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Frontiers Research of Architecture and Engineering

Volume 4 · Issue 2 · October 2021 · ISSN 2591-7587(Print) 2591-7595(Online)

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Volume 04 Issue 02 • October 2021
ISSN 2591-7587(Print) 2591-7595(Online)

Frontiers Research of Architecture and Engineering

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Study on the Application of Drying Furnace Waste Gas Treatment Technology in Painting Workshop

Shuli Liu*

Environmental Technology Group (Qingyun) Limited, Dezhou, Shandong, 253000, China

ARTICLE INFO

Article history
Received: 26 April 2021
Revised: 30 April 2021
Accepted: 9 October 2021
Published Online: 16 October 2021

Keywords:
Oven exhaust gas
Coating
Application

ABSTRACT

With the continuous development of our country's economy, the demand for automobile is higher and higher after people's living standard is improving day by day. In just 40 years of reform and opening up, China's automobile production and per capita possession have made a qualitative leap and a breakthrough in quantity. Greatly promoted the automobile industry's great development.

1. Introduction

The rapid development of the automobile industry has led to the sustainable development and progress of the economy. With the improvement of the economic level, it is the pollution and destruction of the environment and the increasing demand for energy. The development of automobile industry contributes to energy consumption and environmental pollution.

2. Application of Waste Treatment Measures

2.1 Hardware Topology

Taking PLC as the control core, the field sensor transmits the collected temperature and pressure to the PLC, air valve actuator by 4~20 signals, and feedback the position state of the air valve to the PLC. By the switching signal PLC controls fan and pump and air valve actuator after calculation and logical judgment. Safety linkage through hard wire and drying system. The upper computer monitors the state of the system through the workshop network.

2.2 Fan Control

The control fan is used to provide constant pressure high temperature exhausts gas to the heat exchanger. The oven that needs TNV system to deal with exhaust gas in painting workshop includes electrophoretic oven and topcoat oven. The exhaust gas temperature is between 200℃ and 300℃ . A three-way air valve is set up in the roof chimney position to control whether the high temperature exhaust gas leads to the waste heat reuse heat exchanger or directly to the atmosphere. The waste gas of electrophoretic oven and topcoat oven is collected through air pipe and then put into the waste heat reuse heat exchang-

**Corresponding Author:*
Shuli Liu,
Environmental Technology Group (Qingyun) Limited, Dezhou, Shandong, 253000, China;
Email: 13910335155@163.com

 DOI: https://doi.org/10.30564/frae.v4i2.2677

er. When the high temperature exhaust gas is put into the waste heat reuse device, it will be hindered by the pipeline and heat exchanger, and the oven exhaust gas will overflow in the workshop, so the high temperature exhaust gas is discharged into the atmosphere by the induced fan after heat transfer [1]. If the speed of the fan is too high, the negative pressure in the oven will affect the process. It is the basic requirement of the operation of the waste heat system to ensure the constant air pressure in the exhaust gas duct. The pressure sensor is set up in front of the heat exchanger. The pressure measurement value is fed into the PLC, with 4~20 mA signal. The wind pressure data are taken as the PV input of the PID instruction and the output 4 and 20 signals are used to control the frequency output of the fan converter.

2.3 Pump Control

Hot water is needed in the pretreatment process section and air conditioning system of painting workshop, so it is very reasonable to integrate the residual hot water circulation into the hot water system of workshop. The water system relies on the pump to maintain the circulation, the pump is set up for 2 parallel pumps and 1 standby, and when the system stops and starts again, it is switched to another pump to work, so that the pump is worn and lubricated in the same amount. The high temperature exhaust gas contains trace oil steam, which condenses on the heat exchanger after cooling the heat exchanger. This is harmful. Condensed oil will affect the heat transfer efficiency of heat exchanger, the biggest harm is that there is fire risk in high temperature environment. Therefore, in order to avoid this phenomenon, the heat exchanger outlet exhaust gas temperature to maintain above 100℃ . Adjust the heat transfer by changing the flow rate of circulating water under constant wind pressure [2]. When the water flow rate is small, the water absorbs less heat from the exhaust gas, the temperature of the exhaust gas at the outlet of the heat exchanger is higher, and when the water flow rate is large, the heat taken away by the water becomes more, and the temperature of the exhaust gas at the outlet of the heat exchanger will decrease. The outlet temperature of the heat exchanger is fed into the PLC, temperature data with 4~20 mA signal as the PV input of the PID instruction. The output of 4 and 20 signals is used to control the frequency output of circulating water pump inverter. This ensures that the heat exchanger exhaust temperature remains at a set value to avoid condensation of oil steam on the heat exchanger.

2.4 Air Valve Control

Air valves are used to control high temperature exhaust gas to heat exchangers or straight to the atmosphere. When the consumption of hot water in the workshop is reduced, the circulating water heat of the waste heat system may exceed the demand, so the circulating water may reach the boiling temperature. In order to avoid the occurrence of water overheating, the upper limit of water temperature is set to 90 ℃ . When the water temperature reaches the upper limit, the electrophoretic drying waste gas is discharged directly into the atmosphere, and only the topcoat drying waste gas is used to supply high temperature gas to the waste heat collector. Automatically execute sequence start after cooling of circulating water [3]. In order to prevent system oscillation, when the water temperature is reduced to 80℃ , the sequential start action is performed automatically.

2.5 Start-up Sequence

When starting, the circulation of waterway is the precondition of the waste heat reuse system, and the circulating water pump is the first equipment to be opened. Then the induced fan starts, when the induced fan accelerates, the air valve actuator is powered on, and the air valve action drains the high temperature exhaust gas to the heat exchanger. When shutdown, first reset the air valve to drain the exhaust gas directly into the atmosphere, then close the fan, and finally close the circulating water pump.

2.6 Protection

The protection measures in the waste heat reuse system can be divided into temperature protection, pressure protection, position protection and time protection. The severity can be divided into warning and fault, alarm warning and protection action, which are performed respectively.

(1) Temperature protection

The temperature collected in the waste heat reuse system is divided into flue gas temperature and circulating water temperature. The chimney exhaust temperature is used to determine whether the high temperature exhaust gas meets the recovery conditions. The temperature acquisition point in front of the heat exchanger monitors the gas temperature of the heat exchanger to determine whether it is overheated and perform protective action. The temperature collection point after the heat exchanger monitors the gas temperature after the heat transfer to the atmosphere, which is used to judge whether the oil vapor condensation will occur and to control the circulating water flow rate properly [4]. The temperature collection point of the

1 Cng: Cryptography Next Generation.

DOI: https://doi.org/10.30564/frae.v4i2.2677

recirculating water after heat exchanger monitors the temperature of the heated water, which is used to determine whether the circulating water is overheated and perform the protective action. In winter season, in order to avoid the freezing and freezing of circulating water, the winter mode is set for the pump. In winter mode, the waste heat reuse system does not perform the pump shutdown when it stops in sequence.

(2) Pressure protection

Pressure protection is divided into hydraulic protection and wind pressure protection. Monitoring water pressure can determine whether the pump is running normally and whether the pipeline is blocked. The abnormal condition of fan and air valve and air duct can be judged by wind pressure.

(3) Position protection

Position protection is a logical judgment of the position of the air valve to find out whether the position of the air valve is abnormal. The mechanical jam of the air valve and the leakage of compressed air will show the abnormal position of the air valve.

(4) Time protection

Time protection is reflected in the program using timer to filter the fluctuation in the system and improve the stability of the system. When water temperature and flue gas temperature fluctuate, filter by delay before judging whether it is necessary to carry out protection action. In the program, the air valve actuator is given action time to determine whether the air valve is abnormal.

2.7 Linkages with Drying Systems

The waste heat reuse system exists in the form of high cohesion as an independent part of the automobile painting workshop and is associated with the drying system in a low coupling manner [5]. In the waste heat reuse system, temperature collection, pressure collection, air valve operation, pump operation, fan operation and so on are connected by complex hardware circuit and PLC program logic. This reflects the high cohesion of the waste heat reuse small system. When the workshop starts production and all relevant oven chimney exhaust temperature meets the needs of the waste heat reuse system. The waste heat recovery system can be started sequentially. During production, if the air valve of the waste heat reuse system fails and stuck to the waste heat recovery or semi-open and semi-closed state after the system is shut down, the heat exchanger may be burned out or even at risk of fire. Under the condition of no fault, the waste heat reuse system will not affect the normal operation of the oven system.

3. Application of Energy Saving and Emission Reduction Technology for Automobile Coating

3.1 Energy Saving and Emission Reduction Technologies for Pre-drying Equipment

Because the energy consumption in the process of automobile painting is closely related to the pre-drying temperature, in the process of automobile manufacturing, the parties concerned can accurately grasp the drying temperature and control the drying temperature within an appropriate range to save energy. However, in the present situation, the energy saving and emission reduction technology of the pre-drying device is often adversely affected by temperature and humidity, and the drying time will be obviously longer if the air enters the process. In addition, it is difficult to ensure the effectiveness of automobile maintenance, which increases the energy consumption in the process of automobile painting. To really solve this problem, staff must use low-size, powerful air-conditioning cyclones to inject powerful air-conditioning cyclones into the dry environment of the car [6]. This reduces energy consumption during painting and achieves the goal of energy saving and emission reduction. It is also important to select energy saving and environmental protection materials in the process of automobile painting. Staff should select reasonable energy saving and environmental protection materials, such as powder or waterborne special coatings, according to the specific process of automobile painting, in order to minimize the painting process. The harmful substances produced can not only promote the smooth progress of automobile painting process, but also save energy and reduce emissions in painting process. It is reasonable to introduce new machinery and equipment in the process of automobile painting in order to first contact with the current automobile situation in China and provide good conditions for the application of energy saving and emission reduction technology in the process of automobile painting.

3.2 Wheel Technology

a new zeolite roller enrichment technique has been created in the automotive painting process, which can be used in combination with high temperature incineration to treat low concentrations of volatile organic compounds. In

 DOI: https://doi.org/10.30564/frae.v4i2.2677

the treatment of volatile organic substances, zeolite rollers can be used to condense a large amount of waste gas with low concentration and form a small amount of waste gas with high concentration. This can effectively reduce equipment investment and waste gas treatment operating costs, thereby reducing waste. When a large amount of low concentration waste gas is treated, if the zeolite roller is not used to burn directly, if the amount of waste gas is too large, the operating cost of waste gas treatment will be very high. After concentrated with roller, deal with a small amount of high concentration exhaust gas. After the waste gas enters the waste gas treatment equipment, it can effectively save the waste gas treatment cost [7]. Volatile organic compounds can also reduce the amount of combustion during combustion, thereby reducing the operating costs of waste gas treatment. After the concentrated roll is cooled, the air through the cooler will be heated to form recycled air, thus saving energy and reducing emissions.

3.3 New Equipment

For automobile manufacturers, it is necessary to constantly study new equipment to adapt to the rapid development of the times, such as energy-saving air conditioning with thin film pretreatment technology and rough painted windows. Continuously optimize and upgrade mechanical equipment, such as drying room system optimization and waste heat recovery at each station, on the premise of meeting the requirements of new process technology. For example, in traditional spray rooms, water is usually used to treat paint fog, but the treatment process requires fresh air, and the treated air does not combine with fog, so it can be recycled. The less you use, the more energy you consume. With the development of science and technology, the use of robots is increasing, and dry paint capture technology has matured, circulating air can be effectively used. In this process, we combine the use of waterborne coatings. It can also effectively reduce investment costs, reduce wastewater treatment and reuse the resulting solid waste. With the continuous progress of science and technology, equipment control technology has become more and more intelligent, reducing the waste of personnel management. The intelligent control of drying room can adjust the air volume ratio according to the number of vehicles, effectively reduce the exhaust gas emission, and achieve the purpose of energy saving and emission reduction. In addition, energy consumption can be effectively reduced by saving the environment in which the vehicle is located. Advanced transmission equipment can be used to effectively reduce the capacity of electrophoretic tanks, while robots can be used to reduce the jet area that meets the technical requirements of energy saving and emission reduction [8].

4. Concluding Remarks

To sum up, with the continuous strengthening of our awareness of environmental protection, the waste gas treatment in automobile painting has attracted more and more attention. Through effective control measures, the waste gas treatment technology has been increased. Improving the protection of the environment is the direction we should continue to work hard.

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DOI: https://doi.org/10.30564/frae.v4i2.2677

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Cognition, Application and Discussion on Shaped Charge Hydraulic Smooth Blasting Technology

Xiuyong Ni* Suqin Han Peng Li Xiwu Wei

Shandong Transport Vocational College, Taian, Shandong, 271000, China

ARTICLE INFO

Article history
Received: 26 April 2021
Revised: 30 April 2021
Accepted: 9 October 2021
Published Online: 16 October 2021

Keywords:
Shaped energy tube parameters and principle
Technical points
Technical effect

ABSTRACT

In the past, the main method of tunnel excavation in China was drilling and blasting, but the biggest shortcoming of the traditional drilling and blasting method is that it is easy to cause serious overexcavation and underexcavation. At the same time, the operation cycle time of this method is long, which leads to a serious waste of resources. Not only that, a large number of toxic gases and dust produced after blasting also do harm to the health of construction workers. So this is an urgent need for a new construction technology to solve this worldwide problem. In this situation, the leading experts in the field of tunnel, "The survey and design master of China" Shi Yuxin, Liu Pei, and well-known expert in explosion field, yan-sheng ding, professor Chen Chengguang and Gu Yicheng, the experts group, cooperate with The Fifth Branch of China Railway 18th Bureau in northwest project management department, developed a new technology. This technology has passed the appraisal of scientific and technological achievements organized by Tianjin Science and Technology Commission, which is shaped hydraulic smooth blasting technology. The comprehensive evaluation of the technology is "international leading" level.

This paper is mainly aimed at the drawbacks of drilling and blasting construction, combined with the author's cognition and discussion on the introduction of the new technology of cumulative hydraulic blasting and the practical application effect in the tunnel excavation process of the fourth company of China Railway 14th Bureau Group in the second division of the 9th bid section of Zhangjihuai Railway in Huainan Province.

1. Introduction

Traditional smooth blasting requires "small spacing, large inner ring; The bottom of the hole is neat, and the external plug is controlled. Low detonation velocity, uncoupling; Thin wire, heavy blockage; Simultaneous initiation, less disturbance; Fine, smooth blasting well". According to incomplete statistics, the traditional method of drilling and blasting for tunnel excavation caused serious overexcavation, which resulted in serious waste (slag earthwork increased, increased the single cycle construction time, at the same time the initial shotcrete and lining concrete square also doubled), greatly aggravating the construction cost. The hole spacing of traditional blasting operations is generally controlled around 40-50 cm, but the shaped hydraulic smooth blasting technology can increase the hole spacing to 100 cm, which saves a lot of time and labor. The shaped charge hydraulic smooth

**Corresponding Author:*
Xiuyong Ni,
Shandong Transport Vocational College, Taian, Shandong, 271000, China;
Email: nixiuyong@sina.com

 DOI: https://doi.org/10.30564/frae.v4i2.3122

blasting not only shortens the working procedure cycle, but also greatly solves the problem of tunnel excavation, which is difficult to be overcut and undercut. At the same time, the drilling operation is carried out by adopting the drilling trolley newly developed in recent years, which is not only efficient and fast, but also greatly reduces the construction cost. In addition, the water bag added in the blasting hole will produce water mist when blasting. The effective combination of water mist and dust will greatly reduce the effect of dust, reduce the harm of dust on the respiratory system of tunnel workers, and ensure the health of tunnel workers [1].

2. Definition and Principle of Shaped Hydraulic Smooth Blasting

When the traditional drilling and blasting method is used in construction, due to the non-directional blasting force during explosive blasting, the newly excavated face and blasting surface are uneven, especially the convexity of the vault can even reach more than one meter. If there are faults and interlayers in the rock, then this value is immeasurable. The people who have the tunnel excavation blasting construction experience know that the traditional smooth blasting during the construction of the explosive, will spread the rock stress wave generated when the radial stress and tangential stress, is arguably the burst pressure in all directions, the light shot hole adjacent each other "empty holes", so in the light shot hole on both sides of the attachment to produce stress concentration high tensile stress exceeds the rock tensile strength, so the formation of the initial crack in the hole between the rock mass is much more than the other direction, in addition, due to the explosive generated by the effects of the static high pressure gas expansion prompted the initial crack extension to expand further [2]. This is the key point why the tunnel face and the vault will be a large area of uneven and overexcavation. "Accumulated energy" in shaped charge hydraulic blasting is to gather the blasting energy as much as possible to produce a directional energy release. In addition to the stress wave action mentioned above, the high temperature and high pressure jet generated by the shaped charge tank and the "water wedge" effect produced by the water bag in the blast hole under the explosion action promote the extension and expansion of the initial crack in the rock. Due to the compound filling of water bag and mud, the expanded gas generated by explosive explosion is effectively controlled in the gun hole of shaped charge hydraulic photoblast. The static effect of the expanded gas is much stronger than that of the conventional smooth blasting without filling, which is more conducive to the extension and expansion of the formed cracks. Due to the high temperature and high pressure jet of the shaped tube, the function of "water wedge" and the enhancement of the static effect of the expanding gas, the smooth blasting technology of shaped charge water pressure has solved the shortage of the conventional smooth blasting, improved the flatness of the smooth blasting surface greatly and greatly improved the situation of overexcavation and underexcavation. In addition, the tunnel will produce serious dust after blasting excavation, which requires a large fan to support the air belt for dust removal. Under normal circumstances, a blasting operation takes about 0.5-1 hours for dust removal, and the incidence of lung disease among workers engaged in tunnel excavation is many times higher than that of ordinary people. But because the water bag is placed in the holes of water pressure blasting, the water mist produced in the blasting process can reduce the dust, this can improved the working environment, and protect the workers' health, and it can also avoid the dust spread into the atmosphere, also can also save a sum of spending on power resources, reduce the production cost [3].

3. Charge Technology of Shaped Energy Tube Device

3.1 Parameters and Principle of Shaped Energy Tube

The shaped energy tube is made of a kind of special plastic pipe with anti-static flame retardant. The shape of is shaped energy tube is special-shaped double groove, and the length of the pipe is 2, 2.5 and 3 m. The length of the shaped energy pipe on the construction site can be processed according to the depth of the hole. It is composed of two identical half-wall tubes with a wall thickness of 2 mm. There is a recessed groove in the middle of the half-wall tube, which is called "the shaped energy groove". The section size of the energy shaping tube: the top angle of the energy shaping groove is 70°, the distance of the top of the energy shaping groove is 17.27 mm, the width of the half wall tube is 24.18 mm, and the width of the energy shaping tube made of the two half wall tubes is 28.35 mm.The direction of energy accumulation can be adjusted by 8° ~ 10° to adjust the alignment of the energy accumulation groove with the excavation profile.The explosive in the shaped tube device is traditional rock emulsion explosive. The section formed by the dimensions inside the shaped tube is the section of the explosive. Its working principle is that after the charge explodes, the explosion energy near the shaped charge hole will converge towards the axis of the hole, forming a gas jet with high density,

DOI: https://doi.org/10.30564/frae.v4i2.3122

high speed and high pressure. In other words, when the charge pack has a shaped charge hole, it can locally gather in the direction of the shaped charge hole and generate supernormal blasting energy. Therefore, the gas jet with high density, high speed and high pressure formed by shaped charge blasting can improve the explosive power [4].

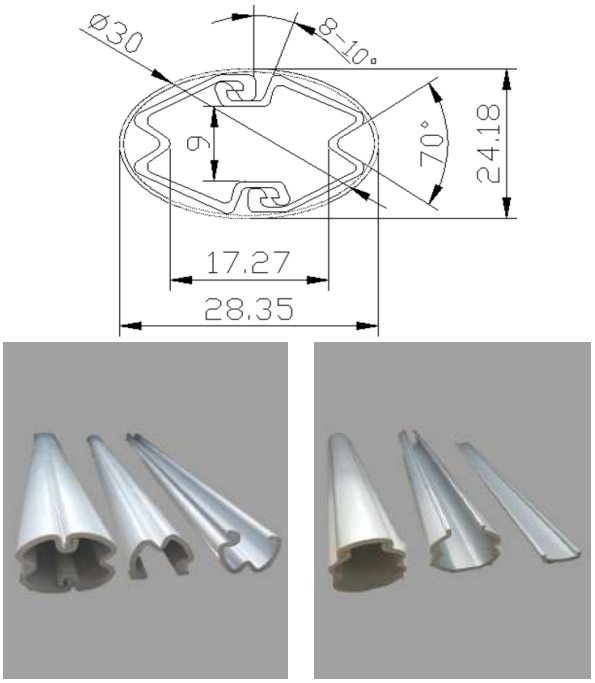

Figure 1. Energy collecting tube

3.2 Assembly Method of Shaped Energy Tube Device

Detonation line and detonator in shaped tube device are common detonating equipment in construction site, and the detonator is the same as the conventional smooth blasting detonator. Injection of half wall tube requires injection gun and air compressor and other equipment [5]. The length of injection gun is 45 cm and the weight is 0.8 kg. Small air compressor power 800 W, weight 23 kg (for reference only, equipment model should be ordered according to the actual need to confirm).

The first step: cut one end of the cartridge and the packing skin along the longitudinal side of the cartridge, then merge the two cartridges along the longitudinal cut surface and put them into the cartridge barrel, and finally tighten the rotating cover;

The second step: pressurize the injector gun with a pressure of 1 ~ 2 atmospheres.

The third step: the hand holds the injection gun along the half-wall tube from head to tail in a uniform speed, the explosive from the muzzle continues to flow into the half-wall tube.The density of line charge is generally 0.35 ~ 0.4 kg/m for hard rock, 0.3 ~ 0.35 kg/m for medium hard rock, and 0.2 ~ 0.3 kg/m for soft rock.Before the two half-wall tubes of explosives are connected, a blasting wire is placed in one of the half-wall tubes, and then assembled together;

Step 4: In order to achieve the ideal blasting effect, make the shaped tube not fit to the hole wall after it is placed in the gun hole, and ensure that the shaped groove in the shaped tube device is aligned with the tunnel contour to prevent rotation, both ends of the shaped tube device should be covered with foam cotton rings and fixed with rubber tape, so that the shaped tube can be completely assembled.

In particular, for the sake of safety, it is better not to install the detonator in the assembling room of the shaped tube device, and then install it when it is transported to the face of the palm.The whole charge injection process is simple and quick, and the number of shaped tube devices needed for one circular light blasting perforation can be assembled in about an hour [7].

3.3 Technical Points of Shaped Hydraulic Smooth Blasting

3.3.1 Determination of peripheral hole parameters

The hole layout of shaped charge hydraulic smooth blasting is exactly the same as that of common smooth blasting, and the drilling tools and techniques are unchanged [6]. The difference lies in the spacing of the surrounding holes. The spacing of the surrounding holes in the conventional smooth blasting is 40-50 cm, while the spacing of the surrounding holes in the shaped water pressure smooth blasting is 80-100 cm. The spacing of the arching line and surrounding rock joints can be appropriately reduced according to the field conditions. Due to the different properties of surrounding rock strata in Zhangjihuai railway construction site where the author is located, the spacing of the surrounding holes controlled by the step method is about 60-90 cm when the step method is used, and the ideal effect is achieved.

3.3.2 Loading operation steps

Before charging, the residue in the hole of the gun must be cleaned up to prevent the loading of the shaped energy tube, and the processed shaped energy tube should be transported to the construction face for loading.

Step 1: fill the bottom of the hole with a water bag. The water bag must be placed at the bottom of the hole without any gap.

Step 2: load the shaped tube device. The length of the shaped tube can be made according to the depth of the hole, usually 2.5m, which is 70% of the depth of the hole.

 DOI: https://doi.org/10.30564/frae.v4i2.3122

The shaped tube device must be next to the water bag at the bottom of the hole, and the shaped groove should be consistent with the contour surface, that is, parallel to the tangent direction of the excavation line.

Step 3: Fill two water bags and pound them properly with wooden guns.

The fourth step: the gun mud processed by the gun mud machine is backfilled and stuffed until the gun hole mouth, and the gun mud is tamped with the gun stick to be solid and plays the role of filling.

After all the holes are loaded, they are connected and detonated like a regular smooth blast.

4. Time Consuming and Analysis of Each Process of Shaped Charge Blasting

According to the shaped hydraulic smooth blasting technology in actual construction application, according to different geological conditions, mechanical equipment, such as climate condition, adopt the realistic record method, the drill hole charge, slag zone, measuring unreeling, bolting and shotcrete time consumption and to keep a record amount of sprayed concrete and the initial design and the actual consumption of sprayed concrete were analyzed, according to the result of field records were analyzed, and a single loop operation time with an average of 17.15 hours, significantly less than the conventional blasting used in 19.2 hours.

The average working time of each process is as follows:

Table 1. average working time of each process

Process	Time(hour)	
	Conventional blasting	Accumulated hydraulic smooth blasting
Drilling and blasting	3	2.5
Eeslag	3.5	3.2
Eliminate danger	0.5	0.3
Measurement	1	1
Floor stand	3.0	2.5
Advance anchor bolt	3	3
Sprayed concrete	5	4.5
Total	19.2	17.15

5. Analysis of Technical and Economic Effect

Table 2. Comparison table of explosive and detonator dosage

Number	Project		Normal blasting amount	Shaped charge blasting amount	Savings	Savings per extension meter	Money saving per extension meter
1	Luji-azhuang tunnel exit	Explosive	194	162	-32	-12.8	-131.712
2		Detonator	165	134	-31	-12.4	-78.12
3		Detonating cord	0	54	54	21.6	61.34
4	Yanshan tunnel exit	Explosive	197	163	-34	-13.6	-139.94
5		Detonator	172	128	-44	-17.6	-110.88
6		Detonating cord	0	54	54	21.6	61.34

Table 3. Comparison table of the amount of tunnel slag and jet concrete

Number	Project		Normal blasting amount	Shaped charge blasting amount	Savings	Savings per extension meter	Money saving per extension meter
1	Lujiazhuang tunnel exit	Quantity of slag	375m³	328m³	-47m³	-15.6m³	-421
2		Jet concete	49m³	36m³	-13m³	-4.3m³	-2322
3	Yanshan tunnel exit	Quantity of slag	380m³	321m³	-59m³	-19.6m³	-529.2
4		Jet concete	51m³	37m³	-14m³	-4.7m³	-2538

DOI: https://doi.org/10.30564/frae.v4i2.3122

Table 4. Statistics of overcut and undercut sections of conventional blasting tunnels

Number	Tunnel section	Starting and ending mileage section	Average Overcut (cm)	Reserved settlement (cm)	Excessive cutting volume of this section (m^3)	Average Excessive Excavation Per Duct (m^3)
1	Lujiazhuang tunnel exit	DK204+124-121	47	10	25.566	8.522
2		DK204+121-118	44	10	24.528	8.176
3		DK204+118-115	50	10	27.183	9.061
4	Yanshan tunnel exit	DK206+191-188	43	10	23.874	7.958
5		DK206+188-185	46	10	25.134	8.378
6		DK206+185-182	51	10	27.906	9.302

Table 5. Overcut and undercut section statistics of shaped charge hydraulic smooth blasting tunnel

Number	Tunnel section	Starting and ending mileage section	Average Overcut (cm)	Reserved settlement (cm)	Excessive cutting volume of this section (m^3)	Average Excessive Excavation Per Duct (m^3)	
1	Lujiazhuang tunnel exit	DK204+115-112	23.4	10	12.766	4.255	6.15
2		DK204+112-109	22.2	10	12.341	4.113	6.16
3		DK204+109-106	25.1	10	13.153	4.384	6.17
4	Yanshan tunnel exit	DK206+182-179	22.1	10	12.324	4.108	6.15
5		DK206+179-176	21.3	10	12.288	4.096	6.16
6		DK206+176-173	20.6	10	12.213	4.071	6.17

Table 6. Comparison of the amount of tunnel resilient: Statistics on resilient of conventional blasting tunnel

Number	Tunnel section	Starting and ending mileage section	Average Overcut (cm)	Designed quantity (m^3)	Excessive cutting volume of this section (m^3)	Outgoing quantity of mixing station (m^3)	Resilient rate amount (m^3)	Resilient rate
1	Lujiazhuang tunnel exit	DK204+124-121	47	18	25.566	50	6.434	35.7%
2		DK204+121-118	44	18	24.528	49	6.472	35.9%
3		DK204+118-115	50	18	27.183	52	6.817	37.8%
4	Yanshan tunnel exit	DK206+191-188	43	18	23.874	48	6.126	34.0%
5		DK206+188-185	46	18	25.134	50	6.866	38.1%
6		DK206+185-182	51	18	27.906	52	6.094	33.8%

 DOI: https://doi.org/10.30564/frae.v4i2.3122

Table 7. Statistics on resilient of shaped water pressure smooth blasting tunnel

Number	Tunnel section	Starting and ending mileage section	Average Overcut (cm)	Designed quantity (m^3)	Excessive cutting volume of this section (m^3)	Outgoing quantity of mixing station (m^3)	Resilient rate amount (m^3)	Resilient rate
1	Lujiazhuang tunnel exit	DK204+115-112	23.4	18	12.76	34	3.24	18%
2		DK204+112-109	22.2	18	12.34	33	2.66	14.7%
3		DK204+109-106	25.1	18	13.15	35	3.85	21.3%
4	Yanshan tunnel exit	DK206+182-179	22.1	18	12.32	33	2.68	14.8%
5		DK206+179-176	21.3	18	12.28	33	2.72	15.1%
7		DK206+176-173	20.6	18	12.21	33	2.79	15.5%

Figure 2. Renderings of Yanshan tunnel exit after blasting

DOI: https://doi.org/10.30564/frae.v4i2.3122

6. Summing up of the Process of Shaped Charge Hydraulic Smooth Blasting

The new technology of shaped charge hydraulic smooth blasting was officially implemented and applied in 2016 [8]. Up to now, the usage of shaped charge tube has been greatly increased. The engineering projects using this technology have reached more than one hundred, and a large number of projects are focused on the roof cutting and mining of coal mines with shaped charge blasting in the tunnel of iron work foundation, as well as a large number of cooperative projects of defense system. Relevant personage points out, in the industry in energy saving, transformation and application, should think of conservation of energy and matter, big blasting has its strengths, but uneven, broken blocks of the secondary crushing will inevitably affect the improvement of mechanical efficiency, and general hand drill hole blasting method, low labor productivity, far cannot satisfy the digging of mechanical operation and production needs [9]. The blasting shaped charge tube is a breakthrough in the technical scope of smooth blasting. Under the environment of advocating energy conservation, emission reduction and effective application of energy in China, it will have an important impact on the current shaped charge tube industry, and is conducive to promoting the customization and promotion of the technical standards and specifications of the new generation of smooth blasting shaped charge tube [10].

The application of the hydrostatic smooth blasting technology in the construction site of Zhangjihuai Railway Nine Standard Two Branch has been strongly recommended and supported by the leaders of the group company [11], and the field trial has also proved that this technology is better than the conventional smooth blasting in terms of construction period, material consumption or environmental protection. Hunan Zhangjihuai high-speed railway project in addition to China Railway 14th Bureau other construction units have also introduced the new blasting technology, have received a good effect. It not only reduces the construction cost and saves the expenditure, but also plays a significant role in the field of environmental protection and teaching [12].

The author thinks that the shortcoming of the tube is that it can not be applied to different rock strata with different properties and joint direction, which requires further innovation in technology.However, with the rapid innovation and development of science and technology, it is believed that there will be more new technologies, new processes, new equipment to serve our engineering industry, and then to improve the quality of life of all mankind better!

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 DOI: https://doi.org/10.30564/frae.v4i2.3122

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Research on Green Transformation of Campus Sponge and Energy Saving Facilities on Sloping Land

Qiliang Tan* **Yuhang Guo**

Nanning No.2 Middle School, Nanning, Guangxi, 530029, China

ARTICLE INFO

Article history
Received: 22 June 2021
Revised: 30 June 2021
Accepted: 9 October 2021
Published Online: 16 October 2021

Keywords:
Slope campus
Sponge and energy saving measures
Water purification terrace
Photovoltaic power generation

ABSTRACT

Based on the renovation of sponge and energy-saving facilities in a middle school in Nanning, this paper systematically studies the overall elevation of the campus, the composition of the drainage system and the layout of space functions, and formulates a characteristic scheme for the renovation of sponge and energy-saving facilities according to the characteristics of the sloping campus. In order to control the total amount of rainwater runoff, the sponge transformation mainly adopts the transformation methods of partition catchment, upper storage and lower use, multi-stage detection and classification treatment. For the purpose of solar energy and wind energy utilization, solar photovoltaic panels and small-scale wind power generation system are adopted. The application effects of sponge and energy-saving facilities are estimated and evaluated.

1. Introduction

With the development of China's social and economic undertakings, there are many serious problems in cities, such as water shortage, water quality deterioration and frequent urban flood disasters, which pose a huge challenge to the sustainable and healthy development of urban and rural areas.

Sponge city is a comprehensive concept to solve urban water and ecological problems. Sponge city breaks through the traditional concept of "drainage as the main", takes buildings, roads and green space as the carrier, and constructs the urban low-impact development rainwater system through a variety of ecological technologies such as "infiltration, retention, storage, purification, utilization and drainage" [1]. The construction of sponge city will make the "steel city", which has been hardened gradually become naturally inhale and breathe. The city and the natural environment are no longer two independent individuals, human and nature live in harmony, shaping a healthy, complete and useful ecological civilization, so that water resources can be recycled [2].

In addition, in the context of green environmental protection, energy conservation and emission reduction, clean, safe, efficient and inexhaustible energy from the sun has become the direction of energy development in the 14th Five-Year and even the future. The development of distributed power supply is the combination of solar energy and architecture, which makes solar energy become an organic part of architecture. It is an important way to build low-carbon, energy-saving and environment-friendly green buildings by integrating mature solar technology

**Corresponding Author:*
Qiliang Tan,
Nanning No.2 Middle School, Nanning, Guangxi, 530029, China
Email: tftlb@163.com

DOI: https://doi.org/10.30564/frae.v4i2.3346

products into buildings.

This paper studies and analyzes the natural geographical conditions and ecological environment of a sloping campus, discusses the feasibility of sponge and energy-saving measures, and completes the design scheme of sponge city and energy-saving facilities transformation of sloping campus. The design scheme will significantly improve the campus environment, save operating costs, and has good economic and social benefits.

2. Present Situation of the Campus

The total land area of a middle school campus is about 28 hectares, among which the roof area is about 37890 m^2, the course area is about 50430 m^2, the road area is about 11500 m^2, the parking area is about 7310 m^2,the green area is about 98830m^2, the water system area is about 4300 m^2. The campus is built according to the sloping land, and the whole campus is high in the north and low in the south. The vertical design of the building and site is more complex and changeable, forming a unique landscape environment of the sloping campus. The average annual sunshine of the campus is 1439~1596 hours, and the total radiation is about 4650 MJ/m^2, solar energy resources are relatively abundant. The campus has the following problems: 1) The current green space in the campus is mostly ordinary green space, which has a large area. The soil permeability is not high, and the water absorption and storage ability is poor, which is not conducive to the retention and drainage of rainwater. 2) The paving materials of the campus sports ground, track, road, parking lot and distribution square are mostly ordinary impermeable paving materials, without the function of rainwater infiltration. 3) The building roof and slope greening are not effectively used for rainwater storage. 4) The existing drainage facilities of the campus can not meet the overall goal of sponge construction in the region. 5) Some distribution plazas have severe heat island effect and poor thermal comfort.

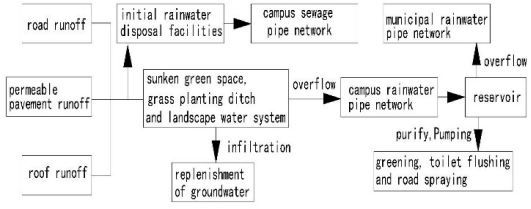

Figure 1. Schematic of Sponge City Design

Source: self drawn by the author

Campus is the main place for teachers and students to study and live. Closely integrate the existing problems of the sloping campus environment with the sponge city and energy-saving principles, systematically and reasonably complete the sponge transformation goal, and the campus landscape effect can be greatly improved. At the same time, distributed photovoltaic and wind power generation systems were installed on the roofs of teaching buildings, and diversified new energy utilization technology demonstrations were carried out to meet the power needs of campuses. At the same time as the green transformation of campus sponges and energy-saving facilities, students will be given sponge energy-saving demonstrations, cultural enhancements and environmental protection quality training to make the campus a base for sponge energy-saving science education.

3. The Reconstruction Measures and Benefit Analysis of Campus Sponge City

3.1 Measures for the Reconstruction of Campus Sponge City

The basic principle of sponge city design is to intercept and permeate rainwater runoff and replenish groundwater by taking measures such as sinking green space, planting ditches and landscape water bodies. The primary overflow is purified by the rainwater storage tank, and used for greening and watering, flushing and road pouring, so as to control the runoff pollution and make full use of water resources [3].

The sponging transformation construction measures include: green roof concave green space, permeable and water-cutting pavement, rainwater disconnection, grass planting ditch, water purification terrace and rainwater storage pond [4].

Combined with the sponge and energy-saving measures requirements and the actual conditions of the campus and other factors, the design of the main transformation measures are green roof, permeable and cut off the water pavement, sunken green space, rainwater storage pond, etc. Its design schematic diagram is shown in Figure 1 [5].

The scheme design covers most of the campus environment, and the overall layout of its transformation is shown in Figure 2.

3.2 Benefit of Campus Sponge City Reconstruction

The average annual rainfall of this campus is 1298 mm. According to the 75% runoff control rate, the corresponding rainfall is 26.0 mm, and the average annual rainfall frequency is 1298/26.0=50 times.

Rainwater recycling can save 300 m^3 water consump-

 DOI: https://doi.org/10.30564/frae.v4i2.3346

tion of tap water greening each time. According to empirical data, excluding depreciation costs, the operating cost of rainwater collection, treatment and recycling is about 0.5 yuan per cubic meter, and the average cost of school water and tap water is about 3.10 yuan. Then, the project will save the inflow of water each year: Q=300×50=15000 m^3 per year. Save 39,000 yuan of water bill every year.

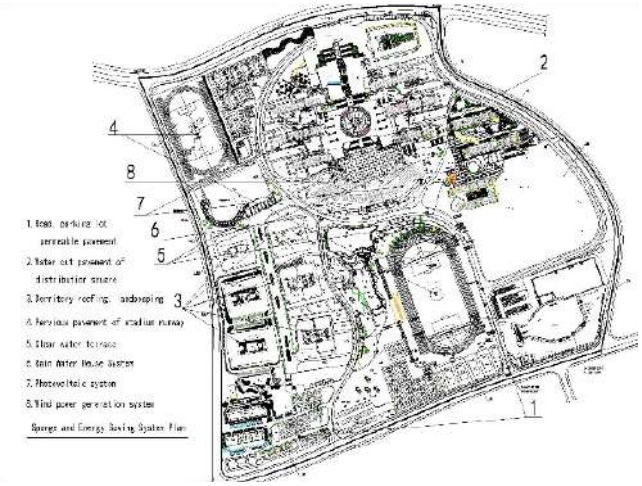

Figure 2. The overall layout of the campus sponge city renovation

Source: self drawn by the author

Roof greening can also alleviate the urban heat island effect. When the roof temperature is between 37℃ and 40℃ in summer, roof greening can effectively reduce the temperature by 3℃ to 6℃ . In addition, it can also absorb dust and reduce the amount of bacteria. Therefore, sponge modification will have a favorable impact on the environmental microcirculation and the reduction of heat island effect within the scope of this project [6].

Water cutting brick pavement can reduce road temperature and alleviate urban heat island effect. The experimental results show that the measured temperature of the block can be reduced by up to 13℃ in the daytime and 3℃ in the evening, no matter in the daytime or at night. It takes 39.8 hours for the water level in the block to decrease from 4 cm to 1 cm [7].

4. Renovation and Benefit Analysis of Campus Energy-saving Facilities

The campus belongs to subtropical monsoon climate, wind and solar energy resources are rich, with the changing of renewable power and micro power grid technology, adjust measures to local conditions to build contains a variety of scenery energy micro grid power supply system, on the one hand, can be used as a renewable energy science base, on the other hand, self-sufficient in electricity, but also contribute to energy conservation and emissions reduction, low carbon environmental protection [8].

In this design, photovoltaic panels are laid on the roof of the flat roof of the teaching building, the administration building and the comprehensive building, and the laying area is 6150 m^2, the construction of photovoltaic microgrid, integrated into the campus power supply network. Small fans are installed at the wind crossings on the top floor of the building for 10 rack points to form a wind power microgrid, which is also integrated into the campus power supply network. The layout of photovoltaic and wind power (partial) is shown in Figure 3 [9].

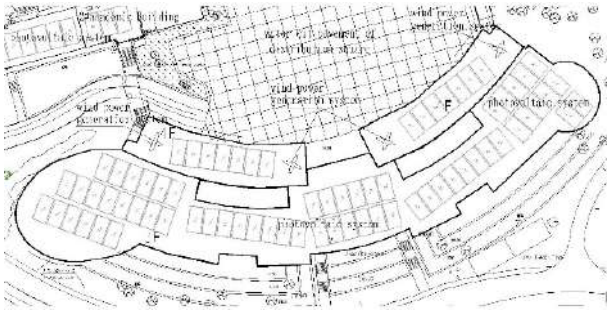

Figure 3. Photovoltaic and wind power system layout drawing (partial)

Source: self drawn by the author

For example, the photovoltaic panel parameter is 200W/1640 mm*670 mm, the module efficiency is 18.2%, and the area of the campus can be laid is 6150 m^2, the net installation amount is 633.5 KW. The photovoltaic utilization hours in this area are about 1500 h. Taking into account the effects of reduction factors, the annual equivalent photovoltaic full load hours are revised to 700 h, and the annual power generation is 443,450 h, which can save 221,000 yuan of electricity. If the small fan parameter is 1000W, then 10 AC permanent magnet synchronous wind generators are 10 KW. The annual utilization hours of wind power in this region is about 2000 h. Taking into account the effects of reduction factors, the equivalent annual full load hours of the wind turbine is revised to 900h, then the annual power generation is 9000 h, and the electricity cost can be saved by CNY4,500. The solar system can save electricity cost of 225,500 yuan a year. At the same time, its energy saving and emission reduction effect are remarkable. The energy saving and emission reduction of the solar system is shown in Table 1 [10].

5. Conclusions

According to the theory of sponge city and energy saving, a systematic combination design was carried out

DOI: https://doi.org/10.30564/frae.v4i2.3484

at the appropriate location of the sloped campus to solve the problems of rainwater ecology and energy-saving measures on sloped campuses, verify the theory of sponge city and energy saving, and realize the economic and social benefits of the campus. The improvement provides practical ideas for solving the sponge and energy-saving transformation of sloped campuses. The program design covers most of the campus environment, and the program practice will greatly improve the campus building and environment, and the effect of energy saving and emission reduction will be significant.

Table 1. Calculation of energy saving and emission reduction of wind and solar system

Comprehensive benefit analysis of environmental protection	Energy saving and emission reduction
Estimated annual power generation(MWh)	452.5
Standard coal (t)	162.9
carbon dioxide CO_2(tce)	451.1
Year Toner Dust TSP (t)	123.1
Sulfur dioxide SO_2 (t)	13.6
Nitrogen oxide NOX (t)	6.8
Purified water H_2O (m^3)	1809.8

Source: self drawn by the author

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 DOI: https://doi.org/10.30564/frae.v4i2.3484

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Preparation and Optimization of Mix ratio for C50T Girder Manufactured Sand and Concrete

Honghong Ye* **Delin Zeng** **Yong Yang** **Xingbo Fan** **Wei Wang** **Pingbo Zao** **Zhusheng Yang**

Yunnan Construction and Investment Holding Group Co., Ltd., Dali, Yunnan, 671500, China

ARTICLE INFO

Article history
Received: 14 July 2021
Revised: 20 July 2021
Accepted: 9 October 2021
Published Online: 16 October 2021

Keywords:
Concrete
Mix ratio
Strength
Water-cement ratio

ABSTRACT

Considering actual construction conditions of Binchuan-Heqing Highway, this paper provides the C50 mix ratio conforming to engineering requirements by strictly controlling the quality of raw materials, optimizing the design of mix ratio scientifically, preparing superior C50 concrete 0 with manufactured sand, and optimizing the concrete mix ratio based on the adjustment of fly ash replacement, water-cement ratio, polycarboxylate-type water reducer mixing amount, sand ratio, etc. The result indicates that, the water-cement ratio has a great influence on the concrete strength, and if the ratio of coal ash is high in the binding material, the early compressive strength of the concrete will increase slowly.

1. Introduction

As an inseparable part of interconnectivity in Yunnan Province, the mainline of Binchuan-Heqing Highway is 66.513 km in the full length, in which it is 18.27 km within Binchuan County, and 48.24 km within Heqing County, and bridge tunnels account for 49.7% of the total length. The specific requirements and quality demand for concrete is high in the whole line. However, due to the insufficiency of natural river sand along Binchuan-Heqing Highway, it's difficult to prepare high-performance concrete, and the river sand required for building the highway must be purchased from other places, and the price of river sand transported to the construction site is very high, up to RMB 250/m^3. As construction enters the peak period, the construction mixing station can be short of sand.

As specified in the *Technical Specification for Construction of Highway Bridge and Culverts* (JTG/T 3650-2020), if river sands are difficult to obtain, fine aggregates can be prepared by limestone, basalt and other hard stones, and then processed into manufactured sand [1]. However, except for hydropower industry and high-grade cement of housing construction industry, manufactured sands haven't been extensively applied in other industries, especially in highway C50 and above mix ratio. Meanwhile, there are obvious differences in the manufactured sand process of highway and hydropower industry. Water conservancy industry is featured with intensive construction points, advanced sand-generating equipment, stable physical properties of the sand generated and excellent quality. However, highway engineering is featured with multiple construction points, wide areas and huge differ-

**Corresponding Author:*
Honghong Ye,
Yunnan Construction and Investment Holding Group Co., Ltd., Dali, Yunnan, 671500, China;
Email: 1758893149@qq.com

DOI: https://doi.org/10.30564/frae.v4i2.3452

ence in the quality of manufactured sands, and unstable physical properties, which are mainly caused by the different lithology of the parent rock, the huge difference in rock strength as well as the small sand-making equipment, different models and huge difference in quality [2], seriously restricting the application of manufactured sands in highway construction. In addition, Binchuan-Heqing Highway is set with multiple bridges, demanding on concrete quality control, so C50T girder manufactured sand concrete is analyzed and studied, in terms of the special construction conditions of Binchuan-Heqing Highway.

2. Raw Materials and Test Method

2.1 Raw Materials

(1) Cement

The cement is the P.O 42.5 cement supplied by Yunan Yongbao Cement Co., Ltd., and the physical properties are as shown in Table 1.

Table 1. Physical Properties of Cement

Standard Consistency/ (%)	Setting Time/ min		Stability	Specific Area (m2/kg)	Strength/ (MPa)	
	Initial Set	Final Set			R3	R28
28%	205	256	Qualified	345	27.3	46.7

(2) Fine aggregate

The manufactured sand is the coarse sand produced along Binchuan-Heqing Highway in Xiangshupo, and the fineness modulus, powder content, total mud content of fine particles, crush index, and MBV are 3.1, 6.2%, 0.2%, 22% and 0.8% respectively, meeting the provisions and design requirements.

(3) Coarse aggregate

The macadam is 5-25 mm continuously graded limestone grains, with excellent appearance, 5.6% of faller content, 19.0% of splinter value, 0.6% of sludge content, and can conform to the provisions and design requirements.

(4) Additive

The additive is the polycarboxylate-type superplasticizer produced by YCIH High-performance Concrete Co., Ltd., with 30% of water reduction amount, 23% of bleeding rate, and qualified 28 d compressive strength rate.

2.2 Test Method

Properties of mixture: The relevant performance test should be implemented in strict accordance with the *Standard for Test Method of Properties on Ordinary Concrete* (GB/T 50080-2016).

Test method of basic mechanical properties: Test the relevant properties in accordance with the *Test Methods of Cement and Concrete for Highway Engineering* (JTG 3420-2020). The standard size of concrete cube is 150 mm, and the 3 d, 7 d and 28 d strength should be respectively measured after maintenance.

3. Design of C50T Girder Concrete Mix Ratio

According to JGJ 55-2011 *Specification for Mix ratio Design of Ordinary Concrete*, the actual strength of concrete is about 58.23 MPa, and since the T-shaped girder is featured with small section area, and small bar spacing, concrete pouring can be quite difficult, so it's necessary to ensure excellent concrete performance [3].

3.1 Influence of Water-cement Ratio on the Strength of Manufactured Sand Concrete and the Workability of the Mixture

As shown in Table 2, as the water cement ratio increases, the workability of the manufactured sand concrete improves to a certain extent, but when the water cement ratio reaches to 0.32, the manufactured sand concrete mixtures are subject to bleeding phenomenon. As the water cement ratio increases, the compressive strength of the manufactured sand concrete decreases along with the small lowering degree of 28 d, and notable decreasing amplitude of 7 d. Based on the compressive strength and relevant performance demand for the actually manufactured sand concrete, the water cement ratio selected is 0.31.

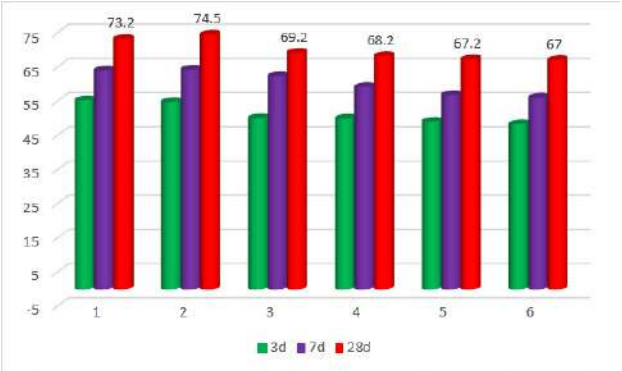

Figure 1. Water-cement Ratio and Strength Result

3.2 Optimized Design of Concrete Strength

Considering the slow development of early compressive strength of concrete after replacing cement with coal ash, the mixing amount of coal ash and cement is tenta-

 DOI: https://doi.org/10.30564/frae.v4i2.3452

tively set as 30 kg - 50 kg and 440 - 460 kg respectively. As can be seen from the reference and construction experience, the early compressive strength lowers with the blending strength of the coal ash. In order to ensure early strength and construction progress, the water-cement ratio of the concrete should be changed to 0.31 and 0.30 respectively, and the test result is as shown in Table 4.

As shown in the result, when the water-cement ratio is 0.30, the concrete can meet the requirements for early durability, but when the sand ratio increases to a certain extent, the workability of the concrete mixture lowers with the increase of the sand ratio, resulting in concrete bottom scrabbling and sinking [4,5] due to excessive thickness. To lower the risk of concrete cracks, the sand ratio in the mix ratio should be adjusted accordingly.

To figure out the influence of sand ratio on concrete cracks, we carried out plate crack test as per the mix ratio listed in Table 5. As for the specific test procedures, please refer to the *Standard for Test Method of Long-term Performance and Durability of Ordinary Concrete* GB/T 50082-2009.

The test result should be calculated and confirmed as per the following requirements:

(1) The average fracture surface of each crack should be calculated as per the following formula:

$$a = \frac{1}{2N}\sum_{i=1}^{N}(W_i \times L_i)$$

(2) The crack number per unit area should be calculated as per the following formula:

$$b = \frac{N}{A}$$

(3) The total crack area per unit area should be calculated as follows:

$$c = a \bullet b$$

In the formula:

W_i --- Accurate the maximum crack width i (mm) to 0.0l m;

L_i--- Accurate the geometric length of No. i crack to 1 mm;

N---Total crack number (pcs);

A--- Accurate the plate area (m^2) to two decimal places;

a--- Accurate the average crack area of each crack (mm^2/pcs) to 1 mm^2/pcs;

b--- Accurate the crack number per unit area (pcs/m^2) to 0.1 m^2 pcs/;

c---Accurate the total crack area per unit area (mm^2/m^2) to 1 mm^2/m^2

As shown in the test result, when the sand ratio increases, the workability of the concrete improves, but as the sand ratio increases, the concrete crack number and crack area also increases accordingly. Considering the mutual influence of the workability and durability, the sand ratio and the quantity of additives are set as 42% and 1.0% respectively.

After repeated test and maximum optimization of the mix ratio, the final mix ratio of C50T girder is set as: C:F:W:S:G:A=460:30:148:776:1072:4.9.

3.3 Engineering Application

According to engineering practices, the slumps of concrete mixtures from the mixing station to T girder prefabrication site can be kept at 180-220 mm, conforming to the construction pumping requirements as well as the requirements for the engineering strength and 3 d tension stress.

4. Summary

By designing and optimizing the mix ratio of C50T girder, we have a deep understanding of the optimization technologies of concrete mix ratio, which can be summarized as follows:

(1) If coal ash is added in the concrete, the early compressive strength of the concrete develops slowly, because coal ash is not involved in the early hydration. In that case, when making concrete with anti-crack and high early strength requirements, the mixing amount of coal ash should be lowered, especially for concrete with low water-cement ratio. In case of preparing high-strength and high-performance concrete, rather than concrete demanding for early compressive strength, the mixing amount of coal ash may increase correspondingly.

(2) Water-cement ratio is a main factor influencing concrete strength, and the concrete strength can be increased significantly by lowering the water-cement ratio, but if the water-cement ratio is low, and the workability for the concrete mix ratio is weak, it's hard to meet the design requirements. In that case, when preparing high-performance concrete demanding for low water-cement ratio and low dissociation rate, it's applicable to adjust the dosage of additives as per the mix ratio, and improve the sand ratio of proper efficiency for concrete mix ratio, to meet the technical requirements.

DOI: https://doi.org/10.30564/frae.v4i2.3452

Table 2. Workability and Strength Result of the Concrete

No.	W/B	Sand Ratio/%	Mix ratio/(kg/m3)					Slumps/Divergence (mm)	Strength (MPa)			Workability
			C	W	S	G	A		R3	R7	R28	
1	0.30	45	494	148	832	1016	5.0	215/550	55.3	64.0	73.2	Poor workability
2	0.30	44	494	148	813	1035	5.2	220/540	54.8	63.3	74.5	Slightly heavy
3	0.31	45	494	153	832	1016	5.1	220/530	50.0	62.3	69.2	Slightly sticky
4	0.31	44	494	153	813	1035	5.0	220/540	49.9	59.1	68.2	Excellent workability
5	0.32	45	494	158	832	1016	5.1	220/550	49.0	56.8	67.2	Slight bleeding
6	0.32	44	494	158	813	1035	5.2	220/540	48.2	56.0	67.0	Bleeding

Table 3. Workability and Strength Result of Concrete Mixed with Coal Ash

No.	W/B	Sand Ratio/%	Mix ratio/(kg/m3)						Slumps/Divergence (mm)	Strength (MPa)			Workability
			C	F	W	S	G	A		R3	R7	R28	
7	0.30	45	460	30	148	832	1016	5.0	215/540	52.1	58.0	67.8	Thick
8	0.30	44	440	50	148	813	1035	5.2	220/580	48.2	55.8	66.5	Excellent workability
9	0.31	45	460	30	153	832	1016	5.1	220/550	47.6	54.3	64.3	Slightly thick
10	0.31	44	440	50	153	813	1035	5.0	220/600	46.8	52.3	62.0	Slightly thick

Table 4. Concrete Strength and Workability Result of Different Sand Ratios

No.	W/B	Sand Ratio/%	Mix ratio/(kg/m3)						Slumps/Divergence (mm)	Strength (MPa)			Workability
			C	F	W	S	G	A		R3	R7	R28	
11	0.30	42	460	30	148	776	1072	4.9	215/540	48.8	57.0	68.8	Excellent workability
12	0.30	43	440	50	148	794	1054	5.0	220/580	46.2	54.9	67.6	Excellent workability
13	0.30	44	460	30	153	813	1035	5.2	220/550	46.0	53.9	66.5	Excellent workability
14	0.30	45	440	50	153	832	1016	5.3	220/600	45.5	52.6	62.8	Slightly thick

Table 5. Influence of Different Sand Ratios on the Early Crack of the Concrete

No.	Average Crack Area of Each Crack [a] mm^2/pcs	Crack Number per Unit Area [b] pcs/m^2	Total Crack Area per Unit Area [c] mm^2/m^2
11	11.24	8.3	93.27
12	45.15	16.7	753.92
13	46.86	16.7	782.59
14	48.62	18.7	885.23

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DOI: https://doi.org/10.30564/frae.v4i2.3452

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Research on Ecological Corridor Planning of Lanzhou Yuzhong Ecological Innovation City from the Perspective of Ecological Civilization

Jiaojiao Wang[1] Fenli Chen[1] Weihong Wang[2] Libao Dou[1,2*]

1. College of Geography and Environmental Sciences, Northwest Normal University, and Key Laboratory of Resource Environment and Sustainable Development of Oasis, Lanzhou, Gansu, 730070, China
2. Gansu Ecological Environment Science Design and Research Institute, Lanzhou, Gansu, 730030, China

ARTICLE INFO

Article history
Received: 10 August 2021
Revised: 15 August 2021
Accepted: 9 October 2021
Published Online: 16 October 2021

Keywords:
Ecological civilization
Ecological corridor
Ecological planning
Yuzhong Ecological Innovation City

ABSTRACT

The practice and research of ecological civilization is a focus of current planning and design, as well as a scientific strategy under the current situation of resource constraint, environmental degradation and ecosystem degradation. Urban elements such as buildings, green land, farmland,water systems and mountains can be connected by ecological corridors into a green ecological system design.At present, many ecological and environmental problems, such as urban heat island effect, fog and haze, automobile exhaust have a negative effect on the construction of social ecological environment. In order to build a new modern city with prosperous economy, beautiful environment and social civilization, scientific and efficient ecological corridors should be designed to improve the environmental quality of the eco-city, and promote the construction and development of ecological civilization and green cities. Based on the relevant research and specific practices of ecological corridors at home and abroad,combine the needs of the planning and construction of the Yuzhong Ecological Innovation City, and discuss on the connotation and characteristics of ecological corridors, and discuss the key elements of ecological corridor planning.This article will take the ecological corridor planning of Yuzhong Eco-Innovation City as an example. We design ecological corridor based on field investigation, literature and geographic information system..

The planning and design of the ecological corridor in the planning area proposed in this paper can provide positive suggestion on the planning and design of the ecological corridor in other ecological innovation cities.

1. Introduction

With the continuous progress of our society, sustainable development has become the main theme of the current society [1]. Since the 1980s, China has put forward the theory of sustainable development, which also confirmed the promotion of national natural ecological awareness. Under the long-term economic development, industrial development conflicts with the ecological environment. How to realize the sustainable development of human society on the basis of ensuring the stable development of society has become the key to the development and progress of all walks of life [2]. With the continuous strengthening of human development and transformation of nature, the

**Corresponding Author:*
Libao Dou,
College of Geography and Environmental Sciences, Northwest Normal University, and Key Laboratory of Resource Environment and Sustainable Development of Oasis, Lanzhou, Gansu, 730070, China; Gansu Ecological Environment Science Design and Research Institute, Lanzhou, Gansu, 730030, China;
Email: 1913388311@qq.com

 DOI: https://doi.org/10.30564/frae.v4i2.3456

fragmentation of natural landscape is becoming increasingly serious [3-5]. Ecological corridor construction should shift from Greenway Construction focusing on leisure and urban-rural connection to landscape connectivity maintenance and biodiversity protection, and should be based on large-scale issues such as natural regional fragmentation, ecosystem deterioration, loss of natural habitat and habitat structure, and species extinction [6]. For example, the European ecological network planning based on the pan European biological and landscape diversity strategy at the continental level [7]; Southwest Australia ecological corridor connecting biological habitat and national important ecological protection area [8]; Ten large ecological corridors [9] in the Caspian coastal assessment plan, which are dedicated to connecting the broken ecosystems in different regions of the Caspian Sea, are relatively successful cases. In recent years, the construction of ecological corridors in China emphasizes more on the green belt construction on both sides of linear space, and more on the early greenways based on aesthetic design in Europe and America, including the construction of greenways in Guangdong, the construction of ecological landscape forest belt or green passage based on main traffic trunk lines, etc. [10]. In 2016, the development planning outline of the Yangtze River economic belt requires the construction of a green ecological corridor for the harmonious development of human and nature [11]. In 2018, Shanghai will promote the construction of ecological corridors, promote the construction of 17 municipal level key ecological corridors, give full play to their functions of blocking NIMBY facilities, isolating urban clusters, connecting the ecosystem, and providing residents with leisure activities [12].

Standing at the strategic height of history and overall situation, the 18th National Congress of the Communist Party of China formulated the strategic goal of promoting the overall layout of "five in one" in the new era from five aspects of economy, politics, culture, society and ecological civilization [13]. The 19th National Congress of the Communist Party of China pointed out that speeding up the reform of the ecological civilization system, building a beautiful China, adhering to the harmonious coexistence of human and nature, and building an ecological civilization are the millennium plan for the sustainable development of the Chinese nation. We must establish and practice the concept that green water and green mountains are golden mountains and silver mountains, adhere to the basic national policy of saving resources and protecting the environment, and treat the ecological environment like life [14]. Therefore, the construction of ecological civilization is an important part of the cause of socialism with Chinese characteristics. The practice and research of ecological civilization is a focus of current planning and design, and also a scientific strategy under the current situation of resource constraints, environmental degradation and ecosystem degradation. When inspecting General Secretary Xi Jinping, General Secretary General of Gansu proposed to accelerate the construction of a happy new Gansu with economic development, beautiful mountains and rivers, national unity and social harmony. Among them, one is to strengthen the protection of ecological environment and improve the level of ecological civilization. From the perspective of ecological civilization, this paper takes Yuzhong ecological innovation city as an example to analyze the ecological corridor planning of the ecological innovation city, and puts forward that through the planning of ecological corridor, we should vigorously develop ecological economy, create green environment, cultivate ecological civilization, and comprehensively enhance the comprehensive strength of Yuzhong ecological innovation city.

In recent years, urban landscape ecological planning is an important way to reshape urban space and environment. The design of urban ecological corridor is an important part of urban landscape ecological planning. Reasonable planning of urban corridor is of great significance to improve the urban ecological environment and people's quality of life, and promote the sustainable development of urban social economy [15]. The planning and construction of Lanzhou Yuzhong ecological innovation city is another major measure of Gansu Province at the end of the 13th five year plan and the beginning of the 14th five year plan. It is also the top-level design of the general secretary's "eight efforts" to lead Gansu's future development. In Yuzhong ecological innovation city, through the scientific design of efficient ecological corridor, promote the construction and development of ecological civilization and green city.

2. Materials and Methods

2.1 Connotation of Ecological Corridor

William, an American scholar, first put forward the concept of Greenway in 1959, which was highly valued in North America and European countries. It mainly serves for aesthetic recreation and provides the way and guarantee for people to enter the green landscape from the working and living environment, and then it is expanded to entertainment, culture, ecological protection and other aspects [16,17]. Forman [18] put forward the patch corridor matrix theory in 1983, and used it to analyze the relationship between spatial pattern and ecosystem in 1995. So

DOI: https://doi.org/10.30564/frae.v4i2.3456

far, the concept of corridor has been extended to the category of ecological structure of regional ecological security protection. Corridor is a long and narrow area different from the two sides of the substrate, which is an important element of ecosystem construction. The concept of ecological corridor is derived from the concept of Greenway and corridor, and more emphasis on the ecological benefits of corridor. The concept of ecological corridor originated from greenway. American greenways, written by little CE, summarizes greenways, including urban riverside greenways, recreational greenways, natural corridors and historical routes. Among them, greenways with natural corridors are usually built along rivers, streams and ridges, with more emphasis on animal migration and species exchange [19]. Ecological Corridor refers to the corridor type with ecological functions such as protecting biodiversity, filtering pollutants, preventing soil loss, preventing wind and sand fixation, and regulating flood, which is an important part of supporting ecosystem operation [20,21]. Generally, urban ecological corridor refers to the type of linear or zonal ecosystem in urban landscape ecosystem. Urban ecological corridor is composed of natural ecological elements such as vegetation and water area. Through scientific and reasonable design, the basic building content in the city is connected, and the organization form of ecological corridor is constructed [22]. Domestic scholars pointed out that ecological corridor is actually similar to green corridor and green channel [23]. Ecological corridor is connected with a wide range of urban internal infrastructure structure, covering residential buildings, office buildings, streets, roads, railways, unpolluted rivers, suburban shelterbelts, etc., so as to show the ecological utility of ecological corridor to the greatest extent.

The difference between the ecological corridor and the general corridor is that the ecological corridor can organically connect all kinds of natural and human resources with typical characteristics and values in the region, and has ecological, social, economic, cultural and other functions. From an ecological point of view, ecological corridor can not only provide enough space for plant growth and animal reproduction, but also a temporary and permanent habitat diffusion channel for species, which can play the role of flood control and soil consolidation, water and air purification, and also provide ventilation corridor for urban areas to alleviate the heat island effect, which helps to better protect the natural ecological environment [24]. From the social and cultural point of view, ecological corridor can provide people with more places close to nature and pull into the distance between human and nature; The function of popular science education is to help people understand and experience nature; With the charm of highlighting local characteristics, it can create an attractive and pleasant ecological landscape [25]. From an economic point of view, ecological corridor can promote the development of tourism, business services and other related industries, stimulate consumption, expand domestic demand, and provide diversified employment opportunities for surrounding residents [26]. At the same time, ecological corridor can enhance the land use value, improve the investment environment, promote economic growth, avoid the disorderly expansion of cities and towns, and promote the harmonious development of the region.

2.2 Characteristics of Ecological Corridor

The characteristics of ecological corridor are mainly reflected in spatial scale and time scale. In terms of spatial scale, ecological corridor is an important part of urban ecosystem. Compared with urban ecosystem, ecological corridor has more length, width and green coverage [27]. From the perspective of ecological civilization, this paper describes the relevant contents of the concept of ecological corridor. As a subsystem of urban ecosystem, ecological corridor is not a lawn or a few trees on the roadside. Only when the degree of green coverage reaches a certain degree, it can be called ecological corridor [28]. In terms of time scale, ecological corridor is not only a stable ecological landscape in the city, but also a fundamental material guarantee for improving the urban greening system. In the ecological corridor, there is appropriate lighting, and with the help of water, nutrients and many other contents, it can ensure the elasticity and stability of the whole ecological corridor structure, effectively resist interference within a threshold range, give full play to its ecological function to the greatest extent, and effectively improve the overall ecological benefits.

2.3 Overview of Planning Area

Yuzhong ecological innovation city is located in Yuzhong basin, starting from qinglongling in the East, Baihu mountain in the west, Xinglong Mountain in the South and North Mountain in the north [29]. That is, Yuzhong ecological innovation city is located in "two towns and one township" in Yuzhong County. Two towns refer to Chengguan town and Xiaguanying Town, and "one township" refers to the urban and rural areas in the triangle" Two towns and one township "are located in the south central part of Yuzhong County, among which Chengguan town is the current urban location of Yuzhong County. The urban and rural areas of the triangle are in the north of Chengguan Town, Xiaguanying town is located in the north of the urban and rural areas of the triangle, and the

 DOI: https://doi.org/10.30564/frae.v4i2.3456

planning area is generally extended from south to north to East“ The total area of “two towns and one township” is about 260 km^2, and the planned construction area is 123 km^2 (Figure 1). Yuzhong ecological innovation city is located in the central accumulation plain area in geomorphological structure. The central part of the mountain is a sloping alluvial and proluvial plain in front of Xinglong Mountain, commonly known as “Sichuan land”, including the high-level loess buried in the county town to the delta plain, lianta to Dingyuan plain, Heping plain and Baihu mountain beam, zhuzuishan beam and shenjiahe mountain beam.

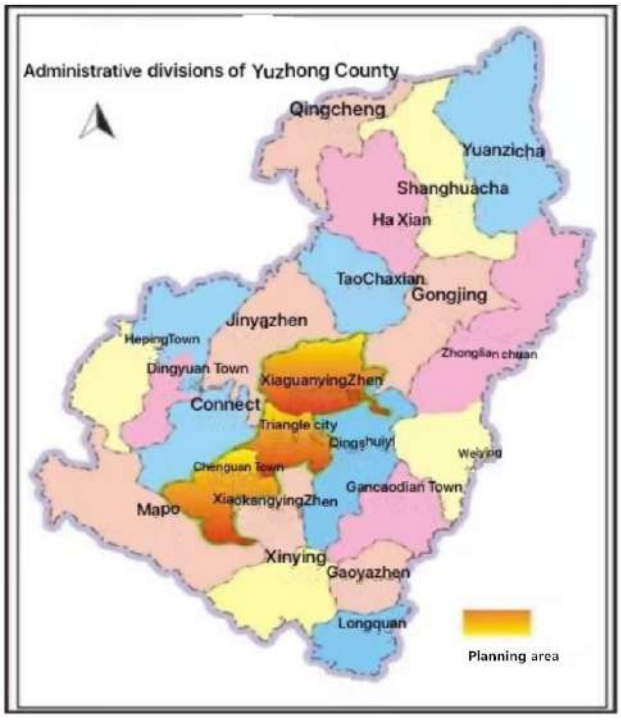

Figure 1. administrative division of the planning area

The inner topography of Yuzhong ecological innovation city is high in the south and low in the north. The geomorphic features are the crisscross distribution area of Piedmont proluvial, alluvial plain and loess ridge. In terms of geography and geological structure, Yuzhong ecological innovation city is a basin with an altitude of 1432~2000m. The planning area has a typical temperate semi-arid continental climate with an annual average temperature of 6.57 ℃ and four distinct seasons. It is windy in spring and drought occurs frequently; In summer, it is hot in the day and cool at night, dry in early summer and rainy in midsummer; In early autumn, it is cloudy and rainy, but in late autumn, it is cool and rainy; It’s cold and snowy in winter. Although faced with some ecological problems, such as climate aridity, land desertification and uneven distribution of forest resources, the natural ecology of the planning area is well maintained and the environmental quality is high. All the natural ecological indicators can reach a higher level according to the requirements of eco-city, so as to improve the overall natural ecological indicators of Lanzhou City and improve the human settlement environment of Lanzhou city to achieve the balance of Lanzhou urban ecosystem.

2.4 Research Methods

This paper focuses on the development and layout of the ecological corridor planning of Yuzhong ecological innovation city, using field investigation, copy investigation and GIS Application Technology (application software is arcgis10.2 and envi5.3).

The ecological corridor in the planning area should be designed scientifically and reasonably to build an ecological civilization city with harmonious and healthy ecological environment as the main symbol and highly unified material civilization and spiritual civilization.

2.5 Analysis of Key Elements of Ecological Corridor Panning

In the process of planning urban ecological corridor, some key elements are often involved, such as corridor number, corridor width, background and key areas [30].

2.5.1 Number of corridors

In general, the more the number of ecological corridors, the better. This can make a variety of ecological flows flow in them, and form a larger radiation area around the corridor, so that the ecological environment around the corridor has been greatly improved.

2.5.2 Background

The ecological corridor is closely related to the surrounding land. The planning area is the main crop planting area in Yuzhong County, which has good natural conditions and is easy to carry out agricultural activities. Cultivated land is an indispensable part of maintaining the integrity of regional ecosystem structure and regional ecological security pattern. The maintenance of farmland ecosystem around the planning area can effectively maintain the ecological service capacity, and the habitat maintenance service, soil conservation service and food supply service have been improved to varying degrees.

2.5.3 Corridor width

Corridor width plays an important role in its ecological function. Too narrow corridor has adverse effects on

DOI: https://doi.org/10.30564/frae.v4i2.3456

the growth of organisms, but also reduces the function of corridor to filter pollutants. Therefore, when we plan the ecological corridor, we should design different widths for different types of ecological corridors according to their own characteristics, so as to achieve the ideal ecological regulation function.

2.5.4 Key areas

There are noise pollution, air pollution and water pollution in the areas near roads and rivers in Yuzhong ecological innovation city.

3. Results and Analysis

3.1 Identify Major Green Corridors

When carrying out the planning and design of ecological corridor, we should first consider the scientific, ecological and green nature of ecological corridor design [31]. For the planning area of Yuzhong ecological innovation city, there are less natural ecological land in the planning area, more rural residential areas, scattered distribution, and insufficient reserve land for development and utilization. The economic development level is low, the industrialization and urbanization rate is not high, the contradiction between land use and ecological environment protection and construction is relatively prominent, the ecological environment situation between regions is obviously different, the infrastructure construction of transportation, water conservancy, energy and so on is relatively backward, and the situation of ecological environment protection and restoration is grim. Therefore, we determine the main green corridor through the reasonable planning of the ecological corridor in the planning area. We need to maintain the balance of urban carbon and oxygen through the planning space of the ecological corridor, so as to realize the exchange of fresh air, effectively solve the problems of urban pollution and poor air quality, and gradually achieve the goal of ecological corridor construction. Ecological corridor is a systematic project, which has different requirements for different infrastructure, so we must carry out differentiated planning efficiently to ensure the comprehensiveness of the planning and design of ecological corridor in the planning area.

According to the statistics of the frequency of each season and wind direction in the planning area for many years, it is concluded that the dominant wind direction in the planning area is southeast wind (SE) in summer and northwest wind (NW) in winter. Because of the influence of valley wind in the planning area, we need to increase the green land area in the planning area and its surrounding areas, adopt new urban planning and design concepts, and plan the wind power transmission channel, The construction of wind power transmission channel in urban planning is one of the important means to effectively reduce urban heat island effect and air pollution. Through the construction of urban ecological corridor, improve the urban air duct.

In the planning and design of urban air duct, 30 ~ 200 m traffic and green landscape passageways with different widths in the northwest and Southeast directions should be built; A 500m wide valley wind passage along Nanhe River and Jiagou River in southwest northeast direction and a 500m wide wind transmission passage along Wanchuan River in northwest southeast direction will be built. In this way, the planning area has cool valley wind in summer, and forms a wind corridor for ventilation and haze removal in winter, so as to reduce the intensity of regional urban heat island to the greatest extent.

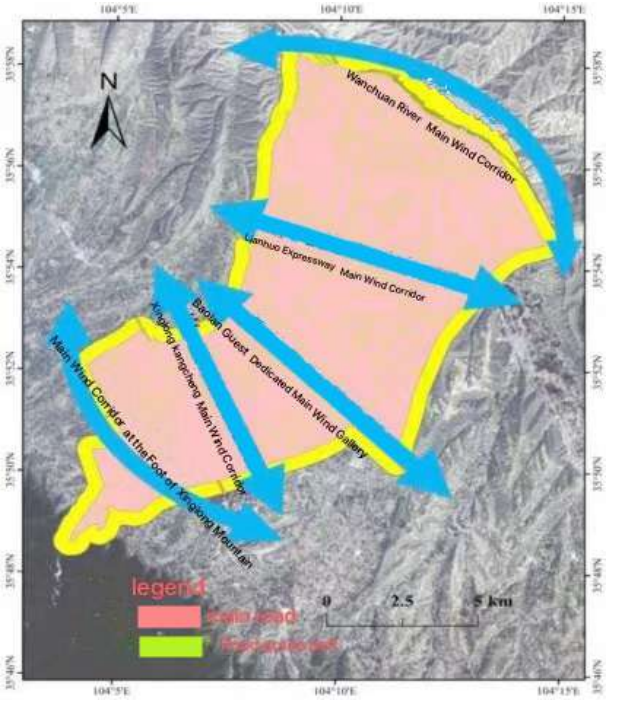

Figure 2. layout of wind corridor in planning area

3.2 Planning and Design of Ecological Corridor for Road Greening in Planning Area

The planning area plans the length, width and height of the Ecological Corridor around the highway to ensure the safe sight distance of drivers, and the plant crown near the lane should not be too large to ensure the smooth discharge of polluted air. Low shrubs and lawns can be planted near the green belt to strengthen the fresh air circulation.

 DOI: https://doi.org/10.30564/frae.v4i2.3456

On both sides of the green road in the planning area, local trees such as pine, cypress, Sophora japonica, Euonymus japonicus, Salix matsudana and Robinia pseudoacacia are dominant; The shrubs are mainly Hippophae rhamnoides, Rhododendron and Tamarix; The main herbs are Poa pratensis, Hemerocallis fulva and Yumei. The specific plants that can be planted are shown in Table 1.

According to the road greening ecological corridor in the planning area, it mainly includes the green corridor of Lianhuo expressway, the green corridor of Baolan passenger dedicated line, the green corridor of Xiaguanying expressway, and the green corridor of Xinglongshan tourism ring line. The width of the corridor is 200 m, 100 m on both sides of the highway and railway, and the surrounding area is arranged with grass, shrub and tree. It also includes a landscape corridor, which is the green corridor of Yuzhong light rail special line. The width of the corridor is designed to be 100 m, 50 m on both sides, and the surrounding area is designed with lawn, trees and shrubs (Figure 3).

3.3 Planning and Design of Ecological Corridor Near Rivers in the Planning Area

The runoff from the mountains around Yuzhong ecological innovation city and the rainwater from the inner plain flow into the North-South stormwater corridor dominated by Jiagou River, xinglongxia River (South River), xujiaxia River and nichangu river; Through these four corridors, the rainwater flows into the Wanchuan River and then into the Yellow River. On the basis of comprehensive river regulation, the water ecological restoration project is carried out in the reach of Yuzhong ecological innovation city of Wanchuan River to restore the water ecosystem and improve the pollutant degradation and self purification capacity of the basin.

For the planning and design of the ecological corridor near the river in the planning area, we should not only consider it from the perspective of ecology, but also analyze it from the perspective of water resources and environment. At the same time, we should also consider the needs of local eco-tourism construction. On the basis of the existing corridor, landscape tourism resources should be added to the planning and design of its ecological corridor, and various kinds of landscape tourism resources such as rivers and forests should be rationally developed and utilized. According to the capacity of landscape tourism resources, the reception scale should be controlled, the ecological tourism network and routes should be reasonably arranged, and the ecological management should be strengthened.

The planning and design of river ecological corridor in the planning area (Figure 4) forms two main ecological corridors, namely Jiagou River and Nanhe river. The width of the corridor is designed to be 500 m, 250 m on both sides of the river, including 35 m artificial buffer zone, which is arranged by herbaceous vegetation combined with artificial wetland; The 215 m green belt is composed of grass, shrub and arbor. A green corridor along the Wanchuan River, 500 m wide, 250 m on both sides, including 35 m artificial buffer zone, is arranged with herbaceous vegetation and artificial wetland. The 215

Table 1. Specific plants planted in the Scheme Area and surrounding areas

Plant type	Plantable Plants
Evergreen trees and small trees	Pinus tabulaeformis, Pinus armandii, Whitebark pine, Arborvitae, Juniper, Prucea crassifolia, Fir, Fir and Juniper
Deciduous and small trees	Poplar, Xanthoceras sorbifolia, Luelantra, Stinky Stakes, Locust, Salix, Crabapple, Torch Tre Yang, Qingyang, Xin-Jiang, etc.
Evergreen shrub	Alpine Cypress, Sand Cyper, Square Branch, Daphne sansa, Chamomile, Rhododendron Mull Rixiang Rhododendron, Fair Azalea, Red-backed Azaleas, etc
Deciduous shrub	Elm, Weigela, Forsythia, Jinlumei, Honeysuckle, Lilac, Redwood, Thyme, Peony, Cherry, Tamarisk, Rhus, Plum, Hedgehog, Acacia, Perilla, Rosa roxburghii, Elderberry, pinnate lilac, etc.
Lawn & Ground Cover Plants	Poa pratensis, Creeping Shearwater, Iris, Tilapia, Faeces, Zoysia, Kentucky bluegrass, Canad Poa, Purple Fescue, Carex heterophylla, Festuca, Woodland Poas, etc.

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m green belt is composed of grass, shrub and arbor. The corridor is 100 m wide and 50 m on both sides, including a 30 m River buffer zone, with herbaceous vegetation and artificial wetland; The 20 m green belt is arranged with grass, shrub and arbor. Planting trees and shrubs on both sides of the river can not only guarantee the ecological value of the ecological corridor, but also ensure the ornamental value of the ecological corridor, and integrate with the local eco-tourism industry to build an ecological corridor for people to watch and keep fit.

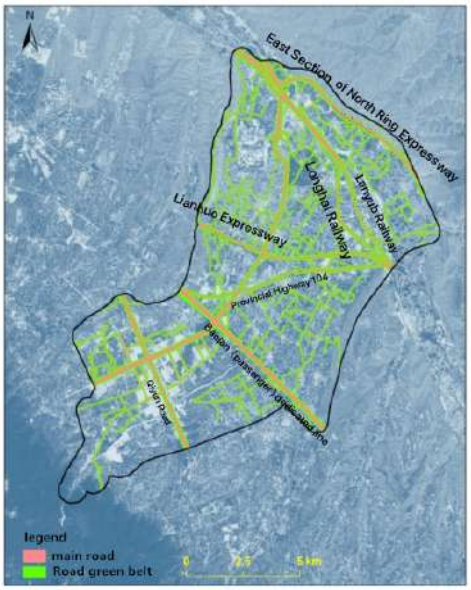

Figure 3. road greening corridor planning

Figure 4. planning of river ecological corridor in planning area

4. Conclusions and Discussions

The natural ecological background of Yuzhong ecological innovation city is "four mountains encircled and five water resources cities" "Four mountains" improvisation of Longshan, Beishan, Qinglong mountain, Baihu mountain. Xinglong Mountain is the eastern extension of Qilian Mountain. The vegetation condition is good, and Xinglongshan National Nature Reserve is set up; The northern mountain is a mountainous Loess Plateau with sparse dry vegetation; Qinglongling is a mountainous Loess Plateau, which is dry and vegetation free. Baihu mountain is a loess hill, and the typical soil Liangshan in Loess Plateau; Baihu mountain, a summer official camp, is a good green mountain in Lanzhou University. Jiagou River, xinglongxia River (Nanhe), xujiaxia River, NICU River and Wanchuan River constitute the water ecological pattern of "five water run cities". Therefore, we should strengthen Shenglong gold belt (Jiagou river ecological corridor), Xinglong cuigu (Nanhe ecological corridor), and form the green skeleton of Yuzhong ecological innovation city. The planning can refer to the concept of "Park City" construction [32], and build a whole park system including country park, waterfront park, comprehensive park, community park and Street Park, and shape a new city with green ecology as the base and slow green road as the context. Based on the planning and design of ecological corridors on both sides of the road and river, the planning of belt green space corridor should be added. The corridor width should be set at 20-40m. The belt green space along the street, adjacent channel and adjacent capillary sponge channel shall be arranged. At the same time, several secondary landscape lines shall be planned, and the main road and secondary main road shall be constructed along the city, and the main road green corridor and secondary main road green corridor shall be arranged, The corridor is 30m wide and the two sides of the corridor are reasonably matched with grass, shrubs and trees according to the landscape characteristics.

In order to make the ecological corridor planning of Yuzhong ecological innovation city more perfect, we propose the following suggestions:

1) Through the research of this paper, we should understand the connotation and characteristics of ecological corridor correctly, and reduce some problems in the construction of planned and built-up area as much as possible. The ecological corridor construction is not equal to the general Greenway Construction. Ecological corridor emphasizes the ecological restoration and comprehensive management of landscape forest, land, lake and grass system. Through the increase of green expansion in Xinglong

 DOI: https://doi.org/10.30564/frae.v4i2.3456

Mountain in the planning area, the ecological innovation city can be maintained with good ecological conservation. In addition, more attention is paid to the agricultural leisure tourism in qinglongling. At present, qinglongling has a high farmland coverage, which is the concentrated area of urban leisure agriculture and sightseeing agriculture. Meanwhile, the corridor is reserved for regional traffic facilities and major infrastructure, which can better construct the network ecological corridor.

2) In the process of planning and construction of ecological corridor, we should consider the barrier effect of artificial infrastructure such as roads and water conservancy on the wildlife in the planning area. On the basis of long-term observation, we need to reserve biological channels for the construction and reservation of biological channels to reduce the adverse effects on the wildlife in the area during the construction of road and river ecological corridor.

3) Establish and improve the long-term mechanism of Ecological Corridor Management and protection. Establish a long-term mechanism of Ecological Corridor Management and protection. We should improve the management and protection mechanism in accordance with the principle of "local management, hierarchical responsibility and responsibility to people", build management and protection infrastructure, establish management and protection team, ensure the management and protection funds, and adhere to the principle of "no main forest". Finally, good management and protection effect is achieved.

4) In the planning and construction of ecological corridor, the construction of ecological isolation green belt between roads, both sides of river and residential land and other land use such as industrial, traffic road and public construction shall be strengthened; Strengthen the construction of the surrounding ecological barrier, form a perfect ecological protection green space system, and protect the residential environment of residents. In the planning and design regulations, the important natural landscape interface principles are controlled along the shenglongjin belt of main ecological corridor and Xinglong cuigu, and the height of buildings on both sides of the landscape interface is strictly controlled. For buildings in the vertical ecological corridor direction, the design method of backbench is recommended, and the height is gradually increased to ensure that the sight of the interface of the corridor is not blocked and a rich landscape level is created.

5) In order to make Yuzhong ecological innovation city develop better from the perspective of ecological civilization, more people pay attention to it. We should actively encourage the exploration of various modes of ecological corridor construction. Through improving the public participation, the public can participate in the top-level planning and design of ecological corridor and the specific implementation process, improve the public participation in the discourse right, and make the ecological corridor construction achievements more effectively reflect the direct interests of the people and get the support of the people.

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 DOI: https://doi.org/10.30564/frae.v4i2.3456

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Study on Influence of Ballast Spring Modulus on Track Structure Based on Finite Element Method

Tian Yang*

China Railway (Tianjin) rail transit investment and Construction Co., Ltd. Tianjin, 300000, China

ARTICLE INFO

Article history
Received: 10 September 2021
Revised: 15 September 2021
Accepted: 9 October 2021
Published Online: 16 October 2021

Keywords:
Railway ballast
Elastic modulus
Finite element method

ABSTRACT

The finite element method is used to simulate the orbital structure, and the finite element model of "rail - sleepers - ballast" can be established. The model of the elastic modulus of different ballast and sleeper is calculated, and the rail displacement, the sleeper stress and the fastening force are deduced. The results show that the elastic modulus of the ballast can be increased to reduce the displacement of the rail and the supporting force of the fastener, but the stress of the sleeper will be increased. When the modulus of elasticity increases, the rail displacement, small.

1. Introduction

Ballast track is widely distributed in China, is an important form of railway transportation. In the course of operation, there are often uneven subsidence problems, the need for regular track maintenance measures to maintain. In the process of settlement and maintenance of ballast track, due to the deformation, crushing and grading of ballast itself changes, its elastic modulus will change accordingly. As an important part of ballast track, the change of elastic modulus of ballast will seriously affect the stability of track structure. In order to study the dynamic response of ballast to track structure, scholars at home and abroad have carried out a series of numerical analysis.

In the simulation analysis, the discrete element method is mostly used by the scholars around the world. Cundall [1] took the lead in introducing the discrete element method to study ballast. Ting [2] adopts two-dimensional ellipse to simulate ballast. This method cannot consider the three-dimensional contact effect of ballast under real conditions, which is greatly different from the actual situation. Xu Yang [3] et al. established a ball cluster unit model that could fit the real partieleshape of ballast, and built a box model for the track bed composed of different grain composition and partieleshape ballast, and focused on analyzing the influence of grain composition and partieleshape on the mechanical properties of the track bed. Xiao Hong [4] et al. used three-dimensional spherical particles to simulate ballast, but did not consider the geometric size characteristics of ballast,and could not accurately simulate the occlusal characteristics of ballast. In terms of experiments, Shi Xiaoyi used finite element simulation to study and analyze the stress distribution in railway tracks. At the same time, he reviewed the predicted settlement results

**Corresponding Author:*
Tian Yang,
China Railway (Tianjin) rail transit investment and Construction Co., Ltd. Tianjin, 300000, China;
Email: 971351161@qq.com

DOI: https://doi.org/10.30564/frae.v4i2.3484

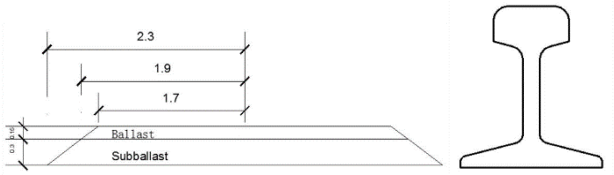
through large-scale triaxial tests. Liu Qingjie et al. tested the change of ballast when the continuous train passed by the way of installing the bulk particle pressure gauge in the sleeper. But in the aspect of finite element simulation, the existing research is very limited [1-3].

In this paper, ABAQUS finite element simulation software is used to establish the contact finite element model between the track superstructure and ballast. Relative to the discrete element method to simulate the real ballast irregular partieleshape and the characteristics of the inertia characteristics, the finite element method to simulate ballast as rail infrastructure contact with sleeper, as a common engineering simulation software, ABAQUS contact module contains a separate, can guarantee the stability of finite element model of each part in contact. Under this premise, this paper focuses on analyzing the influence of the change of the elastic modulus of ballast on the response of each part of the track structure [4,5].

2. Establishment and Validation of the Finite Element Model

2.1 Finite Element Modeling

The finite element model of "rail - sleeper - ballast" is established in ABAQUS. The model is composed of rail, fastener, sleeper, ballast and bottom ballast. In the finite element model, point-to-point springs are used to replace fastener. The section diagram of each component is shown below.



（a）ballast interface figure （b）rail interface figure

Figure 1. Section diagram of the finite element model

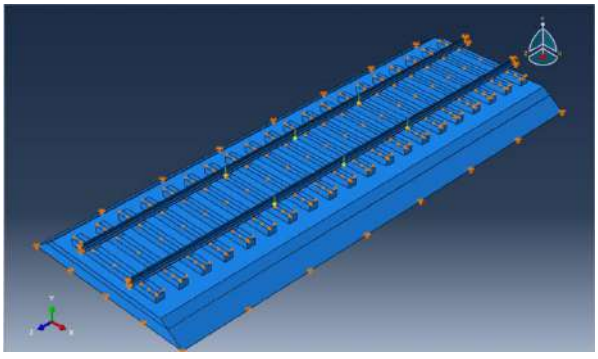


Figure 2. Finite element model of "rail - sleeper - ballast"

Ballast is divided into ballast and bottom ballast. Different elastic modulus is selected when modeling, and the section diagram of rail pillow is simplified to 0.23 m×0.18 m×2.6 m cuboid, rail and ballast length are 12 m. The complete model is shown in Figure 2, where the yellow arrow is the loading position. Three groups of the same vertical loads are added to the model, with a value of 148400N. The boundary conditions restricting the three directions of the bottom ballast ground, rail head and sleeper bottom are set on the model respectively. Contact between rail and sleeper selection of "point-point" spring instead of fastener, the stiffness of $6*10^7$ N / m, sleeper and ballast, ballast and bottom ballast use of "surface-surface" contact. The parameters selected for each component of the model are shown in Table 1.

Table 1. "rail - sleeper - ballst" model parameter table

Material parameters	Elastic Modulus E/pa	Poisson's ratio υ
Rail	$2.1*10^{11}$	0.3
Sleeper	$1.3\ 10^{10}$	0.3
Ballast	$1.5\ 10^{8}$	0.27
Bottom ballast	$5?10^{7}$	0.35

2.2 Finite Element Model Verification

In ABAQUS, implicit and Explicit solving algorithms correspond to the ABAQUS/Standard and ABAQUS/Explicit analysis modules, both of which are capable of solving a variety of problems. Implicit modules are used to analyze the model established in this paper, and Newmark integral method is adopted. It adopts the following assumptions:

$$\dot{u}_{t+\Delta t} = \dot{u}_t + \left[(1+\delta)\ddot{u}_t + \delta\ddot{u}_{t+\Delta t}\right]\Delta t \quad (1)$$

$$u_{t+\Delta t} = u_t + \ddot{u}_{t+\Delta t} + \left[\left(\frac{1}{2}-\alpha\right)\ddot{u}_t + \alpha\ddot{u}_{t+\Delta t}\right]\Delta t^2 \quad (2)$$

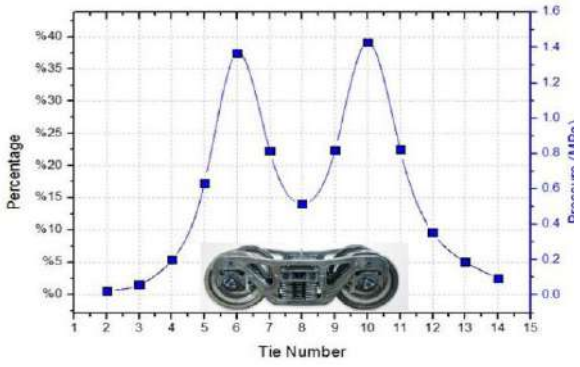
Where and are parameters determined by integral accuracy and stability. For and , Equations (1) and (2) correspond to the linear acceleration method because they can be obtained from the integration of the linear assumed acceleration expression over time interval .

$$\dot{u}_{t+\tau} = \ddot{u}_t + \frac{\left(\ddot{u}_{t+\Delta t} - \ddot{u}_t\right)\tau}{\Delta t} \quad (3)$$

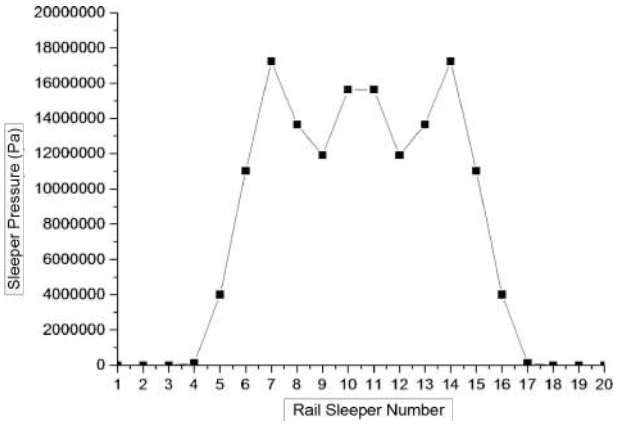
In the formula,.

After the finite element model is calculated according to the selected integral method, the calculation results are extracted. In order to compare the measured results of the sleeper with built-in bulk gauge adopted by scholars such as Liu Qingjie in the United States, the pressure at the contact point between the rail and the sleeper was extracted from the calculation results, as shown in Figure 3.

DOI: https://doi.org/10.30564/frae.v4i2.3484



(a)The measured results



(b)Simulation analysis results

Figure 3. Sleeper pressure diagram under wheelset load

As can be seen from the figure, the sleeper pressure reaches its peak at the action of the wheelset. Since a bogie is adopted in the actual measurement, while three groups of vertical forces are applied to the rail in the simulation model, half of the simulation results can be selected for comparison when comparing the results, and the sleeper stress distribution law is consistent with the actual measurement.

In literature [6], scholars such as Huang Hui used the method of applying static force and sticking strain gages on the waist and axis of the rail to test the wheel-rail vertical force continuously. In order to compare with its results, the rail strain was extracted from the calculation results, as shown in Figure 4, and its distribution rule was the same as that of the rail strain extracted in Literature [7].

By combining the two simulation analyses with the measured results, it can be concluded that the model used in this paper has a good similarity with the measured results under the action of vertical force.

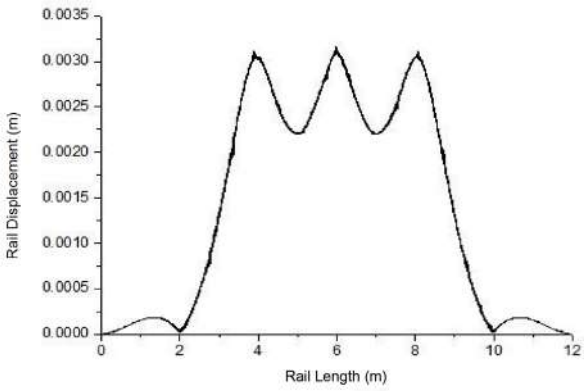


Figure 4. rail strain distribution

3. Calculation Result Analysis

In order to analyze the influence of ballast and sleeper on the response of track structure under different elastic moduli, four groups of different working conditions were selected for calculation. The parameters of each working condition are shown in Table 2. Working conditions one to three for the selection of different ballast elastic modulus of wood sleeper influence analysis, working conditions three, four for the same ballast elastic modulus of wood sleeper and concrete sleeper influence analysis [8,9].

Table 2. calculates four groups of working conditions

	Ballast	Bottom ballast	Sleeper
Working condition 1	75	25	$1.3*10^4$
Working condition 2	150	50	$1.3*10^4$
Working condition 3	211	140.7	$1.3*10^4$
Working condition 4	211	140.7	$3.25*10^4$

Number rail, sleeper and fastener, in which the fastener number is the same as the sleeper number, as shown in Figure 5. The finite element model has a symmetrical structure, so when analyzing the calculation results, only No. 1 rail and No.1-No.10 sleeper can be used for analysis to reflect the overall response.

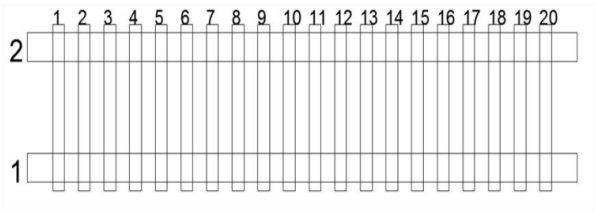


Figure 5. finite element model of each part number

Comparative analysis of elastic modulus of different ballast.With the repeated action of the train load, the sedimentation of the trackbed accumulates gradually, which will lead to the sedimentation of the trackbed or even the whole track structure. The uneven sedimentation of

DOI: https://doi.org/10.30564/frae.v4i2.3484

trackbed caused by the non-uniformity of railway structure along the longitudinal track and the difference of track state will lead to the uneven track surface, directly affect the smooth operation of the high-speed train, increase the workload of maintenance and maintenance, reduce and weaken the strength and stability of the track structure, and threaten the safety of driving.

There are two main factors to produce the settlement of the trackbed, one is the original dense ballast particles under the action of the relative position of the particles change, further compaction of the track bed; The second is particle crushing under cyclic load.Is due to the change of the elastic modulus of ballast, in view of this problem, this paper carried out a detailed analysis [10].

Figure 6 is the rail displacement cloud diagram under the working condition 1. It can be seen from the figure that the rail displacement is the most obvious when the vertical force is used, and the displacement is basically zero at both ends of the rail far away from the point of operation. Figure 7 is the sleeper stress cloud diagram under working conditions. It can be seen from the figure that the sleeper stress is also relatively obvious near the point of operation,in the analysis, only the No.6-No.10 sleepers with obvious results are taken for analysis.

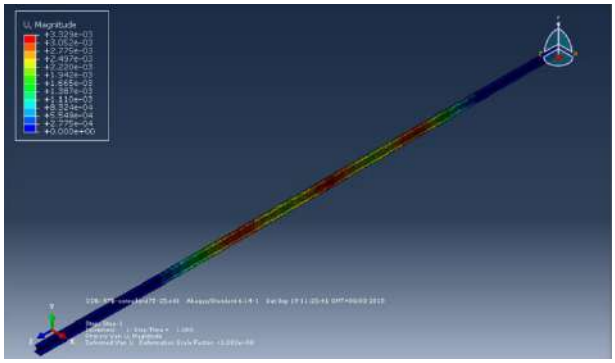


Figure 6. Rail displacement cloud diagram in condition 1

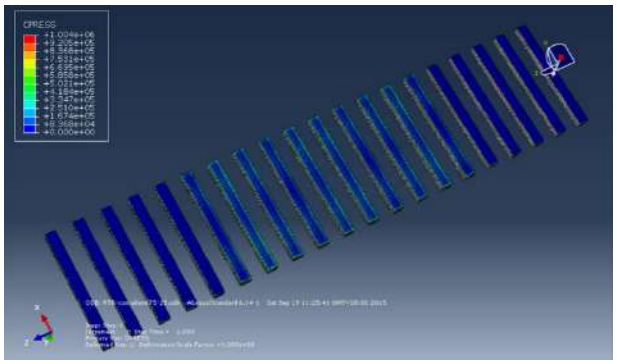


Figure 7. Sleeper stress cloud diagram in condition 1

Taking sleeper No.6-No.10 in the working condition 3 as an example, the stress distribution of sleeper under the action of vertical force is extracted, as shown in Figure 7. With the horizontal length of the sleeper as the abscissor, it can be seen that the stress at the contact point between the sleeper and the rail reaches the peak. By the sleeper number, it can be seen that the stress of the No.7 sleeper, which is used for vertical force, is the largest.

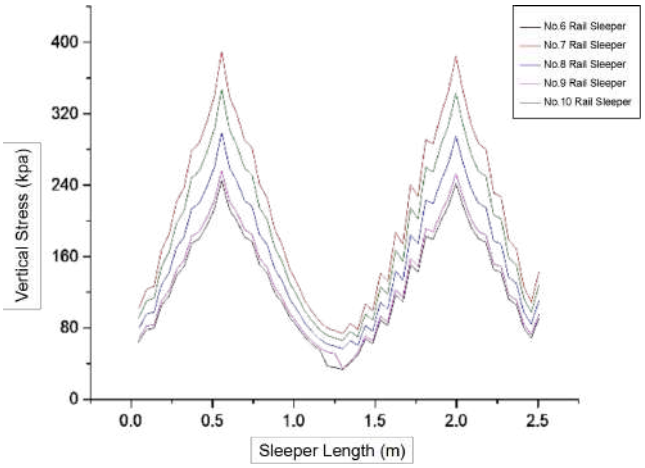


Figure 8. condition 3 No.6-No.10 sleeper stress distribution

In order to compare the change of sleeper stress under different elastic moduli, the stress of sleeper No. 10 in working conditions 1 to 3 is extracted, as shown in Table 3. Among them, the stress of sleeper in working conditions 1 to 3 gradually increases, the stress of sleeper in working conditions 2 increases by about 21.3% compared with that in working conditions 1, and the stress of sleeper No. 10 under working conditions 3 increases by about 21.8% compared with that in working conditions 2. Therefore, with the increase of the elastic modulus of ballast, the sleeper stress gradually increases.

Table 3. Stress of sleeper No. 10

	kpa	psi
Working condition 1	235	34.1
Working condition 2	285	41.3
Working condition 3	347	50.4

In addition to the sleeper stress, the rail displacement and the coupler support reaction are selected as the parameters to reflect the response of the track structure. Because the model established in this paper is of symmetrical structure, one side of the rail is taken as an example when extracting rail displacement and reaction force of coupler support. The extraction results are shown in Figure 8 and Figure 9. The distribution law of rail displacement and coupler support reaction force under different working conditions is consistent, both reach the peak value when the vertical force is used, and the minimum value is at both ends of the rail, and the left and right symmetric

 DOI: https://doi.org/10.30564/frae.v4i2.3484

state is in line with the actual situation. By comparing the results of working conditions 1, 2 and 3, it can be seen that the order of rail displacement and reaction force of coupler support from large to small is: working conditions 1, 2 and 3. Therefore, with the increase of the elastic modulus of ballast, the rail displacement and the reaction force of the fastener gradually decrease.

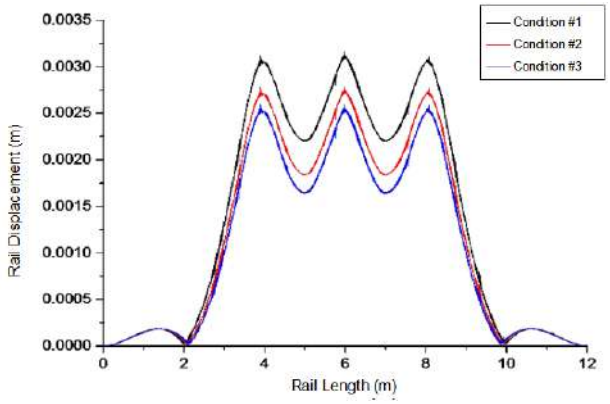


Figure 9. Rail displacements under different working conditions

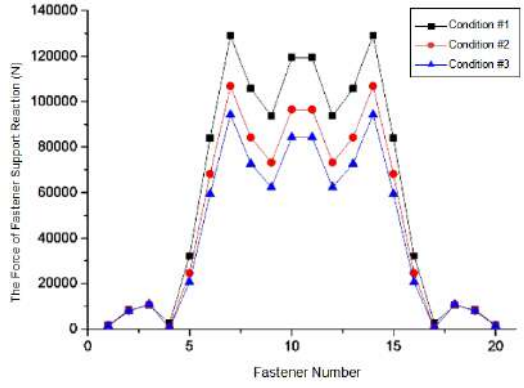


Figure 10. Support reaction force of fastening under different working conditions

Comparative Analysis of the Change of Sleeper Elastic Modulus

With the development of the railway, today there is a ballast railway not only laid wooden sleepers, but also laid concrete sleepers in some high-speed lines. The model built in this paper is also applicable to high-speed lines, in order to study the influence of different sleeper on the response of track structure, the working condition 3 and working condition 4 are selected for comparison calculation, that is, the elastic modulus of sleeper is changed under the same ballast elastic modulus. The selected representative parameters are still sleeper stress, rail displacement and fastening support reaction.

Since only the elastic modulus of the sleeper is changed in the calculation, the distribution rule of the calculated results of the extracted parameters remains unchanged. Taking sleeper No. 10 as an example, the sleeper stress peaks under working conditions 3 and 4 are extracted, as shown in Table 4.

Table 4. Stress of sleeper No.10

	kpa	psi
Working condition 3	347	50.4
Working condition 4	270	39.2

As can be seen from the table, under the same elastic modulus of ballast working condition 4 in the No.10 sleeper stress peak than working condition 3 reduce about 22.2%, that is, with the increase of sleeper elastic modulus, the stress decreases. By comparing other calculation results of working condition 3 and 4, it can be seen that the rail displacement and reaction force of the coupler under working condition 3 are greater than that under working condition 4, that is, with the increase of the elastic modulus of sleeper, the rail displacement, reaction force of the coupler and sleeper stress all decrease.

Comparison of Results

Considering the irregularity characteristics of ballast track, the paper analyzed the sensitive irregularity of ballast track on the existing speeding line and its influence. At the same time, considering the detailed structure of vehicle and track, and based on the vehicle-track dynamics theory, the paper established a coupling dynamic analysis model that could consider the track and its foundation in detail. Among them, the space coupling model of trackbed and sleeper discusses the mechanical behavior mechanism of macroscopic trackbed through analyzing the change rule of microscopic parameters.

Based on the discrete element theory, the authors of the literature mentioned above can study the mechanical properties and behavior of particles from the microscopic perspective, which is suitable for simulating and analyzing the interaction and movement relationship between complex combination particles, and establish the sleeper-track bed discrete element model. Considering the vehicle load and environmental impact will make ballast continuous cracking lead to its elastic modulus change, have an impact on the sleeper hand. In the calculation and analysis, the elastic modulus of ballast is 80 Mpa, 100 Mpa, 120 Mpa, 140 Mpa, 160 Mpa, and the double-wheel load is used to analyze the force of sleeper. The calculation re-

DOI: https://doi.org/10.30564/frae.v4i2.3484

sults are shown in Table 5.

Table 5. different ballast elastic modulus of sleeper under the force and displacement

Elastic Modulus E/ Mpa	Maximum vertical displacement of sleeper/ mm	Maximum vertical compressive stress of sleeper/Mpa
80	5.925	9.40
100	4.862	9.58
120	4.138	9.72
140	3.611	9.85
160	3.209	9.95

According to Table 5, with the increase of the elastic modulus of ballast, the maximum vertical displacement of sleeper decreases accordingly, and the maximum vertical stress of sleeper gradually increases; Increase the elastic modulus of ballast, the maximum vertical displacement of sleeper decreases gradually, and the maximum vertical stress of sleeper increases gradually. This conclusion is the same as the conclusion obtained by the finite element model established in this paper, so the results obtained in this paper are reliable.

4. Conclusions

Through the finite element method, the "rail - sleeper - ballast" model is established to study the impact of different ballast and sleeper elastic modulus on the response of each part of the track structure. Through numerical calculation and comparative analysis, the following conclusions are drawn:

It is completely feasible to use the finite element method to analyze the ballast track problem. The contact module in ABAQUS can well simulate the contact situation between the various parts of the track structure.

In the selection of the same sleeper, sleeper elastic modulus at the same time, with the increase of the elastic modulus of ballast and the bottom of the ballast, the rail displacement gradually decreases, the sleeper stress gradually increases, the coupler support reaction force decreases.

In the selection of the same ballast and the bottom of the elastic modulus of ballast, with the increase of the sleeper elastic modulus, rail displacement, coupler support reaction force and sleeper stress are reduced.

Due to the reliability of the model, the wheel-rail system can be added on the basis of the model in the future to study the impact of the elastic modulus of ballast on the response of each part of the track under the action of dynamic wheel-rail force.

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 DOI: https://doi.org/10.30564/frae.v4i2.3484

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ISSN 2591-7587
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