Simulation of Impact Force Absorption of Synthetic Rubber Materials in Volleyball Court Based on Discrete Element Method

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Abstract. In order to accurately simulate the impact force absorption of synthetic rubber materials in volleyball courts, a simulation method of impact force absorption of synthetic rubber materials in volleyball courts based on discrete element method was proposed. According to the related theory of discrete element method, the mathematical equation is established to solve the maximum impact load that can be absorbed by the synthetic rubber material in the volleyball field in the process of human jumping and falling; According to the model results and the stress characteristics of human lower limb bones, the threshold of impact load borne by synthetic rubber materials in volleyball courts is obtained, and the impact absorption rate and deformation characteristics of volleyball courts under safe conditions are determined, so as to provide a simulation basis for the optimization of shock absorption structural parameters of volleyball courts. Finally, the experiment proves that the simulation method in this paper has high practicability in the practical application process and fully meets the research requirements.

Keywords: Discrete element method · Volleyball court · Synthetic rubber · Impact force

1 Introduction

With the increase in the number of large-scale sports events held at home and abroad, the improvement of people's quality of life and the enhancement of national sports fitness awareness, the construction area of sports facilities is increasing. Volleyball field is the basis of indoor sports facilities. Under the background of the increasing demand and development space of volleyball field and the lack of domestic volleyball field production and testing standards and methods [1]. Domestic and foreign scholars have gradually improved their research on the structure and surface mechanical properties of volleyball court, mainly focusing on the optimization of volleyball court structure and the improvement of volleyball court surface properties. Among them, the performance index of volleyball court structure optimization generally takes the impact load as the research object, and the surface performance improvement takes the rolling load performance index as the analysis goal. Volleyball court is a special floor with the function of

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bearing people's high-intensity sports and providing sports protection. It is an important part of the ground pavement facilities of gymnasium [2]. The research on volleyball field in China started late and the foundation is weak. The research on mechanical properties, testing methods and testing instruments of volleyball field is relatively scarce. Based on the theory of discrete element method and the methods of human motion simulation analysis, algorithm prediction and experimental verification, this paper studies the influence of impact load on the impact force absorption of synthetic rubber materials in volleyball field; According to the impact load experiment and simulation method, the structural parameters of damping pad in volleyball court are optimized to improve the impact absorption performance of volleyball court; Based on the principle of laser displacement measurement, the rolling load detection method of volleyball field is proposed; Combined with the discrete element method and the design requirements of detection standards, a comprehensive load detection simulation method of volleyball court is designed.

2 Simulation of Impact Force Absorption of Synthetic Rubber Materials in Volleyball Field

2.1 Impact of Human Sports on Synthetic Rubber Materials in Volleyball Field

During the jumping movement of sports athletes on the volleyball field, jumping and falling will produce impact load on the floor. According to the relationship between force and reaction force, the impact load acts on the human body in the form of impact rebound. If the impact rebound is too large, it will damage the human sports joints [3]. Based on the mathematical model and simulation solution process established by the discrete element method, the load borne by the human body in the jumping process is obtained: the minimum absorption rate of the impact load of the volleyball court is determined according to the load threshold of the human femoral head joint, which provides a theoretical basis for the subsequent structural optimization of the volleyball court. In the current sports competition, the physical stress status, physical and chemical index changes, psychological and emotional changes and other factors of athletes in the process of sports will have an important impact on the competition results and athletes' physical and mental health [4]. Therefore, protecting athletes' physical and mental health and making athletes have a good competitive state has developed into a multifaceted and comprehensive interdisciplinary subject. Among them, sports medicine, sports physiology, sports biochemistry, discrete element method, sports psychology, sports nutrition, training equipment and other technologies constitute an important scientific and technological support system for sports training [5]. From the perspective of analyzing the force on the human body, the discrete element method plays a positive guiding role in solving the impact load on the human leg in the process of jumping. In order to more clearly describe the impact load and load absorption process during human jumping, the impact load absorption flow chart shown in Fig. 1 is drawn.

The specific process is: the human body generates an impact force F → the volleyball court absorbs part of the impact load and the human body's own legs bend to absorb the impact load b → the human body actually bears the load F1 → according to the

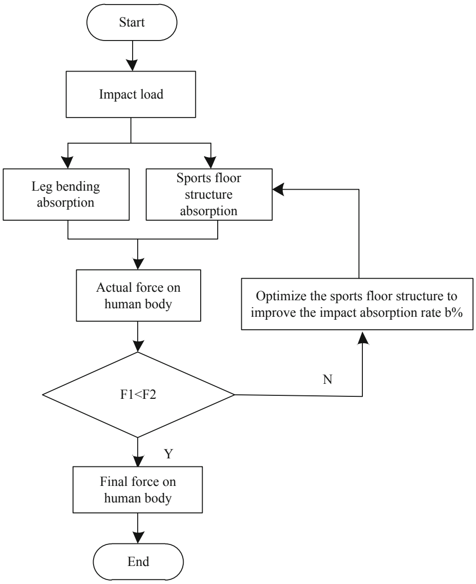


Fig. 1. Shock load absorption process of human motion

human body discrete element method to determine whether the impact load is less than the human bone joint force threshold F2 → If it matches (ie F1 < F2), solve the final impact absorption load F3 of the floor; if it does not meet (ie F1 ≥ F2), change the structure of the volleyball court to improve the absorption performance of impact load a. Among them, the calculation formula of the relationship between the impact load F of the human body and the actual force F1 of the human body is:

$$F_1 = F \times s(1 - a) \times (1 - b) \tag{1}$$

where, F is the impact load generated by human motion, s is the actual force of human motion, a is the bending impact absorption rate of human legs, and b is the impact absorption rate of volleyball court structure. m represents the internal force between the hinges of the knee; g represents the internal force distance, which is the control torque of the human body and is generally a function of $m\ddot{y}$. The dynamic equation of the system can be listed by Newton mechanics, momentum theorem and momentum moment theorem as follows:

$$\begin{cases} m\ddot{y} = F_y - mg \\ (m\ddot{y} + mg)l\sin\theta = M(\theta) \end{cases} \tag{2}$$

where, l is the body mass, F_y is the ground rebound force, and θ is the angle between the lower leg and the vertical direction; $M(\theta)$ is the moment of human leg, ω is the length of human leg, d is the second derivative of the height of the leg contacting the ground from the ground, which describes the constraint equation between the height t between the body and the ground and the included angle θ between the lower leg and the vertical direction when the human foot contacts the ground:

$$\begin{cases} y = 2l\cos\theta \\ \dot{y} = 2l\sin\theta, \omega = -\frac{d\theta}{dt} \\ \ddot{y} = -2l\omega\left(\frac{d\omega}{d\theta}\sin\theta + \omega\cos\theta\right) \end{cases} \tag{3}$$

You can get:

$$M(\theta) = 2F_y l\sin\theta \tag{4}$$

Let $x = 2$, the first-order linear differential equation can be obtained:

$$\frac{dx}{d\theta} + (2\cot\theta)x = \frac{1}{l\sin\theta}\left[g - \frac{M(\theta)}{ml\sin\theta}\right] \tag{5}$$

The expression of the analytical solution of the differential equation is:

$$x = \frac{1}{\sin^2\theta}\left[\int \frac{\sin\theta}{l}\left[g - \frac{M(\theta)}{ml\sin\theta}\right]d\theta + C\right] \tag{6}$$

In order to further explore the motion and stress process of various parts of human lower limbs and analyze the stress of important joints of human lower limbs, the method of human simulation model analysis is adopted. This method is the key technology of the cross scientific research of computer and modern discrete element method, and it is also one of the frontier directions in the field of virtual reality and computer vision [6]. Adams dynamic modeling and simulation software, which has the advantages of fast calculation speed, high simulation accuracy and two-way solution of kinematic and dynamic parameters, is selected to analyze the stress status of each joint of the leg in the process of human jumping, and the three-dimensional modeling software is used to call different human body size parameters to draw the leg model of the human lower limb. The size and mass of each part of human lower limb are shown in Tables 1 and 2.

Table 1. Size and mass of human lower limbs

Project	Company	Average value	Standard deviation
Thigh length	mm	502.758	38.582
Calf length	mm	376.252	21.695
Foot length	mm	249.256	11.165
Thigh weight	kg	8.265	0.865
Calf weight	kg	2.365	0.305
Full weight	kg	0.832	0.065

Taking volleyball as an example, the maximum reaction force F generated by the ground to the human body in the take-off process is 6500N, the standard adult male

Table 2. Hourglass energy of impact deformation of material structure

Cross section	Ehg(J)	Eint(J)	RHI(%)
SQUARE	6.325	652.962	0.98
NCMC12	21.358	1429.658	1.51
NCMC20	43.925	2350.200	1.89

weight is 60kg, the length of thigh and calf is 400m, and the maximum bending angle of leg buffer jump is calculated according to the actual jumping movement law of human body θ The variation range is 0° ~ 30° [7]. Due to the complexity of the functional relationship, in order to clearly and intuitively express the parameter relationship in the functional relationship, the functional relationship between the human leg bending offset force F and the leg bending angle is constructed, programmed with MATLAB software, and the functional relationship image between the human leg bending offset force and the leg bending angle is drawn, as shown in Fig. 2.

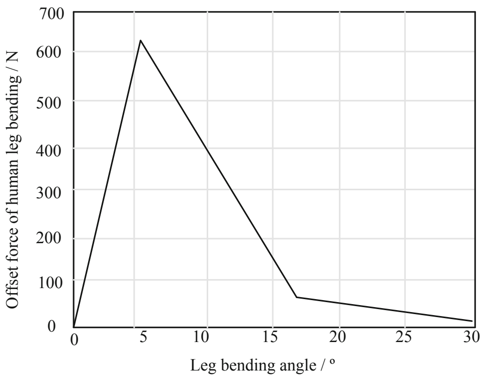


Fig. 2. Relationship between human leg bending offset force and leg bending angle

It can be seen from Fig. 2 that the angle between the resistance generated by the human leg and the vertical direction increases rapidly and then decreases gradually. When the bending angle is 5°, the maximum offset force generated by the human body is 650N, when the bending angle is 18°, the offset force is reduced to 50N, and then the offset force continues to decrease. Therefore, it can be obtained that in the process from the human body's take-off contact with the ground to the bending of the legs, taking the maximum impact force of 6500N as an example, the body itself can absorb 650N impact force by relying on the leg movement mode, that is, 10% of the total impact force received by the body. This data acquisition lays a foundation for subsequent simulation analysis and the design of floor impact absorption and impact instrument.

2.2 Impact Deformation Characteristics of Synthetic Rubber Materials

The synthetic rubber surface sports ground is different from the hard pavement. The impact absorption test must be carried out with a special synthetic material surface sports ground impact absorption tester based on the impact absorption test specification in the national standard GBT36246–2018 to determine FR. FR is the percentage value of the impact absorption performance of the synthetic material surface layer relative to the rubber material base layer. Therefore, before calculating FR, not only the synthetic material surface layer needs to be tested, but also the peak impact force of the hard rubber material base layer needs to be measured [8]. Finally, the peak impact force of synthetic material surface and hard rubber base is calculated, and H is obtained. The energy absorption of each corner part in a folding cycle is:

$$E = M(\theta)\left(16IF_1/x + 2\pi y + 4CIH^2/b\right) \tag{7}$$

where, C is the partial plate length of each corner. Therefore, the energy absorption of a non convex section thin-walled material with I corners in one cross section is:

$$\frac{P_m}{M_0}2H\chi = E\left(16I_1\frac{b}{t}H + 2\pi C + 4I_3\frac{H^2}{b}\right) \tag{8}$$

where, χ represents the effective folding coefficient and N is the perimeter of the material cross section, then:

$$\frac{P_m}{M_0} = \frac{1}{\chi}\left[N\left(8I_1\frac{b}{t} + 2I_3\frac{H}{b}\right) + \pi\frac{L_c}{H}\right] \tag{9}$$

Hourglass deformation may lead to invalid numerical simulation results. Therefore, hourglass deformation must be restrained as much as possible. From the deformation after compression, the deformation of each rubber material is very smooth, and no obvious hourglass deformation is found. The hourglass deformation energy of each material when the impact deformation is 0.73 times the initial material length is listed in the table.

It can be seen from the table that the hourglass deformation energy of the material is lower than 2% of its internal energy. Therefore, the hourglass deformation is well restrained, and the calculation results are effective. The design of specific performance structure is a very common and important problem in engineering application. The energy absorption properties of square materials, multi cell square materials and non convex section materials will be compared and analyzed from the three aspects of the same material dosage, equal energy absorption and equal maximum peak load [9]. The weight of energy absorbing structure is not only directly related to its manufacturing cost, but also very important to the cost of the structure in the whole life cycle. The energy absorption performance of non convex cross-section discrete element is studied by the combination of theoretical analysis based on discrete element method and explicit nonlinear finite element analysis. Based on the discrete element method, it is extended to the discrete element including the cross part, and the calculation formula of the average force of the nonconvex discrete element is deduced. Secondly, the axial deformation of the nonconvex discrete element is analyzed by using the explicit nonlinear finite element analysis software ANSYS /LS-DYNA, and the detailed energy absorption performance parameters of this kind of structure are obtained. Finally, the theoretical prediction and numerical simulation results are compared and discussed, and the advantages of non convex section discrete element are revealed. The schematic cross-section of non convex material is shown in Fig. 3.

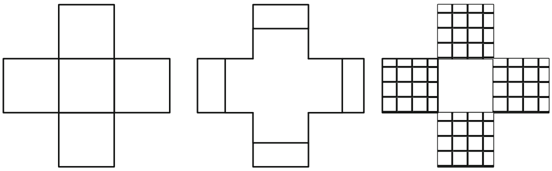


Fig. 3. Cross section of non convex material

Figure 3 shows the geometric composition and energy absorption of the T-shaped part composed of two plates and three plates. Based on the observation of the deformation pattern of the non convex discrete element in the cross part, the composition and energy dissipation of the cross part deformation mechanism are given, and the energy absorption of the deformation mode of the cross part is the same whether at the concave corner of the outer profile or in the middle of the discrete element [10]. According to the impact load in the functional index of the floor used in the standard gymnasium, the impact absorption rate values in the purposes of competition, training, teaching and fitness are shown in Tables 3 and 4.

Table 3. Impact absorption rate of volleyball courts for different purposes

Floor use	Impact absorptivity(%)
competition	≥ 55
Training and teaching	≥ 36
Bodybuilding	≥ 36

Table 4. Constraint setting of sports field on synthetic material surface

Parts	Upper surface	Bottom surface	Front	After	Left	Right
Synthetic surface	Contact constraint	Contact constraint	X = 0;Y = 0	X = 0;Y = 0	X = 0;Y = 0	X = 0;Y = 0
Concrete base	Contact constraint	Fix suport	Fix suport	Fix suport	Fix suport	Fix suport

The impact absorption rate f of volleyball court is 41%, which is the value that can withstand the impact in the range of 35% ~ 53%.

2.3 Simulation of Impact Force Absorption of Synthetic Rubber Materials

As a deformable body, rubber base is usually represented by volume element in the numerical model of impact absorption test, so there are only translational degrees of freedom in three directions, so only translational degrees of freedom constraints are considered in the numerical model. Since the upper and lower surfaces of the synthetic material surface are in contact with the steel dynamometer and the rubber base respectively, it is only necessary to set displacement constraints on the front, rear, left and right surfaces of the synthetic material surface, that is, fully constrain in the XY direction and release only the Z axis. Based on the actual situation, except the contact surface between the rubber material base course and the synthetic material surface course, all other surfaces are added with fixed constraints to suppress all displacement degrees of freedom. The specific settings are shown in the table.

In ANSYSWorkbench, contact description can be applied to the connection relationship between objects. By setting different contact relations, the force and energy transfer algorithm of contact coincidence area between different objects can be defined. The contact types given in ANSYSWorkbench include binding, non separation, no friction, roughness and friction, among which binding and friction are the most representative. Binding contact is used to describe the connection behavior that two contact objects do not separate in the normal direction of the contact surface and can not slide relative in the tangent direction. If there is friction contact, it describes the connection relationship that the normal direction can be separated and the tangent direction can not slide relative. The contact setting needs to set the target surface and contact surface for the contacted object. Generally, the object with fine grid, small surface area and low material hardness is the contact body, on the contrary, it is the target body. The contact surfaces on the contact body and the target body are the contact surface and the target surface respectively. From the complete three-dimensional model of impact absorption test, it can be seen that there are four groups of contact, Among them, normal separation can occur between the heavy object and the anvil, and relative sliding cannot occur in the tangential direction, so it is defined as frictional contact. The other three groups of contacts cannot be separated in the normal direction and relative sliding cannot occur in the tangential direction, so it is set as binding contact. To sum up, the contact definition in the numerical model is shown in Table 5.

In the process of impact force absorption simulation, when the initial displacement and velocity conditions and all time step loads need to be given, the displacement of the next time step can be obtained according to the initial acceleration, and then the velocity and acceleration can be obtained respectively. The displacement, velocity and acceleration of all time steps can be obtained by calculating in turn.

In the pre-processing stage, it is necessary to compare the real physical system and establish a scientific and reasonable numerical model from the aspects of research object model, material model and boundary conditions. The approximation between the numerical model and the real physical system plays a decisive role in the accuracy of

Table 5. Material contact settings

Contact serial number	Contact type	Interface	Target surface
A	Friction	Lower surface of weight M	Upper surface of anvil T
B	Binding	Anvil T lower surface	Upper surface of anvil T
C	Binding	Lower surface of steel side force platform G	Upper surface of moving material layer
D	Binding	Lower surface of moving material surface	Upper surface of concrete base

simulation results. In the calculation stage, select appropriate solution items for calculation according to the research purpose. After the solution is completed, enter the post-processing stage to process the data, evaluate and analyze the calculation results. When it is determined that the numerical model can meet the analysis requirements, output charts, analysis reports, etc. The rebound impact load results obtained are consistent with the results in sports structural mechanics that the first peak range of the vertical component of the ground reaction force of volleyball players after taking off and landing is 1000 ~ 2000N, while the second peak range is 1000 ~ 6500n, which can ensure the correctness of the simulation.

3 Analysis of Experimental Results

Volleyball courts can be divided into prefabricated rubber courts, mixed rubber courts and composite rubber courts according to different materials and pavement structures.

Prefabricated rubber track: it is composed of anti-skid layer and bottom rubber layer, all of which are made of PU and EPDM elastomer. The thickness of Pu is generally 9-13mm, with high resilience. It is a professional volleyball stadium.

Mixed rubber field: the rubber surface of this rubber field has a double-layer structure, with an anti-skid layer and a bottom layer. The bottom layer contains 15% - 25% of waste tire particles, and the thickness is generally 9-13mm. A layer of PU material is poured as the friction surface layer.

Compound rubber field: there is a rubber primer layer (40% - 60%) of rubber bonded waste tire rubber particles, with a general thickness of 9-25mm.

When the impact absorption test of rubber material base is carried out, the test steps are consistent with the impact absorption test of synthetic material surface sample. The main difference is that 11 impact tests are carried out on rubber material base, the results of the second to eleventh tests are valid data, and the final impact force peak F of rubber material base is the average value of the last 10 test results. The calculation method is shown in formula (10):

$$F_{conceere} = \frac{F'_2 + F'_3 + \cdots + F'_{10} + F'_{11}}{10} \tag{10}$$

where: $F'_2, F'_3, \cdots, F'_{10}, F'_{11}$ represents the 2nd to 11th times on the hard rubber material. Prepare one composite and one mixed composite surface sample, numbered respectively

Test_A and Test_B. The test scheme is designed according to the impact absorption test specification, as shown in Tables 6, 7, 8 and 9.

Table 6. Design of impact absorption test scheme

Test piece No	Test No	Weight mass(kg)	Test interval(s)	Length of test piece(mm)	Specimen width(mm)	Specimen height(mm)
Test_A	A	20	60	400	300	14
	B	20	60	400	300	14
	C	20	60	400	300	14
Test_B	A	20	60	400	300	14
	B	20	60	400	300	14
	C	20	60	400	300	14

Table 7. Damping pad parameters.

Serial number	Length (mm)	Width (mm)	Thickness (mm)	Hardness (HA)	Quality (g)	Material properties	Elongation (%)	Proportion(g/cm-3)
A	62	51	20	46	30	Natural rubber	300	1.5
B	77	50	20	46	69	Natural rubber	300	1.5
C	66	66	14	47	22	Natural rubber	300	1.5
D	78	50	10	48	13	Natural rubber	300	1.5
E	80	56	18	47	68	Natural rubber	300	1.5

The sample type is used as the control variable, and the peak impact force acting on the specimen surface during the test is used as the dependent variable. During the test, conduct three impact absorption tests on each sample at an interval of 60s, record the peak impact force measured in each test, and calculate the average of the peak impact force measured in the second and third tests of the sample. The calculation results are used as the final results of the peak impact force of the sample for FR calculation of the sample. The impact test takes the single-layer keel volleyball field as the research object. The test floor is composed of: the surface floor is made of hard miscellaneous wood such as maple; The wool floor adopts waterproof elastic multilayer board; The keel adopts solid wood keel; The experimental assembly size is 3600mm × 3600mm; It is produced by a domestic sports floor Co., Ltd. The impact test uses the five most common damping pads in the market as the experimental materials, and the parameters are shown in the table.

Table 8. Structural parameters of damping pad and experimental results of back impact force

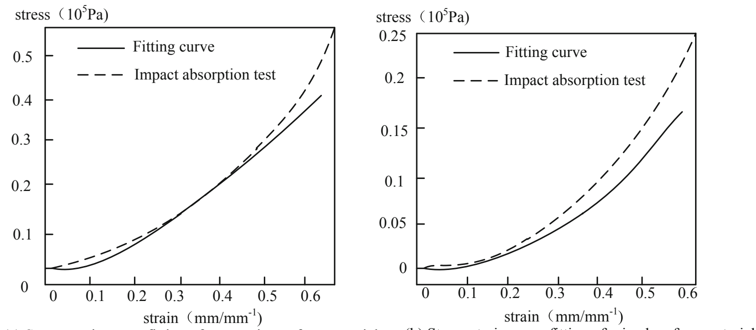
Serial number	Damping pad parameters							Experimental result
	L(mm)	W(mm)	T(mm)	H(HA)	M(g)	A(%)	V(%)	F(kN)
A	61	51	20	46	30	77	92	1.53
B	77	51	20	46	69	42	68	1.99
C	66	66	14	47	22	22	60	1.84
D	78	51	10	48	13	46	83	1.53
E	75	56	18	47	68	69	90	1.65

Table 9. Parameter standardization coefficient

Model parameter	Standardization coefficient
L	−3.652
W	−4.989
T	−3.128
H	−2.658
M	−2.908
A	3.658
V	−4.256

The single-layer keel assembled volleyball field produced by a special floor Co., Ltd. is used as the experimental specimen in the impact test. Combined with the layout requirements of the test points of the impact load test and the floor assembly size used in the test, the center of the sports point is taken as the starting point, five points are selected as the actual test points, and marked on the floor surface. Based on the stress-strain data of composite and mixed composite surface samples obtained from uniaxial tensile test, in ANSYSWorkbench/EngineeringData, Mooney rivilin model is used to fit the Mooney-Rivilin test data of two surface materials. The fitting is shown in the Fig. 4.

According to the structural parameter requirements of the shock pad installed in the actual single-layer keel volleyball court, the parameters affecting the impact performance of the shock pad in the single-layer keel volleyball court include: length (L), width (W), thickness (T), hardness (H), mass (m), area proportion (A), volume proportion (V), etc. In order to determine the reasonable structural parameters of the damping pad, five kinds of damping pads with different structural parameters are selected for impact test to obtain the anti impact force F of the volleyball court under this condition. The structural parameters of the damping pad and the experimental results of the anti impact force are shown in the table.



(a) Stress-strain curve fitting of composite surface material (b) Stress-strain curve fitting of mixed surface material

Fig. 4. Curve fitting of stress-strain data of synthetic material surface

The structural parameters of the damping pad and the experimental results of the back impact force of the single-layer keel volleyball field in the table are analyzed and calculated by using the fitting algorithm of SPSS multiple linear regression equation, and the standardized coefficient values corresponding to the 7 model parameters (structural parameters of the damping pad) can be obtained, as shown in the table.

The greater the absolute value of the standardization coefficient corresponding to each model parameter in the table, the greater the weight coefficient of the parameter, that is, the greater the impact on the back impact force, and the absolute value of 3 ~ 5 is the best. The absolute values of L, W, T, A, V standardization coefficients in the table are greater than 3. Therefore, five parameters L, W, T, A, V are selected as the structural parameters affecting the back impact force of the damping pad. By determining the five main influencing parameters of the damping pad, further explore the relationship between the parameters and the back impact force, and construct an orthogonal test factor level table of 5 factors and 4 levels according to the experimental requirements, as shown in Table 10.

Table 10. Factor level of orthogonal test

Level	Factor				
	L(mm)	W(mm)	T(mm)	A(%)	V(%)
5	61	51	10	20	51
10	68	58	14	40	66
15	75	65	16	60	80
20	82	72	19	80	96

According to the orthogonal test factor level table, the L(4) orthogonal test design scheme with the number of experiments of 16 can be designed. Through the impact test of single-layer keel sports floor, the test results of back impact force of sports floor installed with damping pads with different structural parameters are obtained, as shown in Table 11.

Table 11. Orthogonal experimental design and results

Test parameters					Test result
L(mm)	W(mm)	T(mm)	A(%)	V(%)	Fw(kN)
60	51	10	20	50	1.55
60	58	13	40	66	1.58
60	65	16	60	80	1.62
60	72	19	80	96	1.64
68	51	13	60	96	1.72
68	58	10	80	80	1.71
68	65	19	20	66	1.69
68	72	16	40	50	1.67
75	50	14	60	66	1.75
75	58	10	80	50	1.72
75	65	19	20	95	1.78
75	72	16	40	80	1.85
82	50	19	40	80	1.99
82	58	16	20	95	20.22
82	65	13	80	50	1.89
82	72	10	60	66	1.80

The primary and secondary order of the test parameters (influencing factors) in the table has been determined and screened by SPSS multiple linear regression equation fitting algorithm. In order to avoid repetition, the significance analysis of parameter influence on the test results will not be carried out. The impact absorption curves of two combined material surface samples are shown in the Fig. 5.

The abscissa represents the number of pressure data acquisition points, and the ordinate f represents the untreated impact force value. By comparing and analyzing the test curves, it can be seen that during the impact absorption test, the impact force borne by the sample increases first and then decreases, and the impact force peak is obtained at a certain time in the impact process, and then the untreated impact force peak is determined through the test curve. The establishment of the test table and the acquisition of the experimental results (anti impact force), It can be preliminarily concluded that under the action of a variety of structural parameters of damping pad through orthogonal test, the value of back impact force of damping pad of sports floor changes obviously, indicating that the selection of structural parameters of damping pad is more reasonable.

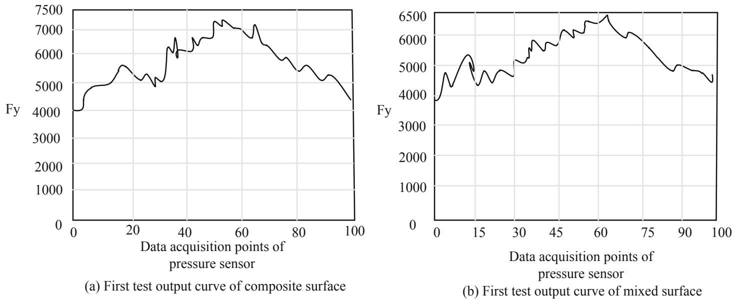


Fig. 5. Impact absorption curve of synthetic material surface sample

4 Conclusion

Combined with the discrete element method and the design requirements of the test standard, and according to the research on the test standard method of impact absorption load in volleyball court, the overall structure design and problem solution of the comprehensive load tester in volleyball court are put forward; The structural design and finite element static simulation analysis of the impact power control mechanism and rolling load operation mechanism of the comprehensive tester are carried out to verify the rationality, feasibility and safety of the design of the comprehensive tester for volleyball field. The research provides a new idea for solving the method of impact load on human lower limbs, provides a theoretical basis for improving the sports protection function of volleyball court by optimizing the damping structural parameters, provides a new method for improving the detection accuracy of impact force absorption mold of synthetic rubber materials in volleyball court, and promotes the development of volleyball court production and detection technology in China.

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