Design towards the conversion between land sports and ice sports in infield space of arena

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Abstract. In order to speed up the realization of the development goal of “300 million people participate in winter sports “, winter sports facilities have been built all over the country. The construction of arena combined with ice sports is also one of the measures to increase ice sports facilities. The article compares the arena combined with ice sports to the common arena, and analyzes its advantages. In view of the special characteristics of ice and land sports, the article summarizes the main factors that need to be coordinated in design and technical aspects of ice sports arenas from the aspects of site, athlete's room, equipment room, site structure and thermal environment, and comes up with design strategies.

1. Introduction
With the development of the strategy of “Extension of Ice sports from the North to the South" and the successful bid for the 2022 Beijing Winter Olympic Games, China's winter sports industry has developed rapidly. Take the development of ice rinks as an example. In 2003, there were only 21 indoor ice rinks in China, reaching 59 in 2011 and 188 in 2016. By 2018, the number of domestic skating venues had reached 334 (Table 1), an increase of 29% compared with 259 in 2017[1], of which 79 ice areas met the requirements of International Ice Hockey competitions. Although the development of ice sports facilities in China is very fast, there are still some problems such as fewer ice rinks, small area and poor ice quality compared with Finland and Canada. According to the statistics of the International Ice Hockey Federation, there are more than 3300 ice hockey pavilions in Canada, and China still has a great potential for development.

Table 1. Statistics of ice rinks in China

| Region       | North China | Northeast | Eastern China | Central China | Southern China | Southwest | Northwest | Others |
|--------------|-------------|-----------|---------------|---------------|---------------|-----------|-----------|--------|
| Count        | 76          | 67        | 86            | 27            | 50            | 24        | 19        | 5      |

As the basic guarantee for the masses to participate in the winter sports, the construction of winter sports facilities cannot be ignored. According to the National winter sports venue facilities construction plan (2016-2022) issued in November 2016 that proposed the construction target of no less than 650 national skating rinks in 2022, of which no less than 500 will be newly built [2]. From the perspective of promoting the development of the main sports industry, there are two ways to build the ice sports facilities:
• Build ice sports sites in combination with commercial facilities and national fitness center to support mass fitness and leisure industry;
• Build arena combining ice and land sports to support competitive performance industry, and give consideration to the needs of mass fitness.

The arena combined with ice and land sports is the focus of this paper. The arena will construct or reserve an ice rink at the beginning of the design, and the site will realize the transformation of the function of the stadium through “ice-land conversion”.

2. Advantages of combining ice sports and land sports together in arena.

2.1. Enrich competitive performance programs
In 2018, The general office of the State Council about accelerate the development of sports competition performance industry guidance put forward the development goal of launching 100 sports events with greater popularity, and creating 100 sports competition and performance brands with independent intellectual property rights [3].

a) Ice hockey  b) Short track speed skating  c) Figure skating  d) Curling  e) Ice acrobatics

Figure 1. Ice sports and activities

In general, the competitive performance items of arenas are mainly ball games, stage setting gymnastics and concerts. On this basis, the arenas combined with ice and land sports have added ice events such as short track speed skating, figure skating, ice hockey and curling, and performance items such as ice dance, Ice Ballet, acrobatics and Drama (Figure 1), which can greatly enrich the types of sports competition performance items.

2.2. Improve the efficiency of venue operation
Small and medium-sized arena can hold competitions and also be used for mass fitness at ordinary times. While arenas are mostly athletic venues, mainly for sports competitions. Due to the high level of configuration and operation cost, it is difficult to open the venues to the public. According to relevant data, the annual activity of the arenas is about 200 games, each time last 2-3 hours, sports events only account for 1/2 to 1/3. If the venue can hold ice events or activities, the operational efficiency of the venue can be appropriately improved. Take the ice hockey competition as an example. The ice hockey season usually ends from October to April of the next year, during which 56 games are held. The playoffs are to be determined and the competition time is about 10-15 days. On the premise that the land activities can be held, the operation efficiency of the venue has been improved .

3. Coordination of supporting spaces to Ice sports use
The integration and collision of the two types of "ice and land" activities will inevitably bring about some new problems for the venue design. As the core of the stadium, the design of the infield space is particularly important. The activity area of athletes, VIPs, journalists, competition organizers and other staff is called infield space, which mainly includes the field area, athletes' room, office, equipment and other auxiliary rooms. For such venues, the design of the infield space needs to coordinate three aspects: the field, the athletes' room and the ancillary room.

3.1. Site
The factors that affect the site design mainly include the shape of the site, the size of the competition area, the size of the mixing area and the layout of the site facilities (Table 2). Gymnastics is the largest
venue in land sports, and ice hockey is the most widely used in ice sports. Therefore, such venues need to meet the needs of the characteristics of ice hockey and table building gymnastic venues at the same time when designing venues.

Table 2. Comparison of ice hockey and table building gymnastic sites

| Site type                  | Site of ice hockey | Site of gymnastic |
|----------------------------|--------------------|-------------------|
| The size of the competition area | 61×30m (Figure 2)  | It is composed of the court and the competition workspace. The court is 52 × 26m and the width of workspace is ≥ 4m. Therefore, the minimum size of the competition area is 60 × 34m (Figure 3). |
| The size of the mixing zone | The positions for punishment, team members and referees shall be set outside the side line, the width ≥ 1.5m and the width of channel ≥ 2m, so the width of the mixing zone outside the side line ≥ 3.5m and the width of the mixing zone outside the end line ≥ 2m. | It is an activity area for journalists, waiting athletes, coaches, etc, the width is ≥ 2m. |
| Field size                 | Minimum size is 65×37m. | Minimum size is 64×38m. |
| Site facilities            | The rink shall be surrounded by a wooden or plastic wall known as the “BOARDS”, set up safety pad around the short track speed skating site (as shown in Figure4). | Open, no boundary wall around the site. |

3.2. The athletes’ room
The room for athletes mainly refers to the athletes’ rest room. Compared with land sports, the athletes’ rest room for ice sports has four features.

3.2.1. Large capacity. In ice hockey, each team is generally divided into three groups to play in turn, with 6 players in each group. Each lounge must accommodate more than 24 players, more than the number of players in general land sports.

3.2.2. Large area. Ice hockey players are required to wear helmets, chest protectors, and other equipment and carry clubs during the competition, which results in large personal space occupied by the users.

3.2.3. Function increase. The rest room shall be equipped with professional auxiliary rooms such as skates drying room and knife sharpening room, so that the athletes can maintain the ice sports equipment in time during the training and competition interval.
3.2.4. Ground treatment. It is possible to wear ice shoes to enter the rest room, and anti-skid and anti-scratch treatment is considered for the ground of the rest room of ice sports hall, the ground is laid with professional rubber plate or rubber pad (Figure 5).

The design of such venues should take into account the four-point characteristics of the above ice sports athletes' rest room. The area should be increased appropriately, including drying room and knife sharpening room, etc. The IIHF (International Ice Hockey Federation) ice field guide suggests that the athletes’ dressing room area is 30 m² and the drying room is 5 m².

3.3. The equipment space

Compared with the general venues, the auxiliary rooms of the comprehensive gymnasium combined with the ice and land projects need to be equipped with special rooms such as power distribution room, refrigeration room and ice-pouring garage, in addition to general office and logistics rooms, air conditioning, lighting and equipment rooms.

The refrigeration room includes two refrigerators, containers for storing refrigerants and other auxiliary equipment, with an area of about 100-120 m² (Figure 6). The machine room should adopt sound-proof measures or stay away from noise sensitive area when the refrigerator is operating. The interior of the ice resurfacer garage stores the ice truck and the ice melting pool. The ice truck plays the role of pouring and sweeping ice. The common size of the ice truck is 3.5 × 2 × 2.5m (Figure 7). Ice melting pool is set at the rear of the ice truck, with a structural elevation of -0.800m and internal heating equipment to facilitate the melting of ice and snow cleared from the ice surface (Figure 8).

4. Technical support of Ice sports use

The technical factors that need to be coordinated in the inner field area of the ice sports complex mainly include the construction of the field and the thermal environment of the competition hall.

4.1. Site structure

The common gymnasium site mostly adopts the sports wood floor system (Figure 9), while the ice rink is another system, including the ice surface layer (structure), filling layer (embedded frozen pipe), insulation layer, etc (Figure 10). Compared with the common site structure, the ice rink has the following features.

4.1.1. Surface layer. Ice and thickness is about 30-50mm. The finished surface of ice is flush with the finished surface of ice field service area, with an elevation of ±0.000.

4.1.2. Filling layer. Generally, it is the embedded frozen drain pipe of cast-in-place antifreeze concrete, and thickness is about 80-120mm.

4.1.3. Frost proof design of foundation. Since the frozen layer of the ice rink will transfer the cold amount to the foundation in the long-term use state, and the foundation is prone to frost heaving, the ice rink should be designed to resist freezing. The common ways are to set air circulation layer under the ground and to bury heating pipes under the insulation layer.
4.1.4. Water and sewer system design. In the sewer system of an ice rink there are two special systems to be taken care of, namely the rink melted water drainage and the melting pit of waste-ice. Surface water drains for melted water from ice defrosting is required outside and around the rink (Figure 11).

4.1.5. Embedded parts arrangement. Embedded parts are set around the site to facilitate the installation of ice dam and boards.

The features of the ice rink should be considered at the beginning of the design of the venue. With the mixing of two different venue media, the organizers need to conveniently realize the functional transformation of the venue in a limited space to meet the demands of different activities.

![Figure 9. Diagram of land sports site construction](image)

![Figure 10. Diagram of ice rink construction](image)

![Figure 11. Drain and ice dam](image)

4.2. Thermal environment of competition hall

There are differences in air flow speed, air temperature and humidity requirements between ice and land sports competition hall (Table 3). During the ice sports, there is a huge difference in temperature between the audience area and the field area, so the temperature of the field area and the audience area should be guaranteed. The general area hall is mainly to control the temperature and the arena combined with the ice sports should focus on the humidity.

| Thermal environment | ice sports competition hall | land sports competition hall |
|----------------------|-----------------------------|------------------------------|
| Design requirements  | Prevent the ice from melting and eliminate the fog on the ice and condensation on the ceiling [5]. | Provide a good environment for athletes and spectators. |
| Air flow speed       | Air flow speed is no more than 0.3m/s. | Air flow speed is no more than 0.5m/s. |
| Air temperature      | Field area Maintain -2–6℃ within 1.5m above the ice surface. | winter is 16-18℃, summer is 26-28℃. |
|                      | Audience area 18-24℃ |     |
| Air humidity         | The optimum humidity of the competition hall should be less than 40% and no more than 55%. | Summer is between 55%-65%, winter is not less than 30%. |

Table 3. Thermal environment requirements of ice and land sports competition hall

5. Conclusion

Compared with the general arenas, the arena combined with ice sports has increased competitive performance items, improve the arena operation efficiency. The infield space design of such arenas need to coordinate the size of the ice and land sports site to meet the conversion. The athletes’ rooms increase area and add professional auxiliary rooms such as drying room and knife grinding room; add equipment rooms such as ice pouring garage and refrigeration room. In addition, the construction of the venue should be consider antifreeze and water and sewer system design. The air conditioning
The design of the competition hall should be based on the dehumidification system, and the temperature difference between the field and the audience area should be coordinated.

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