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Research on Low-carbon Sports Stadium Development in National Forest Park Tourism City Based on Full Life Cycle Model

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Abstract:

Facing up to the "charm" of nature, exploring the ecological world outlook of "harmonious coexistence between man and nature", the national forest tourism city, as a green, environmental protection and the low-carbon construction concept and sustainable development, leads the rapid rise of low-carbon economy, drives the transformation of a series of related industries, and promotes the transformation of stadiums to wooden structure. Based on the national forest city low carbon construction of forest tourism green economy business development, discuss wood structure sports venues than reinforced concrete structure sports venues in material development, transportation, construction, operation, demolition recycling stage carbon displacement, building characteristics, energy saving characteristics, and explore the wood structure stadiums combined with low carbon economic development path. Using life cycle theoretical model, BIM modeling, field research method and other research methods, comparative and analyze the life cycle index value of wood structure and reinforced concrete structure, list the structural advantages of energy saving and carbon fixation, ecological livability, building performance and so on, and demonstrate the feasibility of wood structure for the development of sports venues. New wooden structure has natural environmental protection, durability and safety advantages, and can be used as the new development direction of sports venues. Relying on the "low-carbon economy", we will develop low-carbon industries such as "sports + tourism, culture and health care", undertake new functions such as forest tourism sports function places, regional cultural and sports characteristic buildings, forest health care sports and leisure venues, and promote a new development mode of sports venues in forest tourism cities.

Keywords*: Forest tourist city, Full life cycle theory, BIM model, Sustainable development, Low-carbon gymnasium, Wood structure.*

I. AIMS AND BACKGROUND

In 2021, the topic of ecological reform, building green ecological barrier area " [1], again guide to

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accelerate the pace of national forest city, promote environmental damage restoration, further strengthen the implementation of the" two mountains strategy ", trying to solve the increasingly prominent urban ecological problems: forest ecosystem degradation, biodiversity loss, haze aggravation, water pollution and other problems, maximum efficiency to restore green water ecology [2].The game theory of harmonious development between man and nature is reflected in the transformation between cooperative relations and non-cooperative relations, and the non-cooperative relations formed for the purpose of opposing development, and the harmony between man and nature is the fundamental logic of sustainable social development [3]. Forest tourism cities give birth to low-carbon economy, practice the people-oriented development concept, respect the "charm" of nature, earnestly implement the unity of "development" and "nature", coordinate the overall development logic of "man-nature-society", and limit the main force of human "control" and "control" of natural development to "rationality" [4]. Building harmonious coexistence between man and nature, sustainable economic development and low-carbon economy jointly build a low-carbon urban development system. The former sets up the theoretical basis for the latter, the latter provides an effective way for the former, and interactive development provides a practical basis for the construction of a low-carbon ecological emission reduction system of "intensity + total + neutralization". As an important part of urban ecosystem and an important carrier in the development process of urban ecological service, urban forest is of great significance to promoting sustainable urban development [5].

Figure 1: schematic diagram of the research group investigating the national forest tourism city construction province in 2019

Under the background of the concept of "harmonious coexistence between man and nature" to promote the development of "low-carbon economy", The latest round of national forest cities approved by China in

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2019: Meishan City, Sichuan Province, Qujing city and Jinghong cities, Yunnan Province, Yulin, Hanzhong and Shangluo cities, Shaanxi Province, Dunhua City, Jilin Province, Hebei Province, Tangshan, Baoding and Langfang four provinces and 10 cities and other national forest cities. According to the requirements of the project, the research group drew the schematic diagram of the national Forest Tourism City Construction Province in 2019 to support the research (Figure 1 Schematic diagram of the research group investigating the national forest tourism city construction province in 2019).Establishing the preliminary achievements of carbon emission reduction and urban ecological environment improvement in China, Investigate the forest resource reserve, coverage rate, stock volume and the national forest tourism industry related data, Provide a resource basis for wood structure building research; As well as the Jingzhou Miao and Dong Autonomous County Stadium, Hubei Province, Jiangsu Province "wooden building pavilion" Green Building Expo Park, Shanghai Chongming Stadium, Japan Shihai Stadium, the United States "Ecological Stadium" and other wooden structure sports venues for research, To confirm the feasibility of using wooden structure in the construction of large stadiums, Analyze the seismic resistance, fire resistance, pressure resistance, corrosion prevention, insect prevention and other safety indicators of large wood structure structure, Mining of wood raw material innovation technology, Provide technical support for wood-frame buildings; At the same time, the research trends of national forest city, forest tourism industry, carbon neutrality, wood structure material technology and industrial transformation, To provide feasibility demonstration and related implementation path demonstration for the construction industry of wood structure stadium in China.

II. RESEARCH STATUS

The core of "carbon growth" is reducing "carbon emissions" and "carbon neutrality" through ecological protection, construction and management, and improve and shorten the time span of "double carbon" era in China. The rise of wood structure building is the inevitable result of the construction industry transformation caused by "carbon emission reduction", the industry practitioners of green and low carbon technology, wood warm and exquisite, it will inevitably lead the development direction of a new round of green concept construction industry.

2.1 The National Forest City

Under the background of the rapid development of global economy, the counteracting force of urban expansion at the cost of environment is constantly prominent, and the construction of new alternative resources to make up for the deterioration of urban environment has gradually attracted the attention of all countries. "Urban ecology" clearly pointed out: forest urban construction concept is urban land as the carrier, forest resources as environment, economy, vigorously develop the organic combination of urban ecological landscape and cultural landscape [6], seek the urban forest social benefits and economic benefits "best coupling" [7]. From the side for adhering to the urban sustainable development, the national forest city construction should always with green development concept, and continue to deepen the urban planning and construction from the traditional construction, transportation, Bridges "gray building space" expansion [8], comprehensive urban forest green plants, water system, ecological landscape "green blue

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building space" coordinated development, pay attention to forest city green plants in urban development to improve living ecological environment, carry forward ecological culture, and solve the advantages of urban environmental pollution [9].

2.2 National Forest City Stage Construction

Since November, 2004, The first China Urban Forest Forum was held in Guiyang, The conference adheres to the principle of " let the forest into the city, Let the city embrace the forest " purpose, Set Guiyang as China's first national forest city, [10] The development path of the national forest city in China can be summarized as: the initial stage (2004-2006), This stage is the "trial and difficult stage" of forest city construction in China, it aims to pilot the practice and spread the idea of quality urban creation, The construction focus is mostly focused on the improvement of the national forest city construction evaluation procedures, Including the forest city ecological evaluation indicators and management declaration procedures; System Specifications stage (2007-2012), With the publication of the forest coverage index in the built-up forest areas, And the promulgation of the "National Forest City Evaluation Index", In this stage, we focus on strengthening the standardization of forest city construction indicators, systematic management methods, theoretical and practical knowledge; The Rapid Development Phase (after 2013),and the promulgation of the Measures for approving the Title of National Forest City in 2016, Announcing that China's national forest city construction has entered a rapid development stage, The construction mode is also gradually excessive from a single national forest city construction to the national forest city cluster construction. [11] The ninth national forest resources inventory shows that the first forest surface inventory shows The growth rate of forest accumulation, forest coverage rate and forest accumulation reached 1.8 times, 2.0 times, and 1.81 times. On the basis of the above research, the previous national forest resources survey data in China were drawn, and the difference between forest area, forest stock and forest coverage rate from 1937 to 2018 was compared and analyzed, further showing the development trend of forest tourism city construction in China (As shown in figure 2 inventory data of previous national forest resources).

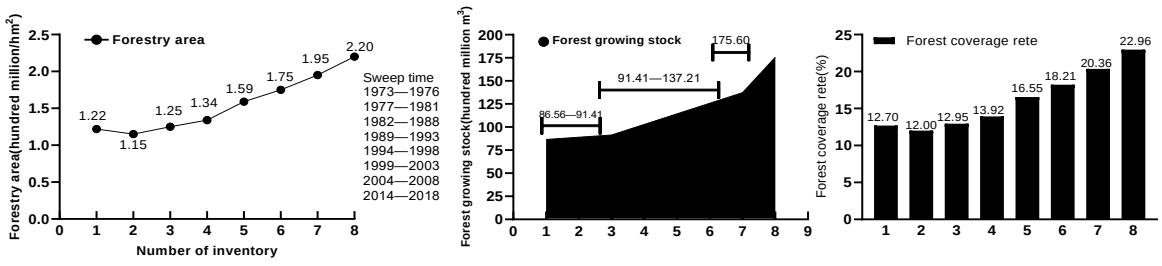

Figure 2: inventory data of previous national forest resources

2.3 National Forest City Tourism Industry

At the beginning of 2016, China has gradually shifted from a single mode of traditional forest tourism to a multi-functional, multi-way, multi-mode and diversified forest ecological tourism industry [12].

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According to the survey conducted by the tourism Bureau during the 13th Five-Year Plan construction period [13], draw up the statistical data of China's tourism industry during the 13th Five-Year Plan period, and compare the development trend of national tourism and forest tourism from 2016 to 2020:China's forest tourism industry created economic benefits of 6.8 trillion yuan, a total of 7.5 billion tourists (Figure 3 Statistical Data of China's tourism industry during the 13th Five-Year Plan period).According to the national forest tourism development overall plan (2011-2020) statistics [14], by 2020 our country forest tourism industry acceptance number of 1.4 billion, the output value reached 800 billion yuan, due to the inevitable revival of tourism industry, forest tourism tourists will increase by 18% a year. At the same time, our country launched forest tourism fitness trails construction plan, the overall planning and design of a total of 12 national forest trails, trails total mileage of 22000 km, in the national forest tourism trails long-term planning, section construction, section tourism demonstration section, tourism demonstration site, let tourists experience health, leisure, entertainment, health, forest tourism experience at the same time, realize the national ecological civilization construction, promote the forest city modern forestry development and tourism transformation and tourism and other important measures.

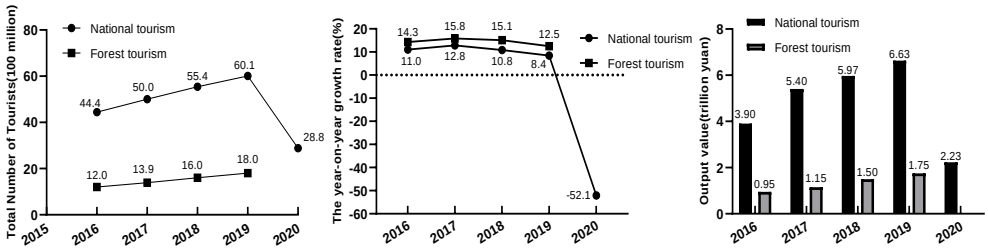

Figure 3: statistical data of China's tourism industry during the 13th five-year plan period

2.4 Carbon Neutralization Review

The International Energy Agency's carbon emissions statistics show the construction industry accounted for 9% of the total emissions, Vancouver carbon on and transportation, China construction industry in 2017 accounted for 19.5% of the total emissions [15]. Through carbon reduction, carbon cycle, the effective implementation of carbon replacement, carbon storage, make global 2030 carbon emissions in 45% compared with 2010 [16]. And the construction of forest tourism city and the earth guarantee the realization of the "forest carbon sink", which as a tourist city construction landmark building structure transformation, will be green environmental protection, reduce carbon emissions of new materials, new structure, new energy as the development trend. In recent years, the application of wooden structure in large comprehensive buildings [17] has greatly stimulated the transformation of Chinese civil, sports and other building structures [18].

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III. RESEARCH METHODOLOGY

3.1 Characteristics of Wood Structure and Frame

As an important part of urban construction and public service, sports buildings, driven by the theme construction of ecological city, waste-free city, green city and other themes, tend to develop in ecological service, performance optimization, value mining, green environmental protection and other aspects [19]. In the "concrete forest" everywhere in modern city, people gradually more inclined to the natural expression of wood structure building [20], so more and more designers will introduce wooden structure design and architectural culture expression, give full play to the wood green environmental protection, thermal insulation performance, high recycling, low construction cost building characteristics [21]. In developed countries, wooden structures have been used in the construction of stadiums, commercial complex of large public buildings, so that evolved different from traditional wooden structure, such as wooden truss, space grid, umbrella dome, steel wood tenon, spherical shell, tree column, truss arch, etc [22]. At the same time, with the combination and development of forest tourism and sports tourism, the wooden structure gymnasium gradually assumes the new functions such as forest health care, tourism events and landscape system.

3.2 Defective Analysis of Wood Structure

The high maintenance cost in the later stage is the weakness of the development of wooden structure stadiums, Due to the own characteristics of wood structure and wood tree species, The suitability of the environment is decisive for its later maintenance, Wood in the humid environment is easy to mold (mostly brown rot, white rot, soft rot), breeding moths, Damage to the original bearing capacity and beauty of the building, General small civil buildings can use moisture-proof coating and anti-corrosion, insect prevention technology treatment can achieve the purpose of prevention and control, But the wood volume used in the wooden structure stadium is huge, Once the structure appears mildew, living insect phenomenon can not be treated in time, It will cause irreparable damage to the structure in a short period of time. So wood structure sports venues in the construction stage should consider wood tree species selection, performance test, anticorrosion treatment (usually copper azole agent treatment: through the agent of different quality fraction level, the wood rubber wood, test treatment of rubber wood surface single layer of load and damaged wood structure quality loss rate to judge the wood structure resistance, small quality loss rate indicates that wood structure rot resistance is good. As shown in Table 1 Corruption resistance of copper azole anti anticorrosion treatment); in the later operation and maintenance, the regular investigation and maintenance of the wood structure, repair and replacement of the wood decay components, increase the operation and maintenance cost for stadiums with low comprehensive utilization rate.

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Table 1. Corruption resistance of copper azole anti anticorrosion treatment

Medicament	Mass Fraction (%)	Surloading on surface surface ($kg \cdot m^{-3}$)	Mass loss rate (%)	
			Brown rot bacteria	White rot fungi
Copper azole agent (CuPT)	0.2	1.10	2.5	22.0
	0.4	1.50	0	1.3
	0.8	2.85	0	0
Untreated	—	0	21.1	37.9

3.3 Analysis of Wood Structure Advantages

"National forest tourism city" construction driven building structure transformation, stadiums as a landmark, often regarded as a forest tourism city characteristic card, in pursuit of green, energy saving, safety, convenience, artistic expression, wooden structure is undoubtedly the most typical expression of green building, wood as a light, strong seismic, high carbon fixation, high insulation, high recycling green renewable resources, in the stadium planning and construction has broad prospects [23].

3.3.1 Energy conservation, carbon fixation and emission reduction will highlight the ecological advantages

In Japan, wood structure buildings is known as the "urban forest", wood as the only one of the four major building materials of "carbon factor" curing renewable energy, with the processing and prefabricated construction of wood structure components, the material transportation and assembly of stadiums in the early construction process total carbon emissions is far lower than the steel structure and reinforced concrete structure. According to statistics, every 1 square meter of the traditional building structure will emit 0.8 tons of carbon, The carbon emissions of the building reach more than 90% of the entire building life cycle of the whole building cycle [24]. In terms of energy conservation and emission reduction: establish a comparative model based on the analysis of the carbon emission factors of various building materials in stadiums (Such as Table 2, the carbon emission factors of different building materials). Wood structure saves 23% energy consumption over brick and concrete structure, and 60% -80% energy saving compared with reinforced concrete structure [25]. Wood relative to other building materials with high "carbon factor" coefficient, and small environmental load, from building material manufacturing, material transportation, prefabricated construction, use and maintenance, to demolition and reuse, f greatly reduce carbon emissions, highlight the "national forest tourism city" green environmental protection development concept, reveal the wood structure stadium ecological advantage.

Table 2. Carbon emission factors for different building materials

Building material	Carbon emission factor	Building material	Carbon emission factor
Ordinary portland cement	735kgCO_2/t	C30 concrete	295kgCO_2/m^3
Pig machine	1700kgCO_2/t	C45 concrete	385kgCO_2/m^3
Ordinary steel	2050kgCO_2/t	Concrete brick	336kgCO_2/m^3
Flat glass	1130kgCO_2/t	Aluminum plastic composite plate	8.06kgCO_2/m^2

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Northeast fir wood	-32.25kgCO_2/m^3	Northeast larch gum wood	-374.71kgCO_2/m^3
North American fir gum wood	-90.63kgCO_2/m^3	North American Citigroup pine gum wood	-295.75kgCO_2/m^3

3.3.2 Safety and durability highlight structural advantages

In North America, heavy wood structure (CLT) buildings gradually occupy a certain market share, and LEED certification standards show that wood structure buildings have certain structural advantages in construction efficiency, seismic resistance, fire resistance [26].

Construction cycle: In view of the good processability of wood, building components are more suitable for factory prefabrication, and on-site construction is mostly prefabricated construction. Standardized production makes the materials completely prefabricated in advance according to the structural design size before entering the site, and the construction site is directly assembled, which greatly reduces the energy consumption of the building construction and shortens the building cycle. According to the construction data report of Fast + Epp Structural Engineering Company, the construction cycle of prefabricated heavy wood structure stadiums is nearly 30% shorter than the construction period of steel structure, saving 25% of construction time, 75% of site construction personnel and 90% of transportation costs [27].

Seismic: wood light weight building features gives wood structure building good elastic function, plus wood structure build unique connection (mortise and tenon structure, steel node structure, wooden truss node), make the wood structure in the earthquake absorption seismic force as small as possible, and has a good elastic resilience, so the wooden structure as the main stadium than steel structure, reinforced reinforced concrete structure has better seismic effect, in instantaneous impact and periodic fatigue damage has good resistance, even if the foundation dislocation, due to the elastic reduction of the wood structure itself and not collapse. According to the Japan Earthquake Administration, built in 1995, the main body of the stadium is built of wooden structure and can withstand a seismic factor of 8 [28].

Fire resistance: China's "Building Design Fire Prevention Code" clearly stipulates that the fire prevention spacing of wood structure buildings should conform to the four-level fire resistance grade building, the building general fire resistance time reaches 1h.With the development of technology and the application of protective materials such as gypsum wall panels, coupled with the characteristics of wood structure material, when the wood structure building suffers from fire, the wood burning surface will quickly form a carbonization layer, isolating the direct contact between wood and fire, greatly enhancing the fire resistance of wood structure building. At the same time, fire retardant coating and flame retardant treatment technology is gradually applied in wooden structure sports venues, the United States International Standards Committee (ICC) pointed out that the wall fire resistance time of the new wooden structure sports venues will be increased to 2h-3h.The critical temperature of static balance stability of steel structure is 500℃, and the impact toughness of steel structure will decrease at 250℃. The fire resistance limit of unprotected steel structure is about 15min. The fire resistance value of ordinary wood structure is 1.5 times that of reinforced concrete structure and 1.3 times that of steel structure.

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Thermal insulation: due to the growth habits and material characteristics of wood, the tissue gap can provide high-quality thermal insulation performance for the building. The thermal conductivity (such as Table 3 Thermal conductivity of different building materials) is relatively low. Analyzing the comparison data of wood structure and steel concrete structure, the energy saving of wood structure sports venues is 50% -70% compared with steel concrete structure.

Table 3. Thermal conductivity of different building materials

Materials	Density(kg/m^3)	Thermal conductivity(W/M.K)	Materials	Density(kg/m^3)	Thermal conductivity(W/M.K)
Hardwood	700	0.18	Eeinforced Concrete	2500	1.74
Cork Wood	500	0.13	Stone Concrete	2300	1.51
Steel Structure	7850	52.34(0°C)	Aerated Concrete	700	0.22

3.3.3 Ecological livability highlights the aesthetic advantages

The application of building materials is the soul of architectural aesthetic expression. As a landmark building of forest tourism city, wood structure stadiums retain wood natural color, clear grain and rich texture to the maximum extent, giving people a gentle experience, strong visual impact and ecological livable aesthetic sense. The traditional steel concrete structure pays attention to the hidden structure, minimizing the weight, cold and gray visual sense of the building, while the wooden structure is more inclined to expose the structure through mortise and tenon, lifting eaves, brackets and other components, to show its natural and rough aesthetic quality. With the gradual maturity of wood structure processing technology, the continuous innovation of structural nodes and the birth of new wood, Promote the qualitative leap in the span of wooden structure stadiums (Japan Tree Sea Giant Egg Stadium stadium span: 178m 157m 52m), Breaking the constraint sense of the internal space and external shape of the traditional wood structure, The emergence of large-span trusses, large frame without column, wooden structure space grid, spherical mesh shell, umbrella dome and other wooden structures, Make the appearance of the stadium more plastic, For the design of modeling, architectural shape, space atmosphere can provide more possibilities, Through the logical architectural form, the coordinated performance of architecture and environment, the expression of sports spirit and other means to better echo the local culture, Highlight the urban culture.

IV. DATA ANALYSIS

Theoretical model of the full life cycle of wood structure gymnasium.

The whole life cycle theory of wood structure gymnasium refers to the whole process of wood structure, from the material mining, construction, operation, life termination, recycling disposal and final disposal. Based on the whole life cycle carbon emission database for the theoretical data model, Calculate the building carbon emission of the whole life week process, such as the construction project planning stage, building construction stage, management and operation stage, and recycling stage, Operation BIM model compares the indexes of the total life cycle, building cycle of the total life cycle, building cycle and

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building characteristics, Demonstration shows that the low-carbon urban wood structure gymnasium has become the main development trend of low-carbon buildings [29]. Build the internal calculation process of carbon emission of stadium building life cycle model (Figure 4 Calculation diagram of the carbon emission in the building life cycle).

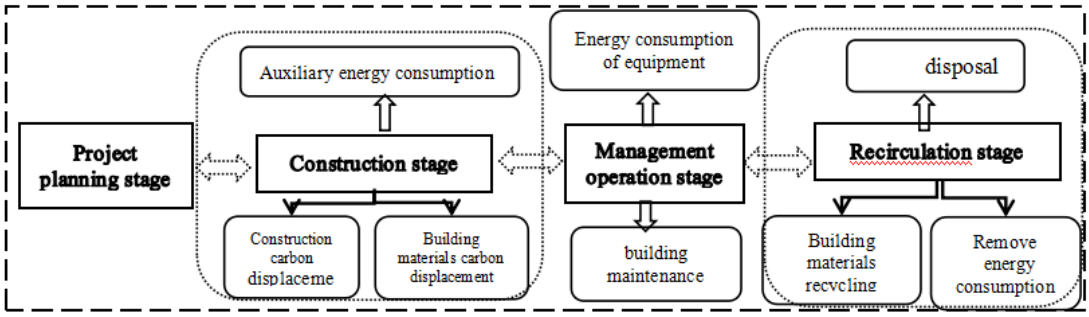

Figure 4: calculation diagram of the carbon emission in the building life cycle

4.1 Model Carbon Emission Calculation Boundary Setting

The data model construction aims to calculate the carbon emission path of wood structure and reinforced concrete structure gymnasium, by comparing the emission factors of the whole life cycle of the two stadiums and the economic effect, the low carbon nature of the wooden structure stadium is demonstrated [30]. The life cycle theory model divides sports venues into three stages: construction stage, use stage and demolition and recycling stage. The material production, material transportation and construction are summarized as the construction stage of sports venues. Due to the late implementation of low-carbon city construction time in China, there is a certain gap between the carbon emission factor used in calculating the total building carbon emission and the international standards, then use carbon emissions EC3 calculation tools, the calculated material carbon emission factor query, and use the computer set a total carbon emissions calculation library and three calculation stage (refined for five carbon emissions calculation library), combined with the calculation model.

4.1.1 The ame boundary setting between the wood structure and RC structure model

The model cycle evaluation boundary adopts 2019 building life cycle stage: production, construction, operation, demolition and recycling stage; the model assumes the same environment, service life of the building and potential conditions. The model calculation method adopts the emission coefficient method, the actual measurement method and the input-output method. Emission factor, also called carbon emission factor, uses CO2 to measure carbon emissions throughout the service cycle [31].

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4.1.2 Different boundary setting between wood structure and RC structure model

Material properties are different, because wood itself carries 45-50% carbon, thermal preservation and carbon fixation with concrete. The stage model calculation and setting is different. In the specific production and construction process, the carbon emission of reinforced concrete structure is far greater than that of wood structure, while the wood structure has the carbon fixation function, so the carbon content of the wood itself is removed in the material production stage.

Because the two structural main building materials are different, the carbon emission factor setting is different, the calculation model setting is different [32]. Set the carbon emission calculation boundary for each stage of the stadium full life cycle model to reduce the interference of other controllable indicators (As shown in Table 4 Calculation boundary of the carbon emission model for each stage of the building whole life cycle).

Table 4. Calculation boundary of the carbon emission model for each stage of the building whole life cycle

Emission stage		Calculate the boundary setting				
Construction stage	Material production M1	primary materials				
	Material transport M2	material transport				
	Construction construction M3	Sub-project	Measures for the project	Construction and drainage	Electricity for temporary facilities	
Use phase M4		HVAC system	Domestic hot water system	lighting system	Elevator system	renewable energy
Remove recycling stage M5		Remove the machinery	Special demolition method	Garbage transportation		

4.2 Construct the Carbon Emission Calculation Model

4.2.1 The total carbon emission calculation model

The main carbon emissions of the stadium cover the whole life cycle, and are refined into the sum of the total emissions in the construction stage, use stage and demolition and recycling stage. See it in Table 4. The calculation formula is:

$$M = M_1 + M_2 + M_3 + M_4 + M_5 \quad (1)$$

Type: M-stadium life cycle; M1-material production; M2-material transportation; M3-construction-stage carbon; M4-use; M5-dismantling and recycling.

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4.2.2 Phase carbon emission calculation sub-model

4.2.2.1 Construction stage

$$M_1 = \sum_{i=1}^{n} Q_i F_i - \mathrm{Q_w F_w} \tag{2}$$

$$M_2 = \sum_{i=1}^{n} Q_i D_i \mathrm{T_i} \tag{3}$$

$$M_3 = \sum_{i=1}^{n} E_{3,i} E\mathrm{F_i} \tag{4}$$

Formula: Qi-i material consumption; Fi-carbon emission factor of i material; Qw-use of material; Fw-carbon content of material; Di-i material average transportation distance; carbon emission factor of unit weight transport distance under Ti-i transportation mode; E3, i-i total energy consumption.

4.2.2.2 Use stage

$$M_4 = [\sum_{\mathrm{i=1}}^{\mathrm{n}} (\mathrm{E_i\ EF_i}) - \mathrm{C_p}]\mathrm{y} \tag{5}$$

$$E_i = \sum_{\mathrm{j=1}}^{\mathrm{n}} (\mathrm{E_{ij}} - \mathrm{ER_{ij}}) \tag{6}$$

Formula: Ei-Class i energy consumption; EFi-Class i energy carbon emission factor; Ei, j-j class i-i energy consumption; ERi, j-Class i energy consumption by renewable energy; i-consumption terminal energy type; j-energy system type; Cp-green carbon sink system annual carbon reduction; y building design life.

4.2.2.3 Demolition and recycling stage

$$M_5 = \sum_{i=1}^{N} E_{5,i} EF_i \tag{7}$$

Formula: E5, i-i total energy consumption in the demolition stage; EFi- -carbon emission factor of class i energy.

Establish gymnasium building carbon emission calculation model, using computer python program model programming, form visualization, quantitative numerical analysis model, wood structure and reinforced concrete structure building main material carbon emission factor into the software, and then the two building structure in the actual process of building materials, energy data, carbon emission calculation.

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4.3 BIM Modeling of Simulated Objects

In order to compare the carbon emission difference between wood structure and reinforced RC structure gymnasium, with A university cottage gymnasium as the theoretical model, Auto CAD2009 software and P-BIM platform 3D modeling, control the building area, structure, service life, external environment, construct the same specification HVAC, water supply and drainage, and electrical system, refers to the main building materials, deepen the model establishment and optimization, using the BIM platform and life cycle carbon emission calculation model(Figure 5 Calculation model of simulated object life cycle carbon displacement).

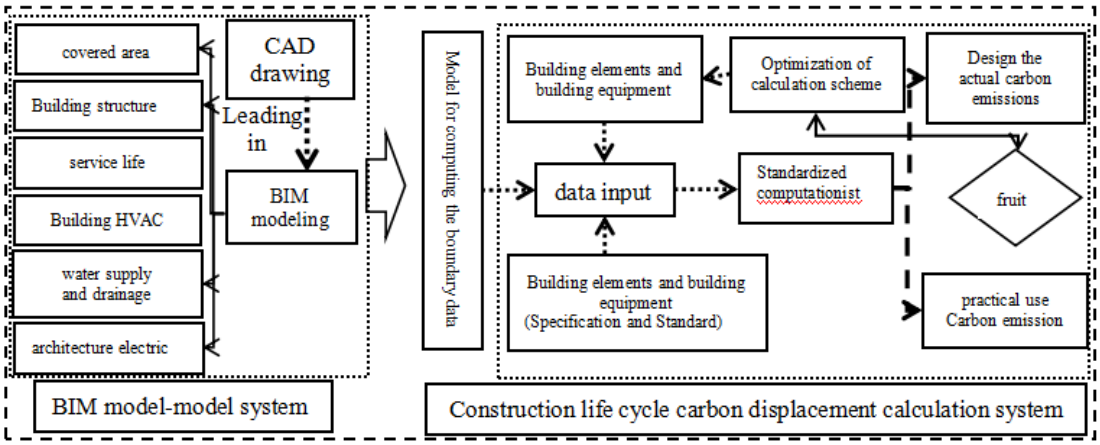

Figure 5: calculation model of simulated object life cycle carbon displacement

The overall framework for the simulated objects was constructed through the BIM modeling software. The application of BIM technology can effectively control and manage the entire lifecycle of a building, and automatically detect and analyze, process, and output data computing files. Based on the experimental comparison of the total carbon emission life cycle of the wooden structure and the reinforced concrete structure gymnasium, and then compare the energy saving effect of the two building structures, the two structures simulate the calculation model of the same shape and the same volume:

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 2235-2256
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

Figure 6: schematic diagram of the simulated object BIM modeling

The reference building of Xi'an A University was built in 2018. The structure model and the wood structure model of the same volume are calculated. The total construction area is 9303.9 square meters, the total height is 15.65m5 and the span is 45m, based on the total carbon emissions. BIM model simulation results (See figure 6 Schematic diagram of the simulated object BIM modeling).

4.4 Life Cycle Simulation Conclusion of Wood Structure Gymnasium

The calculation indexes of the whole life cycle simulation model are in accordance with GB / T 51366-2019, the model measurement parameter, the building performance and carbon emission of the two structural gymnasium, and the results are analyzed to demonstrate the quality design of wood structure compared with the reinforced concrete structure gymnasium.

4.4.1 Simulation and calculation of carbon emission stage in wood structure gymnasium

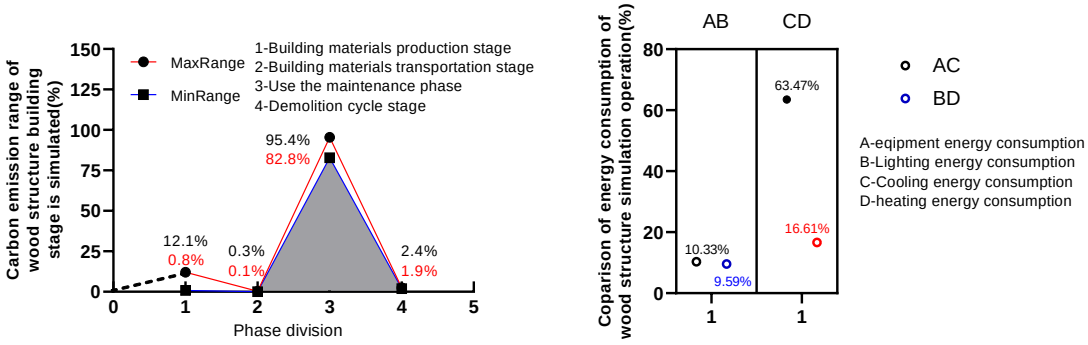

Figure 7: simulation results of energy consumption in wood structure gymnasium

According to the classification standards of Chinese Academy of Architectural Sciences, To define the

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 2235-2256
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

full life-cycle phase of the building model, To calculate the range of total carbon emissions at each stage of the building, Set the total carbon emission of the building at 100% for the entire life cycle, Export the model calculation results, The peak carbon emission is the operation and maintenance phase after completion, This stage is due to the different operation and management mode, Cause the difference in building carbon emissions, Schematic diagram of the energy consumption simulation results (Figure 7 Simulation results of energy consumption in wood structure gymnasium), The specific scope accounts for 82.8%~95.4% of the whole life cycle of the building; In the material production process, Differences in the natural environment, production conditions, production mode and other indicators, Lead in its range control at 0.8% to 12.1%, The difference is more obvious; The construction and transportation and the later building demolition and recycling stage is more unified, Accounting for 0.1%~0.3% and 1.9%~2.4%, respectively.

During the operation and maintenance stage of wood structure gymnasium, ignoring the influence of other carbon emission indicators and comparing the energy consumption ratio of various operating equipment, the main wood structure of the building cannot make up for the energy consumption of lighting and infrastructure equipment, which has good consistency compared with reinforced concrete structure; the low heating energy consumption is thanks to the good insulation of wood structure. The heat resistance is 10 times that of the concrete structure, effectively isolating the impact of the cold environment through the corresponding ventilation system.

4.4.2 Full-life-cycle simulation and calculation

Using the whole life cycle calculation model, set the external calculation boundary of the model for the operation and maintenance stage of the stadium, take the building energy consumption and periodic carbon emissions as comparative indicators, the temperature control at-10℃~20℃, the air humidity is set at 40%, natural gas and water, the building life cycle is limited to 50 years, and draw the analysis chart to further support the argument(Figure 8 simulation results of building energy consumption and carbon emissions in the full life cycle).

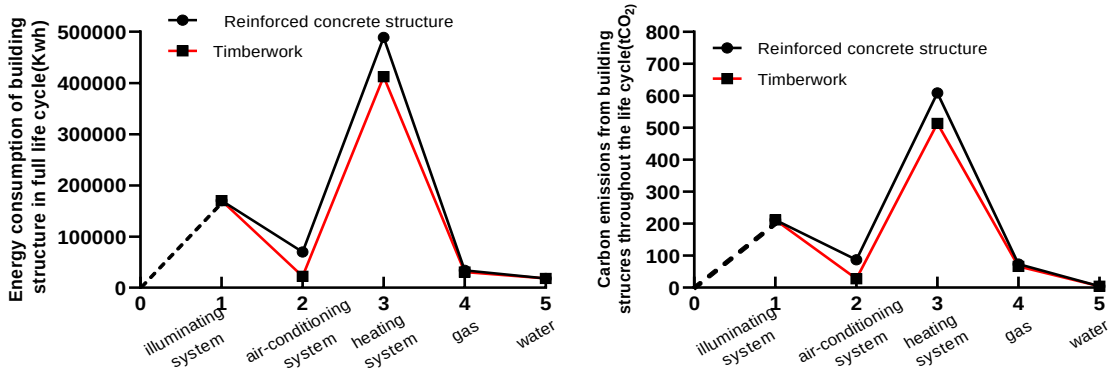

Figure 8: simulation results of building energy consumption and carbon emissions in the full life cycle

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 2235-2256
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

Energy consumption and recovery stage of wood structure analysis and carbon emission are lower than that of reinforced concrete structure, wood structure after demolition can be further recycled, the above stage wood structure is significantly better than the reinforced concrete structure, hence not comparison, only discusses the construction operation use maintenance stage energy consumption value and carbon emissions. Although there is no obvious gap between the equipment and energy for the normal operation of the lighting system, natural gas and water for the stadium that are not controlled by the main structure of the building. The carbon emission generated by the daily operation and maintenance of the two stadium structures is compared. The wood structure is more environmentally friendly and low-carbon. The carbon displacement of the reinforced concrete structure is 1.2 times that of the wood structure, and the energy consumption is 3 times.

4.4.3 Simulation and calculation of building energy-saving performance and building performance

Comparison of energy saving performance between wood structure and reinforced concrete structure gymnasium. Air conditioning system P <0.01, very significant difference; heating system and natural gas P <0.05, significant difference; no difference between lighting system and water consumption (Figure 9 Simulation results of the building special energy of the two structures

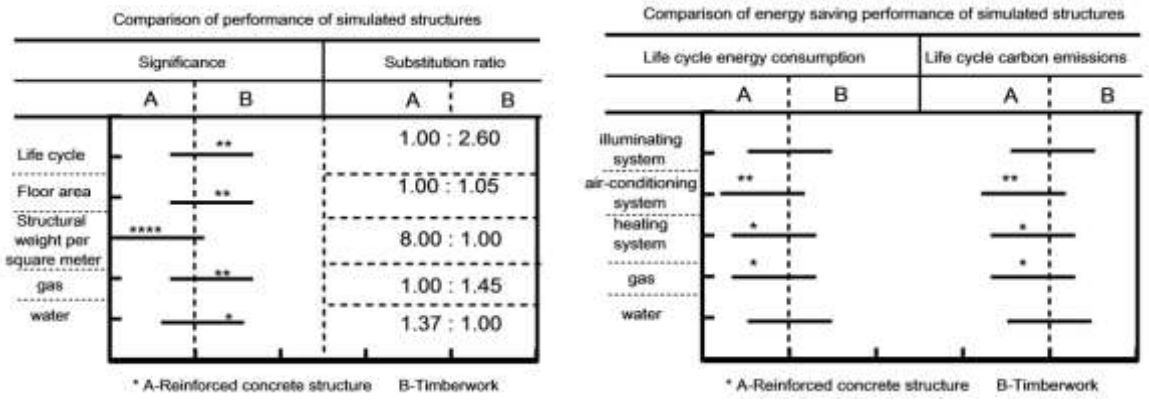

Figure 9: simulation results of the building special energy of the two structures

Note: * * indicates a very significant difference between wood structure and reinforced concrete structure, P <0.01. * Represents a significant difference between the wood structure and the reinforced concrete structure, with P <0.05.

BIM modeling computational models comparing building performance, On the architectural characteristics of living buildings in construction and life cycle, The two structures are very significantly different in the building dead weight, life cycle, building use area, carbon content and other indicators, P<0.01, The wooden structure can last 200 years under scientific and reasonable maintenance, Timely demolition can also be recycled; The high-quality thermal insulation of the wood structure, There is no need to add excessive heat insulation materials during the external wall treatment, The wood structure of the same volume can be 2%~5% more usable area than the reinforced concrete structure, Save 45.24% energy and 46.17% water; The dead weight of the building structure is only 1/8 of the reinforced concrete

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 2235-2256
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

structure; The construction period calculation results showed a P <0.05, with significant differences, The reinforced concrete structure is about 1.37 times that of the wood structure.

To sum up calculation model simulation, wood structure solid carbon emission reduction, construction cycle, service life, safety, economy are far because of reinforced concrete structure, more in line with the low carbon forest tourism city construction concept, strengthen the construction and technical innovation concept, form the wood structure, steel structure, steel structure, concrete structure diversified future building development trend.

V. IMPLEMENTATION PATH

Wooden structure gymnasium leads the new development of ecological city, low-carbon mode analysis and exploration of the realization path

5.1 Feasibility Analysis

Under the historical opportunity of "double carbon", the rise of wooden structure sports venues as a new path of energy saving transformation of sports buildings, an important measure to realize CCUS carbon sequestration has certain feasibility in China:

From the top-level design, In recent years, the guiding wood structure building code documents have been issued, It has spawned the development of China's wood structure construction industry: the "13th Five-Year" prefabricated Building Action Plan " put forward the regional pilot plan to standardize the development conditions of wood structure building, Clearly formulate development goals and issue task indicators, Set up special plans for key development areas, Improve the corresponding system; Strengthen the proportion of prefabricated wood structure construction industry in new buildings in heavy construction areas; The cultural and creative Park on the north bank of the Yangtze River contracted by the local government of Guizhou Province, Realize the role of top policies in leading local development.

In terms of real-world resources, China has a large number of larch trees, sylvestrus and North American spruce, pine and other important building wood, To supplement China's forestry resources, Also for the wood structure construction industry raw material source to do guarantee; Finnish timber enterprises represented by Fenmeisha wood industry, Effectively alleviate the pressure of environmental resources for the development of wood structure construction industry in China, Great integration of transportation, construction and assembly; In addition to China's rich bamboo resources, And the continuous innovation of straw plate production technology, It also provides a controllable operation for the development of wood result building materials and new structural materials in China.

From the point of industry development, foreign related high quality research team involved and related domestic enterprises, university research institutions set up wood structure building research

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 2235-2256
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

projects, construction raw material supply mechanism, avoid bad competition of different suppliers, accelerate technical improvement, structure processing, such as CLT orthogonal adhesive wood high quality building materials, fully mobilize the building materials, construction, environmental protection, forestry, culture, machinery and other industries coupling.

From the point of market terminal demand, in the process of "double carbon" development, wood structure building in advocating green life reality demand to be accepted by the public, while highlighting high quality products, should also be green low carbon brand concept under the guise of specialization, detailed product design, using more mature, low carbon high-tech application to specific projects, provide feasibility for wood structure construction industry development in China.

5.2 Empirical Achievements and Realization Path Exploration

Forest tourism city construction further upgrades and expands the "whole domain" of the construction scope, implements the "long-term" of the strategy, the "scientific" of resource allocation, and the "circulation" of energy utilization. Low-carbon economy emphasizes a green economic model under the premise of reducing greenhouse gas emissions. In this context, wooden structure sports venues like low carbon green building industry, gradually abandon the traditional construction industry high investment, high emissions, build ecological livable at the same time, gradually into nature, realize the harmonious coexistence between man and nature, building ecological balance, reiterated the health, environmental protection, saving of green building development direction. Learn from Japan "3E + S" energy plan, the "low carbon transformation plan" and other advanced strategy, relying on the national forest tourism city wooden structure stadium construction and production, realize low carbon city energy and industrial structure optimization, We will complete the transformation of stadiums and venues in China, and actively explore the "low-carbon revolution" in the green construction of a national forest tourism city.

5.2.1 Sports + tourism mode to promote the development of event tourism economy

Tourism drives sports, and sports promotes the economy. It was first built in 1997 in the famous forest tourism city of Akita Prefecture, The pavilion is by far the largest span wooden structure stadium in Japan, Total space span reaches 178m 157m 52m, The overall structure adopts the wooden arch frame structure, Using 25,0003-5-meter Akita fir trees, built into a grid shape extending from the roof to the main floor, The roof dome is constructed by the two-way adhesive wooden rods and the main support, Roof of wood suspended with special fireproof coating, Fundamentally isolate the fire sources to reduce the fire occurrence factor, Strong stable steel structure is selected for the building base, The exterior wall of the stadium is fixed with glass curtain wall splicing, Maxmaximum exposure of the wood structure to sunlight, Reduce the risk of wood mildew and moth decay.

According to the statistics of China Travel International Overseas Business Division (CITS-OECC), nearly 1,000 tour groups send to Akita County every year, with a total number of more than 50,000 people.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 2235-2256
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

Akita with forest tourism as the carrier, the Japanese professional baseball main venue set up and tree sea egg stadium, tourism drive sports, all kinds of professional baseball games rich forest tourism, combined with Japanese JR railway akaida tree line opened, make a remarkable wooden structure stadiums and professional baseball events together, promote local tourism is a "blowout" growth, the earliest wooden structure sports venues "sports + forest tourism" mode development in the national forest tourism city.

5.2.2 Sports + cultural model, gathering urban cultural and economic development

The construction of national forest tourism city wooden structure stadiums, raw materials, building structure and appearance often contain the cultural heritage and national characteristics of the city. To promote economic development through "sports + culture" is to enhance the unique function of structural stadiums different from other structural system buildings. The Jingzhou Ethnic Stadium in Hunan Province was completed in 2017, winning the Furong Award, In that year. Sports venues to "wind and rain bridge, heavy eaves become warped, miao dong, the soul of sports" as the design concept building wooden structure contains the continuation of Hunan local miao dong ethnic architecture, the overall structure in the form of storm bridge structure will connect each functional area, in the form of Hunan dong bridge hole culture design a floor structure, rich sports culture relief wind and rain bridge facade effect. The roof is made of the characteristic wood of Miao and Dong people, and the building load is distributed in the form of a combination of column and vertical and horizontal beam and tiebeam. Since its completion, it has undertaken nearly 100 competitions, fairs and sports exhibitions. With the help of urban ethnic culture, the commercial added value of stadiums and gymnasiums has been explored to the greatest extent to create good economic and social effects.

5.2.3 Sports + health care mode, to build the economic development of forestry business form

On the basis of forest tourism cities, Guizhou province will have 64 provincial forest health pilot bases by 2021, vigorously encouraging the construction of forest rehabilitation centers, forest oxygen, forest and bath health industries, and currently forming a polymorphic sports and health mode (Table 5 Polymorphism "sports + health care" economic development model):

Table 5. Polymorphism "sports + health care" economic development model

Sports and health care development model	Base pilot
Tea garden and forest health care model	Fenggang charm Guizhou tea forest health care pilot base
Hot spring forest health care model	Ciquan CuiValley forest health base
Lake / river and forest health care model	Swan Castle National Forest health care pilot Base
Mountain karst forest health care model	Guizhou 12 back health care tourism area national forest health care pilot base
Bamboo forest / flower sea forest health care mode	North Guizhou flower sea tourism scenic spot health care base
Terrace / grassland forest health care mode	Terrace / grassland forest health care mode

Forest Chemicals Review
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ISSN: 1520-0191
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Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

"Sports + forest" kang mode in Guizhou rongjiang county indoor swimming pool as an example: swimming pool one floor with reinforced concrete structure, the second floor using wooden structure architecture, building central flower bridge and drum tower adopts the traditional wooden structure, fully integrated into the local national characteristics and regional characteristics, roof with string wood system for double composite wood components, span of 50.4m, is the largest span wooden structure roof building in China. Guizhou province to the swimming pool as the forest health pilot foundation, make full use of the forest, trails, rivers and other resources, forming local characteristics of health, fitness, food, culture, education, economy industry: greenway concept into slow traffic system construction, meet the forest walking, jogging, cycling, climbing, yoga and other health needs; the spirit of adventure into outdoor development base, meet the needs of tourists limit rope, rock climbing, rafting, adventure and other sports; Leisure and entertainment will be integrated into building a natural health care base to meet the needs of tourists for hiking, gliding, grass skiing, horse racing and hunting. We can also rely on the sports venues to build the health and yoga culture corridor, Tai Chi Square, the activities and entertainment center for the elderly, and the tea ceremony, tea ceremony and performance area, to maximize the function of the "sports + forest" health care mode.

VI. CONCLUSION

The new perspective of economic development in the new era, adhering to the "man-nature and economy" harmonious symbiotic development model structure, explains: the social development tone of the unity of opposition between man and nature. The construction of national forest tourism city integrates the concept of low-carbon city into the urban planning and design, Wood-structure sports venues, as a subsystem of green and low-carbon buildings, Calculate the stadium full life cycle model data indicators, Compared with reinforced concrete structure sports venues have better energy conservation and emission reduction, safe earthquake resistance, ecological livable and other building characteristics. More can give architectural cultural characteristics; Wood structure technology is gradually mature, The forms of wooden structure stadiums are gradually diversified, More can highlight the building plasticity; Structural system is more diversified, Material composite structure system (rubber and wood structure, steel and wood structure, etc.) has become a new trend of wood structure development, better reflect the social benefits of the low-carbon economy; the development of the "sports +" model, The economic system of promoting the local characteristic elements of the forest tourism city, It can better highlight the economic benefits of wooden structure sports stadiums, To achieve low-carbon city construction and social and economic development in coordination and win-win results.

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Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

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