics hope to announce the past of the

special era in a gentle way. Thus, based on the concept of earth stadiums, Munich Stadium is built in a pit made by bombings Munich suffered during World War II. By taking advantage of the existing topography, space for the field and seating for 90,000 spectators were carved out of the ground instead of being built above it. Subsequently, the addition of the transparent canopy made of tensile and membrane structure increases the building's unique feature without damaging the sense of integration between the building and the environment. From the perspective of the relationship with nature, instead of hiding and weakening itself, this landform sports building achieves a balance between its own image display and the purpose of integrating with nature through making use of the terrain, structure and material.

Similar to the strategy used in Munich Olympia Park, according to the valley topography, a sports center proposal designed by Perrault in the Badalona Valley area was designed in a crater shape partly covered with the metal mesh. The building interprets the designer's understanding of the relationship between sports architecture and the park environment: mutual connection and full integration.

Fig. 3-1-68: The Environment Map of Munich Olympia Park (Frei Otto and Gunther Behnisch)

Fig. 3-1-69: The Panorama of Munich Olympia Park

Description: It is very hard to distinguish out the sports facilities in this park since the integration of buildings and the natural landscape is perfect. Meanwhile, together with the park, the sports facilities are well integrated into the urban context in this district which is composed by artificial built elements and natural landscape elements.

Source: Google Map; gigapan.com/gigapans/9412

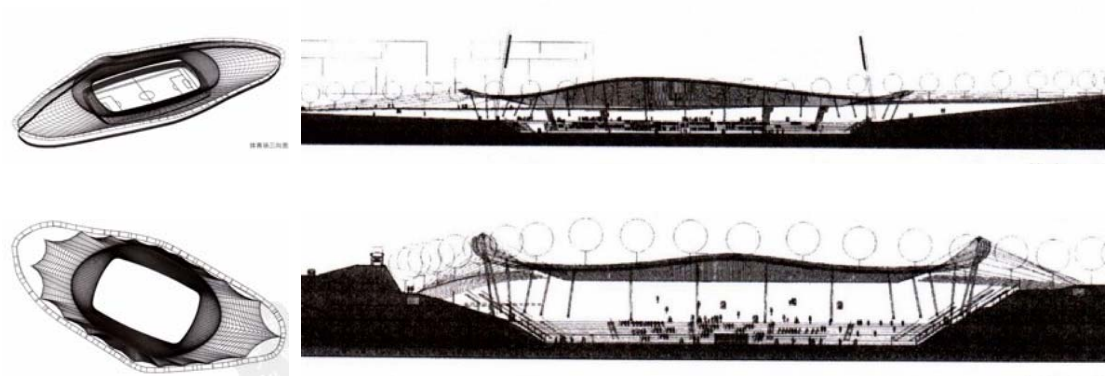


Fig. 3-1-70: Roof and Section Picture of a Sports Center Proposal Designed by Perrault
Source: 多米尼克·佩罗的作品与思想 [M]. 中国电力出版社. 2006: 117-121.

Rock Stadium Proposal also regards establishing the combination of the architecture and environment as the breakthrough point of this stadium design. It is a typical project that hopes to keep the sense of presence while not bringing too much artificial interference to the natural environment. The site is in a desert environment where large-scale sports and entertainment events will happen intermittently. A building which has a large volume and is often vacant will visually create a long-standing, conspicuous and inefficient artificial void in this pure natural environment. Therefore, the landform technique is very suitable as the form design strategy in this situation. Through the combination of the environment and architecture, the main space sinks into underground, its roof form is like the boundary of the earth's rip, and the whole form directly connects with the desert environment. The event space which is humble but magnificent conveys power as the desert. Generally, the whole form of the stadium camouflages well in the environment so that it does not destroy the overall natural atmosphere due to excessive artificialization. The integration of the architecture and nature responds well to the need of monumentality and the local situation.

Fig. 3-1-71 & 3-1-72 & 3-1-73: Rendering Images of Rock Stadium Proposal (MZ Architects)
Description: Though integration, the project not only gracefully blends itself into the site but also plays on the notion of distance to alternate between a strong camouflage at distance and a forceful presence at close range.
Source: www.archdaily.com/317267/rock-stadium-proposal-mz-architects

Compared with above projects which show strong and direct integrations with the environment, the designer of Gymnasium Palais des Sports de Loudéac hopes the two main buildings of the gymnasium be like peaceful stones in the environment in order not to destroy the beauty of the agricultural background. On one hand, the volumes have been cut to be similar with natural stones. On the other hand, soil-covering sloping base at the bottom connects two volumes with the land. In the actual effect, the addition of the soil-covering base meets the need of linking different functions in the two volumes. But from the perspective of form combination, because there is no corresponding terrain to coordinate with the base and the slope is not smoothly connected to the land, it emphasizes the boundary of the “stone” volumes and their fields, making the entire building seem artificial. To make the appearance of the “stone” more natural, the landform base with a clear limit may not be a suitable choice, but it may be appropriate to extend the base and make its interface fade into the environment. So to speak, for sports architecture which aims to integrate with nature, it is more effective to design its form with the landform technique which considers about the natural environment and the building integrally.

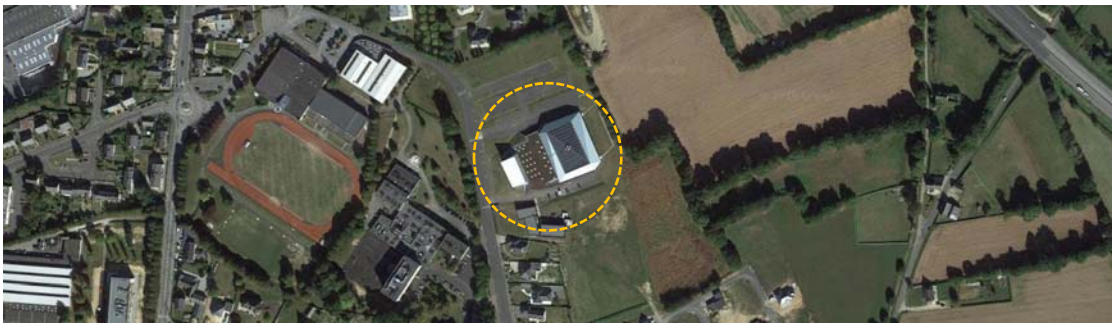


Fig. 3-1-74: The Environment Map of Gymnasium Palais des Sports de Loudéac (Bohuon Bertic Architectes)
Description: Sloping is usually a good landform technique for weakening the boundary of the building and the environment. But looking from the map, this soil-covering sloping base has little contribution to the integration of the building and nature because the limit is clear and the building is outstanding in the agricultural land.
Source: Google Map

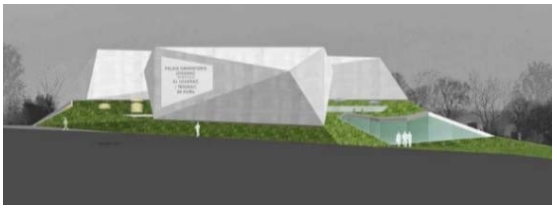


Fig. 3-1-75: Street View Image of the Gymnasium
Fig. 3-1-76: Elevation Drawing of the Gymnasium
Description: When looking from the ground level, the base is not that prominent. The shape of volumes looks like stone and the soil-covering slopes weaken the interfaces between the “stones” and the land to make it seem more natural.
Source: www.bohuonberticarchitectes.com/palais-des-sports-loudeac-22/

(2) For the Purpose of Echoing Nature

a) Terrain Compensation

Echoing nature through terrain compensation is a landform technique generated from environmental factors which concern about ecology. For example, Estádio Municipal de Braga is a stadium located in Portugal. In the construction, the mountain was blasted and the obtained granite was crushed to make concrete for building the new stadium on the blasting site. The new stadium is connected to the cutting surface formed after the blasting. As part of the terrain compensation, the artificial object coexists with the nature. The stands in the stadium are high structures standing on the flat area next to the cutting surface of the mountain. It creates a rough and wide atmosphere together with the mountain. Although the structures are enormous and prominent, they look harmonious in the particular environment. This example explains if a landform sports architecture is successful or not significantly depends on common characteristics the building and the landform both have.

Fig. 3-1-77: The Environment Map of Estádio Municipal de Braga (Eduardo Souto de Moura)
Source: Google Map

Fig. 3-1-78 & 3-1-79: Bird View and Street View Images of Estádio Municipal de Braga
Fig. 3-1-80: Image of the grand structure of Estádio Municipal de Braga
Description: The structure of the stadium is very grand when being looked at separately, but it coordinates with the magnificent landscape created by mountains and the cutting surface. By opening one side of the building, the audiences can enjoy the view and the mountain can be exposed to show it natural beauty. Meanwhile, the straightforward feeling brought about by the roughness of the building which reflects “muscles” in its impactful environment also compensates for the momentum of the overall natural landscape.
Source: www.archcollege.com/archcollege/2017/11/38029.html

Municipal Pool of Povoacão is another landform sports architecture whose architectural volume compensates for the changed terrain. By sacrificing part of the natural slope, a rectangular outdoor platform for viewing and activities is inserted into the hill and the architectural volume is embedded into the terrain under the platform. Thus, the building located at the bottom of the hill takes the original place of part of the slope. Through connecting the surface of the rest slope and the roof of the building, the building seems like growing out from the hill. It echoes the nature in an artificial way but causes little impact to the natural image since it has been integrated into the overall natural landscape in the area.

Fig. 3-1-81 & 3-1-82: Bird View and Street View Images of Municipal Pool of Povoacão
Fig. 3-1-83: Section Drawing of Municipal Pool of Povoacão (Barbosa & Guimarães Architects)
Description: Through being embedded into the slope at the bottom edge and connecting its green roof with the rest slope smoothly, although the construction of the building changes part of the terrain, it creates an image that the building and nature are symbiotic
Source: bbs.zhulong.com/101010_group_201810/detail10046048/

b) View Echo

In fact, achieving the goal of echoing nature does not necessarily need landform techniques, especially for echoing the distant view. As mentioned above, one of the most important characteristics of the landform technique is that it establishes direct relationships between the building and the surrounding environment. For sports buildings which aim at echoing the distant view, this characteristic cannot be reflected, so that the necessity and applicability of the landform technique in sports architecture design will be questioned. Although there are many projects having a close relationship with the distant view and their forms are generated with the help of landform techniques, it should be pointed out that these cases only prove the landform technique has the possibility of echoing distant natural environment while echoing distant view is not a decisive factor for choosing the landform technique as the form design strategy.

For example, Mantes-la-Jolie Water Sports Center uses the soil-covering roof with a flowing shape to echo the landscape of mountain and river. This is a common technique in landform buildings. The building itself is weakly connected to the land environment, but the use of the landform technique as design method makes it become part of the overall landscape environment from a macroscopic perspective. Similarly, Medellín Sports Coliseum uses its mountain-shape roof to echo distant mountains around the town and creates such an artificial mountain in the town.

Fig. 3-1-84: The Environment Map of Mantes-la-Jolie Water Sports Center (Agence Research)
Description: The project is situated at the junction of cityscape and landscape. On the banks of the Seine, it constitutes an exceptional opportunity to reinvigorate the dialogue between the housing projects and hillsides. The architecture is conceived as landscape.[9] Echoing the beautiful view and urban context are both requirements for the building design.
Source: Google Map

Fig. 3-1-85 & 3-1-86: Image Viewing from the River and the Street
Fig. 3-1-87: Interior Space of Mantes-la-Jolie Water Sports Center
Description: The green roof resonates with hillsides and embodies the symbolism of the project. The design of the public garden reprises distant hills with an abstract undulating form that is extended and accentuated with the building. The landscape thus becomes architecture and the building takes on the scale of the surrounding countryside.[10] Meanwhile, the architectural form creates a good view in the building and let users feel the connection with nature.
Source: bbs.zhulong.com/101010_group_201810/detail10057348/; bj-bsc.lofter.com/post/4c714_78215

[9] Partly excepted from bj-bsc.lofter.com/post/4c714_78215

[10] Partly excepted from bj-bsc.lofter.com/post/4c714_78215

Fig. 3-1-88: The Environment Map of Medellín Sports Coliseum (Mazzanti Arquitectos)
Description: The sports building is located in the middle of the town. The architectural form echoes mountains around the town. When looking from the map, the mountain-shape building is different from the surrounding urban environment. The recognition of its concept requires a large background.
Source: Google Map

Fig. 3-1-89 & 3-1-90: Bird View Images of Medellín Sports Coliseum
Description: The pictures clearly show the form relationship between the building and distant mountains. Creating view echo by association through the mountain shape is the purpose of designing this sports building with the landform technique. What is worth mentioning is that this kind of landform technique does not aim to hide the building in the environment but to provide an association of natural elements.
Source: www.gooood.cn/medellin-sports-coliseum-by-mazzanti-arquitectos.htm

Another example is Guadalajara Volcano Stadium. The designer selects the volcano as a prototype to design the stadium. The original intention is to integrate the stadium into the natural environment by simulating a geographical element. However, in terms of the actual effect, its white roof is very conspicuous and becomes the main role of the stadium. The roof is a symbol of cloud which is also a natural element and it helps establish the building's characteristics. But from the perspective of landform sports architecture, this stadium does not achieve its original intention because of it prominent image. Both Medellín Sports Coliseum and Guadalajara Volcano Stadium use landform techniques in the architectural form design, but their effects are different from landform sports buildings which are well integrated with surrounding environment. Their relationships with the distant view are difficult to be recognized intuitively.

Fig. 3-1-91: The Environment Map of Guadalajara Volcano stadium (Jean-Marie Massaud and Daniel Pouzet)
Description: The stadium is located in the suburban district between the city and natural environment. From the map, it is just a common stadium because the color of the roof is really highlighted in the environment.
Source: Google Map

Fig. 3-1-92 & 3-1-93: Distant View and Street View Images of the Stadium
Description: The landform technique is mainly used in the design of the lower part and the volcanic form of it could be integrated into the environment by echoing the distant mountains if the white roof does not steal the show too much.
Source: www.gesep.com/news/show_174_287534.html

(3) For the Purpose of Retaining Nature

The reduction of natural environments during the rapid construction of cities has been paid more and more attention to. Especially in high-density cities, retaining nature has become a factor that cannot be ignored in the process of the artificial construction. Under this background, the landform technique sometimes works as an effective method for promoting buildings to coexist well with nature in cities. For example, Osaka Municipal Central Gymnasium is a landform sports building located in a park in Osaka, Japan. It is necessary to build a large gymnasium there but people also hope to retain this green space in the city at the same time. Thus, instead of designing a common stadium which occupies the space on the ground, the public green space and the new stadium are organized vertically. The stadium is built into the artificial hill formed by bulged land. In this way, the rising roof space takes the role of the original green space. It is used as a new park for people to participate in outdoor activities. Moreover, it becomes a tsunami evacuation place since it is very high.

Fig. 3-1-94: The Environment Map of Osaka Municipal Central Gymnasium (Nikken Sekkei)

Description: By covering the hill-shape gymnasium with plants, the whole site becomes a green park in the city, keeping a green space in the high-density city and also a leisure space for citizens. Since the site is close to the ocean, making such a large artificial mountain also meets the requirement of excavation when tsunami is coming.

Source: Google Map

Fig. 3-1-95: Bird View Image of the Gymnasium

Fig. 3-1-96: The Entrance of the Gymnasium

Description: Besides protecting nature by designing green roofs, creating a comfortable internal environment is also important for an underground public building designed with the landform technique. In this project, a more natural internal space is achieved by courtyards, top sky windows and other sustainable technologies in the building.

Source: www.hdre.com.cn/workasp/zszc/; osaka-info.jp/en/page/mice-osaka-municipal-central-gymnasium

3.2 Factors of Characteristic of Sports Architecture

3.2.1 Building Scale

Large-scale is one of the characteristics of sports architecture, which usually makes sports architecture become a landmark. For sports buildings that need to be landmarks, the large scale can be emphasized and presented prominently. But for sports buildings which aim to become a friendly building for citizens' daily use in communities and which aim to show respect to the environment with a humble gesture, to partly hide the architectural volume can reduce the negative influence on the surrounding environment and the exaggerated impression left to people. In these situations, the landform technique is usually applicable in the architectural form design. Generally, hiding the architectural scale has two aspects: hiding the height and hiding the volume. Examples are as follows.

a) Height Hiding

Berlin Olympic Velodrome and Swimming Pool are two landform sports buildings. As large-scale sports buildings, the architectural form is derived of the contradiction between its special location and the building's large scale. The project is located at the junction of importance urban elements: one is the wide urban avenue which is the main axis connecting the center of the city; another one is the subway line which connects East and West Berlin. Meanwhile, the different urban textures of East and West Berlin meet here. That is to say, one side are compact blocks developed under the capitalist system, the other side are houses with big courtyards built under the socialist system. In the important period of reunification of the two parts of Berlin, the government does not want a large and tall building to appear here suddenly, which may expand the gaps, hinder unified development and have negative effect on communication between different urban areas. Therefore, the designer wanted to create green public space as the main element of stitching the city. Since appearing the great height of the sports buildings will damage this intention, the velodrome and swimming hall are sunken into the green space. Through this landform technique, the two large buildings disappeared in the field, leaving the city with a beautiful orchard and two "quiet lakes".

Fig. 3-2-1: The Environment Map of Berlin Olympic Velodrome and Swimming Pool (Dominique Perrault)
Description: Looking from the map, the sports buildings are prominent because of the shape which is different from the surrounding urban texture. Even though hiding the height of buildings is meaningful from the perspective of people's feelings when standing on the street in the city, the rectangular shape of the plot still seems so artificial that makes it more like the base of building instead of a friendly landscape.
Source: Google Map

Fig. 3-2-2: Bird View Image of the Site and Buildings
Description: Instead of directly embedding the two buildings into the original ground, the park plot has been uplifted. People who want to get into the building can find entrances along the street while people who want to have fun in the park will go upstairs to the park level. Although it is not the common way for creating a natural space in the city, in order to eliminate the influence on the site brought about by big buildings, this is still a reasonable landform technique.
Source: www.uedmagazine.net/UED_Column_con.aspx?one=1&two=12&three=60&pid=6044

b) Volume Hiding

As mentioned above, one reason for building Gjovik Olympiske Fjellhall in the hill is due to the good insulation of rock and soil, which can maintain comfortable interior environment and the good quality of the icy field. Actually, another reason of using such a kind of landform technique is to avoid a discordant invasion of the sports hall's huge volume to the town with small buildings.

So to speak, from the perspective of volume hiding, using the landform technique as the form design strategy for sports architecture can have a relatively good effect.

Fig. 3-2-3: The Environment Map of Gjovik Olympiske Fjellhall (Moe-Levorsen AS Architects)
Description: The sports building has been totally hidden in a mountain in the city, which has no impact on the urban texture in this small town. It is a relatively extreme method for dealing with the relationship between the scale of large sports buildings and the urban context.
Source: Google Map

3.2.2 Function Requirement

Beginning with the well-known phrase “form follows function” attributed to Louis Henri Sullivan who was an influential architect and critic of the Chicago School, the discussion on the relationship between form and function has become a typical topic in the architecture field. Subsequent similar phrases such as “form follows art/ finance/ environment/ rule/ climate/…” could be the simple interpretation of the factors discussed in this chapter. Back to the original phrase “form follows function”, the specific requirements of functions are often accompanied by the limitations of the corresponding space design, and then producing limitations or needs for particular form design solutions. Although there are examples that landform techniques help solve functional and spatial problems, which shows the unity of form and function, the function requirement is generally not the primary influence factor that directly determines the applicability of the landform technique. It can only be said that from the perspective of function requirements, to use the landform technique in specific projects may be reasonable. Examples are as follows.

a) Dealing with Special Function Requirement

The reason for the form design of Slowtecture M Gymnasium relates to the interior physical control as mentioned before. In addition to this, it also depends largely on the space requirement brought by the special function. This gymnasium is designed as an emergency refuge, which is added with sports functions in consideration of the efficiency for daily use. Since the conventional stands in gymnasiums will separate the whole space, which do not meet the requirement of the refuge space, so the main field and stands have been sunken into the ground. Although the solution brings height difference in the internal space, the continuity of sight and traffic has been guaranteed. This solution is an important feature of this landform sports building.

Fig. 3-2-4: The Environment Map of Slowtecture M (Shuhei Endo)
Description: The gymnasium is located in a natural park in the suburban district as an emergency refuge.
Source: Google Map

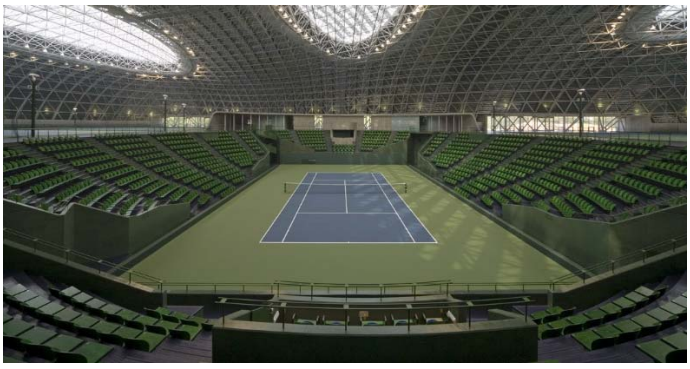


Fig. 3-2-5: Interior Space of Slowtecture M
Fig. 3-2-6: Plan and Section Drawings of Slowtecture M
Description: The main field is located in the middle of the gymnasium to ensure the convenient utility for daily events, and the sunken form meets the requirement of using as a refuge
Source: www.archdaily.com/6853/slowtecture-m-shuhei-endo

b) Reflecting Function Division

Using the form of buildings to reflection internal functions is a direct and logical form generation strategy. In the complex sports buildings, different sports events need different spatial scales, and different ways of composing these functions produce different shape of architectural volumes. This could be the basis of form generation. For example, Langreo Sports Center uses a flowing roof which is often used in landform buildings to cover functional spaces and reflect internal function division. Specifically, the roof fluctuates into different heights above different functional spaces: greater height for the sports hall, even more height for the rhythmic gymnastics area, less height for the swimming pool, etc. Finally, the roof presents a folding form in the terrain.



Fig. 3-2-7: The Folding Form of Langreo Sports Center (ACXT)
Fig. 3-2-8 & 3-2-9: Interior Space of the Center
Description: Generally, the architectural volume is designed as the direct expression of the volumetric requirements of the complex. But the logic is not fully complied with the need of space scale. The design also takes the space effect into consideration. For instance, the swimming pool for children does not need a high space but the roof rises up to provide natural lighting and to create a good view for children.
Source: www.archdaily.com/7391/sports-facilities-for-colegio-vizcaya-acxt

c) Expanding Functional Space

Since the landform technique usually takes more interfaces of the building and the environment into consideration, there is a possibility of utilizing these interfaces as new sports space. Thus, this form design strategy can make the sports building more interesting and open. For example, in Polur Rock Climbing Gymnasium proposal, the form of the building is designed in a mountain shape to reflect its function of this climbing gymnasium. Meanwhile, the external architectural interfaces are designed in a tortuous way for creating outdoor climbing space. Thus, with the cooperation of the internal and external interfaces, the internal function of the building has been expanded out to the open space and this landform sports building becomes more attractive.

Fig. 3-2-10 & 3-2-11 & 3-2-12: Rendering Images of Polur Rock Climbing Gymnasium (New Wave Architecture)
Description: By dealing with the interfaces of the building, the design not only expands functions from inside to outside, but the fragmented mass with partly transparent fractures invites nature and landscape to creep into the building visually to offer daylight and establish a strong connection between climbers and the surrounding landscape.
Source: www.archdaily.com/470579/new-wave-architecture-designs-rock-gym-for-polur

There are also some sports fields that belong to landform sports facilities due to the characteristics of the special sports type. For example, the informal extreme sports space in the city such as Street Dome which has been mentioned before needs uneven space for skateboarding, cycling and so on, thus the ground naturally becomes a continuous artificial landform. Another example is the sports facility for outdoor ski jumping. The slides are usually built along the mountain slopes, which makes it become a landform sports space. However, since such facilities are more like structures but not architecture, they are only briefly mentioned here.

3.2.3 Form Symbolization

The symbolic meaning is almost purely subjective and can be used as an explanation or excuse for the form generation. The rationality of the landform sports architecture designed under the influence of this factor needs to be tested by users' approval.

For example, Max-Schmeling-Halle in Berlin uses "green bridge" as the design concept to create a symmetrical form. It intends to convey the meaning of connection between the former East and West Berlin regions. It is a landform sports building because the "bridge" touches the ground with green slopes on both sides, which shows a close relationship between the architectural form and the land. Another example is Yangzhou Li Ning Sports Park in China. Symbolizing the landscape with mountain and river is its concept. Through landform techniques, the sports buildings have been designed as artificial mountains to cooperate with landscape water on the site, which expresses the spirit of landscape in Yangzhou City. The architectural

forms of the two projects are both generated from symbolizing a clear object. Their deep meanings need to be explained.

Fig. 3-2-13: The Environment Map of Max-Schmeling-Halle (Jörg Joppien, Albert Dietz and Annette Maud-Joppien)
Description: The sports hall locates on the border of former East and West Berlin. The form symbolization is meaningful.
Source: Google Map

Fig. 3-2-14: The Map of Li Ning Sports Park (Australia PT Design Consultants Limited)
Fig. 3-2-15: Rendering Image of Li Ning Sports Park
Fig. 3-2-16: Bird View Image of one part of Li Ning Sports Park
Description: The symbolization is mainly reflected on the landscape design and buildings play the role of one element in the overall landscape. Slopes are very important in the landscape design because they break the complete volumes, create the guidance and becomes the basement of sports halls.
Source: Google Map; www.treemode.com/case/1129

3.3 Factors of Objective Support Condition

Objective factors such as society, economy, politics, municipal conditions influence the feasibility of a building in reality and also become the handle for people to question the efficiency of the design. At the same time, special and fascinating projects may appear due to particular restrictions. For landform sports buildings, there are examples whose forms are generated because of rule restrictions, time limitation, experience support, etc. And there are also examples whose forms are difficult to be achieved due to economic and municipal facility problems. Thus, when discussing the applicability of landform sports architecture in particular situations, the specific objective support conditions are also important influence factors. Examples are as Follows.

3.3.1 Economy and Efficiency

Vizcaya Indoor Swimming Hall is a typical landform sports building that is designed under requirements of economy and time efficiency. The swimming hall is located in a school. The three basic requirements of designing the building are: the short construction time, the limited budget and the need of a roof garden. Thus, the designer used the low-cost and rapid prefabricated construction method that are commonly used in tunnel construction, and chose the dome-shape and soil-covering roof to complete this landform swimming hall. Finally, this strategy not only achieves the goal of low cost and low energy consumption, but also creates a flexible roof space and a cave which is a secret place presented in many stories of children's imagination.

Fig. 3-3-1: The Environment Map of Vizcaya Indoor Swimming Hall (ACXT, SA Grupo IDOM)
Description: The swimming hall is located in a corner formed by the shape of other buildings in the school.
Source: Google Map

Fig. 3-3-2 & 3-3-3: Street View Images of Vizcaya Indoor Swimming Hall During Day and Night
Description: Related to the economic issue, the form of the swimming hall is very simple.
Source: www.idom.com/project/vizcaya_school_swimming-pool/#

The economic issue is often a stumbling block for innovative architecture. For example, the form of Dalian Shide Stadium Proposal is designed with the concept of unfolding earth's surface. In order to create a different viewing experience for audiences, the form and technology adopted by the building are revolutionary and sustainable. The idea of combining the new energy system with the building skin and materials is relatively avant-grade at the moment, and the actual construction will cost much. This is an important reason why this experimental sports building is not easy to be realized in reality. Another example is Quzhou Sports Center which has been mentioned before. 3.5 billion yuan has been invested for building the first phase of this innovative sports center. The government's economic condition is a strong support to promote the construction.

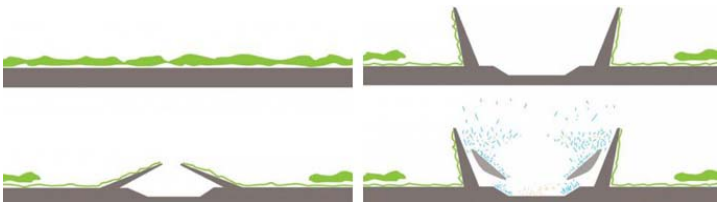


Fig. 3-3-4: Rendering Image of Shide Stadium (NBBJ)
Fig. 3-3-5: Form Generation Diagram of Shide Stadium
Source: bbs.zhulong.com/101010_group_201810/detail10032642/

3.3.2 Municipal Condition

(1) Regulation Restriction

The special form generated due to relevant regulation restrictions on the construction site is an obliged result, but also the ingenuity thought out by the designer when facing difficulties. Chofu City Gymnasium is such a landform sports building. It is located in the north part of a botanical

garden in Tokyo. In order to retain the botanical garden and its surrounding scenery, there is a maximum height restriction in the area which is 10 meters from the ground. So, it is not possible to build a conventional gymnasium on the ground. Therefore, the building is sunken into the ground. Except for meeting the regulation, this technique also makes the gymnasium become a part of the landscape facility in the botanical garden.

As mentioned above, the Osaka Municipal Central Gymnasium in Japan is designed as a landform sports building for the purpose of retaining nature. In fact, the form is also generated due to the restriction of the local “Park Law”. The government hopes to retain the city park, but the “Park Law” stipulates that buildings in a park cannot occupy more 7% of the total ground area. So, the arena cannot be built on the ground. Thus, the special form of the arena was generated under this background.

Fig. 3-3-6: The Environment Map of Chofu Gymnasium (Kume Sekkei Co., Ltd.)

Fig. 3-3-7: Bird View Image of Chofu Gymnasium

Description: By sinking the gymnasium into ground and covering the roof with soil and plants, the landform sports building is successfully integrated with the botanical garden instead of bringing much negative impact on the overall landscape. By adding a courtyard in the building, the quality of underground space has been improved. Natural elements like wind and sunlight can interact with users in the building better.

Source: Google Map; thetokyofilesmedia.wordpress.com/2016/05/16/chofu-gymnasium-green-roof/

(2) Municipal Facility Support

Because landform sports buildings usually use the underground space, in order to have necessary equipment and primary resource, the site needs to have complete municipal systems. Otherwise, water, electricity and heating supply in the building cannot be guaranteed, which causes difficulties for the design concept to be achieved. For example, Rock Stadium Proposal which has been mentioned above is located in a desert environment far away from the city. Although this environment background can create spectacular atmosphere for this stadium, supports like the transportation route, municipal pipe network and surrounding

necessary services are deficient. Because constructing lots of infrastructure will cost many efforts and investments, the proposal is difficult to be achieved.

In contrast, Helsinki Underground Swimming Hall is a totally underground swimming hall which has been built successfully many years ago. Even though there are many difficulties when building underground sports buildings, the local background provides supports for it. Firstly, the development of underground space in Helsinki is systematic. The underground network is composited by underground lakes, underground water plants, subway stations and vacant underground space reserved for future development. The continued development of the system has laid the foundation for the realization of this underground swimming hall. Moreover, the swimming hall is a planned municipal refuge site. Local government is willing to pay for the construction. Similarly, jovik Olympiske Fjellhall in Norway is an underground ice hockey stadium as mentioned before. Before building this stadium, there was already an underground swimming hall in the adjacent space in the hill. Based on the precedent, the accumulation of technologies, construction experience and relevant municipal facilities can support for the construction of a new stadium.

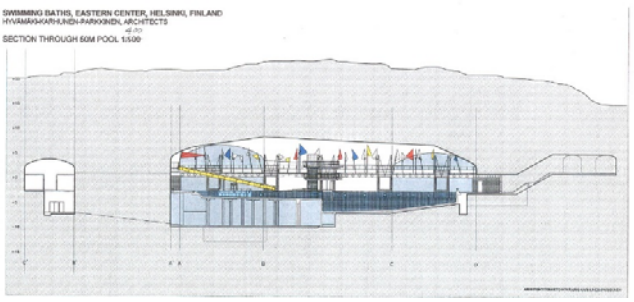


Fig. 3-3-8 & 3-3-9: Interior Image and Section Drawing of Helsinki Underground Swimming Hall (Hkp Architects)
Source: www.hkp.fi/?project=itakeskus-swimming-hall

3.4 Summary of the Chapter

This chapter mainly summarizes the factors affecting the applicability of landform sports architecture by analyzing existing projects. Generally, it is influenced by factors of architectural environment condition, characteristic of sports architecture and objective support condition.

For factors of architectural environment conditions, the height difference of the terrain, the need for thermal insulation due to climatic characteristics, the environmental limitations in particular site, the positioning of building and the establishment of relationship with surrounding environmental elements can drive and determine the application of the landform technique in sports architecture design.

For factors of characteristics of sports architecture, the need of hiding the architectural volume visually, the requirement of specific functions on the architectural form and the subjective symbolic meaning of the architectural form can cause sports architecture to be designed with the landform technique.

For factors of objective support conditions, the requirement about economy and efficiency, the municipal condition and regulation can lead to the design of landform sports architecture with a special form. Meanwhile, as objective limitations, they can influence the realization and construction of landform sports architecture.

To determine if the landform sports architecture should be designed and built in a specific site, designers should take all the factors mentioned above into consideration. Although some of the factors can directly lead to the application of the landform technique, other factors cannot be ignored at the same time. The form design is not a step with an impulsive decision or just about the beauty and innovation. In reality, the applicability of the landform technique in sports architecture design is a complex issue but can be judged through comprehensive analysis of influence factors for specific projects. Generally, the design and construction of landform sports architecture should obey several principles:

a) It expresses respect or has positive reaction to the environment.
b) It makes use of physical advantages brought about by this special form.
c) It meets spatial needs of sports functions
d) It can be supported by objective conditions.
e) It can be accepted and approved by users.

The original intention of this chapter is to discuss about what influence factors can trigger the use of the landform technique in sports architecture design. It aims to help designers make a correct judgement before designing a sports building in such a special form. Through all the analysis and projects discussed in this chapter, it is also proved that landform sports architecture is applicable in many different environments and landform techniques are applicable widely. From a general description of these projects, this chapter has hinted that the proper landform techniques are distinct according to the different environments and needs of specific projects. In the next chapter, landform techniques will be summarized and discussed respectively.

CHAPTER 4

Design Strategies and Techniques of Landform Sports Architecture

4.1 Form Design of Landform Sports Architecture

4.1.1 Form Design Principle

Architecture is a kind of concrete physical product. People's understanding of architecture is formed with various senses, while the most direct and basic one is the visual sense. As a physical image, "form" is a certain shape that people feel. It is an intuitive visual element that plays an important role in reflecting images and characteristics of architecture. Therefore, the importance of visual sense has led the development and creation of the architectural form for a long time. The excessive attention to the architectural form often leads to neglect of the relationship between architecture and the environment. As mentioned above, landform sports architecture which is closely related to the theories of genius loci and landscape urbanism emphasizes the integration of sports architecture with the environment, especially with the landform. It is undeniable that the spatial experience and cultural echo are also conducive to the realization of this purpose, but in terms of the architectural form design, treating the sports architecture's own form with a proper attitude and balancing the status of sports architecture and the environment are keys of designing landform sports architecture well. Generally, from the perspective of form, landform sports architecture should be integrated into the landform instead of standing out visually. This design principle attaches landform features as a kind of limitation to the architectural form which is dominated by visual sense, thus laying a good

foundation of the establishment of the relationship between sports architecture and the environment from the starting point of form design.

The design of conventional landform architecture usually abandons the pursuit of strange architectural form and shows respect to the environment by weakening its own form to create a hidden image. However, the scale of sports architecture is relatively large. When it is difficult to hide the building sufficiently due to specific requirements of function and space, it is also reasonable and meaningful to achieve an image which is harmonious and unified with the landform while still maintaining a certain degree of self-identification. For landform sports architecture with the design principle of hiding and weakening itself to integrate into the environment, it should be noticed that the effect of the hidden image is not only due to the weakening of the physical elements of the building, but also to the processing of subjective perception of the architectural form by people. For example, the weakening of expressiveness, completeness, three-dimensional sense, weight and stability of the building all can reduce viewer's perception about the presence of objects. At the same time, because the landform sports building is hidden in the environment, the dissolution of the architectural form involves the cooperation between the building and the environment. Taking account of the use and change of the landform will promote the integration. For landform sports architecture with the design principle of unifying with the landform, different from the former one whose form design can start from aiming at weakening itself, it is necessary to analyze the environment first to fully recognize the characteristics of the landform and extract its main morphological elements. Then providing viewers with the medium to perceive the association through the simulation or translation of morphological elements on the architectural form. Finally, achieving visual echo of the architecture and the environment.

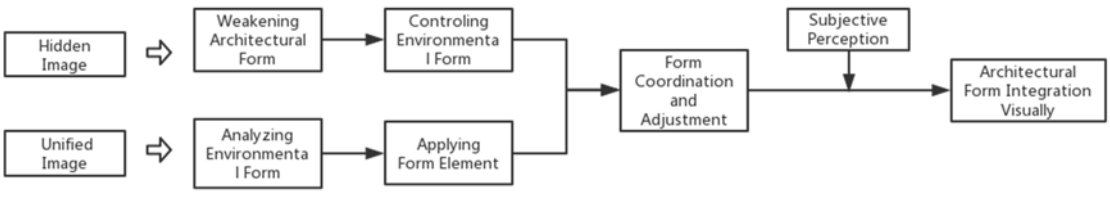


Fig. 4-1-1: Two logics of the form design of landform sports architecture
Source: Elaborated by the Author

Based on the above principles, in the specific design logic, architectural form design can be

summarized into three main aspects: volume design, interface design and space design. The volume is the basic physical entity formed by the enclosed state of architectural space. The volume design starts from the integrity of the building and environmental elements, and discusses the relationship between the building mass and the environmental medium. The interface refers to the physical entity on the surface and the intersecting part. It reflects the surface characteristics of the architectural form which let people recognize the existence of the building. The architectural space is a physical place for people to stay and experience inside. Usually, its complete presentation requires not only visual perception, but also the experience perception. But the space studied in the aspect of form design is mainly about its visual form. The object is the kind of space that directly changes the external form or affects people's perception of the architectural form.

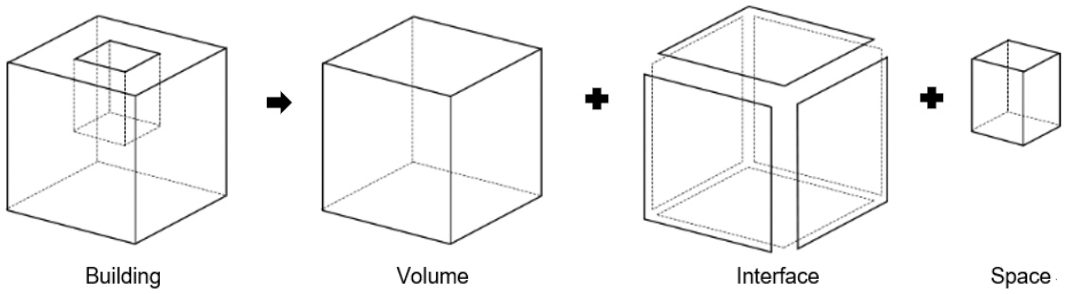


Fig. 4-1-2: sketches showing meanings of the volume, the interface and the space of a building
Source: Elaborated by the Author

4.1.2 Volume Design

4.1.2.1 Strategy

Volume design plays a very important role in the early stage of the architectural design. The architectural volume not only reflects the scale of a building, but also shows the basic form logic of the building. On one hand, the volume of landform sports architecture is relatively important because it helps to create a proper scale for the sports space; on the other hand, designing landform sports architecture takes the integration of the architecture and environment into consideration, which makes the architectural volume directly affects the degree of interaction between the building entity and the overall environment. It is true that the volume can be designed by transforming and combining geometric prototypes to get various results. But for landform sports architecture, some of volume forms will be excluded due to the need of

matching specific functions, and the requirement of its integration with the environment also limits the architectural volume design. That is to say, exaggerated, strange and prominent volume forms which are incompatible with landform features are not applicable. Therefore, in terms of the stereoscopic feature and visual influence of the architectural volume, the volume design of landform sports architecture follows the following strategies.

(1) Reduce Size Visually

The volume includes the parameters of area and height. The relationship between the architectural volume and the landform is reflected from the overall spatial image macroscopically and is related to people's visual experience microscopically. Specifically, in general, the former emphasizes the coordination between the building's area and the environmental texture in the two-dimensional figure-ground relationship, as well as the coordination of the building's size and the environmental form in the three-dimensional bird-view image. While the latter emphasizes people's perception of the building's size in daily life, which reflects the presence of the building. Reducing the size of the building visually can be achieved by adjusting the scale of the building itself. Otherwise, through taking the environment into consideration, the architectural volume can be appropriately hidden by the shielding effect of the environment.

(2) Break Configuration Visually

The real environment is not pure and perfect. Both natural and urban landforms have complex and diverse characteristics. In the ancient time, because lacking of technologies and advanced tools, buildings were constructed in a freer and more random way which was close to the natural state. At present, as a kind of technical product, architecture is influenced by industrialization and the principle of formal beauty, and the transformation of geometric forms has become the mainstream of the volume design logic. This also makes architecture become a means of expressing artificial intervention in the environment and highlights architectural own features. Therefore, to integrate itself into the environment requires architecture to weaken its complete geometric features and show the characteristics of fragmentation, instability and interdependence that match the feature of environments. To break the configuration of the architectural volume visually, one way is to separate and disperse the large and complete

volume into the landform to achieve mergence, another is to create an unbalanced form to avoid the building conveying a much too complete and independent image, thus promoting a visual connection with the environment.

(3) Create Association Visually

The visual association is generated in the visual interaction between human and the architecture. For architecture that regards simulating landform elements as the basis for the morphological construction, viewers associate the prototype of landform elements simulated by the architectural form based on their experience and imagination, so as to recognize the architecture and the matching landform integrally, and realize the integration of the architectural form and the environment visually and psychologically. In addition, based on the theory of gestalt psychology, people have a priori perception of an object's configuration. Similarly, the perception of architectural form does not require people to receive information of a complete volume visually. Even if the main volume is hidden or shielded, the exposed part with a universal hint can also play a meaningful role in establishing the sense of presence of a building. Relying on this kind of visual association, architecture can promote the integration with the landform through less visual intervention in the environment.

4.1.2.2 Technique

(1) Architectural Volume Blends into the Landform

This method aims to create hidden effect for landform sports architecture by regarding the original landform as the subject and sports architecture as the object. In this way, the form of landform sports architecture is weakened, producing smaller interventions in the landform environment in terms of form.

1) Embedding

a) Overall Embedding

It is a relatively extreme technique which totally gives up the display of the external form of a building and regards the architectural volume as the entity of architectural functions and space.

From the perspective of architectural design, the technique's main purpose is to satisfy the need of practical use. Just like Gjovik Olympiske Fjellhall in Norway, the building is completely hidden in the mountain. The image of the external mountain landform has been maintained and highlighted, while the architectural form sacrificed. What is worth mentioning is that it is difficult for people to find this kind of landform sports architecture by looking from the outside. So, in order to keep the sports architecture's identity, it is necessary and important to design small volumes or special structures at the entrance or in the surrounding environment as hints to maintain the sense of presence for the public building. And the guiding system is also very important for this kind of building.

b) Partially Sinking

Relative to overall embedding, partially sinking is a common design operation method belonging to the embedding technique. It can avoid excessive conflict between the building and the environment by reducing the volume exposed above the earth surface. Using this method in sports architecture not only visually weakens the architectural form, but also help solve some functional issues. For example, multi-height interfaces on the ground floor and the basement floor will be formed by volume sinking, thus different groups of people such as staff, audiences and athletes can enter the building on different levels to avoid circulation crossing. Moreover, the grandstands in a large-scale sports building are usually very tall and steep, which causes difficulty in evacuating people on the upper level. Generally, large sports buildings deal with this kind of problem by constructing a platform on the upper level around the building, but the efficiency is limited by the platform's area and the vertical traffic condition. After sinking the volume, audiences can be evacuated with up route and down route simultaneously to improve evacuation efficiency and safety. For example, Berlin Olympic Velodrome and Swimming Pool is a typical project which is designed with the volume sinking method. Except for sinking the architectural volume, its environmental interface has been lifted accordingly to emphasize the building's disappearing, and to integrate the site as a whole. In addition, for the landform sports building which needs to reduce the height of its volume in order to integrate with the earth environment or reduce the exposure of the architectural volume, the main spatial volume is often sunken partially. Like French Oprah's Stadium in France, the original ground floor has been sunken into the land, leaving the upper part exposed like a hanging box. Since the whole volume has been separated into two parts and part of the size has been hidden visually, it

reduces the strong sense of solidity of the architecture.

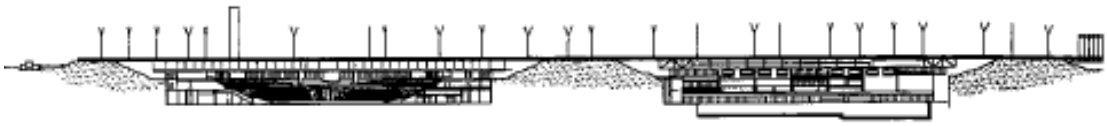


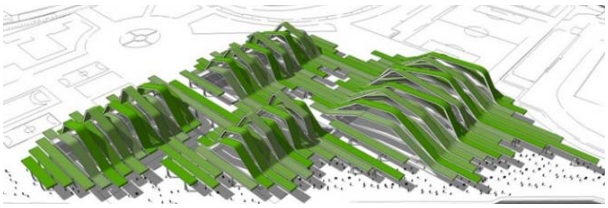
Fig. 4-1-3: Section of Berlin Olympic Velodrome and Swimming Pool (Dominique Perrault)
Source: 建筑设计资料集（第三版）第 6 分册. 中国建筑工业出版社，2017.

Fig. 4-1-4: Sections of French Oprah's Stadium (Bohuon Bertic Architectes)
Source: bbs.zhulong.com/101010_group_201810/detail10124203/

2) Digesting

a) Break up the Whole into Parts

This technique breaks and decomposes the architectural volume to dissipate it into the environment. According to the three-dimensional property of the volume, the specific operation methods of breaking up the whole into parts include volume distribution, texture decomposition, volume split, volume-surface transformation and so on. Among them, the relatively common method is texture decomposition. Typical projects are Medellín Sports Coliseum in Colombia and Zamet Center in Croatia. The architectural volumes of the two projects seem like being decomposed into strips while the complete large spaces are covered under the roof whose texture is small. In this way, the volume of the former one is digested in the small town while the latter one is integrated into the urban texture in the city. It should be noted that this technique aims to visually weaken the form of sports architecture, but it is still necessary to guarantee the integrity of architectural function and space. When the spatial gap is formed between the decomposed or broken volumes, it is also possible to maintain the unity of the building by generating a correlation between the discrete bodies through a certain form echoing or hidden physical connections.



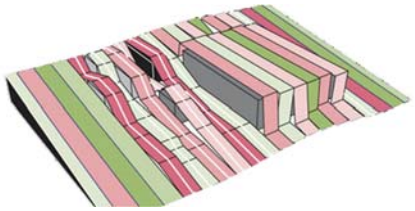


Fig. 4-1-5: The Decomposed Texture Form of Medellín Sports Coliseum (Mazzanti Arquitectos)

Fig. 4-1-6: The Decomposed Form of Zamet Center (3LHD Architects)

Description: The decomposed roof of Medellín Sports Coliseum not only covers each large sports volume but also connects them together to create a complete sports center. The decomposed volume of Zamet Center has been copied and extended to the square, thus making the whole site integrated and digested into the background environment.

Source: www.gooood.cn/medellin-sports-coliseum-by-mazzanti-arquitectos.htm; www.designboom.com/architecture/

b) Volume Cutting

This technique breaks completeness of original volume to create an unstable, unbalanced and flexible form to reduce the sense of heaviness and stability brought about by the complete volume, as well as to change the image that the building occupies the site independently. According to the scale and form of cutting, specific operation methods include sloping cutting, setback cutting, partial surface cutting and so on. They all aim to create a gradual change effect for viewers to weaken the conspicuity of the sports building visually.

(2) Building Form Simulates the Landform

This method does not focus on weakening the importance of the architectural form, but extracting landform elements and reflecting them on the architectural form to achieve the echo between the architectural form and environmental characteristics. Thus, the architecture in the landform and the corresponding environment present a harmonious and unified effect.

1) Volume Co-construction

a) Artificial Terrain Compensation

Volume co-construction refers to the situation that the architecture and the environment are regarded as a complementary and symbiotic integrity in terms of form. Specifically, in the construction of large-scale buildings, it is inevitable to produce damage to the original landform. So, if using the newly added architectural volume to compensate for the missing topographic

space in the form design, through techniques like connection and interlocking, the combination of artificial and natural elements or connection between the new building and the old environment may be realized. This approach intuitively reflects respect and retrospect of the original landform features. Estádio Municipal de Braga is built on the site where a part of a mountain has been cut. It attaches to the cutting surface of the mountain and uses the cut rocks as the main building material to compensate for the missing part of the mountain. Even though the final form of the building does not strictly follow the original shape of mountain, the concept of the technique is similar to volume co-construction. Actually, this technique is not a repair of the missing terrain, but to create a connection between the building and the environment by actively changing and restoring the original condition of the landform. So, it is not suitable for sports architecture which will be built in areas with high environmental protection requirements.

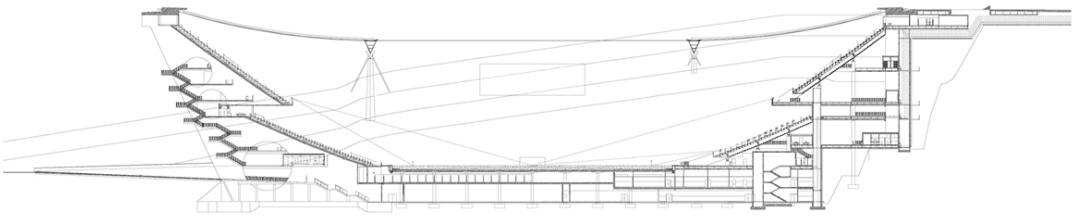


Fig. 4-1-7: Section of Estádio Municipal de Braga (Eduardo Souto de Moura)
Description: One side of stands obeys the original mountain shape to enhance the co-construction relationship.
Source: www.archcollege.com/archcollege/2017/11/38029.html

2) Form Simulation

a) Overall Prototype Simulation

This kind of technique is common in the simulation of natural landform elements, especially the mountain shape. In some urban environments, buildings which are designed as artificial mountains are mainly designed for the purpose of landscaping. They want to emphasize the concern for ecology as well as show the thinking of natural elements and future architecture. Due to the height characteristic of the mountain, simulating mountain shape is common in high-rise building design. While for sports architecture, the hills are used as prototypes. For example, Quzhou Sports Park designed by MAD fully simulated the undulating shape of hills to create a flowing place for sports and leisure. And in Stožice Sports Park, the sports hall in the shape of a small hill coordinates with the artificial natural base. Projects like Kofun Stadium Proposal for 2020 Olympics, Yangzhou Stadium and Osaka Municipal Central Gymnasium are all typical

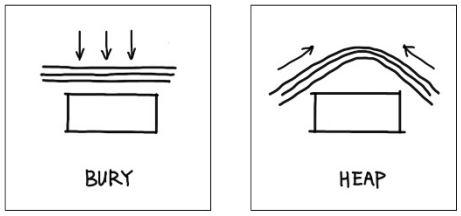
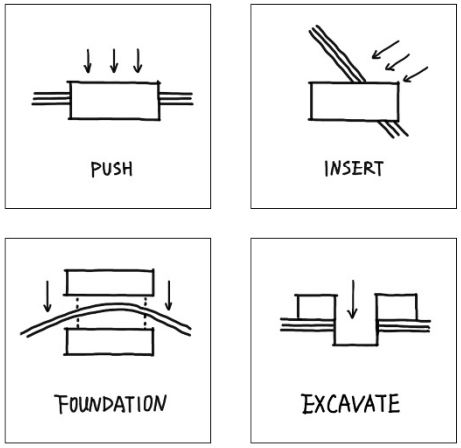
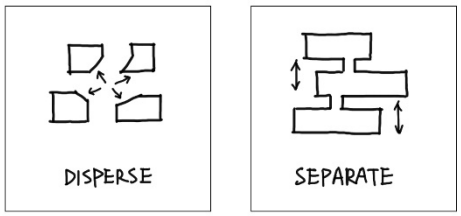
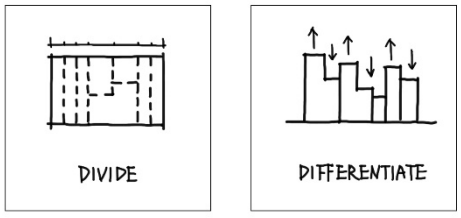
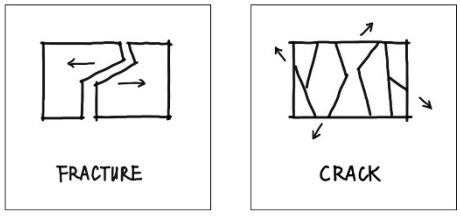
landform sports buildings which simulate the mountain shape. In addition, there are also some examples of simulating other natural elements such as rock and water. For instance, Gymnasium Palais des Sports de Loudéac and Polur Rock Climbing Gymnasium both grasped the multifaceted feature of rock to design the architectural volume. Although the simulation of natural elements in cities often lacks a basis from the perspective of echoing environment, it provides a possible starting point for volume design from a conceptual perspective.

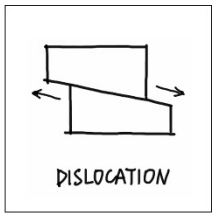
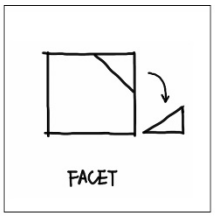
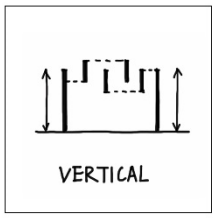
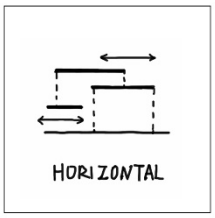
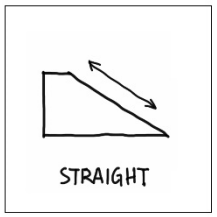
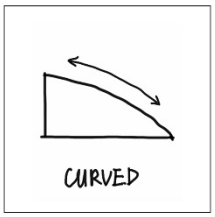
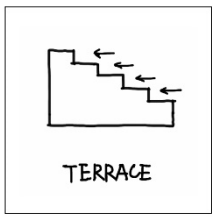
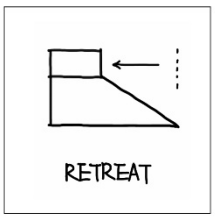
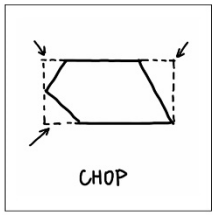
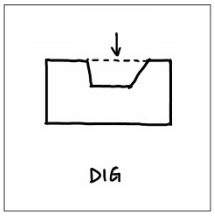
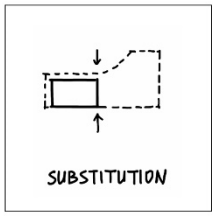
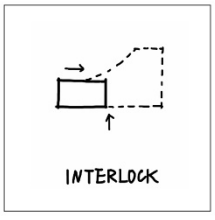
Fig. 4-1-8: Form Diagram of Polur Rock Climbing Gymnasium (New Wave Architecture)
Source: www.archdaily.com/470579

b) Partial Element Simulation

This technique corresponds to the technique of overall prototype simulation. Instead of repeating or approximating a complete form, it is more flexible to adjust architectural volumes by adding elements that can lead viewers to associate the building with the corresponding landform. For example, the volume of Mantes-la-Jolie Water Sports Centre does not simulate a complete landform element, but borrows the undulating form of water waves to design the roof, thereby making the whole volume seem flexible and creating an association between the building and the river next to it to achieve a harmonious and unified effect. Meanwhile, when applying a landform element to parts of the architectural volume, specific operation methods like rotating, distorting, tilting and so on could be used to integrate them in an indirect way.

Fig. 4-1-9: Roof Form of Mantes-la-Jolie Water Sports Centre (Agence Research)
Source: bbs.zhulong.com/101010_group_201810/detail10057348/

	Volume Design Techniques	Notes
Embedding	**Overall Embedding** 	It is an extreme technique and can be used in the site with a grand environment where the sports architecture should not interrupt, or to meet special requirements of hiding the building. Project No. 4 / 5 / 6 / 7 / 26 / 29 / 30 / 42
	Partial Sinking 	It is a very common technique for landform sports architecture and it can be applied with other techniques to achieve a better effect of hiding the building or creating a unified image of the building and the landform. Project No. 1 / 2 / 4 / 9 / 10 / 15 / 16 / 17 / 21 / 22 / 23 / 24 / 27 / 31 / 32 / 34 / 35 / 36 / 42
Digesting	**Volume Distribution** 	It is suitable for sports buildings which contains several sports fields or several kinds of functions. It can help avoid a large and concentrated volume by distributing various sports venues of different functions. Project No. 7 / 10 / 13 / 15 / 16 / 19 / 30 / 31 / 32 / 38 / 42
	Texture Decomposition 	It is mainly used in landform sports architecture that needs to be integrated into an urban environment with a small-scale texture or that wants to change the large and complete volume image of the building itself. Project No. 13 / 15 / 19 / 25 / 30
	Volume Split 	It is usually applied to sports buildings with large and inseparable internal space. They have certain requirements for concentrated volumes but hope to eliminate the integrity through partial form processing.

Digesting	 		Project No. 33
	Volume-Surface Transformation  	It is suitable for sports buildings with high openness. When it is not necessary to create a complete wrapping image for the building, decomposing the solid volume into enclosing surfaces can break the sense of heaviness.	Project No. 15 / 18 / 19 / 25 / 30 /
	Sloping Cutting  	It can form a simple volume but may produces uncomfortable space because of the height limitation at the edge area. Usually, the slope will be covered with grass to connect with the landform and offer people a leisure space.	Project No. 3 / 8 / 20 / 29 / 37 / 40 / 41
	Setback Cutting  	It is suitable for spots buildings with multiple levels since the terrace can be utilized as traffic space or functional space which may be connected with internal floors. And it can also be used to simulate natural bench terrains.	Project No. 28 / 37 / 40
	Partial Surface Cutting  	It is a flexible technique for volume adjustment. Cutting on different places of the building in different angles will present different forms and new spaces to offer possibility of interacting with the landform.	Project No. 32 / 33
Volume Co-construction	Artificial Terrain Compensation  	It can be used to fill up original void space of the landform but mainly be used for actively creating an image that the building and the landform are symbiotic and complementary with each other.	

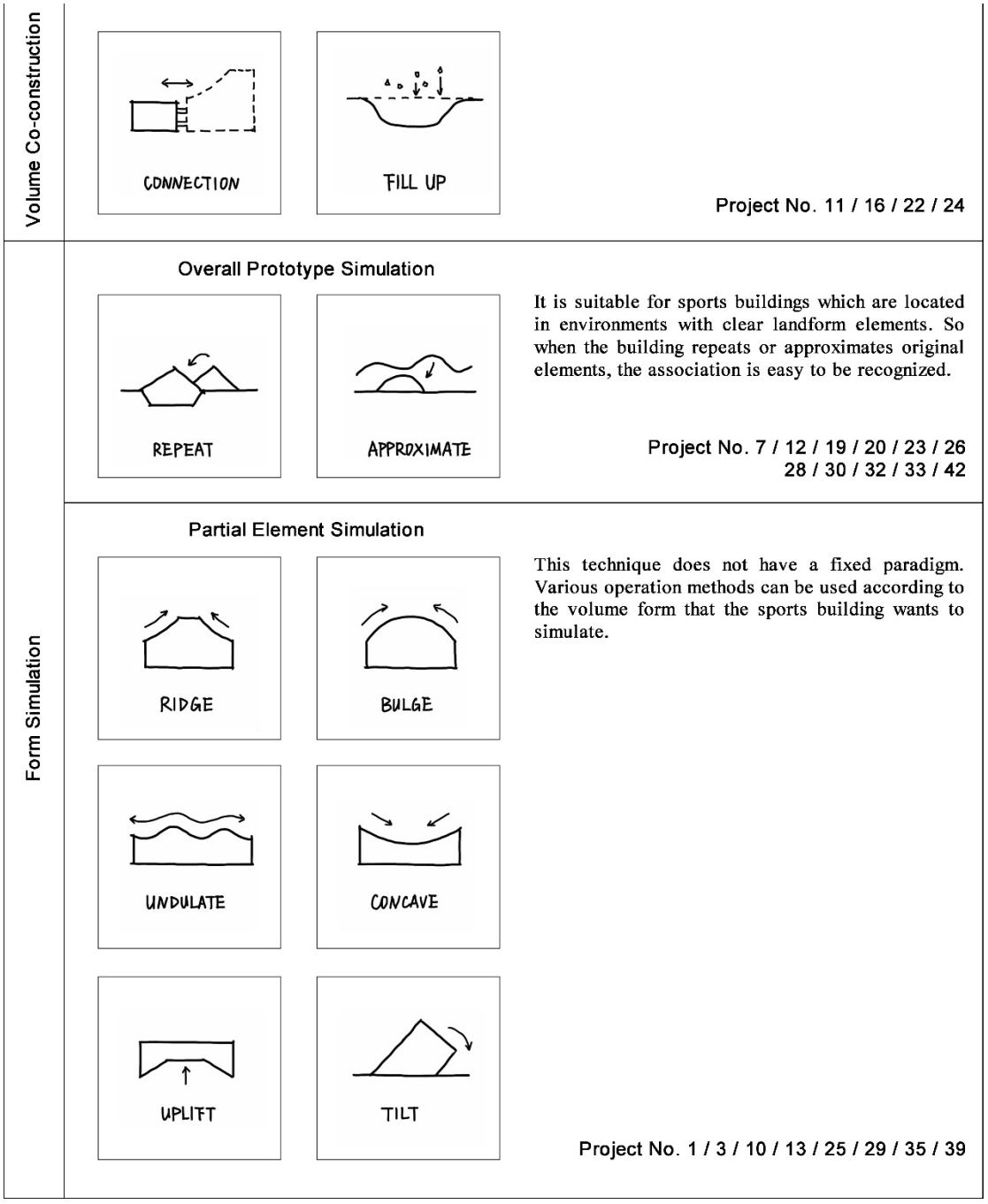


Fig. 4-1-10: Volume Design Techniques Lexicon

Source: Elaborated by the Author

4.1.3 Interface Design

4.1.3.1 Strategy

“Interface” is a term derived from the physical field. It refers to the interface between phases of the material. In the field of architecture, the term refers to the division of the external environment and the internal space of buildings, and is the medium for the division of entities in different spatial fields. Originally, the architectural interface was regarded as a flat plane, and the architectural interface design usually refers to the facade design. So, the architectural interface has become a barrier between the building and the environment. With the transformation of architecture from “Monism” to “Dualism” in the post-modern period, the interface was gradually given the thickness and spatial meaning, expanding the effect of interface as a spatial connection. For landform architecture, in order to enhance the integration of architecture and the environment, it is necessary to weaken the barrier effect of the interface. Through creating the permeability, transition, continuity and spatial meaning of the interface, the circulation of internal and external space will be promoted, then the connection of architecture and the landform will be enhanced. It is worth mentioning that unlike general buildings, landform architecture is designed with overall consideration of the architectural form and the landform, so the interface design is not limited to the divisional area of architecture and the external environment, but also needs to consider the environmental interface that is incorporated into the form design, for instance, the earth surface, the mountain surface, the surface of other buildings in the site and so on. Moreover, since the large volume of sports architecture is difficult to be perceived intuitively by users, the interface becomes an important medium for users to recognize sports architecture. Especially for open sports architecture like outdoor stadiums, because the lack of limitation on the top, they usually do not have a complete and specific volume, thus the responsibility of relating a stadium to the physical environment mainly on the surrounding surface. Therefore, whether the interface and the landform are integrated or not affects the form of landform sports architecture. Its design follows the following strategies.

(1) Create Continuity Visually

As David Leatherbarrow described in his book *Topographical Stories*, the terrain never stands out in front but is always hidden behind things that attract attentions. It reveals the conventional relationship between architecture and the landform: the landform around architecture is

integrated into the vast earth environment and fades into the background, while architecture is highlighted as a close shot. To break this inherent visual cognition, from the perspective of the interface design, by creating a continuous interface of the architecture and the landform, the common interface between architecture and the environment can be blurred, and the depth difference between architecture and the landform in the visual picture will be decreased, thus creating a visual continuity to achieve the integration of architecture and the environment.

(2) Reduce Weight Visually

Generally, visual weight is a measure of an element's force of attracting vision. Objects produce visual appeal through their inherent characteristics such as size, color, shape, density, depth and so on. For example, when considering about a single factor, large objects are more attractive visually than smaller ones, and bright objects are more attractive visually than dark ones. While the effects of these features are interrelated, the dark color weakens the visual weight of large objects and the bright color enhances the visual weight of small objects. In the field of architecture, the architectural form becomes an attraction in the visual picture. For architecture located in a specific environment, through the adjustment and interaction of various visual features of the building and the landform, the effect of highlighting or hiding the architectural form can be changed. Specific to the interface design of landform sports architecture, because sports buildings usually have a large volume, when changing the visual intensity in the environment through the volume design, applying the light and transparent texture and material in the interface design can change people's perception of the building to further weaken the visual weight generated by the large volume. Thereby promoting the effect of landform sports architecture disappearing.

(3) Establish Echo Visually

Different regional landforms have their own unique natural textures and cultural symbols. These regional symbols are not only the accumulation of history, but also the medium for people to recognize specific environments. The architectural interface is an external medium for communication between architecture and the environment, and its image is significant for displaying the cultural connotation and regional architectural style. The simulation or metaphor of landform features through designing the material, color, texture and other aspects of the

interface can create visual echo, which is an easy-to-operate strategy for promoting the integration of architecture and the environment.

4.1.3.2 Technique

(1) Environmental Interface Design

Because the landform sports architecture is closely related to the landform environment, the design of the environmental interface can provide the architecture with direct places to connect or integrate with the landform for creating visual continuity. Specifically, the environmental interface that can be changed and processed includes the natural one such as the mountain surface, the earth surface, the water surface and the urban one represented by the ground, the external wall, the landscape barrier, etc.

a) Interface Utilization: Create Spatial Limitation

The most basic design technique for the environmental interface is not to change it, but to utilize it appropriately for enclosing of the new architectural space, thereby establishing a connection with the space and achieving integration of the building and the existing environment. On one hand, this method can be used for enclosing the sports space in urban landform. For example, Gammel Hellerup Gymnasium uses the facades of the surrounding buildings to form a courtyard for outdoor sports activities. Especially in high-density urban environments, the compact space itself has many existing interfaces such as existing walls and landscape interfaces. To utilize them can omit the construction of new interfaces in such an intensive environment. On the other hand, the technique also creates opportunities of displaying the existing landform interface. For instance, in Estádio Municipal de Braga, the cutting surface of the mountain and the two stands on both sides of the stadium together enclose the sports space. The display of the cutting surface gives audiences a unique experience when they watch a game with the original atmosphere of the nature. Meanwhile, sports buildings in the natural landform can be designed with this technique to save budgets and protect the original environment.



Fig. 4-1-11: Estádio Municipal de Braga in Portugal (Eduardo Souto de Moura)

Fig. 4-1-12: Gospic Dolac Stadion in Croatia

Fig. 4-1-13: Cocodrilos Sports Park in Caracas, Venezuela

Description: The three projects all make use of the mountain surface to help enclose the sports space. Especially the latter two projects, they are in places where the economic and technical conditions are not very good. By utilizing the environmental interfaces, the sports field can be built with a lower cost easily.

Source: en.wikipedia.org/wiki/S.C._Braga_in_European_football; caredrogba.blogspot.com/2012/12/stadion-gospin-dolac.html; manslife.gr/sports/weirdest-sports-stadiums-world/

b) Interface Deformation: Create Spatial Enclosure

As mentioned above, landform sports architecture creates visual continuity by blurring the relationship between the building and the landform instead of regarding them as the subject and object respectively. In the volume design, landform sports architecture mainly uses the volume transformation technique to meet the purpose of interacting with the environment. In the interface design, if the building is regarded as the subject while the environment is regarded as the object, in order to comply with the architectural volume change and to clearly emphasize the interactive relationship visually, the environmental interface deforms according to the volume change. Thus, to present the result of mutual influence to reduce differences of the subject and object. On the contrary, if the environment is regarded as the subject while the building is regarded as the object, the active change of the environmental interface can directly form a new spatial enclosure which provides space for sports activities, thus it is possible to create landform sports architecture attached to the landform. Specifically, operation methods like wrinkling, bulging and sinking the environmental interface are all useful to create the new spatial enclosure. For instance, In Maruzen Intec Arena Osaka and Kofun Stadium Proposal for 2020 Olympics, the earth surface has been bulged and the sports space is added inside, finally presenting an image of hills in the city. Similarly, in Langreo Sports Center, the earth surface is wrinkled to create spaces with different heights for different sports events inside. Together with the green roof, the building seems being generated from the earth and being merged into the ground.



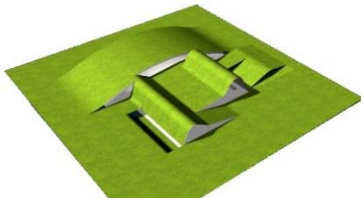


Fig. 4-1-14: Bird View Image of Osaka Municipal Central Gymnasium (Nikken Sekkei)
Fig. 4-1-15: Rendering Image of Kofun Stadium Proposal for 2020 Olympics (DGT & A+ Architecture)
Fig. 4-1-16: Form Concept diagram of Langreo Sports Center (ACXT)
Source: www.periodicodaily.com; www.gooood.cn/kofun-stadum-by-dgt.htm; www.archdaily.com/7391

c) Interface Reconfiguration: Create Spatial Expansion

Interface reconfiguration refers to the creative break of the original landform interface, especially the earth surface. It can expand space or form new interfaces by operation methods like folding, cutting, lifting up, carving and so on. Then cooperating with architectural volume to achieve the integration. Compared with the former two interface techniques, this method has a stronger intervention in the design. It considers about not only the spatial form and scale of the building, but also the landform's ability of interface shaping. And it is determined by designer's subjective purpose, too. Therefore, this technique discards the concept of subject and object, but emphasizes the equal relationship between architecture and the environment. It often helps to create buildings with the unconventional form. Like Rock Stadium Proposal in United Arab Emirates and Shide Stadium Proposal in China, they both fold the earth surface to create new space. The former one creates underground space while the latter one extends on-ground space through earth surface reconfiguration. There are also some projects whose forms are not that innovative but related to this technique, such as Putuo Fitness Center in Zhoushan and Sanwayao Community Sports Center in Chengdu. Their architectural forms can be regarded as integration of lifted land surface on one side and inserted boxes in the middle.

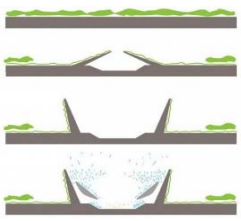
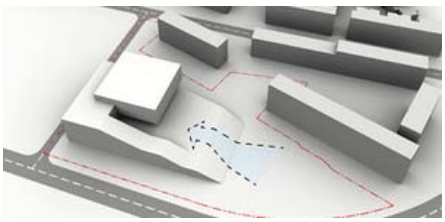




Fig. 4-1-17: Rendering Image of Rock Stadium Proposal (MZ Architects)
Fig. 4-1-18: Form Generation Diagram of Shide Stadium Proposal (NBBJ)
Fig. 4-1-19: From Diagram Sanwayao Community Sports Center (CSWADI)
Source: www.archdaily.com/317267; bbs.zhulong.com/101010_group_201810; www.archdaily.cn/cn/769553

(2) Architectural Interface Design

The spatial limitation of the architectural interface is often affected by the form change of the environmental interface, and they work together. What is more crucial is the selection of architectural interface materials because it is directly decisive for the overall image of the building. To take Vallehermoso Sports Center in Spain as an example, in the original proposal, the texture and color of this building have been designed to be coordinated with trees in front of it in order to partly hide the building in the environment. However, in the real construction, the building is very standing out because of the bright color and a different texture. Therefore, especially for the landform building whose volume is exposed, the coordination of the interface and the environment in aspects of the material, color and texture is very important.

Fig. 4-1-20: Proposal Rendering Image of Vallehermoso Sports Center (ABM Arquitectos)
Fig. 4-1-21: Real Bird View Image of Vallehermoso Sports Center
Source: www.archdaily.com/153705; www.strunor.com/en/proyectos/vallehermoso-sports-centre/

1) Interface Form

a) Comply with Environmental Interface

In the case of creating architectural space through the utilization or change of the environmental interface, the direct way of placing the architectural volume and space is to conform to the enclosure of the environmental interface by fitting and combining the architectural interface closely to the environmental interface. Rock Stadium Proposal in United Arab Emirates is a good example of this technique. The roof of the stadium has been perfectly attached to the interface reconfigured from the earth surface. Thus, the whole architectural interface of the stadium is hidden under the earth surface, and the space of the stadium looks like being generated and enclosed naturally.

b) Change Actively to Simulate Landform

For the environment with relatively common terrain conditions, the integration of architecture and the landform often starts from the form change of the building itself. For sports architecture with weak sense of volume, especially open buildings such as outdoor stadiums, the active change of the architectural interface is the main way to simulate the feature of the landform. For example, Insular Athletics Stadium in Santa Cruz de Tenerife is an outdoor stadium which does not need a completely enclosed volume. Its form is created by the enclosure of the side interface around it. Instead of standing on the ground simply, the wall has been thickened into a space and the edge of it has been extended out to merge into the ground, therefore producing a continuous landform image. Moreover, the active change of the architectural interface can also coordinate with volume change to better realize the landform simulation. Like Beijiao Sports Center Proposal in China, the roof of the building has been cut into several strips and they fluctuate to create an image of the valley. In this way, the roof not only covers the architectural space, but also creates a new interface for people to walk and stay like on the ground of a valley.

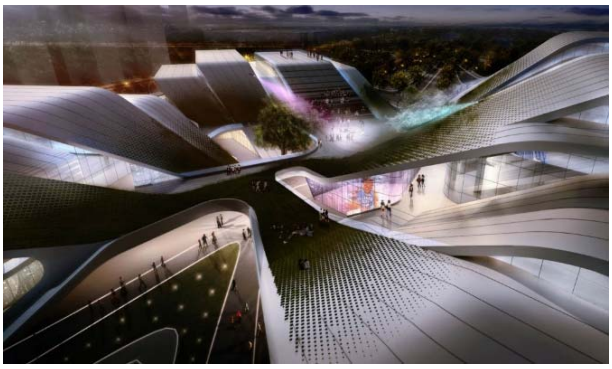


Fig. 4-1-22: Wall Interface of Insular Athletics Stadium in Santa Cruz de Tenerife (AMP arquitectos)
Fig. 4-1-23: Roof Interface of Beijiao Sports Center Proposal (Decode Urbanism Office)
Source: www.archdaily.com/2822; www.gooood.cn/beijiao-sports-center-by-duo.htm

2) Material Selection

The properties of materials include two aspects: the physical property and the perceptual property. The physical property is the intrinsic property of materials, including the mechanical, thermal, optical, chemical property. While the perceptual property of materials is the subjective feeling conveyed by materials. It is determined by the texture, color, transparency, pattern, etc.

it depends on the environmental conditions and the person who is experiencing it, so it has a rich expression dimension. Materials and architectural forms correspond to each other in the early discussion. Because of the technical limitations, the architectural form largely depends on the construction way, and the construction way is determined by the property of materials. Thus, the value of materials in architecture is mainly reflected in the physical property. Nowadays, with the development of materials and structural technologies, the realization of architectural form has been expanded, and the value of materials has evolved from simple physical needs to aesthetical significance. So the perceptual property of materials attracts attentions in the design.

For large-span sports architecture, the discussion on materials is often connected to the structure for achieving the integration of materials, structures and architectural forms. However, for landform sports architecture, when the integration of architectural interface and the environment is emphasized, the discussion on materials focuses on the perceptual property which is important for the visual expression of architectural forms. Different kinds of materials have different perceptual properties. To follow principles of landform sports architectural form design, selecting suitable materials for architectural interfaces aims at reducing the building's weight visually or simulating colors and textures in the surrounding environment.

a) Traditional Material

Traditional materials here mainly refer to natural materials including wood, bamboo, stone, grass, soil, etc. These materials are taken from the natural environment and coordinate with the natural landscape. In the natural environment, they can help buildings to hide themselves; while in the urban environment, they can help buildings to create a light image compared with surrounding heavy buildings or to be a part of the landscape.

Wood is widely used because of its good plasticity and the large amount in the world. From the perspective of perception, on one hand, the color of wood is warm and mild which brings friendly and relaxing feelings to people. On the other hand, the plant's own growth characteristics give the wood a natural and special texture which has a decorative effect. Although wood is made into components of roof structures in districts like Japan where the forest resource is abundant, it is mainly used as decorations on the facade of small sports architecture because the size of wood is limited by the growth of trees and the physical property such as thermal insulation is

not good. Meanwhile, the good plasticity of wood determines the diversity of its products. Wooden strips, wooden blocks and wooden boards of different sizes can create different interface textures through collage mix, density adjustment and color change. In designs, the selection is based on the specific environmental conditions and architectural form intentions to form a natural interface that is harmony with the environment. Actually, bamboo has a similar effect with wood. But because its generation is limited by geography, it is less practical.

Fig. 4-1-24: Side Interface of KAU Gymnasium (URA Yves Malysse Kiki Verbeeck)
Fig. 4-1-25: Roof Interface of Bamboo Sports Hall for Panyaden International School (Chiangmai Life Architect)
Description: KAU Gymnasium is located in the woods, to use the wood component as an element of the facade, the side interface of the building coordinates with the environment, which not only creates a humble image of the building by reducing the weight of the facade visually, but also weakens the separating effect of walls to offer people a natural atmosphere inside. Bamboo Sports Hall for Panyaden International School actually is made totally by bamboo. Besides the amazing bamboo structure, the curved roof made by bamboo creates an interface whose form is similar to nearby buildings to achieve the integration of the building and environment.
Source: www.gooood.cn

Stone has played an indelible role in the development history of architectural structure in west because of its stable properties. However, with the increasing demand for spatial span and light weight of buildings, stone is gradually replaced by concrete and steel after the emergence of modern materials, and stone is more used as a decorative material. In sports architecture, the use of stone is actually little. But for landform sports architecture that simulates forms of mountains and rocks, the facade made by stone material with natural textures and colors could form the brutalist image to show the regional feature. In addition, nowadays, through special processing technologies, the stone can be cut thin enough to achieve the light transmission, which adds new possibilities in the material selection for landform sports architecture.

Natural materials with relatively poor mechanical properties such as grass and soil are usually used in architectural envelopes. They often appear in wall and roof coverings in landform sports architecture. Even for a building with a prominent volume, by adding grass and soil elements into its interfaces, the building could camouflage as a more natural one and meanwhile enhance its thermal insulation performance. Like Longvic Sports Center and Omiyamae Gymnasium.

Their architectural volumes are not highly integrated into the landform, but soil coverings on their roof interfaces help weak the sense of presence of volumes.

Fig. 4-1-26: Roof Interface of Longvic Sports Center (Dietrich | Untertrifaller Architekten)
Fig. 4-1-27: Roof Interface of Omiyamae Gymnasium (Jun Aoki＆Associates)
Source: www.archdaily.com/801859/; www.domusweb.it/en/architecture/2015/02/13/dynamic_public_space.html

b) Modern Material

Modern Material represented by concrete, metal and glass are widely used in bearing structures and envelopes of architecture. Since concrete is simple, glass is transparent and metal is flexible, they create different images of architecture through their different characteristics when being applied as interface materials.

As an important modern material, concrete is often used in structural components. In fact, this simple concrete also has the aesthetic value. As-cast-finish concrete which is favored by Tadao Ando is decorative because of its natural and elegant appearance. Actually, due to its artificial characteristics and the sense of stability, concrete is rarely discussed as a typical material in landform architecture. However, since many sports buildings are built in the urban environment, using concrete as the interface material can make the building coordinated with the urban environment which is a reinforced concrete “forest”. Like Zamet Center, the concrete roof has been merged into the ground of the public square which is paved with the same material, thus increasing the connection of the building and the land. In this way, the architectural interface material can be harmonious with both the architectural structure and the landform. Similar to stone, light and transparent concrete is now available. The appearance of fiber-optic transparent concrete and resin transparent concrete provides new ideas for the use of concrete in architectural interfaces. In order to avoid direct light inside the sports building, using the transparent concrete as facade material may be a good choice for creating an indoor sports space with the soft light environment.

Glass has a special optical effect. Transparency and reflection are its two characteristics. Since the glass material was used as the architectural interface in “Crystal Palace” in 1851, glass’s interpretation of transparency is irreplaceable in modern materials. It has an excellent effect of visually reducing the huge architectural volume. At the same time, through the adjustment of the transparency degree of glass, it can be made into translucent frosted glass to create a hazy relationship between the indoor space and the outdoor environment. Moreover, transparent glass with a large size creates an excessively bright indoor light environment, which is not good for sports activities inside. By adding colors or reflective film to the surface of glass, the traditional transparent glass becomes a mirror glass with a reflective effect. It reduces the strong direct light and simultaneously reflects environmental elements on the outside surface of the building, causing an illusion that the building does not exist , thus to hide the building into the environment.

Fig. 4-1-28 & 4-1-29: Reflective Effect of Glass on architectural interface
Description: Keynes Botanical Garden Visitor Center designed by Charles Wright Architects in Australia and Cabins of the Sacromonte Hotel designed by MAPA Architects in Uruguay.
Source: www.dezeen.com/2013/03/11/; www.gooood.cn/sacromont-shelter-by-mapa-architects.htm

Metal materials have been widely used in architecture with the development of the industrial society, especially the use of steel in structures is a leap in the history of architecture. As for architectural interface, the relatively lightweight metal is often used for the realization of large-span roof in sports architecture. While the use of metal on facades of modern sports architecture is also very common, but most of them create an industrial and indifferent appearance for highlighting the power of the architectural form. In landform sports architecture that emphasizes form disappearing, metal materials need to be applied according to environmental characteristics. For example, the polished metal itself is dazzling but can reflect surrounding environmental elements, coordinate with landscape under the bright sunlight or be in harmony with lighting in the city at night. With the metal roof, Berlin Olympic Velodrome and

Swimming Pool have a slight luster which makes the sinking building look like a calm lake in the orchard. Thus, the building adds a natural and romantic atmosphere to the place. The unique luster of matte metal materials makes the building humbler. With different colors and textures of coatings and patterns, it can generate special appearances to simulate the environment. In particular, hollowed metal facades could reduce the integrity of architectural interfaces by transparency and create different light and shadow effect inside. For example, the facade of Barakaldo Sports Hall in Spain is made of hollowed metal panels, which makes the interface seem light like a veil.

Fig. 4-1-30: Metal Roof of Berlin Olympic Swimming Pool (Dominique Perrault)
Fig. 4-1-31: Hollowed Metal Interface of Barakaldo Sports Hall (Garmendia Arquitectos)
Source: www.uedmagazine.net; bbs.zhulong.com/101010_group_201810/detail10046501/

c) Innovative Material

A typical innovative material that can achieve the humble effect for landform architecture is the membrane. Limited by durability, polymer membrane has been considered as a cheap envelope material to be used in temporary buildings. In recent years, membrane has been gradually improved and it has got a place in architectural interface materials because of its flexibility, transparency and plasticity. Common membranes are PVC, PTFE, ETFE, etc. The use of lightweight membranes in sports architecture reduces the weight feeling of buildings and its good plasticity creates smooth forms, which are in line with the natural image that landform sports architecture wants. Meanwhile, the light transmittance of membranes provides natural light for sinking landform sports architecture. Similar new materials include polycarbonate. Roofs of Guangzhou New Stadium are made of polycarbonate panels. Three architectural volumes of the stadium look like three white clouds echo with the distant mountains. They create a poetic image. A sports hall in Latvia also uses polycarbonate as the envelope material, allowing the entire building to merge into the sky during the daytime and to be bright at night.

Fig. 4-1-32: Roof Interface of Guangzhou New Stadium (Paul Andreu)

Fig. 4-1-33: Envelope of a Sports Hall in Latvia (Substance)

Source: image.baidu.com; bbs.zhulong.com/101010_group_201810/detail10031962/

3) Texture and Color of Interface

a) Rhythm Creation

From the perspective of interface, the direction of environmental elements can be divided into horizontal and vertical. For example, the earth is horizontal while the trees and high-rise buildings are vertical. In an environment with an obvious directional feature, creating a corresponding feeling of direction for architectural interface elements is a way to promote the integration of architecture and the environment. In commonly used techniques, using vertical structure components to create the rhythm of the external interface not only matches the interface with surrounding environments like the woods, but is also helpful for creating an open architectural image. For instance, both Shenzhen Bao'an Stadium in China and Grand Stade de Bordeaux in France form a rhythmic and open facade through fine and dense structural columns. Although they are not in a typical environment with vertical elements and they never intend to be hidden like landform buildings, this technique certainly weakens their side interfaces and even architectural volumes. Another example is Comprehensive Training Hall of Winter Sports in China. The horizontal texture on the facade forms the same rhythm with the landscape, creating an integrated image.

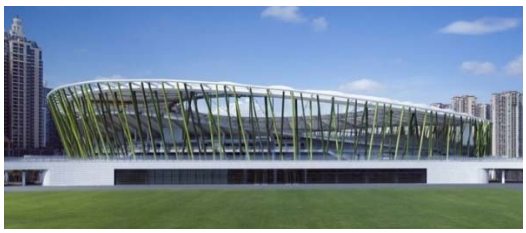


Fig. 4-1-34: Side Interface Shenzhen Bao'an Stadium (GMP Architekten)

Fig. 4-1-35: Side Interface of Grand Stade de Bordeaux (Herzog & de Meuron)

Source: www.gooood.cn/2011-universiade-in-shenzhen-baoan-stadium-by-gmp.htm; www.archdaily.cn/cn/767725


Fig. 4-1-36 & 4-1-37: Horizontal Interface Texture of Comprehensive Training Hall of Winter Sports in China
Source: bbs.zhulong.com/101010_group_201810/detail10050752/

b) Pattern Hollowing

Influenced by indoor physical environment or safety control, the interface of some sports buildings needs to be completely enclosed. Reducing the physical area of the enclosed interface and increasing the transparent area is an effective technique for optimizing landform architecture in this situation. The facade of large-scale sports architecture usually does not pursue complex material combinations, but pays attention to uniform texture effects. Therefore, for the interface hatched with repeated pattern, weakening the interface in a regular hollowing manner will not damage the visual integrity of the architectural interface but can reduce the visual weight of the interface. And this method is not limited by the type of materials, so it has wide applicability. Of course, applying this method to landform sports architecture to achieve the interface hiding effect needs to adjust the texture shape and the ratio of the physical and transparent parts according to the material's characteristics in order to get a better result. For example, Gymnastics Pavilion in El Retiro uses the metal mesh as the facade. This kind of pattern is dominated by the transparent part. When looking from a distant place, it is like a translucent façade. When looking from a very close place, the detail of texture can be felt. In Es Puigd'en Valls Sports Center in Spain, the hollowed facade is made of white bricks. Even though it does not make the building hidden because of the special architectural volume, it proves that the technique is feasible to reduce the weight of interfaces visually. It is possible to be tried in landform sports architecture.



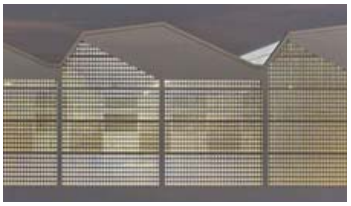


Fig. 4-1-38 & 4-1-39: Facade of Gymnastics Pavilion
Fig. 4-1-40: Facade of Es Puigd'en Valls Sports Center (MCEA Arquitectura)
Source: bbs.zhulong.com/101010_group_201810/

c) Color Matching

The color of landform sports architecture tends to be humble and simple. It usually shows the original color of the material directly and is not decorated with bright colors which are prominent in the environment. Through summarizing the basic colors on interfaces of typical landform sports architecture projects, the most common colors are green, earth-yellow, brown, grey, black, etc. These colors match with the natural environmental elements like tree, grass, soil and rock, as well as the urban environmental elements like cement, metal and sculpture. What is worth mentioning is that these common colors are suitable for landform sports architecture in most general areas. But in districts with special regional colors, it will be feasible and interesting to add reginal colors into the building for integrating it into not only the physical background but also the cultural context. For example, the building's color could be blue if it is near the ocean in Greece while the color could be red if it is in central town of Tibet. In all, the primary principle of color selection for landform sports architectural interface is matching with colors of the corresponding environment.

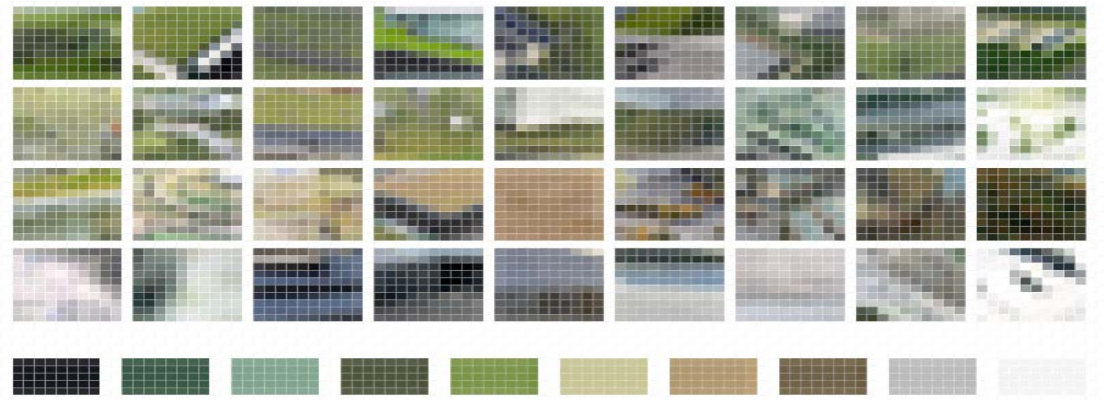


Fig. 4-1-41: Basic Colors on Interfaces of Typical Landform Sports Architecture Projects
Source: Elaborated by the Author

(3) Interface Between Environment and Architecture Design

The design of the environmental interface and the architectural interface is essentially the establishment of their boundaries respectively, while the design of interface between environment and architecture is the breakthrough of the boundary, which is necessary for the integration of architecture and the landform. Because generally buildings are built near the level of land, the principle of this kind of design is to create a flexible boundary in a vague or

transitional condition for the interface between the architecture and land.

a) Direct Connection: Create Vague Interface

In the case of direct connection, the techniques are mainly for creating vague interface to avoid direct and hard collision of architecture and the landform by connecting with buffering elements such as the slope and terrace. For example, when the roof of City of Jaca Hockey Arena attaches the ground level, a slope of ground in-between is created to make the roof seems like slowly extending to the land. Also, between Hill of Fame Stadium and the ground, the step part for entering each level of the stadium has been enlarged to become terraces, which enlarges and smooths the interface between the stadium and the ground.

Fig. 4-1-42: Interface Between the Roof of City of Jaca Hockey Arena and the Ground (Coll-Barreu Arquitectos)
Fig. 4-1-43: Interface Between Hill of Fame Stadium and the Ground (Studio 44)
Source: www.archdaily.cn/cn/627997; bbs.zhulong.com/101010_group_201810/detail10061235/

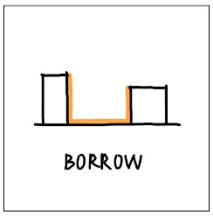
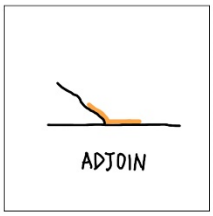
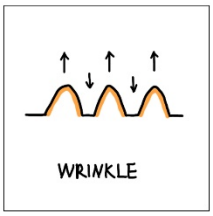
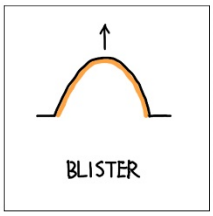
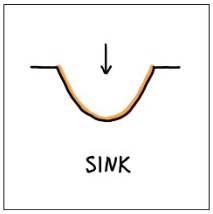
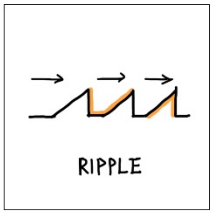
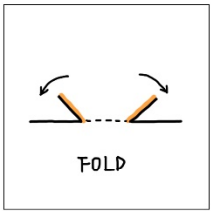
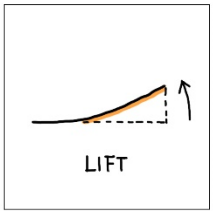
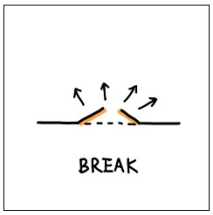
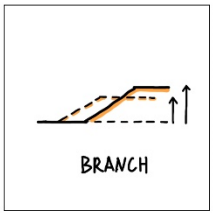
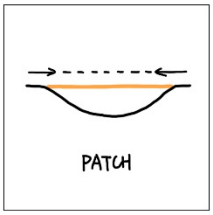
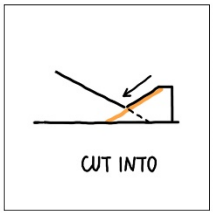
b) Indirect Connection: Create Transitional Interface

Indirect connection focuses on creating transitional interface between architecture and the landform by introducing a third element. This new element could be a void space generated by changing the shape of interfacing area, such as a side courtyard. And it could be a grey space such as an open corridor which is commonly used in architectural design.

The element could also be a component intentionally extended and transformed from architecture or the landform. Like Canadian Montreal Football Stadium, its folding roof is slightly overhanging to form a half-covered entrance plaza which weakens the interface connection, while the roof then slowly folds down and continues forward along the ground to become the audience stand for the outdoor football field. In this way, the simple interface relationship

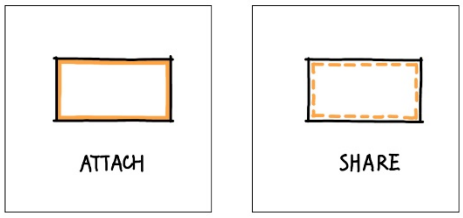
between the building and the ground becomes more complex and unclear by the extending roof. Similarly, the roof of Guangzhou Gymnasium for Asian Games is extended out flexibly to become the road connecting to the building and be merged into the ground in other directions. Besides extending architectural components to be the third element, the landform also can be extended when designing the landscape. To take Yangzhou Stadium as an example, in the interfacing area between the building's roof the ground, small hills which comply with the original landform has been introduced to form a connection between them. Therefore, the relationship between the building and the landform looks closer. Moreover, another technique is to transform the interfacing area between the architecture and the landform with the same feature on the interface of architecture and the landform. For instance, in Comprehensive Training Hall of Winter Sports in China, the architecture and the landscape have similar horizontal texture which transits naturally.

Fig. 4-1-44: Extended Roofs of Canadian Montreal Football Stadium (HcmaSaucier + Perrotte architectes)
Fig. 4-1-45: Guangzhou Gymnasium for Asian Games (GDAD)
Fig. 4-1-46: Landscape Connecting the Roof of Yangzhou Stadium and the landform (TUS-DESIGN Group)
Fig. 4-1-47: Landscape Interface between Comprehensive Training Hall of Winter Sports in China and the landform
Source: bbs.zhulong.com/101010_group_201810; map.baidu.com

	Interface Design Techniques	Notes
Environmental Interface	**Interface Utilization**  	It is suitable for sports buildings which are located closely near environmental elements which can limit space. Project No. 11 / 23 / 24 / 27
	Interface Deformation    	It is suitable for sports buildings whose environment dominants the site while the building needs to be hidden. Project No. 1 / 15 / 26 / 29 / 35 / 42
	Interface Reconfiguration      	It is suitable to be applied for a normal landform without special form features since these techniques can create new characteristics for the landform and generate limited space for buildings. Project No. 15 / 16 / 18 / 20 / 27 / 32 / 37 / 40 It also creates new limited space but needs to rely on original landform features. Project No. 16 / 24

Architectural Interface Form

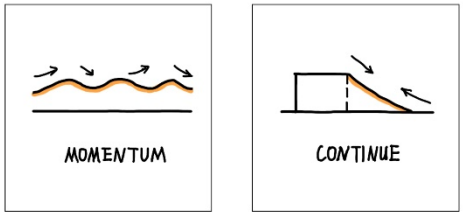
Comply with Environmental Interface



It coordinates with environmental interface design techniques.

Project No. 1 / 5 / 6 / 15 / 16 / 18 / 20 / 24 / 26 / 27 / 29 / 32 / 35 / 37 / 40 / 42

Change Actively to Simulate Landform

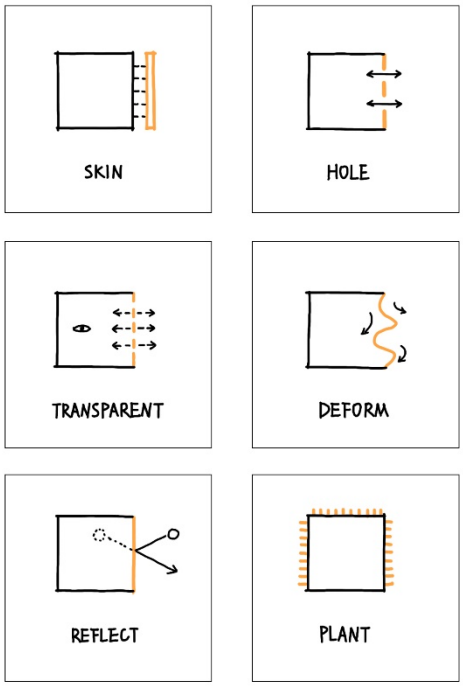


It is suitable for sports buildings in a site with common landform but has special environmental elements around.

Project No. 7 / 8 / 12 / 13 / 14 / 19 / 23 / 25 / 28 / 30 / 39

Architectural Interface Material

Material Selection



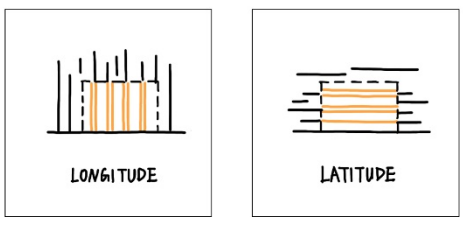
The primary principle of these techniques is to create light, transparent and flexible surface of buildings

Project No. 3 / 4 / 7 / 8 / 9 / 10 / 13 / 16 / 17 / 18 / 20 / 21 / 24 / 25 / 26 / 31 / 32 / 36 / 37 / 41 / 42

Color Matching

The primary principle for selecting colors for landform buildings is to match the environment's color.

Rhythm Creation



It is suitable for sports buildings in environments with elements in a same direction obviously.

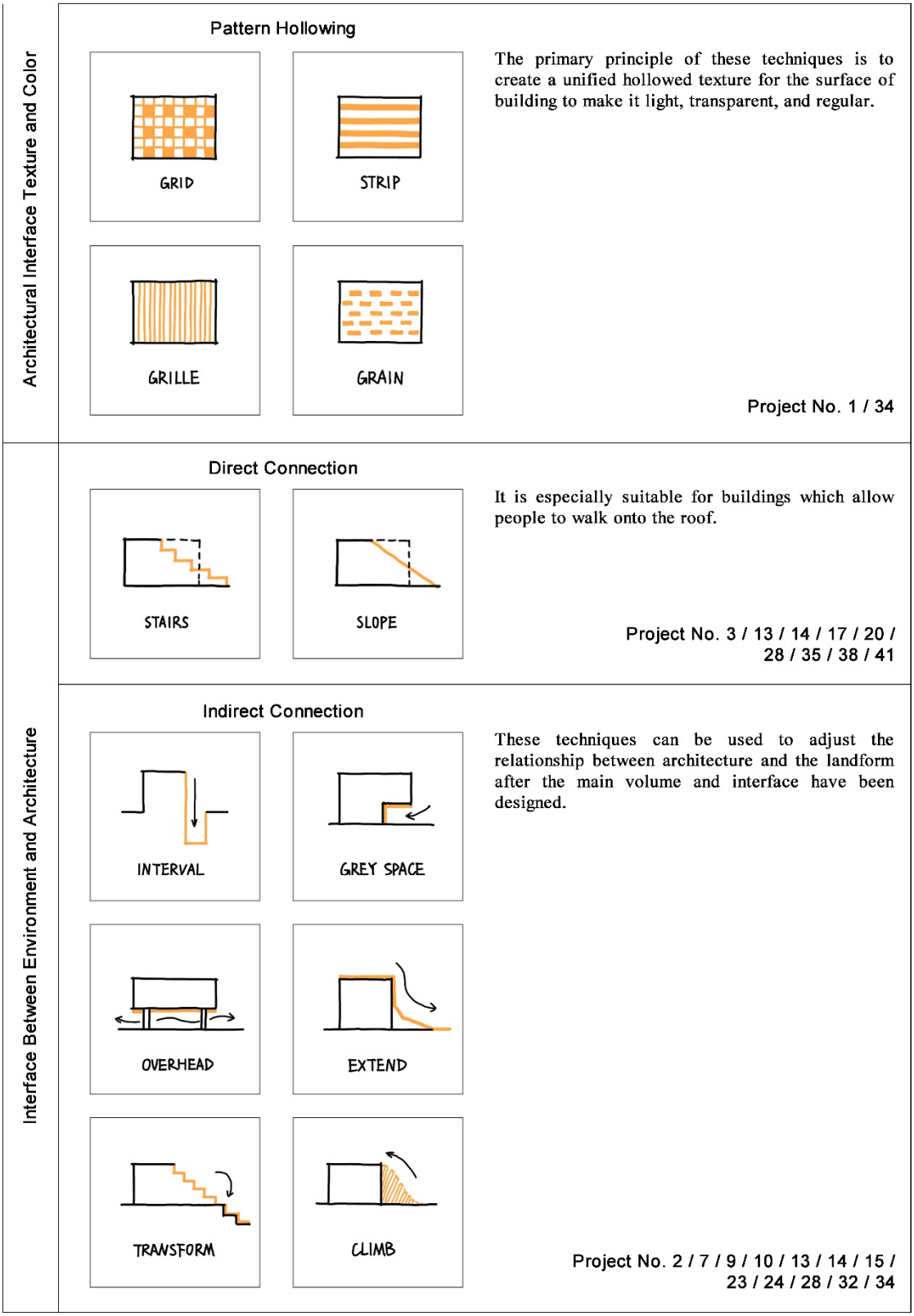


Fig. 4-1-48: Interface Design Techniques Lexicon

Source: Elaborated by the Author

4.1.4 Space Design

4.1.4.1 Strategy

In fact, the architectural form and space interact with each other. The special form brings special spatial experience while the placement of special space also affects the visual image of the architectural form. Different from weakening the form of landform sports architecture by volume design or interface design which mainly focus on the visual effect, to achieve the same goal by space design needs to pay attention to visual and experiential perception simultaneously. What needs to be illustrated is that the main object researched in this chapter is the form of landform sports architecture, so the space design discussed here mainly aims at space that will directly change the architectural form or affect people's perception of the form. Meanwhile, the main space of sports architecture usually has certain design paradigms and rules, so the space design here tends to discuss how the entrance space, traffic space and special experience space strengthen the integrated relationship between sports architecture and the landform. The design follows the following strategies.

(1) Strengthen Visual Extension

In the part of interface design, using spatial transition to blur the interface of the building and the landform has been mentioned. The transitional space extends the spatial condition of the landform into the building to create spatial interaction, extend the landform visually and enhance the influence of the landform. Thereby weakening the state in which the building occupies the site lonely.

(2) Enrich Form Perception

Space is an important medium for people to perceive architecture. Although the perception of architectural form can be achieved by vision, the design of space like courtyard and special traffic space can enrich the angle and approach for people to perceive the architectural form. Designing these kinds of space with the landform technique which relates to environmental elements will enhance the integration of architectural form and the landform in another dimension.

4.1.4.2 Technique

(1) Form Design of Necessary Space

1) Entrance Form

a) Natural Attachment: Create a Coherent Sequence

The entrance plays an important role in using a building conveniently. Due to the humble form, most landform buildings do not have a special entrance form, but only comply with the architectural form and is attached to a proper location of the building to meet the functional requirement. For landform buildings with a form that has a strong guidance, the entrance could be placed at the end of the circulation, allowing people to enter the building in a coherent sequence of precepting the architectural form. For example, Sanwayao Community Sports Center in China has an entrance at the upper end of the wide steps. People walk onto the upper level through these stairs and naturally find the entrance. Meanwhile, the architectural form gets a functional role as a traffic space.

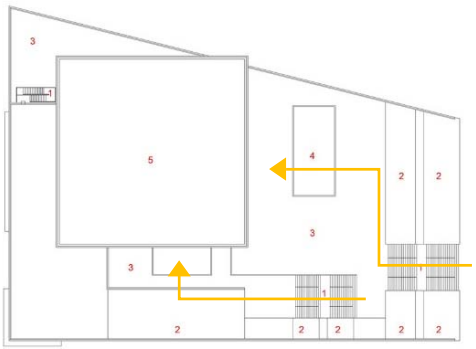


Fig. 4-1-49: Entrance Image of Sanwayao Community Sports Center (CSWADI)
Fig. 4-1-50: Diagram of Circulation to the Entrance of Sanwayao Community Sports Center
Source: www.archdaily.cn/cn/769553

b) Heterogeneous Intervention: Create a Clear Hint

The landform architecture presents a continuous and homogeneous state due to the topology of the form and the consistency of the texture, conveying a static and stable visual feeling. If a small part of heterogeneity is introduced into the complete volume, the vision will be attracted there and the original static condition will be changed since the heterogeneity becomes the focus in the homogeneous background. Applying this phenomenon to the entrance design of

landform sports architecture can highlight the position of entrance and bring clear hints of space and outside circulation to users. Like a gymnasium in Creps, side walls of the building are designed into slopes to connect the roof to the ground gently. But at the entrance on both sides, the edge and corner of the volume are purposely folded up and the color of components there are changed to be conspicuous. Of course, these changes break the unity of the building. Generally, in order to ensure the hiding image of the overall form of landform architecture and integrate it with the landform, it is important to pay attention to the coordination of heterogeneous elements with the environment. Maintain the morphological relationship between the main part of the building, the heterogeneity and the landform. Instead, to make changes in color, material or texture of the entrance. For example, in Antony Gymnasium in France, the external interface of the building uses stone materials which have similar texture with the ground to increase the stable image of the building and to integrate it with the environment. But at the entrance, the facade material is replaced with glass, thus the entrance is clearly indicated by the contrast of materials. And internal activities are displayed externally, which arises people's curiosity. while the entrance of Podčetrtek Gymnasium in Slovenia is highlighted with red color, which makes it prominent on the building with a dark color. Therefore, the recognition of the entrance is increased.

Fig. 4-1-51 & 4-1-52: Entrance of a Gymnasium in Creps (Laurens & Loustau)
Source: bbs.zhulong.com/101010_group_201810/detail10039538/

Fig. 4-1-53: Entrance of Antony Gymnasium (Archi 5)
Fig. 4-1-54: Entrance of Podčetrtek Gymnasium (ENOTA)
Source: bbs.zhulong.com/101010_group_201810/

c) Deep Guidance: Create a Clear Orientation

Landform elements like caves and tunnels are natural entrance forms due to the strong strength contrast and strong feeling of depth. Applying these kinds of natural forms to the landform building, the feeling of depth in the entrance space gives the building a smooth passage to communicate with the outdoor space, providing sufficient transitional space for users' psychological changes when entering the landform building. Water Temple designed by Tadao Ando is a typical case of this technique and it starts a special space experience from the entrance. For landform sports buildings, this technique is usually on ones that are sunken into the ground and covered by soils. For example, in Sport Center ETH Honggerberg, a downhill ramp is set at the upper entrance to connect the outdoor space with the first floor of the building. The entrance provides a clear orientation for users who is entering from the upper level. A similar application appears in Rock Stadium Proposal. The entrances for spectators on both sides are places in the gap space between the folding interfaces to form a visual attraction with a deep guidance to the stadium.

Fig. 4-1-55: Entrance of Sport Center ETH Honggerberg (Dietrich | Untertrifaller Architekten)
Fig. 4-1-56: Entrance of Rock Stadium Proposal (MZ Architects)
Source: bbs.zhulong.com/101010_group_201810/detail10057377/; www.archdaily.com/317267

2) Traffic Space

a) External Traffic Space as the Form Element

The use of traffic space in architectural form design is to incorporate the external circulation into the form design, so that the traffic becomes a form element and adds functional value to the architectural form. The large-scale sports architecture usually needs a large number of external traffic to meet the requirement of evacuation. These traffic elements are directly

exposed as part of the architectural facade. For example. The spiral ramps in San Siro Stadium leading people to the upper level is combined with structural columns to become striking vertical elements. Together with the evacuation ramps for people on different levels, these ramps constitute the horizontal texture. In landform sports buildings which have similar scale with San Siro Stadium, Hill of Fame Stadium Proposal also combines evacuation traffic on various levels with the transitional interface between the main volume of the building and the ground. This technique kills two birds with one stone. Korea Dalseong Gymnasium Proposal combines a cutting corner of the building with the traffic which leads people to the roof level. It achieves the connection between the ground and the roof. This technique is used in many large or well-known cultural buildings, and it makes sense for enriching the functionality of the architectural form, for presenting the open image of the architectural form, as well as for strengthening the connection between the ground environment and the architectural form.

Fig. 4-1-57: Hill of Fame Stadium Proposal (Studio 44)

Fig. 4-1-58: Korea Dalseong Gymnasium Proposal (Pedro Livni + Fernando De Rossa)

Source: bbs.zhulong.com/101010_group_201810/

Fig. 4-1-59: Shanghai Opera House (Snøhetta)

Fig. 4-1-60: TEK in Taiwan (BIG Architects);

Fig. 4-1-61: Water Temple in Japan (Tadao Ando);

Fig. 4-1-62: National Veterans Memorial and Museum (Allied Works)

Description: Four Cultural Buildings Which Use External Traffic as Architectural Form Elements.

Source: mp.weixin.qq.com/s/cHGYaKcilQ1sJ734CRCIOw

(2) Special Space Changes the Form

a) Courtyard Insertion: Break the Whole Volume

Courtyard insertion is a common design technique that enriches architectural space and changes the hard shape of the building. In order to ensure the integrity of sports venues inside the sports building, for buildings with multiple sports venues, venues can be dispersed and the courtyard can be inserted between the venues. Like in Texas Gymnasium Proposal designed by BIG, several sports venues are under the same large roof. And the roof is broken by eight inserted courtyards. Thus, the large building is visually divided into smaller volumes attaching to each other, which avoid people to feel the oppression from the huge building. At the same time, the technique increases chances of interaction between the building and landscape in the courtyard. As for building that only have one venue which cannot be divided, side courtyards are often inserted in the auxiliary function area. For example, Chofu City Gymnasium inserts a courtyard next to the main functional volume, which meets the need of lighting and ventilation in the underground space, and also increases exposed interfaces for the building, so that the building whose main body is buried in the ground presents an open image.

Fig. 4-1-63: Courtyards in Texas Gymnasium Proposal (BIG Architects)
Fig. 4-1-64: The Courtyard in Chofu City Gymnasium (Kume Sekkei Co., Ltd.)
Source: bbs.zhulong.com/101010_group_201810/detail31278023/; thetokyofilesmedia.wordpress.com

b) Special Volume Insertion: Partially Form Visual Attraction

Inserting courtyards is to change the form of landform sports architecture by means of subtraction, while highlighting special functional volumes is to form a visual attraction by means of addition. Like introducing a heterogeneous entrance mentioned before, this technique also has the risk of destroying the humble gesture of the building. Thus, when using this technique, it is necessary to think carefully about the new volume's form and try to integrate it with the

environmental elements. For example, in Putuo Fitness Center, a box containing a main sports hall is inserted directly into the sloping architectural interface. It is very prominent. Although it is visually attractive, it largely influences the relationship between the original architectural form and the ground. However, Aquatic Center in Alps is different. The whole building crawls on the mountain. On the building's roof, spaces for lighting and viewing are emphasized by arched volumes with sky windows. These small volumes are organically connected to the main body of the building. Thus, they do not seem abrupt, and also become windows of dialogue between architecture and the environment.

Fig. 4-1-65: Prominent Box on Putuo Fitness Center (TJAD)
Fig. 4-1-66: Sky Windows on Alps Aquatic Center (Auer Weber)
Source: baike.baidu.com; www.dezeen.com/2016/01/28

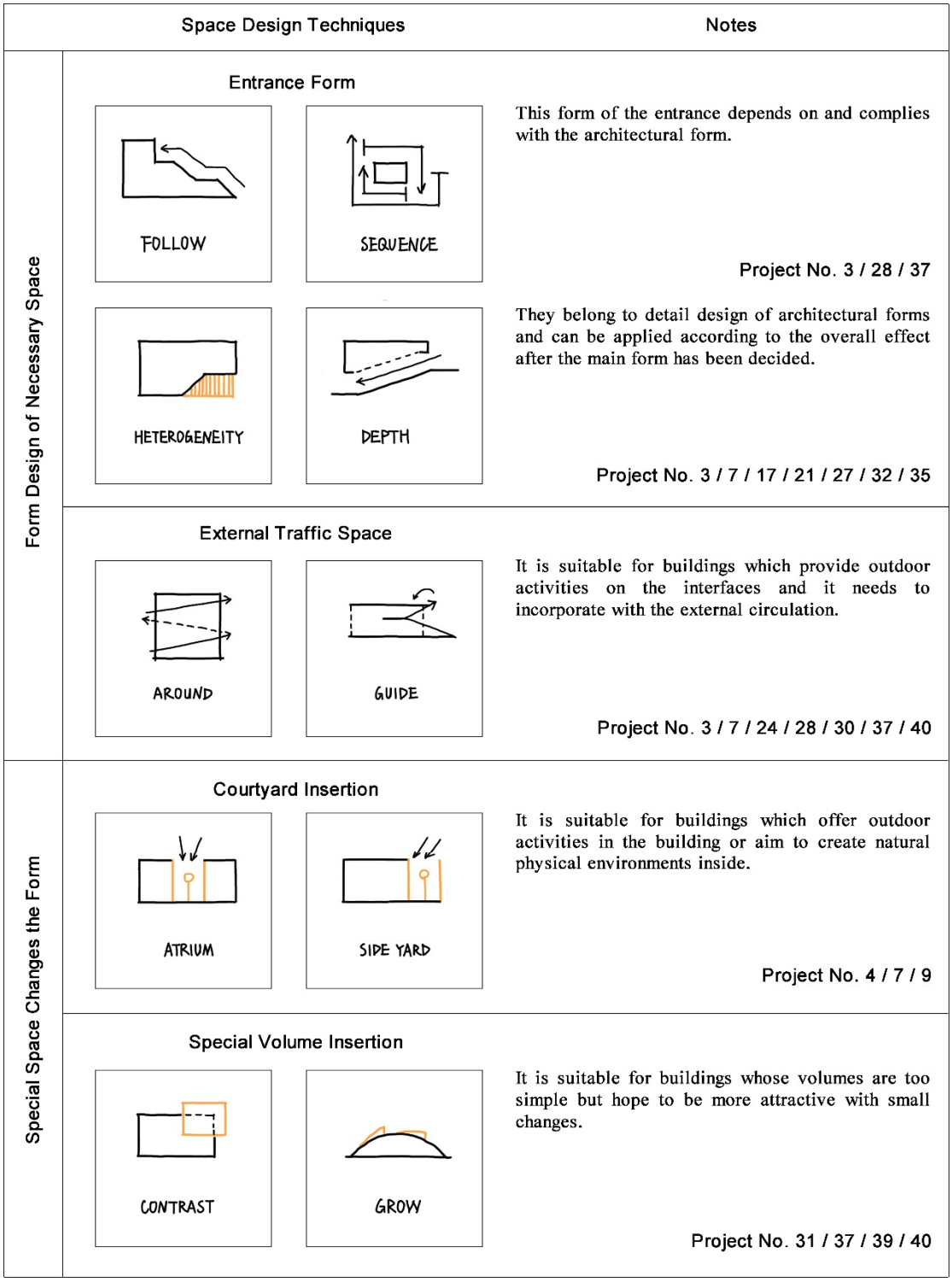


Fig. 4-1-67: Space Design Techniques Lexicon

Source: Elaborated by the Author

4.2 Functional Space Design of Landform Sports Architecture

4.2.1 External Functional Space

The external environment serves as an extension of the building as well as the connection between the building and the district. Its functional planning and corresponding spatial design have three aspects of meanings: the meaning to the building, the meaning to the corresponding site and the meaning to the larger background environment.

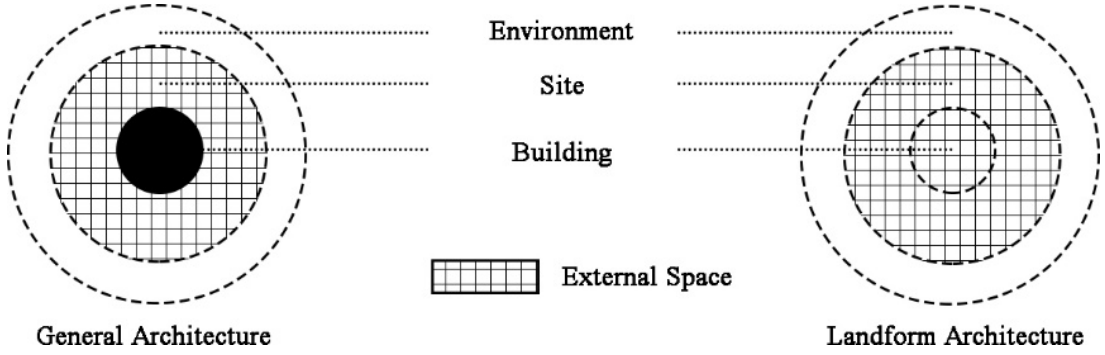


Fig. 4-2-1: Diagram of External Space Relationship for General Architecture and Landform Architecture
Source: Elaborated by the Author

For the meaning to the building. The landform architecture has the feature of blurring the interface between the internal and external space of the building. Thus, there is a natural advantage of integrating the building and its external space in the aspect of spatial form. Specifically, for landform architecture with a humble form, the spatial sequence and atmosphere formed in the external space announce the presence of the building. For landform architecture with a certain self-expression, the overall creation of environmental functions and atmosphere can increase functional and spatial dimensions to the form integration of architecture and the landform, which lets users feel the integration of architecture and the environment in more aspects. Especially for sports buildings which are open to the public, building a dynamic atmosphere inside and outside the building can make up for the humble gesture created by the architecture form. In this way, the functional value and influence of the building can be enhanced comprehensively.

For the meaning to the corresponding site. External functions and space provide people with different types of activity places. Danish famous urban design expert Jan Gehl simplified activities in public space into three types, necessary activities, social activities and spontaneous

activities. Among them, for social activities, in addition to daily communication among people, thematic events related to culture, commerce, entertainment and sports attract people to stay and participate in for a period. While spontaneous activities do not emphasize specific functions but need a free place. But the flexible functions are influenced by the atmosphere created by the other two types of activities. Because the function of landform sports buildings is relatively clear and the sites are integral parts of architectural forms because they are directly linked to the landform environments, the function design of sites should be considered in conjunction with functions in buildings. They can complement with each other for creating activities in different types. The functions and activities on the site can continue the sports function to create a professional sports place, or can be combined with other public functions to increase the complexity of the site.

For the meaning to the background environment. The background environment refers to the natural environment, urban environment and the artificial natural environment in the city where the site is located in. The functional positioning and spatial characteristics of the background environment influence and even determine the function of the architectural site and impose restrictions and requirements on its spatial design. Conversely, the external space in the architectural site is also the expression of regional characters and spatial features. It establishes the connection between the user and the background environment. Especially in the complex urban environment, designing the morphological relationship between the landform building and the landform of its site is only the first step to integrate the landform building into the urban space. the consistency and rationality of functions determine whether the landform building can be rooted in and contribute to the urban environment for a long time. These contributions include space, economy, life, culture, landscape and other aspects, which will guide the functional design of the landform sports building’s external space.

This section will introduce several types of design ideas of landform sports architecture’s external function and space. And to illustrate their advantages and limitations respectively by analyzing corresponding projects.

4.2.1.1 Continue with Sports Activities

a) Reflect the Openness of Landform Sports Architecture

From the perspective of continuing the internal function into the external space, the external

space with sports functions can reflect the functional openness of the landform sports building and play a role in hinting the internal function of the building. Like Street Dome in Denmark, the internal field and the external field are directly connected by the continuous landform. The open building acts as a shelter on the field, providing enough space for extreme sports and labeling the entire site with sports.

b) Create Outdoor Sports Space on the Site

Architecture usually provides indoor space that can shelter from the wind and rain. Except for outdoor stadiums, most gymnasiums, sports halls and swimming pools which are used for people's daily exercise and professional events aim to provide comfortable and professional indoor sports space, which is also in line with urban citizens' daily fitness habits. In fact, as we all know, outdoor and indoor sports both have their own advantages and disadvantages for people's health. Indoor sports are not influenced by weather and avoiding pollution is beneficial to the health of sports players, while outdoor sports provide people with a more natural environment. The supply of sunlight, oxygen and beautiful scenery is not only good for health but also help people to relax themselves. By providing indoor and outdoor sports spaces simultaneously, it is possible to provide a variety of choices for participants with different needs. A typical example is Sport Center ETH Honggerberg. In addition to the internal sports field, there are two volleyball fields, two tennis fields and a small football field on the top of the building or attached to the edge of the building's roof.

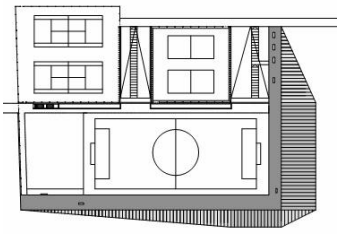


Fig. 4-2-2: Multipurpose Sports Field Inside Sport Center ETH Honggerberg (Dietrich | Untertrifaller Architekten)
Fig. 4-2-3 & 4-2-4: Photo and Plan of Outdoor Sports Space on the Top of Sport Center ETH Honggerberg
Source: Google Map; bbs.zhulong.com/101010_group_201810/detail10057377/

By distinguishing sports types for professional exercise and daily leisure, in Korea Dalseong Gymnasium Proposal, the internal sports function is continued to the roof with a free space for people to do some leisure sports such as yoga, aerobics, exercise dance and so on. In this

way, the external space not only complements the sports function for different purpose, but also shows the dynamic atmosphere of this architecture.

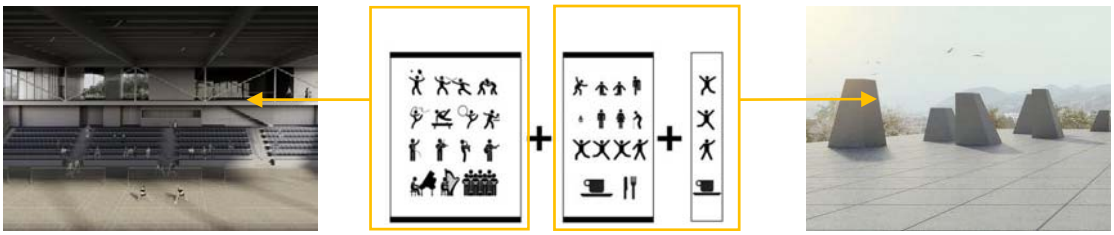


Fig. 4-2-5: Multipurpose Sports Field Inside Dalseong Gymnasium (Pedro Livni + Fernando De Rossa)
Fig. 4-2-6: Diagram of Different Sports Types Inside and Outside of the building
Fig. 4-2-7: Outdoor Sports Space on the Roof of Dalseong Gymnasium
Source: bbs.zhulong.com/101010_group_201810/detail10125375/

c) Expand Sports Activities to Background Environment

In addition to construct fields on the site out of the building, the special form of landform sports architecture adds innovative ideas to the creation of outdoor sports space on the landform which is integrated with the building. Specifically, for landform sports buildings that are built based on the environmental interface deformation and reconfiguration, the shape of the architecture connects with the shape of the landform smoothly, creating a natural place for outdoor sports such as running, skateboarding, extreme cycling that require smooth linear space. By connecting with the urban linear sports space like green ways, the external space of landform sports architecture has become the transition point and connection nodes of such outdoor sports in the city, expanding the value and serving range of the building.

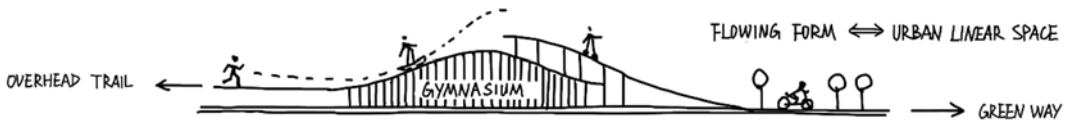


Fig. 4-2-8: Concept Diagram of Landform Sports Architecture Extending to Urban Sports Space
Source: Elaborated by the Author

4.2.1.2 Transit with Landscape and Leisure Functions

a) Provide Outdoor Entertainment Space for Landform Sports Architecture

Since landform sports buildings well integrate sports and the terrain landscape in form, it is very

common to provide the landscape function in the external space of the building. Meanwhile the social purpose of sports requires the internal and external spaces of the building to offer users places for leisure, entertainment and communication. Then the landscape space that combines the functions of leisure and entertainment naturally comes into being. Different from the internal professional sports venues, landscape leisure space is freer and closer to the public, thus it can become a good place for the public to take a walk with family, walk dogs and do other daily leisure sports. To take Ice Hockey Rink Proposal designed by BIG as an example, a part of the external space is designed into a sunken landscape plaza based on the natural topographic feature. It mainly has cultural and recreational functions. Every summer, the building's wall could be opened up to integrate the internal and external spaces into one continuous space which could be used as an outdoor landscape theater. At the same time, the external space also provides a place for people to have picnics and leisure communications, which gives full play to the landscape characteristics of the building's external space.



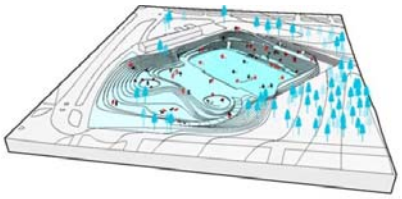


Fig. 4-2-9 & 4-2-10: External Landscape Space of Ice Hockey Rink Proposal (BIG Architects)
Fig. 4-2-11: Integrated Internal and External Landscape Space in Ice Hockey Rink Proposal
Source: www.designboom.com/architecture/big-architects-ice-hockey-rink-in-umea/

It is worth mentioning that this type of external space welcomes people of all ages. So it will be a good choose to add leisure sports facilities such as children's sand pits, amusement facilities, fitness equipment, running and biking trails to make it interesting and enrich functions of the landscape.

b) Create Theme Landscape Park on the Site

Creating a themed landscape park based on natural environment outside the building to increase the publicity of the site is a way to identify the site integrally.

In fact, there are some limits for this idea. If the landscape theme is too strong in the external space, it will make a clear distinction between the sports function and the landscape function,

which may decrease the integration of architecture and the environment from the perspective of functional transition. For sports buildings that serve large-scale events, their daily use frequency is relatively low. In daily life, although the theme park can become a gathering space and increase the fun of the place, the large sports buildings will become a disused land in the park, and then they cannot reflect the close relationship between the site and the landform architecture. Like Berlin Olympic Velodrome and Swimming Pool, the whole site is lifted up and the external environment of the buildings on the site was planned as an apple tree garden in the original design. With the hiding image of the buildings, the garden would become the main role and provide citizens a landscape park to enjoy their leisure time. But the sports buildings which are not always open to public would look like decorations in the park, thus their sports significance would become weak. However, in the real construction, there is no complete apple garden but just some apple trees dispersed on the site, creating the site as just an external green space for the building.

In comparison, this idea is more suitable for public sports facilities aiming to serve citizens every day. Based on the public's dual needs of the park experience and sports activities simultaneously, the relationship between the two functions is established through daily high-frequency public activities. Therefore, the themed landscape park becomes the front space of the sports building while the sports building becomes a surprising and highlighting spot in the themed landscape park. Like Chofu City Gymnasium which is a landform sports building located in a botanical garden. Since the gymnasium serves citizens with various sports spaces inside such as the swimming pool, fitness center, sport hall for table tennis and badminton and so on, people can go to play sports and enjoy the scenery in the botanical garden every day. The whole site becomes a leisure and sports place for urban people and the sports building becomes one of the landscape elements for people to stay in the garden.

c) Connect with Landscape in the Background Environment

The landscape leisure space essentially plays an important role in the high-density urban environment. The transition with landscape and leisure functions is for the transition between architecture and the site, and meanwhile for the transition to the urban landscape, making the external space of the building serves the architecture and the background environment simultaneously. For example, an underground sports center will be constructed in Zhengzhou, China. This sports center is located in an important station of the subway. By combining with

the station, this underground sports complex will be really convenient for people to come and play sports here. Since this site will become a significant node in the city, the above area has been planned as a sports themed urban landscape park to connect with the function of sports center and the space of urban environment. In this way, the large-scale landscape area no longer only serves for the sports center, but becomes a large open space in the background environment. Similarly, Munich Olympiapark in Germany also creates the whole site as a landscape park including some sports facilities for the city.

Fig. 4-2-12 & 4-2-13: Urban Landscape Park on the top of Complex Sports Center in Zhengzhou
Source: k.sina.com.cn/article_2716593467_a1ebed3b01900b5z7.html

In addition to the situation that the external space of the building is directly connected to the background environment as mentioned above, the establishment of their relationship can also be realized by visual echo. Like Kofun Stadium Proposal for 2020 Olympics, on one hand, the mountain-shape stadium creates its large roof as a landscape park in the city by planting on the surface. The shape of the site is not regular, which makes the roof park be connected with nearby landscape like green corridors and be organically merged into the urban context. In this way, it becomes a part of the landscape system of the city. Meanwhile, the height of the park provides a good viewing of the high-density urban image on the other side. The relationship between the architecture, site and city has been promoted by visual connection. The external space of the stadium makes the building and the city become a landscape for each other.

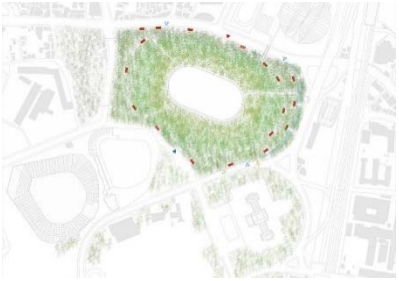


Fig. 4-2-14: Urban Background Environment of Kofun Stadium Proposal (DGT & A+ Architecture)
Fig. 4-2-15: The External Space of Kofun Stadium Proposal as a Park in the City
Source: k.sina.com.cn/article_2716593467_a1ebed3b01900b5z7.html

4.2.1.3 Implant with Cultural and Commercial Functions

a) Complement the Singular Function of Sport Buildings

The implantation of cultural and commercial functions in the external space of sports architecture is an effective way to improve the utility of single-function sports buildings from the perspective of increasing both economic benefits and activity types. For example, Daegu World Cup Stadium is located at the peripheral area of the city. In order to serve for people coming to participate in events in the stadium, an external site above the garage near the stadium is renovated to be a cultural center with exhibitions, entertainment, leisure and family activities. This cultural center is a sunken plaza with various functions around the central courtyard, and it is connected with the stadium through the underground path. With this center which the public always comes to have fun in their daily life, the external space of the stadium becomes dynamic even though there are no sports activities in the stadium.

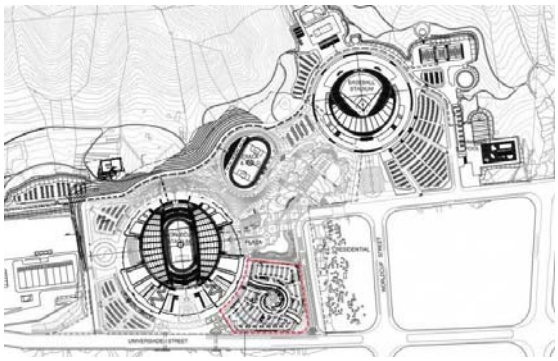


Fig. 4-2-16: The Cultural Center in the External Space of Daegu World Cup Stadium (Jerde Partnership)
Fig. 4-2-17: Location of the Cultural Center in the Sports Park
Source: bbs.zhulong.com/101010_group_201810/detail10064836/

b) Create a Public Life Center on the Site

Culture, sports and commerce almost cover all the people's daily leisure activities in contemporary society. There are countless examples of integrate culture, commerce and sports facilities to create a public life center. Many of these cases incorporate relevant functions in a complex building. Like Vango Sports Center in Shanghai, it is the first sports mall in China. It is a multi-functional sports complex which contains a variety of sports like fencing, swimming, cycling, dance, basketball, yoga, fitness, badminton and life services such as manicure, flower

art, café, restaurant and sports supermarkets.[11] The integrated functions provide a one-stop service place for the daily leisure life of the citizens, which is efficient and convenient. However, this kind of complex is large, and it is relatively difficult to be used in landform sports architecture with a humble gesture. Therefore, implanting cultural and commercial functions in the external space of the landform sports architecture by dividing them into several volumes is a way to realize the integration without changing the scale, function and form of the sports building itself, making the whole site a complex leisure life center. Zamet Center is a typical example. Functions like the library, community office, retail commerce and service space are integrated into the same site of the sports hall with a unified architectural form. Thus, the whole plot becomes a public life plaza and the multiple functions serve the public together to make this city plaza vibrant.

Fig. 4-2-18: Vango Sports Center in Shanghai, China
Fig. 4-2-19: Public Life Plaza in the External Space of Zamet Center (3LHD Architects)
Source: image.baidu.com; bbs.zhulong.com/101010_group_201810/detail10033689/

c) Create a Complex Area in the Urban Environment

Actually, through the combination of functions on the site, the influence of sports architecture is bound to be improved. But in order to become an important node of cultural, commercial and sports activities in the urban environment, it is necessary for the complex site to have a sufficient scale to increase its attraction. Like Stožice Sports Park, the external space of the stadium and the multi-purpose sports hall includes a large landscape park on the upper level of the site and a big shopping mall under the platform. Because of the large-scale complex functions, it becomes one of the major focal points of Ljubljana's urban life, attracting people of different interests and generation both during the daytime and in the evenings.

[11] Information from www.sohu.com/a/156897372_806068

Fig. 4-2-20: Rendering Image of Stožice Sports Park (Sadar Vuga + KSS + MYSI + OFIS)
Fig. 4-2-21: Section Drawing of Stožice Sports Park
Source: bbs.zhulong.com/101010_group_201810/detail10029025/

4.2.1.4 Combine with Refuge Functions

The sports building itself is often used as a resettlement site for disaster-stricken people in the city due to the gathering function generated by its large and open internal space. Aiming at the type of disaster risk in the specific region, making appropriate changes to the landform conditions to create a good place for refuge is a possible design idea to make the external space of the sports building which is combined with the landform carry more functions. Osaka Municipal Central Gymnasium is a good example. Because the space of the gymnasium is created by bulging the land surface into a hill, the top of the external space is higher than other places in the area, it is used as a tsunami refuge place as well.

4.2.1.5 Develop with Complex Functions

Operation after games is always an important challenge for large stadiums in the city. Garincha National Stadium which hosted games of the World Cup in Brazil has been degraded into a bus station due to operational problems. And Maracana Stadium was once the main venue for the opening and closing ceremonies of the World Cup. But now it has become a “wasteland”. Facilities have been damaged and stolen frequently. 10% of the 78000 seats have disappeared, and the TV broadcast equipment has all been stolen. Similar problems have happened after Olympic Games in many cities. It was reported by the foreign media “VOX” that the London

Olympic Park and the Olympic Village renovation plan ended in failure. And the Berlin, Athens and Munich Olympic Games also met the similar problems.[12] These situations are attributed to the poor operation which makes the utility frequency of the sports building too low to make ends meet. On the other hand, it is because of lacking of consideration in the early stage of design about the utility of the building after games. Specifically, the site selection is improper, the construction is isolated, the function is single and the place lacks popularity. Therefore, more and more stadiums start to consider the overall development of the site environment in the early stage of construction planning.

a) Complex Development with Urban Functions

In urban environment, one way is to combine multi-functional integrated spaces such as entertainment parks, concentrated shopping malls, theme restaurants, residents and special hotels to promote each other on the basis of spatial complexity and form an efficient urban district with the sports function. For example, in Madison Square Garden in New York, the stadium is built in on the transportation node. The leisure, entertainment, life, and commerce functions gather here. While the stadium adds cultural and sports facilities to the district, various functions in the external environment also drive the stadium to gain higher popularity and finally achieve a win-win situation. Another example is Huaxi LIVE Wukesong in China, which integrates the bar street, catering, entertainment, shopping and other commercial facilities in the external environment of the stadium to provide a new life experience consumption for the public participating in sports here.

Fig. 4-2-22: Complex Function on the Site of Huaxi LIVE Wukesong in China
Source: www.sohu.com/a/156897372_806068

[12] Information from www.sohu.com/a/156897372_806068

b) Complex Development with Sports Industry

Another way is to focus on combining sports-related functions and industries. Expanding the influence brought about by group buildings, sports parks, sports industrial parks and so on to form special themes and characteristics to attract popularity. Like Yangzhou Li Ning Sports Park, it introduces modern leisure sports such as rock climbing and trampoline on the basis of traditional sports activities. At the same time, it introduces relevant derivative functions such as sports training, health rehabilitation, catering services, etc. to the site, providing a complex activity space for the city. Moreover, a large number of people brought by the stadium promotes the consumption of derivative functions.[13] Thus, various functions on the site and the sports buildings support each other to improve the functional and economic efficiency. What needs to be mentioned is that for complex development of the external space of landform sports architecture, it is necessary to pay attention to the form coordination between buildings with different functions. The overall architectural form of the complex district needs to be controlled in order to avoid an indifferent collage image.

Fig. 4-2-23: Sports Industrial Park—Yangzhou Li Ning Sports Park (Australia PT Design Consultants Limited)
Source: www.treemode.com/case/1129

c) Complex Development with Local Characteristics

The complex urban environment needs various functions, so the overall development of the external space of sport buildings is diverse. However, the landform sports architecture in the natural environment faces higher requirements of protecting the natural environment, so the degree of commercial development in this kind of area is limited. Meanwhile, because of the

[13] Information from www.treemode.com/case/1129

location, it is impossible to attract so many people to come every day. The sports architecture needs to have a proper positioning based on these local conditions and limitations if combining with other functions to develop the whole site. For example, Aquatic Center in Alps positions itself as a leisure sports building which serves for tourists coming to relax the natural environment. so, it cooperates tourism functions such as hotels around to create a natural tourism destination.

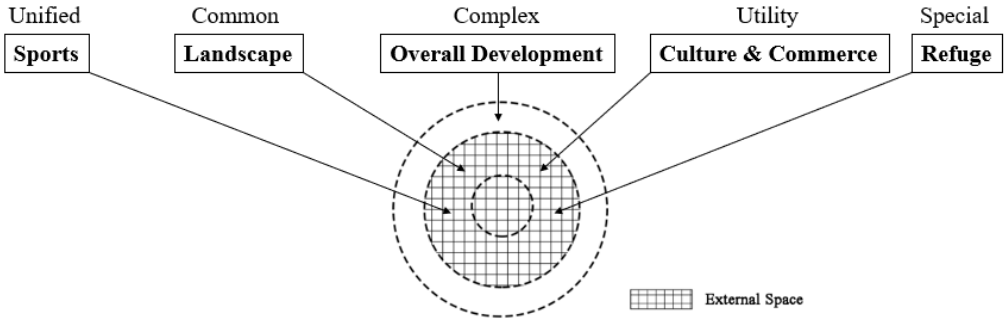


Fig. 4-2-24: Directions of Designing the External Function and Space of Landform Sports Architecture
Source: Elaborated by the Author

4.2.2 Internal Functional Space

Internal functional spaces are places where sports buildings provide people with activities. The rationality of the functional organization and the quality of space directly determine the convenience and comfort of use for the public. As a special type of sports building, firstly, the architectural form of landform sports buildings connects with the landform closely, and mostly they are sunken into the ground or partially hidden in the environmental elements, which brings difficulties for getting natural light and ventilation inside as well as evacuation. Secondly, the architectural form changes with the landform. It usually forms small-scale corner space that is not easy to be used, which challenges the organization of internal functional space.

4.2.2.1 Functional Space Organization Strategy

The sports buildings discussed in this research refer to public buildings mainly carrying sports activities. Generally, its main internal functional spaces include sports venue area for competitions and trainings, stand area for watching games and resting, and auxiliary area for logistics and equipment rooms. For conventional sports architecture, especially large-scale

sports architecture for professional events, the functional space organization is relatively fixed because of the restriction of regulations. The typical way: the sports venue is located in the center, the raising stand is around the venue, the space under the stand is combined with auxiliary rooms, the logistic rooms and upper audience hall are connected with the venue and stand by the traffic space located in different directions on different levels. For daily sports buildings that mainly provide fitness and sports place for the public, there is usually no special viewing stand are. The sports space and auxiliary space are arranged in a box-composition manner through necessary transportation links. Because the sports space is relatively large and high, it is often a single level volume, while the auxiliary space can be spatially superposed to form a multi-level space. Combining the two manners can help achieve intensive internal space. The space organization logic of landform sports architecture's internal space is similar to the conventional sports architecture. The specific change and limitation of functional space design brought by its special form will be considered carefully in the specific project. the differences in various landform environments and the different forms of the architecture make their functional space design techniques without clear versatility and regularity. By comprehensively analyzing the functional space organization characteristics of typical landform sports architecture, the following points are drawn at the strategic level:

a) Space Organization Fully Complies with the Flexible Shape of the Site.

The site of landform sports architecture is often connected to the landform closely, and its shape is usually irregular. By flexibly organizing sports spaces with regular shapes and auxiliary spaces without fixed shape, the internal space can make full use of the site shape and promote the unification of the architectural function and form.

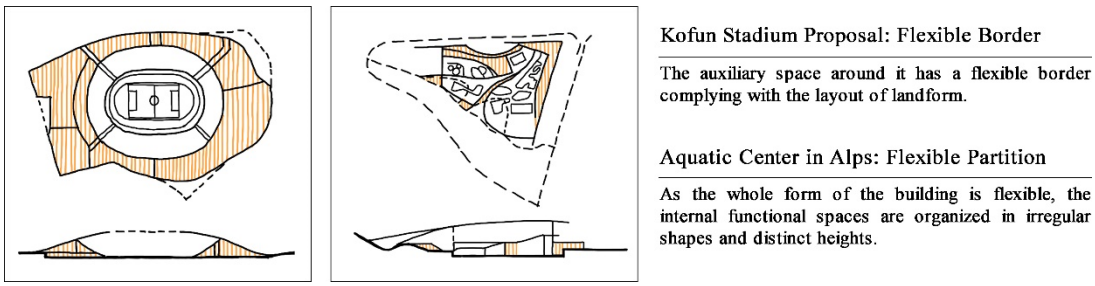


Fig. 4-2-25: Examples of Space Organization
Source: Elaborated by the Author

b) Space Organization is Partially Adjusted According to the Landform.

For landform sports architecture for professional events, the functional space organization could change partially according to the special landform, but needs to base on the standard and common ways. Like in mountainous landform, when the stadium is located in a sunken area, instead of placing auxiliary functions under the stand in conventional stadiums, the stand could be directly set on the slope to comply with the terrain. And for landform sports architecture which is totally hidden in the mountain, the internal organization can copy the conventional one except for adding traffic areas to connect the building with the external space.

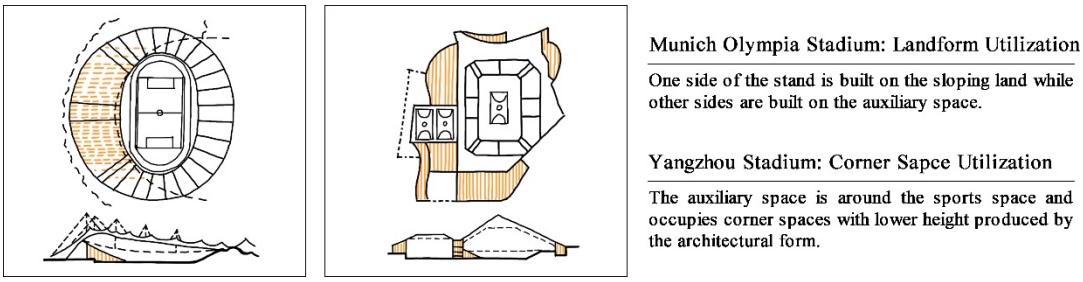


Fig. 4-2-26: Examples of Space Organization
Source: Elaborated by the Author

c) A Single Complex Sports Space Combines with Flexible Auxiliary Space.

It is a common way in sport buildings to design a venue for various sports by adding different signs on the ground and putting different facilities correspondingly. It has gadvantages for land intensive use. This method can be used in landform sports architecture to avoid the trouble of organizing large sports spaces and create more flexible space for the architectural form design.

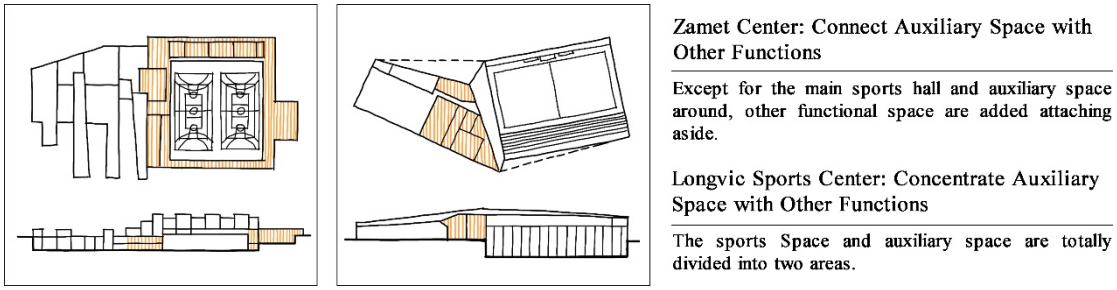
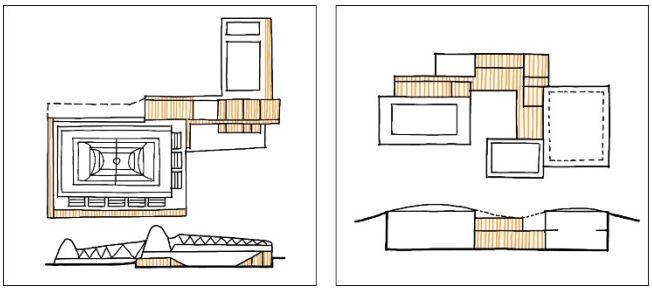


Fig. 4-2-27: Examples of Space Organization
Source: Elaborated by the Author

d) The Auxiliary Space Connects Several Dispersed Sports Spaces.

The horizontality nature of the landform sports architecture provides great flexibility for the plan design of the internal functional space. for landform sports buildings that require multiple sports venues, by dispersing those large spaces instead of superposing them, it will be easier to integrate with the earth form. And the auxiliary spaces which connect sports spaces can also serve for sports spaces in different directions at the same time, which improves spatial efficiency of the building.



Langreo Sports Center: Horizontal Composition

The auxiliary space connects three kinds of sports spaces and the height differences are reflected in the architectural undulating form.

Chofu City Gymnasium: Vertical Composition

The auxiliary spaces with lower height are composited vertically to match with the sports space with higher height.

Fig. 4-2-28: Examples of Space Organization
Source: Elaborated by the Author

4.2.2.2 Space Optimization with Light Environment

For the internal space atmosphere, the use of the landform design techniques such as volume sinking and interface covering often affects the natural lighting of the internal sports space and auxiliary space. In order to meet the needs of ecology and create a comfortable and natural sports atmosphere, choosing the right design techniques to introduce natural light is an important part of optimizing the internal space of landform sports architecture.

(1) Introduce Natural Light for Sports Space

a) From Top Interface

Introducing natural light from the top interface is a conventional mode of getting natural light in large sports architecture. This technique is simple and economical, and it is suitable for all type of venues with different scale except for the one whose volume and interface are completely hidden in the landform. In landform sports architecture, the conventional skylight window can be combined with the texture of the roof interface and form to create a more natural way for

getting light. Like in the Medellín Sports Coliseum, strips of the roof fold in different angles and shapes, while let natural light come in from the in-between space of strips. In addition, the translucent polymer materials mentioned in the interface design chapter can also be used to achieve roof lighting, like the roof in Guangzhou New Stadium in China. But since the applicable membrane is mostly white, it may be conspicuous in the environment, which may have a negative impact on the hiding image of the landform building. Meanwhile, applying top interface lighting should pay attention to avoid glare, and ensure the comfort of the internal sports space by adding louvers or filter materials.

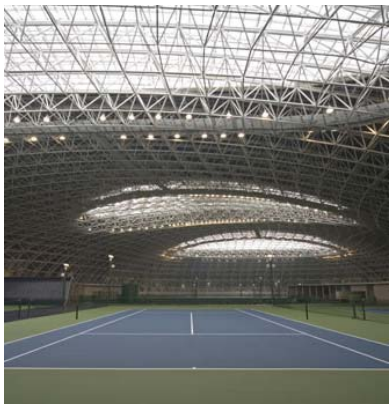


Fig. 4-2-29: Sky Window in Slowtecture M Gymnasium (Shuhei Endo)
Fig. 4-2-30: Side Sky Window in Medellín Sports Coliseum (Mazzanti Arquitectos)
Fig. 4-2-31: Polycarbonate Panels on the Top Interface of Guangzhou New Stadium (Paul Andreu)
Source: www.archdaily.com/6853; www.gooood.cn/

b) From Side Interface

In order to get natural light but avoid glare, high side windows and foot windows are usually set on the side interface. For landform sports architecture which is closely integrated with the landform, especially for small and medium-sized landform sports architecture, high side windows can be applied to get natural light, while applying the foot windows needs to make the building and the landform disconnected by adding side courtyard.

(2) Introduce Natural Light for Auxiliary Space

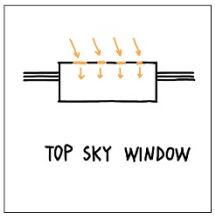
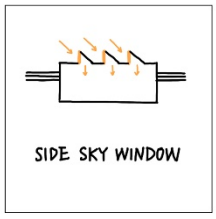
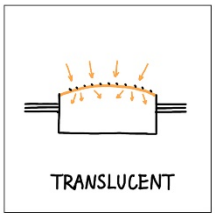
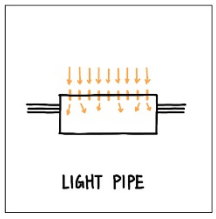
As mentioned in the previous section, the auxiliary space in the landform sports architecture is usually arranged on the same floor with the sports space, so its lighting is also influenced. For

the situation that the auxiliary spaces are concentrated on one side of the building, natural lighting can be realized with interfaces by the similar techniques for sports space. while for the situation that the auxiliary spaces are dispersed in the building to connect different sport spaces, it is necessary to add a courtyard or patio to achieve natural lighting. At the same time, the patio and courtyard can be designed combining with landscape to add interest to the space atmosphere inside the landform sports architecture.

Fig 4-2-32: Courtyard in Osaka Municipal Central Gymnasium (Nikken Sekkei)

Fig. 4-2-33: Courtyard in Yangzhou Gymnasium (TUS-DESIGN Group)

Source: Lu Shiliang. Embedment and Development-- Research on Sports Architecture Design Based on the Sinking Mode [J]. Journal of Human Settlements in West China, 2017, 32 (06): 21

	Design Techniques for Natural Lighting	Notes
For Sports Space	From the Top Interface	
	 	It is suitable for space with a large scale and the lighting efficiency is high. Project No. 4 / 7 / 12 / 13 / 17 / 23 / 29 / 36 / 39 / 41
	 	It is suitable for space with a large scale and the illumination is uniform and comfortable. Project No. 1 / 16

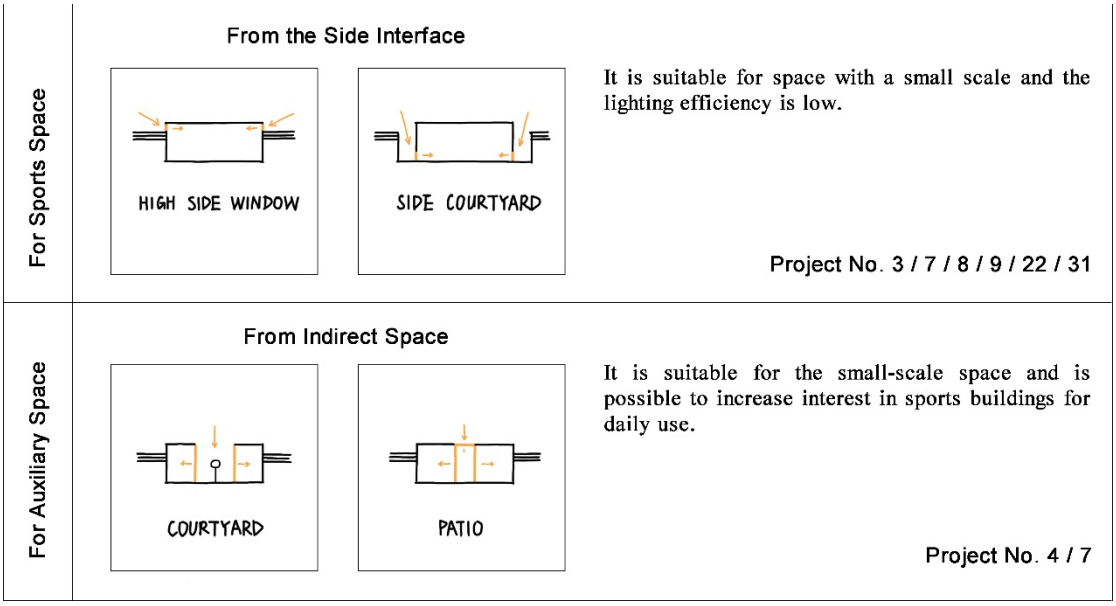


Fig 4-2-34: Design Techniques of Natural Lighting in Landform Sports Architecture
Source: Elaborated by the Author

4.2.3 Connecting Functional Space

4.2.3.1 Underground Space Connection in Cities

With the development of urban transportation, large cities in developed countries like Japan usually have a very complete underground transportation system, which links different places in the city and also links underground refuge space and reserved space. Generally, public buildings such as commercial complexes and office buildings use their underground functional space to connect with the transportation system to become nodes of the underground system, enhancing their accessibility. The sunken landform sports building forms a natural underground space interface, providing an opportunity for the building to be introduced into the underground system of the city. Professional large-scale sports buildings originally use entrances on the bottom level as the evacuation passage and the special entrance for participants. While the sunken landform sports building could extend out the traffic space through these openings to access the underground system. Moreover, combining other functions such as underground shops properly may increase the urban vitality to the closed traffic space.

4.2.3.2 Expand Vertical Connection in Urban Space

After the landform sports building is closely connected with the landform, a plurality of horizontal

interfaces such as a top interface, an intermediate level interface and a bottom interface are formed. Through utilizing and extending interfaces on different height levels, it is possible to establish connections with environments in areas with special landform conditions. For example, in mountainous cities, the multi-dimensional connection brought by expanding functions of architectural interfaces helps the building to hide in the environment. While for the mountainous city, this building can play the role of vertical transfer node. Thus, through the connection function of the architectural space, the vertical connection of the urban space is expanded. However, it should be noted that the impact on the environment requires the building to have considerable scale to achieve meaningful vertical communication. Although a regular-scale landform sports building may only have a certain significance in a small area, this idea can inspire architectural and environmental interface design to expand the function of traffic connectivity.

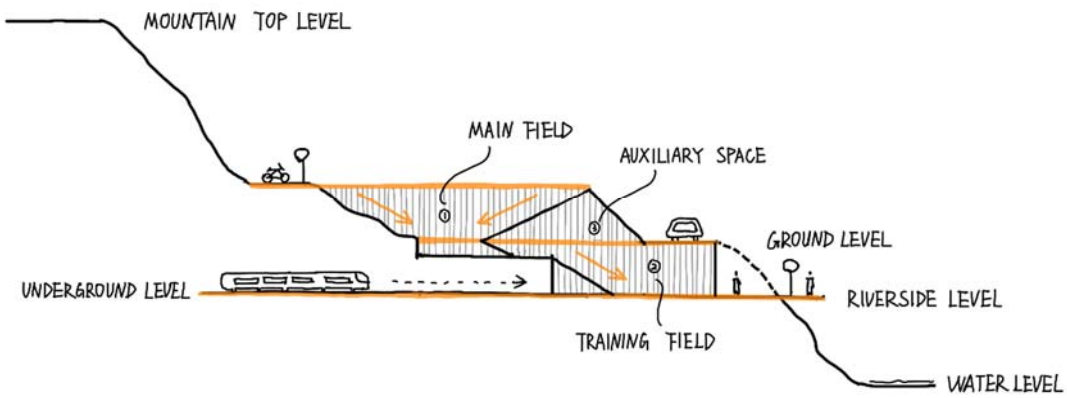


Fig. 4-2-35: Concept of Landform Sports Architecture as the Vertical Connection Node in Mountainous City
Source: Elaborated by the Author

4.3 Summary of the Chapter

This chapter mainly refines and summarizes the design strategies and techniques of landform sports architecture from two aspects of architectural form and functional space through the targeted analysis of typical landform sports buildings.

The architectural form design strategies and techniques are summarized from perspectives of volume, interface and space based on the principle that the building is visually integrated into the environment rather than highlighted. In terms of volume, the main strategies are to reduce size visually, break configuration visually and create association visually. Through specific operation techniques, the volume is integrated into or simulate the environmental elements. In terms of interface, this section analyzes the morphological changes of the environmental interface and architectural interface, the material and color selection of the architectural interface, and the special design techniques at the interface between the building and environment based on the strategy of create continuity visually, reduce weight visually and establish echo visually. As for space, this section analyzes and summarizes design points of special space that changes the architectural form, such as entrance space, traffic space and courtyard space.

For the functional space design, this section summarizes the advantages and disadvantages of the external functional space types in five directions cooperating with the landform sports architecture, and summarizes some points of the internal functional space organization strategies as well as the techniques of optimizing the internal space atmosphere by introducing natural light. At the same time, the connection function between the landform sports architecture, underground space and mountainous space in the urban environment is proposed.

Some of the strategies and techniques summarized in this chapter have been applied to the landform sports architecture project, while some them are extracted from landform architecture with other functions, but they can also be reference for landform sports architecture design. With the design lexicons provided in this chapter, in actual practices, designers can select and combine relevant techniques accordingly.

CHAPTER 5

Idea and Significance of Landform Sports Architecture in Milan

5.1 The Basic Idea of Landform Sports Architecture in Milan

As mentioned above, landform sports architecture in a suitable environment have advantages in aspects of landscape, openness, regionality, ecology and so on. Through creative architectural form design, function combination and space optimization, not only can it meet the special limitations and needs of various factors, but also expand the possibility of sports architecture design. Especially in the urban environment, because the relevant functions of sports are closely related to people's life, the needs of accessibility, convenience and practicability require the sites of sports buildings to be located inside the city as much as possible. And they are also required to be near communities, commercial centers, core districts and other densely populated areas. At the same time, the concept of nature and ecology has been developed and emphasized more and more in the increasingly compact urban space, which has caused limitations on the site selection of artificial facilities, especially large buildings. Therefore, seeking the combination of architecture and landscape becomes the trend and approach of artificial environment development in urban space. From this perspective, the discussion on landform sports architecture in the urban environment focuses on the functional expansion of the landscape infrastructure and also the innovation of the sports architecture form related to the landscape.

Italy has always been a famous and powerful sports nation in the world. From the historic

Roman Arena for traditional sports events to San Siro Stadium which serves for famous football teams, from Palazzetto Dello Sport of Rome which is well-known for the beautiful structure to modern Juventus Stadium, as well as a series of sports buildings which will be renovated and newly built in the future, they all show the large investment and good development in sports architecture in Italy. Meanwhile, gyms and sports halls also provide daily leisure sports venues and facilities for urban residents, laying a foundation for the development of Italian sports. Milan, the capital city of Italy, as an international metropolis with history, art and fashion, has many places for people to exercise. In addition to the large-scale sports and gathering places like San Siro Stadium, there are some sports centers and fitness centers scattered throughout the city. Together with leisure sports venues provided by parks and squares, they all offer convenient daily sports opportunities to people in Milan.

Fig. 5-1-1: Distribution of Gyms and Sports Centers in Milan
Fig. 5-1-2: Distribution of Parks, Green lands, Sports Fields in Milan
Source: Elaborated by the Author

However, based on the life experience and observation of life in Milan, as well as the comparison with daily sports life in other cities in Europe, it is found that although there are many sports places in Milan, they are mainly distributed in the way of points. Thus, sports often occur in specific places and lack flexibility, openness and consistency. One reason is the lack of coherent leisure spaces such as urban greenways and waterfront spaces in Milan's urban structure has largely restricted people's outdoor sports activities. Although it has to be acknowledged that people's tight and orderly working and living conditions in this modern time make indoor fitness in fixed locations more and more popular, and professional indoor sports

venues are also favored by urban people. But sports itself pursues the freedom of body, derives from nature and is close to nature. The positive and active condition of runners and cyclists along the canal and in the Parco Sempione always reminds us that if we create natural, safe, comfortable and open sports space in the urban environment, it will help promote the healthy urban lifestyle and integrate the positive lifestyle with the urban environment more tightly. In this way, sports not only become a type of fashion in Milan, but also improves vital atmosphere of the city. Based on this intention, the design and construction of sports facilities should tend to cooperate with the landscape and to connect with the urban space. Thus, conventional sports architectural forms that show iconic and independent images is not suitable, while landform sports architecture has corresponding advantages and becomes a type which may be applied. Even though this kind of sports architecture itself with a relatively humble gesture has limited influence to surrounding environments, more diverse, open and continuous leisure sports space for Milan could be created through the landscape brought by landform sports architecture and the flowing image of the attached landscape, and further enhance the vitality and quality of the city.

It should be noted that this idea is not a totally subjective assumption. The inspiration and support coming from the relevant background of Milan’s urban development route lead to the opportunity and condition for designing and constructing landform sports architecture in Milan, and it becomes a possibility that is worth discussing.

5.2 Background and Opportunity Analysis

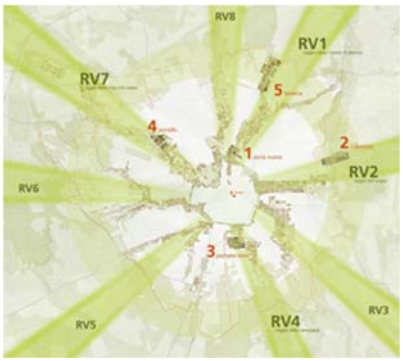
(1) Running for 2026 Olympic Winter Games expands the sports culture and provides opportunity of combining sports with urban sustainable development.

The process of Milan and Cortina d'Ampezzo running for 2026 Olympic Winter Games has just come to the end, and the result of the competition with Sweden has been announced on June 24th. Italy won this competition and will host Olympic Winter Games again in 2026. As the country that has hosted two Winter Olympic Games (the 7th Winter Olympic Games in Cortina d'Ampezzo in 1956 and the 20th Winter Olympic Games in Turin in 2006), Italy's proposal this time fully reflects the concept in *Olympic Agenda 2020*, like reducing the costs for running and hosting the event, paying attention to sustainable development and humanity, improving credibility and so on. The Olympic Games have always had an important impact on the development of the city and the establishment of its international image. From the perspective of guiding principles, the Olympic Games in the future will not only highlight the power of the host city by strengthening the professional service of the event itself, but also hope to pass on sports spirit, culture and value to the public, as well as to improve the sports atmosphere for the long-lasting significance of the Olympic Games in the host city and even in the country. That is to say, the Olympic Games in no longer just a springboard for promoting the international status of a country or city, it is also a good opportunity to build sustainable sports facilities to help create a multi-faceted and inclusive sports life, and then effectively enhance the city's vitality in more aspects.

In the document of Milan and Cortina d'Ampezzo running for 2026 Olympic Winter Games, it is mentioned that one target of hosting the event is to inspire Olympians/Paralympians of the future and promote sport at all levels, using sport and physical activity as the catalyst to change lives. Hosting the Olympic Winter Games will help deliver a range of sporting legacies, using the inspirational power of sport and events to transform lives. These legacies includes: ① Improvements to sporting infrastructure and places for sports participation, training and competition; ②Social and health benefits attributed to increased participation in sport and physical activity, or involvement in sport in other ways, such as coaching, officiating or

volunteering.[14] It can be seen that from the perspective of economy, the construction of large-scale professional sports venues may be few, but Milan will pay attention to improve sports infrastructure and places for people in the city, and to enhance the public participation of sports activities. So to speak, this intention brings opportunities for Milan to build more open and flexible sports architecture for public. At the same time, the relationship between the advantages of urban development in Milan and the concept of running for the Olympics has been pointed out. It is mainly reflected in *Milano 2030 Urban Development Plan* which emphasizes sustainability with the purpose of creating a green, livable, resilience city. Specifically, it is planned to construct a city-wide metropolitan park by connecting the Northern and the Southern parks, through the so-called 'Environmental regeneration areas'. These areas include the seven abandoned railway yards (among which the Porta Romana site hosting the Olympic Village) that will be regenerated to host seven new parks completed with new residential housing and other community services.[15] Thus, after the election is successful, the related construction of Olympics will take the improvement of the sustainable urban landscape system proposed in the plan into consideration, and it is a possibility to combine them. In this way, to lay the foundation and provide background support for the practical application of landform sports architecture that emphasizes the combination of architecture, landscape and sports.

(2) The development of "Green Rays" project provides a systematic and continuous landscape infrastructure for leisure sports.



"Green Rays" project is an urban development model developed in Milan proposed by Andreas Kipar, which proposes significant ideas for the landscape system in Milan. The application of this model has been started, developed, stagnated and continued for several turns, and its core connotation has been continuously affecting the urban planning development in Milan.

[14] Excerpted from Milano Cortina 2026 Candidature Dossier (Pocket Edition) P11.

[15] Excerpted from Milano Cortina 2026 Candidature Dossier (Pocket Edition) P17.

This model derived from the condition Kipar saw when he arrived in Milan in the early 1980s that the urbanization had yielded to the dictates of the industry while little attention had been paid to leisure and entertainment activities like most post-industrial cities at that time. This situation led to Kipar's idea about creating a landscape system in Milan and the "Green Rays" project was officially proposed by Municipality of Milan Area Development of the Territory and the Furniture Sector, Urban and Green Decor in 2006. The main content is to create eight long cycle routes from the city center to the suburb. It is a new network of pedestrian and cycle paths that enriches the urban fabric with greenery: this is to improve the movements in the city and the daily life of all citizens. Specifically, the "Green Rays" will be linear spaces shaded by thousands of trees, where it will be possible to walk, idle, run, ride a bike and simultaneously enjoy the greenery already present and planned in the urban area: gardens, squares, neighborhood parks and so on.

However, affected by the funding problem, the process of this project has been hindered for several times. In order to achieve it, the relevant departments began to seek support from the construction of urban projects along the "ray" lines. They tried to exploit the urban transformation plans as much as possible in order to force the private investors and builders in the city to realize parts of the beams at zero cost for the administration. For example, they tried to create the seventh ray with the aid of Portello which is an established project with green landscape. And the route that connects the Arco della Pace with the Portello area will be achieved through the construction of the urban project at City Life. Unluckily, since it is a hard process, the whole "Green Rays" project has not been finished so far and only a little part of it is realized.

Although the "Green Rays" never became a reality (only two were actually developed and only partially), the core thinking that originated them is clearly taken into account in the Milan 2030 Territorial Plan, presented last year and now approved. Because the what makes the Milan 2030 plan revolutionary is not so much the dramatic increase in green areas but the desire to turn nature into an infrastructure and a system. Besides new parks, there will be a single large metropolitan park connected. The urban area will then be equipped with a green belt that will be born from the transformation of the railway stations.[16]

[16] Partly excepted from www.designatlarge.it/milan-design-green-lanscape-future/?lang=en

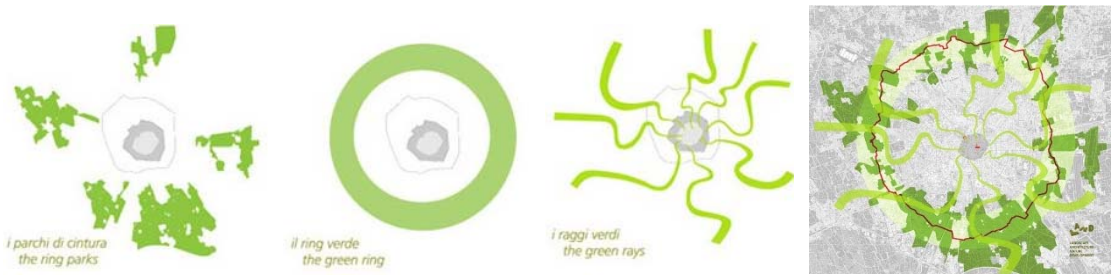


Fig. 5-2-1: Landscape System Proposal derived from “Green Rays” project in Milan
Description: The landscape system is composed by parks, rings, rays to connect the whole city.
Source: www.archilovers.com/projects/17999/un-raggio-verde-per-milano.html

Therefore, in the plan, in addition to the existing individual leisure landscape areas such as parks, the landscape system has been emphasized. It is undeniable that the landscape system itself, as an infrastructure, naturally has a strong combination with leisure, entertainment and sports activities. So, the inclusion of sports places in this continuous landscape system will be possible to promote the construction of coherent and open urban sports space. In concrete operation, sports fields and facilities which highly combined with the landscape could be constructed at the node of the system and various sports elements could be added into the linear space in the system to create “green rays”, “green loops”, “green connections” composed with sports theme based on the landscape plan. In this way, the construction of landform sports architecture which is integrated with urban landscape in the system not only provides natural and convenient sites for sport architecture in the compact urban environment, as well as gives the landscape system more complex functions, but also brings significance to the creation of urban sports space continuity.

Fig. 5-2-2: Concept of Sports Nodes and Connections in the Sports-Landscape Integrated System
Source: Elaborated by the Author. Pictures from www.pinterest.com and www.baidu.com

(3) The renovation of abandoned railway yards as starting development nodes in the landscape system could provide experimental sites for landform sports architecture.

It has been mentioned that in the development plan for the urban landscape system in the Milan 2030 Territorial Plan that seven abandoned railway yards (Farini, Porta Genova, Porta Romana, Rogoredo, Greco-Breda, Lambrate and San Cristoforo) will be important development nodes. The renovation design of them has attracted much attention in recent years. Discussions and competitions about Scali Milano have been carried out for several times, and many design companies and teams proposed ideas from different angles. Among them, there are some discussions about the transformation of railway yards combined with culture, life and the landscape system, which want to create centers for attracting young people and provide them with meeting places, to encourage healthy lifestyles through sports and games, to provide a variety of functions that are closely integrated with the landscape system, to enhance the connection between urban areas with public functions, and to create a humanistic and livable public space, etc. These ideas greatly encourage the combining development of sports space, landscape and city. It is therefore possible to renovate the railway yards into the landscape infrastructure and to add into sports facilities. In the following part, these railway yards are selected as experimental nodes for constructing sports architecture in the sports-landscape integrated system. They will be examples for putting forward the idea and significance of designing landform sports architecture in the urban landscape system by comprehensively analyzing site factors and concepts of existing proposals.

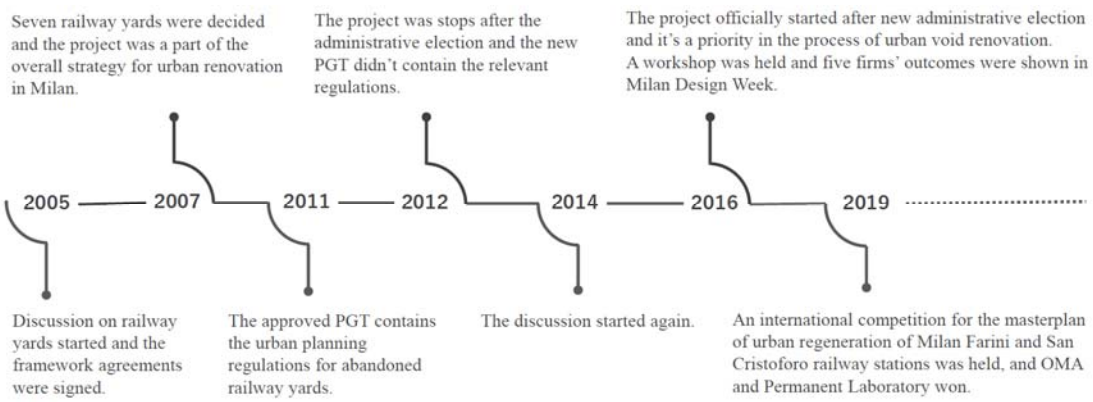


Fig. 5-2-3: Timeline of the process of Scali Milano Project
Source: Elaborated by the Author

5.3 Overall Vision

Fig. 5-3-1: Overall Vision Sketch Map of the Sports-Landscape Integrated System Structure in Milan
Source: Elaborated by the Author

Based on above background, to integrate sports functions into the landscape system of Milan, one aspect is to improve the connection of urban landscape spaces and sports spaces like existing parks, green lands, sports centers, sports fields and so on by linear and continuous sports elements such as green tracks, bike lanes, sports creeks, riverside running spaces, etc. Another aspect is to create landform sports facilities in the nodes of the landscape system like natural parks, normal woods and landscape squares to be as catalysts which serve for surrounding citizens and also people coming through the continuous system. Therefore, cooperating with urban landscape planning of Milan which provides the framework of the system and Scali Milano project which provides nodes of the system, the overall vision of this sports-landscape integrated system structure could be formed.

5.4 Idea of Combining Landform Sports Architecture with Scali Milano

5.4.1 SWOT Analysis of Combining Landform Sports Architecture with Scali Milano

(1) Strength:

- The railway stations are naturally systematic because of the connection through railways, which could a basis of creating continuous sports space.
- Since the abandoned railway stations are distributed in different directions, sports buildings built there could serve for residents living in different parts of the city.
- Like the example of City Life project, Scali Milano project will be carried out by different companies with many programs, which could help solve the investment problem for the government to achieve the landscape system as well as to form the sports system simultaneously in Milan.

(2) Weakness:

- The positioning of these sites is not mainly about sports. If sports architecture with such a humble gesture is added into, it may be ignored.

(3) Opportunity:

- The Scali Milano project is a part of creating the landscape system of Milan, so the new landscape in railway yards will provide good sites for constructing landform sports architecture which is integrated with the landscape in the compact city.
- With the remaining railways which are in use and new public transport which will be built nearby, the site will be easy to reach and the sports architecture can serve for more people.

(4) Threat:

- Some parts of the original sites of the Scali Milano project are railways. If they are protected in the perspective of maintaining historical marks, there may not be enough space for building sports architecture integrated to the landscape.
- The remaining railways which are in use separate the site and limit the utility efficiency of sports architecture built on one side.

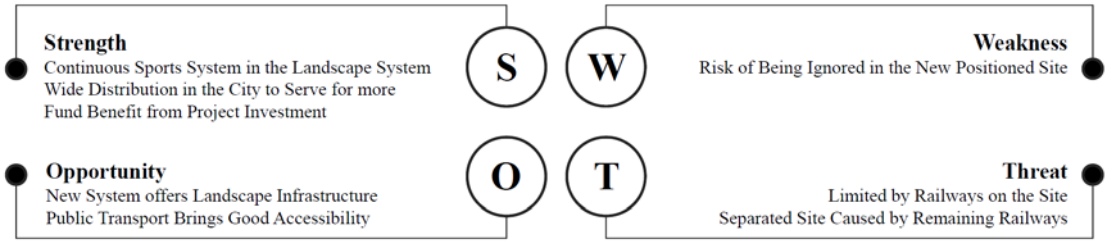


Fig. 5-4-1: SWOT Analysis Summary of Combining Landform Sports Architecture with Scali Milano Project
Source: Elaborated by the Author

According to the above SWOT analysis, some principles for designing and constructing landform sports architecture in renovated railway yards are proposed in order to make use of strengths and opportunities, as well as to deal with weaknesses and threats.

- Make use of track continuity to strengthen connection between sports architecture in different sites and establish leisure sports system.
- According to actual situations of the environmental conditions, distribute sports architecture with different scales and types into each site.
- Find the combination of sports architecture and renovated areas to improve efficiency and value of the sports architecture.
- Intervention into landscape does not undermine the integrity and continuity of the system.
- Rely on the surrounding public transport, especially the new connected routes which rely on the railway system.
- Improve the accessibility of sports architecture by establishing links across railways between public buildings on both sides of railways.
- Establish relationship with the historical railways.

5.4.2 General Idea and Proposal Related to Scali Milano Project

In the discussions and competitions of Scali Milano project, the most notable ones are the systematic designs with the themes of connection, life, culture, green and source proposed by five firms in the Milan Design Week 2017, and OMA and Laboratorio Permanente's winning masterplan of Farini and San Cristoforo railway yards in the international design competition

organized by the Municipality of Milan in collaboration with RFI. These proposals have their own characteristics and it is hard to give a certain judge on their quality. But all of them aim to trigger the formation of the landscape system and the creation of comfortable urban life in Milan through the renovation of abandoned railway yards. Using these proposals as experimental sites with different types and themes for designing and constructing landform sports architecture in the planned landscape system of Milan is an opportunity for testing the feasibility of combining landform sports architecture with Scali Milano Project under the background of different development concepts.

5.4.2.1 Experimental Site 1: “Historical Future” Proposal in Farini Designed by MAD Architects

This experimental site belongs to a new, flowing and sustainable infrastructure for the whole system. The whole project aims to renovate the old site with a strong sense of future and think about station nodes with the trend of development. The Farini site is regarded as a new central business district and is organized as a topographic civic landscape which could reconciles the congestion of the inner city with the tranquility of a rural environment. Thus, three “villages” with a special layout and a large warehouse have been combined and inserted into the center of the new park transformed from the abandoned railway yard while mixed-use towers and social housing developments sit in dialogue near the boundary of the site.

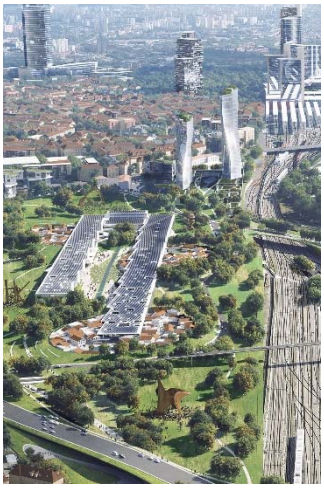


Fig. 5-4-2 & 5-4-3: Proposal in Scalo Farini Designed by MAD Architects
Source: www.designboom.com/architecture/mad-architects-scali-milano-masterplan-historical-future-milan-design-week-04-10-2017/

The original site in Scalo Farini is located in the northwest part of the city. It is a connection zone of an educational district and the new central city. There are many communities around the site and it is close to the exhibition area, the ancient castle park, the central station, the commercial center, the cemetery, Chinatown and other important areas in the city. So the functional environment of the site is relatively complex. However, the railways limit the connection of the north and south side of the site, which blocks the penetration of the prosperous urban atmosphere in the south part to the north part. Since the site has been positioned as a new CBD district in the proposal, besides constructing enough office buildings with good quality, attracting people to come through complex functions will drive its development. Meanwhile, because of the value of the CBD area, it is better for the landscape to be as infrastructure and be integrated with other functions to increase its efficiency in such a golden area. Therefore, designing and constructing landform sports architecture there is possible and reasonable.

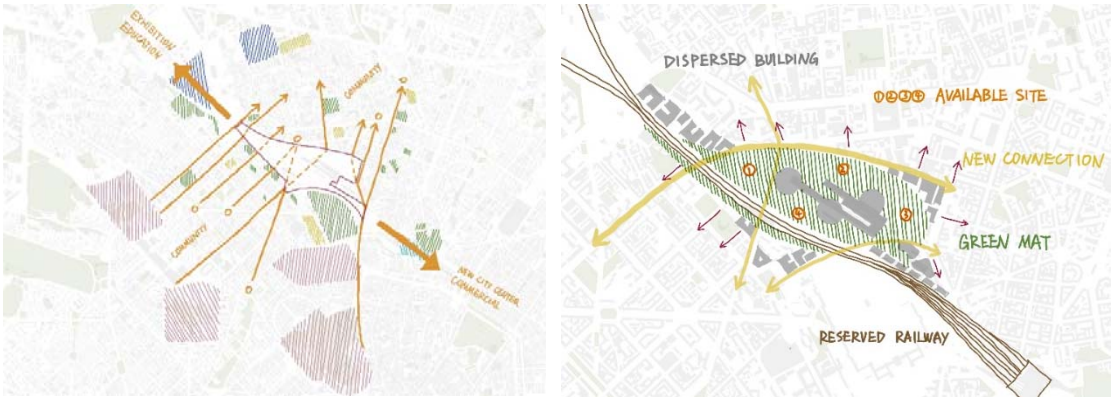


Fig. 5-4-4 & 5-4-5: Site Analysis of the Inside and Outside Environment
Source: Elaborated by the Author

Site Condition Keywords

Connection / Complex / Future CBD / Penetration Limit / Surrounded and Dispersed

Concept Proposal

In the urban design, the new buildings are scattered at corners of the site, and most of the main area is covered with free and green landscape, which looks like a green mat covering on the old railway yard and beginning to be decorated with future buildings. The form concept of the landform sports building placed in the site is “dance of green mat”. It expresses the dynamics

of sports and the flexibility of landscape interfaces simultaneously. By adopting the interface design techniques of landform buildings, the edge of the green mat undulates to form new space, which transforms into the indoor gymnasium or limited space for outdoor sports fields. The main opening of the building faces the linear sports space transformed from old railways in order to join into the sports-landscape integrated system of the city. Since the building is close to the new trails which could become part of the continuous tracks in the city, and the whole site is important and convenient for people to come, this sports building could become a starting point of big events like marathon in Milan. Moreover, the sinking sports building uses the underground interface to connect with the sunken “village”. Thus, it not only forms a sunken yard for the sports building to get natural light, but also better connects with the existing buildings in the site, so that different functions and activities can serve for each other more closely, creating this site into a complex center.

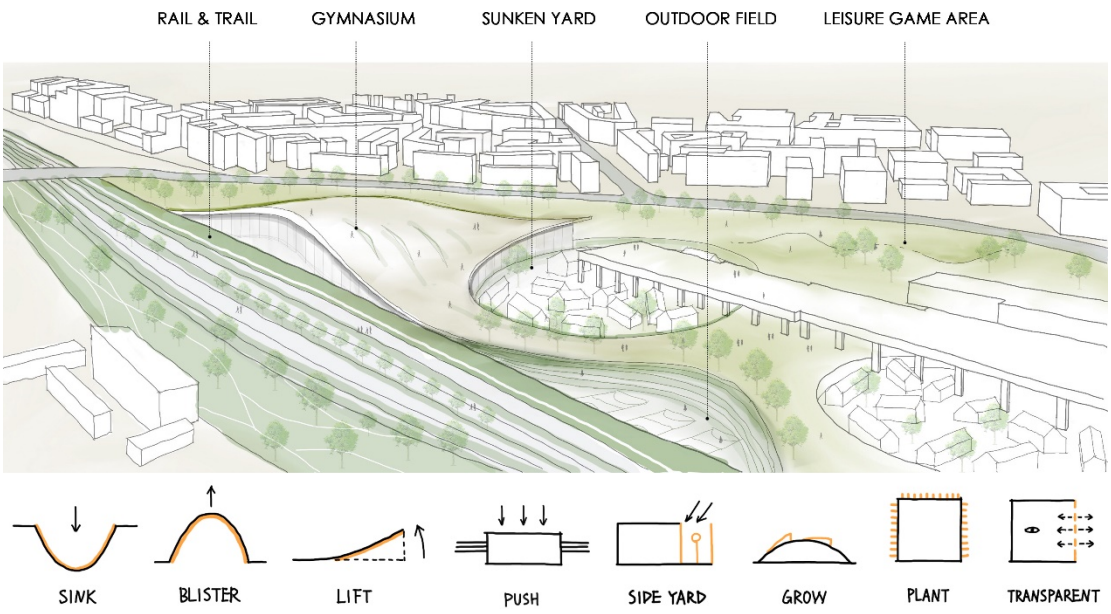


Fig. 5-4-6: Concept Proposal Sketch and the Landform Techniques Applied in the Proposal
Source: Elaborated by the Author

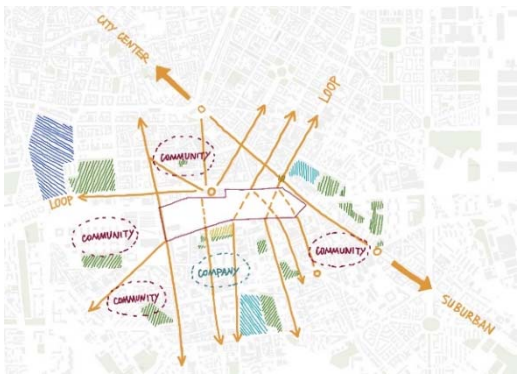
5.4.2.2 Experimental Site 2: “Seven Beautiful Broli” Proposal in Porta Romana Designed by Cino Zucchi Architects

This experimental site is one of the seven beautiful broli in Zucchi’s proposal. In the whole proposal, the railway yards are designed into parks and gardens which are not only services to the citizen but design tools of the city and the territory. These parks are open to different uses.

Except for some new buildings on the corners of the site, Porta Romana site has been designed into a sloping lawn with a market square between the railway station and the bus terminus.

Fig. 5-4-7 & 5-4-8: Proposal in Scalo Porta Romana Designed by Cino Zucchi Architects
Source: www.scalimilano.vision/visioni/

The original site in Scalo Porta Romana is located in the southeast of the city. Compared with other sites, the most prominent feature of it is that there are many companies and some factories near the south side of the site. Since part of the site has been transformed into a free market, it could be developed cooperating with these companies. Actually, the concept of the free market in the proposal is similar to the significance of landform sports architecture to be built with the landscape infrastructure. They both aim to increase functions of a pure green land and promote it to serve for people in more aspects. Even though it is not compulsory to build sports facilities in this area, if the sports function could be compounded into the site, market events and sports activities could together enrich the significance of the site. In addition, according to the plan for Milan to run for 2026 Olympic Winter Games, this site is intended to be changed into the Olympic village. In this way, it is meaningful to provide sports facilities for athletes and create the sports atmosphere in this site.



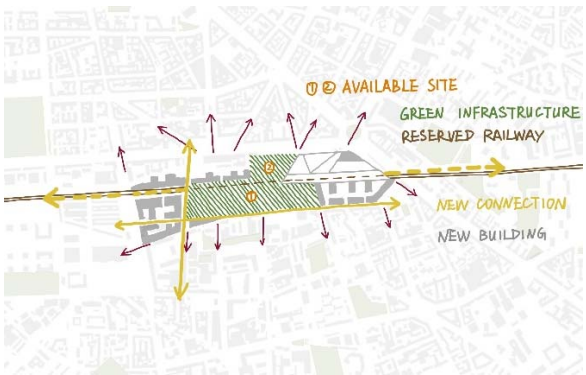


Fig. 5-4-9 & 5-4-10: Site Analysis of the Inside and Outside Environment
Source: Elaborated by the Author

Site Condition Keywords

Accessible / Landscape Free Market / Olympics Village / Near Company Area

Concept Proposal

After selecting the landscape interface for flexible activities in the site into consideration, the landform sports building is inserted into the middle part of the landscape infrastructure where is the intersection of east-west axis of the railway and north-south axis of pedestrian flow from communities and companies. The building continues the folding form of adjacent buildings, and the separated volumes which are respectively raised and sunken are mutually dislocated. Part of the form conforms to the original landscape slope to achieve morphological integration. The landform sports architecture placed in the intersection, on one hand, severs citizens coming from north and south of the site; on the other hand, becomes the node of the green trail and track transformed from the abandoned railways. Therefore, it is connected into the sports-landscape integrated system in Milan.

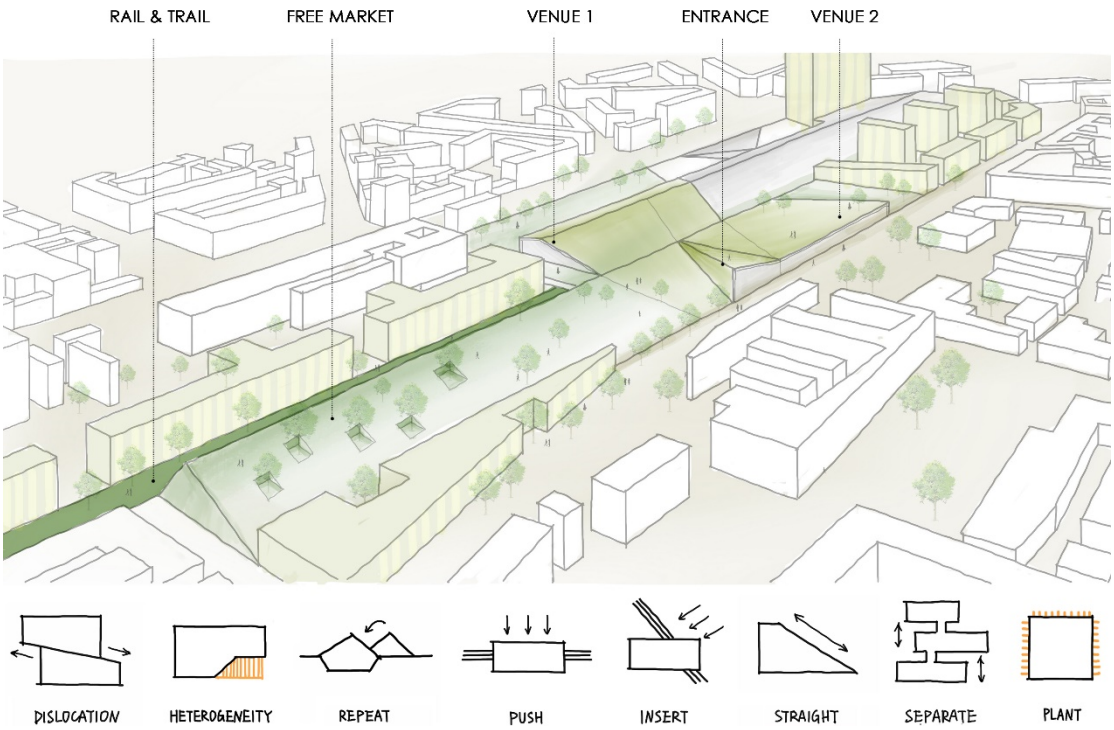


Fig. 5-4-11: Concept Proposal Sketch and the Landform Techniques Applied in the Proposal
Source: Elaborated by the Author

5.4.2.3 Experimental Site 3: “Green River” Proposal in Scalo Porta Romana Designed by Stefano Boeri

This experimental site belongs to a green system called “green river” proposed by Stefano Boeri. In the system, seven abandoned railway yards are respectively renovated into parks, woods, orchards, gardens, etc. And they are connected by green corridors and cycle paths built on the stretches of railroad tracks. Scalo Porta Romana will become an area dedicated to a botanical garden which is a large open-air inventory of Lombard plant species. There are few buildings in the site and it becomes one of natural nodes in the “green river” system.

Fig. 5-4-12 & 5-4-13: Proposal in Scalo Porta Romana Designed by Stefano Boeri
Source: www.stefanoboeriarchitetti.net/project/un-fiume-verde-per-milano/

Since this place is almost totally natural, buildings in the site must respect the landscape and intervene as little as possible. Like Osaka Municipal Central Gymnasium in Japan, because of the intention to maintain the garden and the regulation of “garden law”, the sports architecture has been built underground. Therefore, in Scalo Porta Romana, sports architecture could also be designed in a humble gesture to emphasize the natural image of this site. And these sports architecture provide places for people to feel nature and relax themselves in a free atmosphere when doing sports like yoga, which will be a special experience in a modern city.

Site Condition Keywords

Nature / Green System / Landscape Exhibition

Concept Proposal

This site has been designed as a botanical garden with few artificial structures. Besides the nature, important elements which could be utilized is the old railway and the new hanging

corridor, which are both traffic elements. In order not to disturb nature, it is not proper to building a big stadium containing gathering activities in the site. Therefore, the main concept of this proposal is to make use of and extend the two traffic elements to create a landform sports building mainly composed by linear sports space. Linking the hanging corridor, ground forest space and underground railways by the rotary track creates a sports circulation for people from the surrounding urban area and also the trail which belongs to the sports-landscape integrated system. Meanwhile, the limited round space containing woods is a good space for leisure and calm sports activities like Yoga and Taiji. Underground space around the sunken round yard is for simple sports and resting. The facade material of this round space could be transparent or reflective to hide the vertical structure and emphasize only the horizontal circulation. For creating indoor space for sports mentioned above, the whole space could be covered by a light and flexible roof made of membrane when needed.

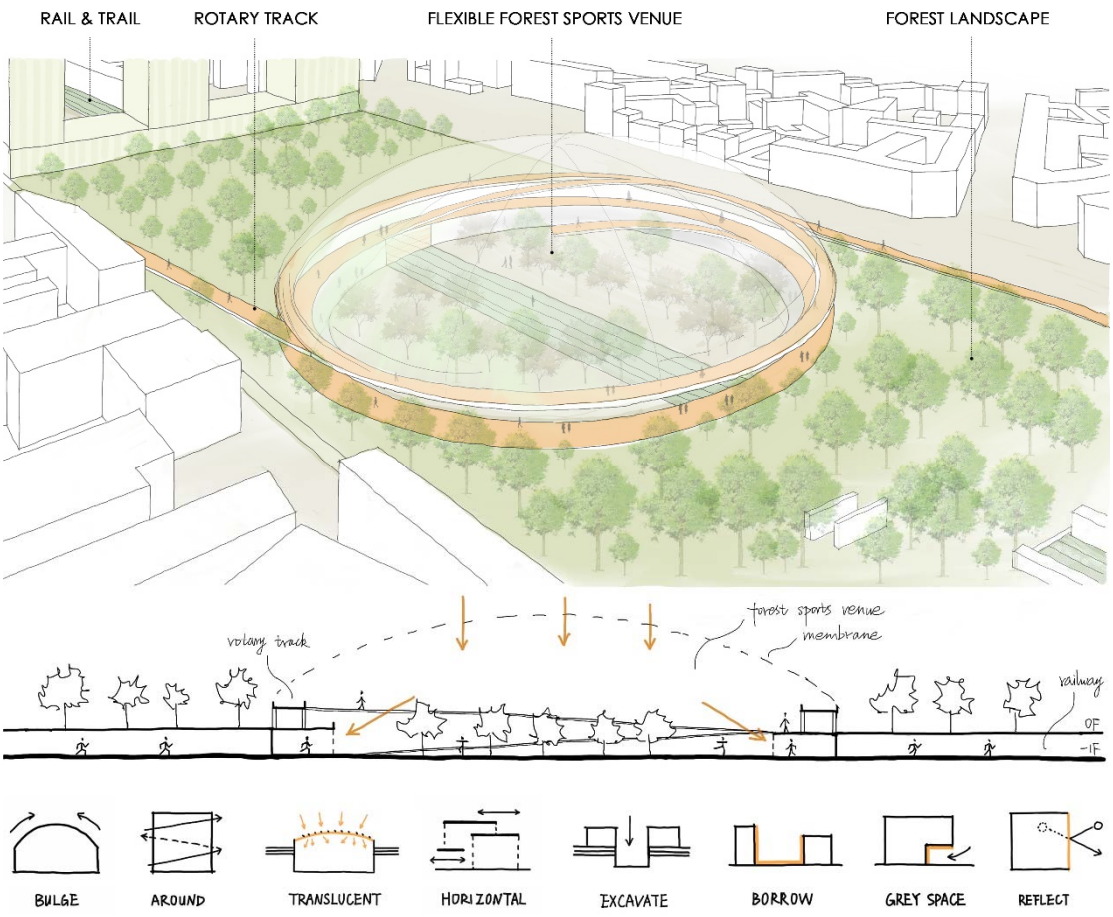


Fig. 5-4-14: Concept Proposal Sketch and the Landform Techniques Applied in the Proposal
Source: Elaborated by the Author

5.4.2.4 Experimental Site 4: “Miracles in Milan” Proposal in Scalo Porta Genova Designed by EMBT

This experimental site belongs to the proposal design by EMBT. The main concept of the whole project is to focus on the importance of water as a means to connect the city its population, nature and history. Based on this concept, Scalo Porta Genova which is near the canal has been design as a creative hub. It aims to young companies and start-ups. The site contains new office buildings, entrepreneurs, markets and a center for nightlife with pubs, romantic waking paths and lights reflected in the canal water.[17]

Fig. 5-4-15 & 5-4-16: Proposal in Scalo Porta Genova Designed by EMBT
Source: www.archdaily.com/869952/embt-unveils-proposal-to-revitalize-seven-of-milans-disused-railway-yards

The original site in Scalo Porta Genova is located in the southwest of the city. The linear site connects sports centers and Tortona fashion and art district. There are many functions popular with young people such as sports fields, clubs and pubs, art shops, fashion exhibition halls. That is why the EMBT’s proposal has positioned this site as a creative hub for young people to work and live. Therefore, sports architecture in this site should mainly serve for young working people and follow their preference. As the existing sports fields are mainly open-air and are for tennis, basketball and football, new sports architecture in the site could be indoor and provide leisure activities like table tennis, billiards, climbing or gym activities which welcome young people to play sports and socializing simultaneously. Meanwhile, since new office buildings have controlled the site, integrating small sports buildings with the landscape is a good way to balance the image of the artificial and natural part, as well as provide young people with sports space close to the nature, especially to water which is an important element of the project.

[17] Partly excepted from //www.archdaily.com/869952.

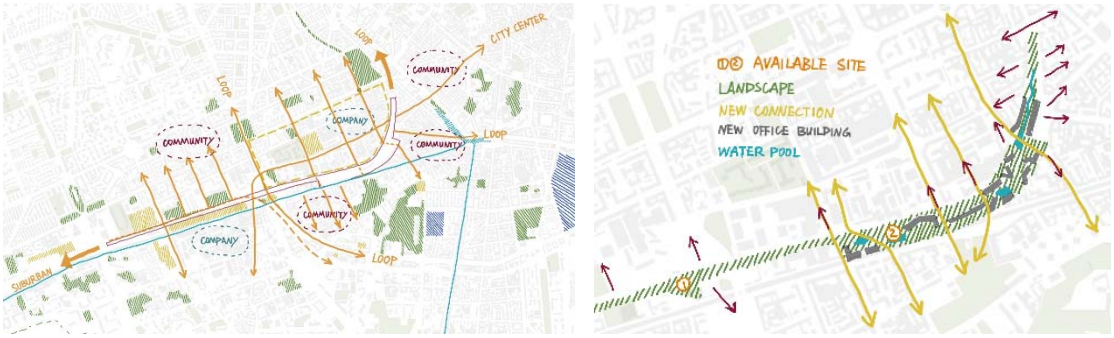


Fig. 5-4-17 & 5-4-18: Site Analysis of the Inside and Outside Environment
Source: Elaborated by the Author

Site Condition Keywords

Linear / Young Life / Water / Flowing Buildings

Concept Proposal

The landform sports architecture proposal on this site aims to serve for young people with leisure sports activities during their breaking time. Since the site is linear and water is an important natural element, the architecture simulates the flowing momentum of water, as well as integrates itself into the site by conforming to the division of the landscape and directions of office buildings, which makes it look like natural wave near the pool in the creative hub.

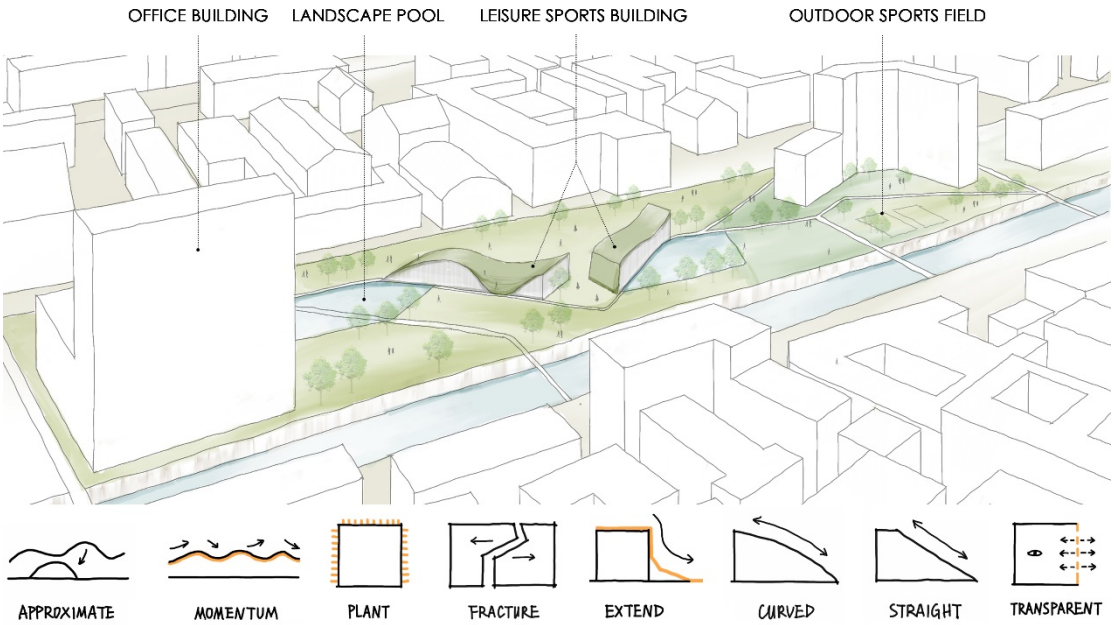


Fig. 5-4-19: Concept Proposal Sketch and the Landform Techniques Applied in the Proposal
Source: Elaborated by the Author

5.4.2.5 Experimental Site 5: “Ecological Filter” Proposal in Scalo San Cristoforo Designed by OMA and Laboratorio Permanente

This experimental site belongs to the proposal “Ecological Filter” which aims to regenerate the ecology of Milan by providing clean air and water, addressing climate change and pollution on a metropolitan scale. It is a long linear system for water purification and meanwhile provide citizens with a sports hill, a market and an outdoor swimming pool based on the landscape substrate.

Fig. 5-4-20: Proposal in Scalo San Cristoforo Designed by OMA and Laboratorio Permanente
Source: www.laboratoriopermanente.com/?p=3672#more-3672

The original site is located in the southwest of the city and it is near Scalo Porta Genova. Communities and sports centers are near it but the main part of site has been enclosed and blocked by the canal on one side and the track on the other side. As an ecological park with leisure and sports activities, the site could be a relaxing destination for citizens around. Sports facilities to be inserted inside must reduce its artificial image to comply with the natural condition.

Fig. 5-4-21 & 5-4-22: Site Analysis of the Inside and Outside Environment
Source: Elaborated by the Author

Site Condition Keywords

Blocked / Ecological / Leisure and Sports

Concept Proposal

Since the site is ecological without new buildings, the landform sports building is placed in the park across the railway. By changing railways into linear sports tracks and continuing the form to create the interface covering part of the sunken venue, the railway no longer blocks the site, and the building is integrated with both the historical element and the new landscape system. Moreover, due to the stadium's openings in different directions, service functions in the stadium can simultaneously serve for sports field, swimming pool and leisure activities on both sides.

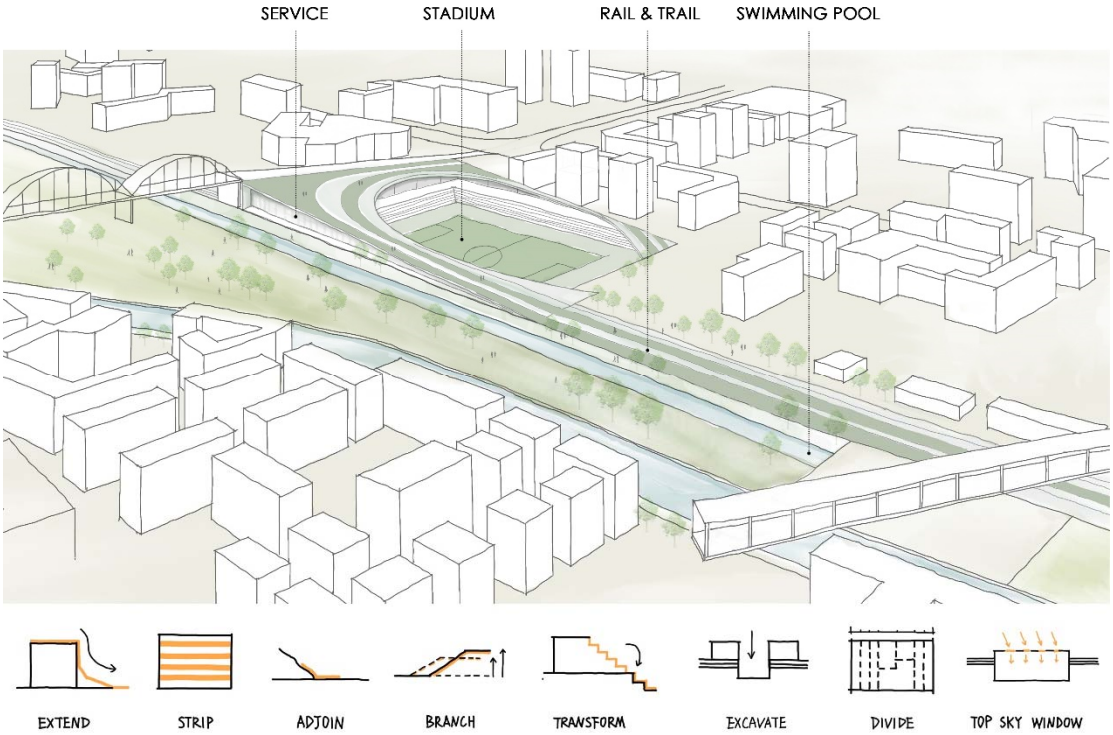


Fig. 5-4-23: Concept Proposal Sketch and the Landform Techniques Applied in the Proposal
Source: Elaborated by the Author

5.4.2.6 Experimental Site 6: "Catalysts for Sustainable Living" Proposal in Scalo Lambrate Designed by Mecanoo

This experimental site is one of the hubs on a system aiming at sustainability. Mecanoo wanted to create a green system with multiple public transport systems to call for sustainable living.

Based on this concept, scali have been transformed into mobility hubs which are vibrant places for people to enjoy being, working and living. These hubs work as catalysts for a radical transformation of Milan. As for Scalo Lambrate, the site has been connected to the university area on the other side of train tracks and the whole area can become a city of outdoor sports. Therefore, this hub could be a leisure and cultural center in the system.

Fig. 5-4-24 & 5-4-25: Proposal in Scalo Lambrate Designed by Mecanoo
Source: www.mecanoo.nl/Projects/project/196/Scali-Milano-Catalysts-for-sustainable-living?d=4&t=0

The original site in Scalo Lambrate is located in the east of the city and near the university city. Around the site, besides the university, some government departments and Lambrate art district which are accessible to the site are nearby. Since the proposal wants to create a sports city in this place which is full of atmosphere of culture and the public non-motorized system will be established, sports architecture with leisure functions connecting to the system could be built to provide different sports activities for students and residents living around and even people come from other parts of the city through the system.

Fig. 5-4-26 & 5-4-27: Site Analysis of the Inside and Outside Environment
Source: Elaborated by the Author

Site Condition Keywords

Link / Sports City / Culture & Education / Slow System / Concentrated Buildings

Concept Proposal

The site is close to the campus, the art district and some sports facilities, and the original design intends to design a sports hub in the landscape system. So, this concept proposal directly uses the new building in the site to change into a landform sports architecture which can serve for surrounding people and also be an attractive hub in the city. Due to the large number of young people in this area and there are already some ball game fields, this building can mainly carry sports events suitable for young people and provide sports education functions. Different from previous architectural forms which are based on the integration to the landform elements in other sites, this building is formed by simulating the rock element related to rock climbing. It is anchored to the site with a heavy sense of the architectural form. Together with the trails and leisure sports space transformed by the railway yard, the whole site becomes an extreme sports and education center with a pictographic form, which expresses the echo of nature but does not lose the opportunity to display its architectural image. Therefore, the building plays the role of a functional landscape sketch in the sports-landscape integrated system.

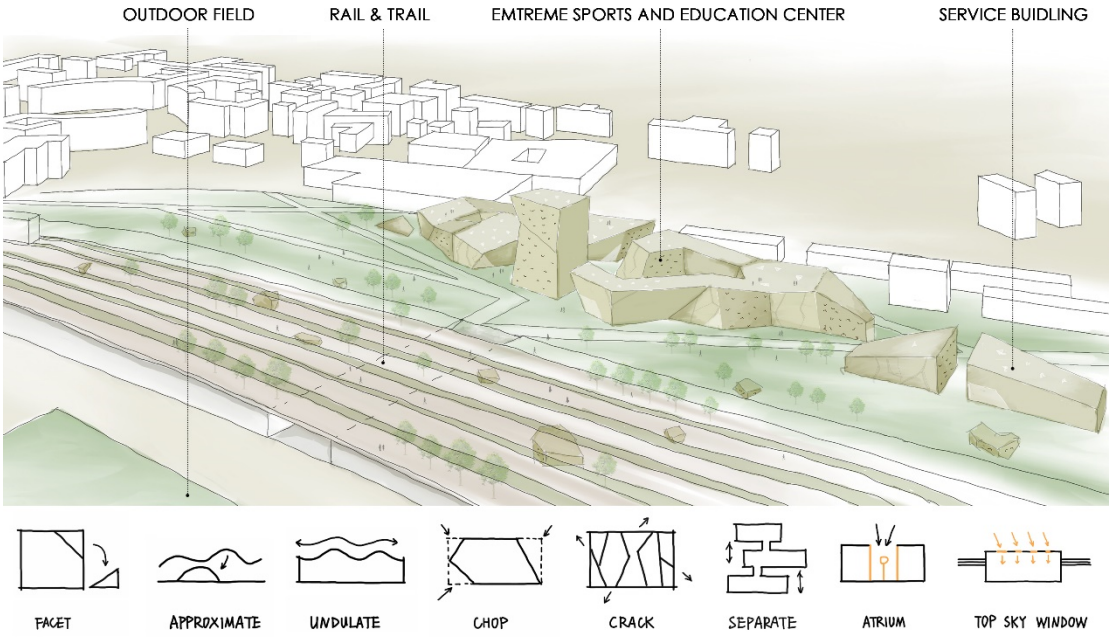


Fig. 5-4-28: Concept Proposal Sketch and the Landform Techniques Applied in the Proposal
Source: Elaborated by the Author

5.5 Summary of the Chapter

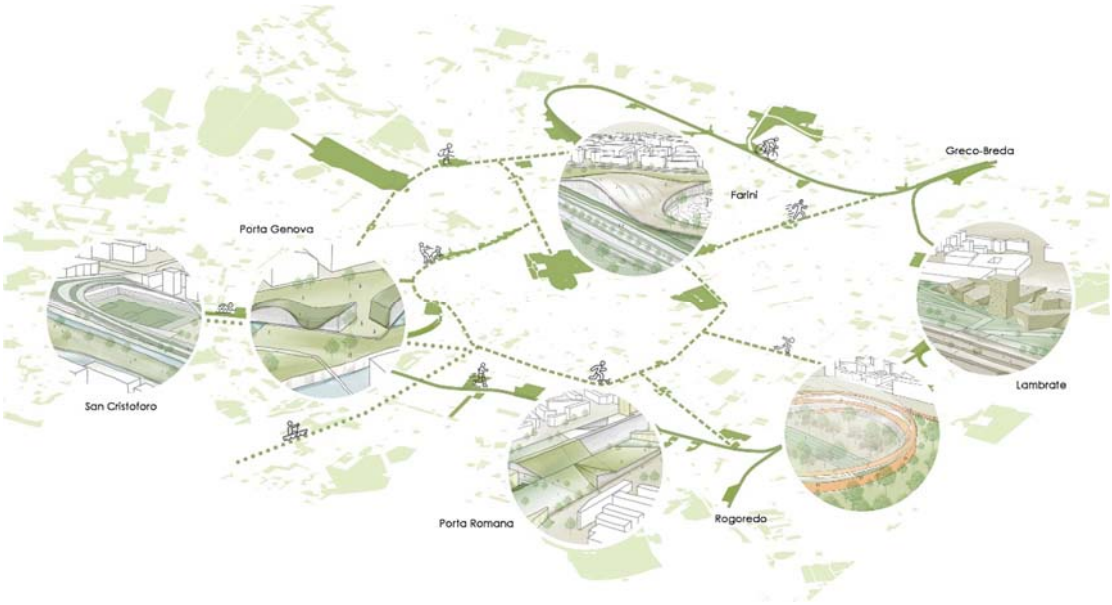


Fig. 5-5-1: Concept Proposal of Sports-Landscape Integrated System with Sports Nodes in Railway Yards
Source: Elaborated by the Author

The first half of this chapter mainly discusses the significance and possible ways of applying landform sports architecture in Milan. Through the analysis and observation of the distribution of landscape space and sports venues in Milan, it is found that Milan lacks a continuous outdoor sports space system which provides citizens with more natural sports space and is good for enhancing vitality in the city. And the historical and current condition of urban landscape space in Milan as well as the related development background for bidding to host the Winter Olympics show that the construction of urban landscape system is continuing and there are opportunities to build an urban sports system. Therefore, this chapter proposes the idea of constructing the sports-landscape integrated system in Milan. By integrating landform sports architecture with the landscape in node spaces represented by the seven abandoned railway yards in Scali Milano Project, and compositing linear sports space like greenways along the abandoned railways and part of the urban roads, the urban landscape infrastructure will be combined with sports function which is helpful to improvement of sports vitality in the city.

In the second half of this chapter, several landform sports architecture concepts are proposed based on six renovation scenarios for five abandoned railway yards, which aims to show the possibility of achieving landform sports architecture in the nodes of the overall system. in fact, architecture proposals in these nodes are just an attempt based on form design techniques

summarized before. The specific designs will be affected by influence factors mentioned in the third chapter and the architectural forms have various possibilities. But generally, it shows that integrating the sports architecture with landscape nodes could be an important part and a possible way to realize the sports-landscape integrated system in Milan.

CHAPTER 6

Conclusion and Outlook

6.1 Conclusion

Sports architecture, as the important and relatively large public building in the city, leads to disconnection with the historical context and current environment due to the blind pursuit of iconic and special visual effects. Today, when sports become a daily social activity and when the harmony between human and nature are continued to be emphasized, the relationship between sports architecture and the environment begins a new discussion. Landform sports architecture fully combines the architecture with the landform, providing new ideas for the interaction among sports architecture, environment and people. Based on the understanding of the theoretical background like genius loci, landscape urbanism, field condition, integrated design of city, architecture and landscape, as well as the analysis of typical landform sports architecture projects, this research has a deep study on the definition, characteristics, design strategies and application of landform sports architecture. So far, the following results are obtained:

(1) Landform sports architecture is a type of public building which mainly supports sports activities. It emphasizes the integration with the landform environment morphologically. The integrated relationship with the natural environment is reflected in hiding the architectural form or simulating natural elements with a humble gesture. While the integrated relationship with the urban environment is reflected in the respect for urban

texture, the combination with urban landscape, the satisfaction of urban spatial needs and the breakthrough of interfaces between architecture and ground. Landform sports architecture breaks the pursuit of the iconic, monumental and grand character of traditional sports architecture. Instead, it establishes a symbiotic form with the environment through creating an inclusive, experiencing and suitable building. A full understanding of these definition and characteristics is a prerequisite for designing rational landform sports architecture.

(2) The form of landform sports architecture is influenced by environmental conditions, characteristics of sports buildings and objective support conditions. The comprehensive analysis and judgment of multiple influence factors in different environments provides logical support for the establishment of the landform design technique. In the design, the classification and comprehensive evaluation of the influence factors such as the landform feature, climatic characteristic, site location, space limitation, building scale restriction, function requirement, architectural form significance, municipal conditions, issue about economy and efficiency are necessary for designing suitable landform sports architecture. And it is proved that landform sports architecture is suitable in many conditions.

(3) The form design strategy of landform sports architecture bases on the principle of creating the visual integration of the building into the environment instead of highlighting it. The design strategies aim at changing visual effects and specific techniques include three aspects: volume, interface and space. For the volume, the integration is achieved by designing the form of the volume itself and the position relationship between the volume and the landform. For the interface, designing the environmental interface, architecture interface and interface between architecture and environment promotes the blurring and transition of the boundary between them. For the space, the rational design of space which can change the architectural form such as courtyard space, traffic space and entrance promotes people’s perception of the relationship between the building and the landform.

(4) The functional space design strategy of landform sports architecture is divided into three parts: external, internal and connecting functional space. The external space cooperates

with functions about sports, landscape, leisure activity, culture, commerce, refuge and so on to expand the overall value, influence range and development potential of landform sports architecture. For the internal space, by organizing sports space and auxiliary space in a proper way, as well as introducing natural light by corresponding techniques, to mitigate the difficulty of corner space use and problem of poor spatial atmosphere due to the volume sinking and special form design of landform sports architecture.

(5) For the application of landform sports architecture in the actual construction in cities, this research takes Milan as an example. The condition is that Milan lacks a continuous urban sports system and expects to expand sports culture in the city by hosting 2026 Winter Olympics. Thus, under the background of establishing the urban landscape system with the “Green Rays” idea and with the opportunity of railway yard renovation in Scali Milano Project, a sports-landscape integrated system in Milan is proposed in this thesis. Five scenarios in Scali Milano Project have been used as experimental sites for landform sports architecture proposals. With the proposals, it shows the possibility of integrating landform sports architecture into urban landscape system.

6.2 Outlook

As Karl Heinrich Marx pointed out, history has always spiraled up. The artificial construction depended on nature and was integrated well with nature in ancient time. Since the industrial time, the large-scale construction in cities encroached on nature. While as the environment deterioration problems become serious, the discussion and reflection on the relationship between people and environment, between human and nature have been emphasized again. Demands for nature in a city have gradually promoted the construction concepts of achieving a balance between people and environment. Today, as the development of urban space is becoming mature and complete, the appeal and creation of natural landscape space in the city has gradually occupied an important position in the field of architecture and urban planning. In fact, the design and construction of new buildings which pay attention to integrate with environment especially landscape space is not to add artificial buildings with a label of fake-nature, nor can it make a great contribution to deal with the ecological issues in the city. But it is meaningful from the perspective of architecture because it is an intuitive way to show human's attitude of respecting the environment and expectation of harmonious coexistence with nature. This research chooses landform sports architecture as the subject to explore the relationship between architecture and environment, and studies the technique and significance of its organic integration with the landform. On one hand, it provides strategies and techniques for designing this particular type of building to promote its better application. On the other hand, hoping to emphasize and inspire the vision and thinking of the integration of people, life, architecture, city and environment through activities (sports) that are closely related to nature and people's lives, and through the special type of public buildings (sports architecture) that are important in cities.

The relationship between human and nature is a profound and enduring topic. One person, one study or one subject has weak power. But small contributions and continuous improvement can finally lead to the answer. As far as this topic is concerned, the research materials of the landform sports architecture are scattered and independent. The strategies and techniques of the form, function and space design are almost based on the summary of existing projects, which lack of innovation. And the related technical issues appeared in real constructions are not discussed in detail. For the depth of the research, the design innovation and technical problems of the landform sports architecture can be the starting point for future research. In

terms of breadth, its ecological value and its role in the urban landscape system can be discussed further. In all, there are still many issues left and the research on this topic has a long way to go.

Architecture grows out of earth and returns into the nature. Human beings, too.

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(Note: [M]: Monograph; [J]: Journal; [D]: Dissertation; [Z]: Others)

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