Discussion and analysis on the improvement of the widening technology of cement concrete pavement of rural highway

Zesong Zhu and Xiaorui Chen
Chuzhou Polytechnic, College of Architectural Engineering, Chuzhou, China

ABSTRACT
In order to improve the widening technology of cement concrete pavement of rural highway, this paper further studies the blockage simulation process of permeable concrete pavement. Moreover, this paper separately studies various external conditions such as sediment gradation, horizontal runoff velocity, seepage velocity, porosity, etc., and reveals the mechanism of pore blockage in permeable pavement. After decades of self-gravity consolidation and the effect of traffic load on the subgrade of the rural old road, the consolidation of the old road has been basically completed. At the same time, after the new road is built, due to its own load and vehicle load, it gradually generates its own settlement, resulting in differential settlement of the old and new subgrade. In addition, this paper explores this difference through digital simulation, and puts forward several suggestions in combination with the simulation model. Finally, on this basis, this paper verifies the method proposed in this paper through experimental research. The research results show that the improvement strategy proposed in this paper is suitable for the widening construction of cement concrete pavement of rural highway.

Introduction
The commonly used widening forms of rural cement concrete pavement mainly include two types of widening of rural cement concrete pavement on both sides and widening of asphalt pavement on both sides. The common diseases in the combination of new and old roadbeds mainly include roadbed instability, support structure damage, road surface damage and decline in overall road performance. This article further analyzes the causes of the above-mentioned common diseases. The instability of the roadbed is mainly due to the insufficient strength of the joint between the new and old roadbed during widening, which causes the joint surface to slip and the settlement difference between the new and old roadbed. The faulting of slab ends of the new and old subgrade will cause the road surface at the joint to crack, and the rainwater will affect the strength of the joint surface of the new and old subgrade after entering through the cracks, which will bring huge risks to the stability of the later subgrade, and even cause the overall collapse in severe cases (Guerra-Santin & Silvester, 2017). The damage to the supporting structure is mainly due to cracking of the retaining wall, sliding of the wall, overturning and so on. When the bottom of the retaining wall is immersed in water or the wall is under excessive pressure, the retaining wall will be unstable, the wall will crack, the wall will slip, overturn, the support structure will be damaged, and the stability of the roadbed will be affected. Reversing fractures, especially a few at transform boundaries, are linked to the most violent disasters, known as major earthquake seismic events, which account for nearly all natural disasters of intensity 8 else greater. Pavement damage is also one of the common diseases in the widening of rural cement concrete pavement. After the old rural cement concrete pavement was widened, faulting of slab ends, broken slabs and other damages occurred in a short time. The appearance of pavement diseases and other problems causes changes in the performance of the road structure. If the structural bearing capacity and flatness of the road surface are reduced to a certain level, it will have an adverse effect on the traffic safety of the entire road (Dodd et al., 2020).

As a stable and durable pavement type, rural cement concrete pavement developed rapidly at the end of the 20th century. However, due to the growth of heavy-duty and overloaded vehicles, and the alternating effects of temperature and humidity, the rural cement concrete pavement that has been built for several years has suffered damages of varying degrees and complex causes. The types of concrete pavement are continuously reinforced concrete pavement (CRCP), jointed plain concrete pavement (JPCP) and jointed reinforced concrete pavement (JRPC). The advantages are concrete roadways have a longer life span than those of other types of roads, are more robust, in addition to, it is relatively untouched with corrosion agents. Also, they give a superb means of transportation in all environmental circumstances, as
well as an impermeable, dustless and hygienic platform. Moreover, the roads built early can no longer meet the current increasing traffic demand and need to be widened (Abuimara et al., 2019). However, there are many problems and difficulties in the maintenance and widening of rural cement concrete pavements, which are mainly manifested in the following aspects: (1) The old pavement shows different types and different degrees of damage. Especially for the rural cement concrete pavement that has been used for more than 10 years, the damage is relatively serious due to the rapid increase of heavy load and overloaded vehicles. Generally, plate fractures are accompanied by road surface subsidence, broken joints, mud and other diseases, which not only affect the road appearance, but also affect the driving safety of vehicles, so timely maintenance must be carried out. For some damages, such as the aging of the joint filler and the failure to repair the minor cracks in time, although it has not seriously affected the normal use of rural cement concrete pavements, as time goes by, ground water easily penetrates into the base. At this time, under the action of the vehicle load, the base layer will be washed out, and the destruction of the rural cement concrete pavement will be accelerated. This will not only bring difficulties to the future repair work, but also affect the safety and service life of the vehicle. (2) The main diseases of the pavement after widening are various types of damage caused by the uneven settlement of the new and old pavements. When the rural cement concrete pavement is widened, if differential settlement occurs, a faulting of slab ends will occur along the junction of the old and new rural cement concrete pavement. This will not only affect the road capacity, but the excessively high faulting of slab ends will also endanger driving safety, accelerate the joint breakage and the loss of the joint filler. Furthermore, it will cause ground water to infiltrate the base layer, which will wash out the hollow base layer under the action of dynamic load, and cause the bottom of the board to vacate, weaken the strength of the base layer, and finally cause the plate to break.

This paper analyzes the cement concrete pavement of rural highways, completes the analysis of its pavement widening technology, puts forward several suggestions for improvement, and verifies the effectiveness with experiments. In this paper, the widening forms of cement concrete pavement is analyzed. In section 1 & 2, the prior information about the pavement technology and its traditional methods are discussed. Section 3 shows the basic law of porous flow. Section 4 illustrates the technical analysis of widening of pavement of rural highway, while section 5 depicts the experiment analysis of the proposed method. Finally, section 6 is completed with the conclusion part.

Related work

The research on cement concrete pavement repair technology plays an extremely important role in the cement concrete pavement repair project, and the focus of the research is mainly focused on material research and process research, especially material research, which is the basis of another research and plays the most fundamental role. There are three processes for repairing cement pavement such as the evacuation and repair of a PQC panels with severe fractures, rebuild using low viscosity epoxy grouting, repair fractures through sewing else cross-stitching, and repairing machinery. The types of repairing materials for cement concrete pavement mainly include crack repairing and plate replacement repairing. The crack repair type can be divided into sealing type and reinforcing type (Remmen et al., 2017). Sealing is an earth’s crust connecting procedure for substances that uses a fluid that clings to the interfaces of the individual followers to be connected, transmitting pressures through one adherence toward the other. A sealant else sealer is the material utilized for binding. Reinforcement either tames or promotes undesirable behavior. Reinforcement is a strategy in behaviorism that is accountable for taught behavior. Reinforcement refers to the act of strengthening or encouraging. The common reinforcing materials are epoxy resin, phenolic resin and other adhesives, and the sealing type mainly includes olefin and rubber. When cracks occur on cement concrete pavement, the overall strength of the pavement is affected and it cannot continue to bear the vehicle load effectively. At this point, it is necessary to use reinforcing materials to improve it so as to improve the overall bearing capacity of cement concrete pavement. At the beginning of concrete pavement pouring, concrete pavement cracking may be caused by concrete shrinkage or temperature shrinkage, which has little influence on the overall bearing capacity of concrete. Once the completed structures are in position, the cement may be installed. We might be capable of driving the prepared cement vehicle up towards the location as well as pour right into the molds. But if it is not practicable, we employ a hydraulic jack to transport the cement to its final destination. While, weather is nearly always such a factor in the onset of spontaneous breaking in concrete surface. The saturation as well as expansion of cement are influenced by evapotranspiration, air movement, moisture content, and sunshine. These elements can either warm or cold the cement, or they might suck humidity from the uncovered hard floor. However, when water penetrates into the base course from this crack, it will weaken the strength of the base course and cause other diseases for a long time. Therefore, in the early stage of crack occurrence, sealing material can be used to seal the crack to prevent
subsequent diseases. By analyzing the development process of crack repair materials at home and abroad, it can be found that the early repair materials are mainly asphalt adhesives, which have the advantages of simple construction and low cost (Endo et al., 2019). The repair method is to close the crack of concrete pavement by penetrating hot asphalt into the crack, but its treatment effect is not obvious and cannot solve the problem fundamentally. Later, epoxy resin was developed, which has been greatly improved in strength and adhesion compared with hot asphalt. However, it has poor flexibility and high brittleness, and will break under load during use, thus affecting its service life (Beausoleil-Morrison, 2019). Nowadays, many foreign countries, such as the United States, Germany and other countries, have modified existing repair materials and developed some good crack repair materials, such as modified epoxy resin, which have not only high strength but also good durability. At the same time, some scientific research institutes have specially developed polymer repair materials which are suitable for repairing cracks with width less than 0.5 mm (Xiong et al., 2020). In addition, QUIKRETE series materials developed in the United States have the advantages of good repair effect, simple construction process and convenient use, but their relatively high cost limits their promotion (Black, 2018). Crack repair materials can effectively prevent ground water from penetrating into the base through cracks to weaken the strength of the base and cause diseases such as void at the bottom of the board. At the same time, the reinforcing material can improve the load transfer capacity of the whole plate to a certain extent. However, these are all aimed at solving the problem of repairing the slight cracks in the concrete pavement slab. If the panel cracks are wide and there are several cracks which have caused the panel to break, the use of crack repair materials cannot fundamentally improve the working condition of the panel, so in this case the pavement panel should be replaced (Hanson et al., 2018).

The repairing materials of high-performance concrete made of fly ash have achieved good results (Wati & Widiansyah, 2020). The relevant municipal departments in Fujian Province have developed high-strength cement mortar by mixing cement, mineral powder, expansion agent, latex powder, ether, water reducer and water in a certain proportion. The mortar has also achieved good results in repairing the old cement concrete pavement. Lee and Cho (2017), HW type super early strength repair agent was developed by using aluminate, silicate, surfactant, sulphaoluminate and other admixtures. When it was used in actual roads, it was found that the strength of concrete increased rapidly and stably, and it could be opened to traffic in 7 days after using it. At the same time, it is found that the temperature shrinkage and dry shrinkage of the pavement are small, and its performance is good after four years of operation. Miller et al. (2018) used early strength agent and water reducing agent to prepare super early strength agent and mixed it into cement concrete. It was found that the compressive strength reached 20 MPa and the flexural strength reached 3.0MPa in 24 h. TF rapid repair agent for concrete pavement is characterized by rapid and stable strength growth and shrinkage temperature reduction (Xie & Gou, 2017). When it is used to repair the old concrete pavement at night, the road can be opened to traffic during the day. The me-4 high-performance repair agent reduce the water consumption by 20% on the premise of ensuring the good workability and water retention of concrete, and also ensure the good bonding performance with old cement concrete (Adilkhodjayev, Mahamataliev et al., 2019a, 2019b). Imam et al. (2017), W-type and S-type concrete pavement rapid repair materials suitable for winter construction and summer construction are respectively manufactured by using sulphaoluminate cement, Portland cement, accelerator and retarder and other raw materials. The concrete mixed with this material has good impermeability, frost resistance and corrosion resistance. JJ type and GG type rapid repair not only have high early strength, but also have good bonding performance with old concrete pavement and strong corrosion resistance (Pei et al., 2020). Longitudinal expansion connections are produced in asphalt concrete to limit the sites of fractures that can sometimes occur owing to warmth and humidity mobility restriction (that is, warping, curling, shrinkage and thermal contraction).

The basic laws of porous flow

Darcy’s law

Darcy’s law defines this phrase as the ease with which fluid flows throughout a permeable material. Darcy’s law asserts that the movement of a liquid with viscous fluid over a solid is simply a consequence of surface tension, and that the rock parameters (for example, susceptibility) stay stable over time. Darcy’s formula is as follows:

\[ Q = KAJ \]  

(1)

Among them, the velocity of porous flow is:

\[ V = KJ \]  

(2)

In the formula, \( Q \) is the flow rate \( (m^3/s) \), \( K \) is the permeability coefficient, also known as the hydraulic conductivity \( (m/s) \), \( v \) is the average porous flow velocity of the section \( (m/s) \), \( J \) is the hydraulic slope, also known as the permeability slope, and \( A \) is the area of the porous flow section \( (m^2) \)
The physical meaning of permeability coefficient $K$ can be understood as the seepage velocity per unit hydraulic gradient. In isotropic media, the permeability coefficient refers to the unit discharge under the unit hydraulic gradient. Moreover, the permeability coefficient can express the difficulty of fluid passing through the pore framework, and comprehensively reflect the influence of soil and fluid on the permeability performance. Researchers usually use empirical method, laboratory method and field method to determine the permeability coefficient (Brunelli et al., 2020). The efficiency with which groundwater may move across sediments is referred to as porosity. The permeation factor aids in the resolution of difficulties such as: Liquid layers supply. Massive stone structures’ sturdiness.

The permeability coefficient can be converted into permeability:

$$k = \kappa \frac{\rho g}{\mu} \quad (3)$$

In the formula, $\kappa$ is the permeability ($m^2$), $\rho$ is the fluid density ($kg/m^3$), $g$ is the acceleration of gravity, and $\mu$ is the hydrodynamic viscosity coefficient ($Pa\cdot s$).

The formula for viscosity coefficient is, $F = \mu Au/y$, where, $F$ is force, $\mu$ is viscosity, $A$ is area of every plate, $u/y$ is proportion of shear distortion. Permeability refers to the ability of porous media such as soil to allow fluid to pass through under a certain pressure difference, which is a parameter to characterize the ability of porous media such as soil to pass through fluid. Moreover, its size is related to porosity, pore geometry and other factors, but has nothing to do with the properties of the liquid in the medium. The relationship between permeability and permeability coefficient is as follows: permeability coefficient is the unit flow rate under unit hydraulic gradient, which can be considered as a constant when the same liquid infiltrates into the same material. The bigger the porosity in the sediment, the softer the surface structure and the greater the transparency of the soil. In comparison, the lesser the porosity, the thicker the sediment. In principle, the larger the diffusion coefficient, the larger the moisture content of the strata beneath the aquifers. In Darcy’s law, the permeability coefficient is a constant, and the value of the porous flow coefficient can be deduced by Darcy’s law $k = v/J$. However, the permeability coefficient is not determined by the porous flow speed and pressure gradient, but by $k = \kappa \frac{\rho g}{\mu}$, which is related to the viscosity of the liquid, the density, and the permeability of the material. There is a relationship between the permeability coefficient and the seepage velocity: the permeability coefficient is generally fixed, while the seepage velocity changes with the inlet pressure, and the slope of Darcy’s law is the permeability coefficient. However, Darcy law can get the average flow velocity of cross-section, but it is impossible to describe the details of the flow in pore structure.

Darcy law is applicable to the seepage of particles with an average particle size of 0.01–3 mm, which is expressed by Reynolds number as shown in Figure 1. The proportion of viscous forces is represented by the Reynolds number. The Reynolds number (Re) aids in the prediction of turbulent flows in various process flow scenarios. Streams with low Reynolds numbers are characterized with unidirectional (sheet-like) movement, whereas streams at high Reynolds numbers are chaotic. In the book of porous media seepage theory, bear explained that when the permeability or seepage velocity is large, the Reynolds number is generally more than 10, and the flow is no longer laminar but turbulent, and Darcy’s law is no longer applicable. Collapse by piling or weakening. Whenever seepage water maintains enough remaining pressure at the arriving groundwater time of performing, it has the potential to push up sediments. As a result of the gradual process of erosion from under the structure, the soil moisture increases.

The Darcy-Forchheimer law, a modification to Darcy’s law, is utilized to study the mobility of a human tissue’s extracellular space. The body is represented as a saturating bilayer media made up of liquid as well as a flexible structure. Forchheimer’s Law means that when the groundwater seepage velocity is large and the Reynolds number exceeds a certain limit (greater than 10), the groundwater movement begins to deviate from Darcy’s law. In 1901, Fuxi Haimai obtained binomial seepage law based on experimental data (Petrov et al., 2019).

$$J = \frac{\mu}{\kappa} q + \beta \rho q^2 \quad (4)$$

In the formula, $j$ is pressure gradient ($Pa/m$), $q$ is groundwater seepage velocity ($m/s$), $\beta$ is non Darcy coefficient ($m^{-1}$), also known as inertia coefficient, $\kappa$ is permeability ($m^2$), $\rho$ is fluid density ($kg/m^3$), $\mu$ is hydrodynamic viscosity coefficient ($Pa\cdot s$). In an oscillating pulse stream, the hydraulic parameters of an immersed component of a construction are directly measured through evaluating an interferometric, detailed replica of the component.

When the Reynolds number is less than 1, the viscous force plays a leading role in the seepage, and the second term can be ignored to obtain Darcy’s law. When the Reynolds number is greater than 1, the order of magnitude of the first term and the second term, i.e., inertial force and viscous force, is approximately equal, and the nonlinear vadose begins to appear. When the Reynolds number is greater than 10, the flow has the characteristics of turbulence. When the Reynolds number is very large, the first term is basically equal to 0, and the turbulence law can be obtained.
According to the rule of conservation of momentum, volume in an individual entity is not generated or eliminated through biochemical processes or physical changes. The energy of the products of a combustion process should reflect the concentration of the reactants, as per the rule of conservation of momentum. The conservation of mass equation is also called continuity equation, and the basic principle is that the net mass flow from the control surface equals to the time change rate of the reduction of mass in the control body.

\[
\frac{\partial \rho}{\partial t} + \text{div}(\rho u) = 0
\]  

(5)

Among them, \(\rho\) is the fluid density, \(t\) is the time, \(u\) is the velocity vector of the fluid, \(\text{div}\) is the divergence symbol, and the units are the same as above.

The momentum conservation equation is (Gibeaux et al., 2018):

\[
\rho \frac{D\phi}{Dt} = \frac{\partial(p\phi)}{\partial t} + \text{div}(p\phi u)
\]  

(6)

Physical meaning: The rate of increase of \(\phi\) in the fluid cluster is equal to the rate of increase of \(\phi\) in the fluid cell plus the net outflow of \(\phi\) in the fluid cell.

Taking the x direction as an example, when we set \(\phi = u\), the momentum change rate in the x direction is:

\[
\rho \frac{Du}{Dt} = \frac{\partial(p\phi)}{\partial t} + \text{div}(p\phi u)
\]  

(7)

The resultant surface force in the X direction acting on the unit fluid cluster:

\[
\frac{\partial(-\rho + \tau_{xx})}{\partial x} + \frac{\partial\tau_{yx}}{\partial y} + \frac{\partial\tau_{zx}}{\partial z}
\]  

(8)

The influence of the volume force is attributed to the source phase \(R_{Sl}\), and the law of conservation of momentum in the x direction is obtained by using Newton’s second law:

\[
\frac{\partial(pu)}{\partial t} + \text{div}(puu) = \frac{\partial(-\rho + \tau_{xx})}{\partial x} + \frac{\partial\tau_{yx}}{\partial y} + \frac{\partial\tau_{zx}}{\partial z}
\]  

(9)

The above momentum conservation equation contains an unknown viscous stress component \(\tau_{ij}\). For an isotropic fluid, the viscous stress is a function of the fluid’s local deformation rate. There are 6 independent strain components in an isotropic fluid element.

\[
\varepsilon_{xx} = \frac{\partial u}{\partial x}
\]

\[
\varepsilon_{yy} = \frac{\partial v}{\partial y}
\]

\[
\varepsilon_{zz} = \frac{\partial w}{\partial z}
\]

\[
\varepsilon_{xy} = \frac{1}{2} \left( \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)
\]

\[
\varepsilon_{xz} = \frac{1}{2} \left( \frac{\partial u}{\partial z} + \frac{\partial w}{\partial x} \right)
\]

\[
\varepsilon_{yz} = \frac{1}{2} \left( \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \right)
\]

\[
\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = \text{div}(u)
\]  

(10)

As per Newton’s permeability rule. The shearing rate is linked towards the variation of speed. The shear force among two neighboring liquid molecules is exactly proportional to the increasing quantity of the pressure gradients among the same two neighboring liquid molecules. The shape of the relationship among tensile force and tensile stress relies on the liquid, and most popular liquids follow Newton’s equation of viscous, which says that shear force is directly proportional to the applied rate: \(\tau = \mu \text{dy dt}\). According to Newton’s law of viscous isotropic fluid, the relationship between viscous stress and strain is:

\[
\tau_{xx} = 2\mu \frac{\partial u}{\partial x} + \lambda \text{div}(u)
\]  

(15)

\[
\tau_{yy} = 2\mu \frac{\partial v}{\partial y} + \lambda \text{div}(u)
\]  

(16)

\[
\tau_{zz} = 2\mu \frac{\partial w}{\partial z} + \lambda \text{div}(u)
\]  

(17)

\[
\tau_{xy} = \tau_{yx} = \mu \left( \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)
\]  

(18)
\[ \tau_{xx} = \tau_{xx} = \mu \left( \frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} \right) \]  
(19)

\[ \tau_{yx} = \tau_{xy} = \mu \left( \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \right) \]  
(20)

Among them, \( u \) is the dynamic viscosity coefficient of the fluid (the first viscosity coefficient), and \( \lambda \) is the volume viscosity coefficient (the second viscosity coefficient). Therefore, when the fluid is incompressible, according to the mass conservation equation, \( \nabla \cdot \mathbf{u} = 0 \).

Finally, the Navier–Stokes equation can be derived. Since they explain the mechanics of numerous events of science and engineering importance, the Navier–Stokes formulas are valuable. They may be used to simulate climate, flowing water, moisture in a tube, as well as air circulation about a wing, among other things. Taking the \( x \) direction as an example, the source term of \( S_m \) is:

\[ \frac{\partial (\rho u)}{\partial t} + \nabla \cdot (\rho u u) = -\frac{\partial p}{\partial x} + \nabla \cdot (\mu \cdot \text{grad} u) + S_m \]  
(21)

CFD (Computational Fluid Dynamics) is a modeling method for evaluating complicated heat transfer and fluid processes. CFD software is essential for front-loading production process in determining the most effective conceptual models in the designing phase. The fluid governing equations of computational fluid dynamics include the mass conservation equation, momentum conservation equation in three directions, energy equation and gas state equation. The number of equations is equal to the number of unknowns, so it is solvable mathematically. In general, the above equations should be discretized, and the finite volume method or finite difference method should be used for the difference, then the boundary conditions should be assumed, and the numerical solution should be obtained by iteration. The above equations are the core equations solved by CFD software.

Technical analysis of widening of cement concrete pavement of rural highway

(1) The slope of the old road should be brushed first, and the thickness of the slope should be controlled above 30 cm. At the same time, it is necessary to clear the surface within the base of the new subgrade with a depth of 30 cm, and then level and compact. The compaction degree needs to reach 90%. For the weak foundation, quicklime powder can be added for reinforcement or replacement. (2) Step excavation. It is necessary to excavate steps on the slope of the old road after slope brushing. The excavation process is to establish the cornerstones, inspecting the ground & upper levels, excavating to the specified depth, strewing the loose dirt, draw a line through the cut-off level, the development of dewatering wells & interconnected ditches, delineating the building’s borders and the building of protective drains. The width of the steps is 1–2 m and the height is less than 0.5 m. The top surface of the steps is made into an inward inclined 2% – 4% slope to prevent the new subgrade from sliding outward. The specific method is shown in Figure 2.

(3) Set up geogrid. In order to enhance the integrity and strength after the combination of the new and old subgrade and prevent local settlement, displacement and deformation, geogrid is set at the junction of the new and old subgrade. Technical requirements: the geogrid is made of two-way steel plastic, the tensile strength is greater than or equal to 45KN/m, the elongation is not greater than 4%, and it is appropriate to extend 2 m to the widened side of the paved steps. (4) Scientific and reasonable rolling and compaction. The rolling machine, rolling speed and frequency are determined through the test section, and the change of the junction between the new and old subgrade is monitored by the instrument, which not only meets the requirements of compactness, but also ensures the stability and integrity of the junction between the new and old subgrade.

The general widening scheme and typical subgrade structure are as follows:

(1) Widen both sides of fill subgrade. In general, this kind of widening scheme is mainly located in the section with flat terrain. There are two ways of widening: symmetrical widening and asymmetrical widening. According to different terrain conditions, there are symmetrical widening on both sides of soft foundation, on both sides of shoulder wall or shoulder guard, and on both sides of foot guard. The advantage of this widening method is that the center lines of the new and old subgrade coincide, and the pavement remains on the base compacted by vehicles. The disadvantage is that when the widening value is small, the compaction between the new and old subgrade filling is difficult. In particular, the settlement of the soft soil foundation section is large, and the deformation between the new and old subgrade is large, which makes a series of diseases often occur at the junction of the new and old subgrade, as shown in Figures 3–6 below.

(2) Unilateral widening of fill subgrade. According to the different terrain conditions, it can be divided into two ways: unilateral widening of retaining wall and unilateral widening of foot guard. The feature of unilateral widening is that the center lines of new and old subgrade are not coincident, and the advantage is that the construction of widening subgrade is
The construction of new subgrade is concentrated on one side of subgrade, large area operation can be carried out. The disadvantage is that part of the new pavement will fall on the new fill, and its strength is relatively easy, and the quality can be guaranteed. As the center line of the carriageway of the double-sided slope is moved, the amount of pavement materials is increased. The details are shown in Figure 6.

Before the formal construction of subgrade, the professional survey team is responsible for surveying and setting out, comprehensively restoring the middle line of the road, fixing the control piles in the route, and determining the position of the foundation sideline. At the same time, we need to protect all the sign piles to avoid damage during construction. Before embankment filling, the toe line of widened subgrade can be measured according to the design width of widened subgrade and slope gradient. The filling sideline of embankment should be 50 cm wider than the toe line, so as to ensure the compactness of embankment edge to meet the specified requirements.

Within the scope of subgrade construction, it is necessary to completely remove the debris on the ground, including planting soil, turf, etc., to ensure that the depth of the surface is not less than 15 cm. The roots of the trees buried in the ground should be removed completely or more than 50 cm. After the meter cleaning is completed, the original ground can be excavated into steps with a width of more than 1.0 m and compacted.

The layered method is used to pave the soil. A cement replacement is a coating of pavement that is laid across an established roadway (elastic, stiff, or hybrid) to enhance its efficiency. Cement coverings can satisfy any life span and transportation pressure ratios. Their characteristics vary according to the prevailing road surfaces, expected throughput, and planned service life. According to the actual amount of each layer of soil, the distance when the vehicle is unloaded is reasonably determined. After the soil is laid out, a bulldozer or a grader can be used for paving, and the paving thickness can be determined according to the soil quality and the compaction machinery used.

Under normal circumstances, the maximum paving thickness of each layer should not exceed 30 cm. Use
bulldozers for leveling, and you can gradually advance from the middle of the road to both sides. Pay attention to the cross slope of the roadbed. Especially in the rainy season, you can increase the cross slope to about 3% to 4% to improve the drainage effect.

Compaction is the most important process in subgrade construction and the key to ensuring the overall quality of subgrade. Therefore, before compaction, the water content of the roadbed soil should be tested on site, and it is best to grab it by hand and lose it on the ground. If the water content is too high or too low, adopt corresponding methods to make adjustments to achieve the best water content. The roller compaction process should be static compaction and then vibration compaction, rolling from both sides to the middle, the roller width should overlap by 1/2. In order to achieve the expected degree of compaction, the rolling speed should be controlled, and 4.0 km/h is appropriate. The key points of cement concrete pavement construction technology are summarized as follows:

Mold steel is a component in making molds such as cold-punching molds, metal forming dies, die-casting molds, and more. The mold is the material handling equipment for the equipment production, engine, radar, and other industries. Steel molds are used for the construction of cement concrete pavements, and wooden templates are used for smaller bends. In order to ensure the construction quality of cement concrete, the formwork used should not only have sufficient rigidity and strength, but also be straight and clean. The height of the formwork should be consistent with the thickness of the pavement slab, and the error should not exceed the limit; the removed formwork continues Check before use to see if there are defects such as defects, deformations, etc., if there are defects, repair them, and eliminate the defects before reuse; before supporting the template, check the top elevation of the base layer to ensure that the template is firmly supported Stable, straight and tight joints.

The mixture is mixed in accordance with the mixing ratio given by the laboratory, and is transported to the site by a transport vehicle for paving. For semi-dry cement concrete, the paving thickness should be controlled to ensure that the paving interval of each layer is within 30 minutes. Cement concrete paving, vibration, plastering and other processes should be carried out continuously and uninterruptedly, and the plug-in vibrating rod should be used for vibrating and compacting, and curing should be carried out in time after construction.

Prefabrication is the assembling of structures or their elements away from the construction site. The strategy reduces building efficiency and saves work, labor, and resources. The purpose of prefabricated construction technologies is to provide a method for obtaining a very well structure that would be at least vaguely fitted to the demands of inhabitants. Prefabrication techniques in infrastructure design have the greatest impact on reduction of costs.

Table 1. Statistical table of expert ratings.

| NO. | Expert rating | NO. | Expert rating | NO. | Expert rating |
|-----|---------------|-----|---------------|-----|---------------|
| 1   | 93.07         | 21  | 95.59         | 41  | 94.78         |
| 2   | 96.29         | 22  | 94.74         | 42  | 90.81         |
| 3   | 94.55         | 23  | 93.45         | 43  | 90.76         |
| 4   | 93.70         | 24  | 93.15         | 44  | 96.87         |
| 5   | 90.50         | 25  | 90.59         | 45  | 94.00         |
| 6   | 91.61         | 26  | 93.60         | 46  | 96.04         |
| 7   | 92.21         | 27  | 90.39         | 47  | 95.46         |
| 8   | 93.98         | 28  | 90.02         | 48  | 93.48         |
| 9   | 95.97         | 29  | 94.60         | 49  | 94.87         |
| 10  | 96.21         | 30  | 92.63         | 50  | 92.14         |
| 11  | 93.23         | 31  | 92.26         | 51  | 90.09         |
| 12  | 95.09         | 32  | 90.78         | 52  | 92.67         |
| 13  | 95.49         | 33  | 95.85         | 53  | 96.26         |
| 14  | 96.87         | 34  | 93.57         | 54  | 92.19         |
| 15  | 92.11         | 35  | 92.00         | 55  | 93.43         |
| 16  | 90.03         | 36  | 94.56         | 56  | 94.15         |
| 17  | 92.34         | 37  | 93.12         | 57  | 93.93         |
| 18  | 96.31         | 38  | 93.95         | 58  | 96.75         |
| 19  | 96.29         | 39  | 96.04         | 59  | 94.08         |
| 20  | 96.09         | 40  | 91.29         | 60  | 94.80         |
After the cement concrete is consolidated, the transverse shrinkage joints can be constructed with corresponding machines, and the transverse expansion joints should be at right angles to the center line of the road and the width of the joints should be consistent. Expansion joints can be set in the lower part of the gap, and the upper part can be filled with sealing material. The expansion joint plate can be made by a prefabrication method to ensure that the joint wall is clean and tightly combined.

**Experimental analysis on widening technology of cement concrete pavement of rural highway**

On the basis of the above analysis, this paper conducts an experimental analysis on the widening technology of the cement concrete pavement of the rural highway proposed in this paper. The
experiment is performed through expert evaluation and simulation experiment analysis. Firstly, the technical improvement of this paper is evaluated by expert rating method. Expertise Process is a review in which one or so more UX specialists serve as clients as well as evaluate a structure, program, or business in order to detect accessibility issues and give suggestions to enhance it. Following end of every iteration, the experts should draw up a list of all accessibility issues and make ideas and solutions. A total of 60 sets of data are evaluated. The results are shown in Table 1 and Figure 7.

On the basis of the above analysis, the simulation test analysis is carried out, and the results obtained are shown in Table 2 and Figure 8 below.

From the above test results, it can be seen that the widening technology of the cement concrete pavement of the rural highway proposed in this paper has a certain effect, and the method of this paper can be used to verify the effect in practice (Figure 9).

Conclusion
With the gradual acceleration of the process of building a new socialist countryside, the rural economy has developed rapidly. Therefore, some roads built in the early days have been unable to meet the needs of vehicle traffic. In order to solve this problem effectively, the existing cement concrete pavement can be widened and reconstructed. However, the widening and reconstruction of cement concrete pavement of rural highway is a complex and systematic work. In order to avoid wasting too much money and resources, we can make rational use of the original subgrade, and take effective technical methods to ensure the quality of the widened cement concrete pavement and improve the driving safety and comfort. This paper analyzes the diseases of cement concrete pavement widening and reconstruction. Moreover, through theoretical research, combined with engineering practice, this paper summarizes and puts forward several technical measures for widening the old and new subgrade pavement, which can be selected and applied according to the actual situation in the reconstruction project. Finally, the simulation engineering test shows that these measures are effective and feasible.

Disclosure statement
No potential conflict of interest was reported by the author(s).

References
Abuimara, T., O’Brien, W., Gunay, B., & Carrizo, J. S. (2019). Towards occupant-centric simulation-aided building design: A case study. Building Research & Information, 47(8), 866–882. https://doi.org/10.1080/09613218.2019.1652550
Adilkhodajev, A. I., Mahamataliev, I. M., & Shaumarov, S. S. (2019a). Theoretical aspects of structural and simulation modeling of the macrostructure of composite building materials. Journal of Tashkent Institute of Railway Engineers, 14(2), 3–14. https://doi.org/10.22281/2413-9920-2018-04-03-312-320
Adilkhodajev, A. I., Mahamataliev, I. M., & Shaumarov, S. S. (2019b). BioExcel Building Blocks, a software library for interoperable biomolecular simulation workflows. Scientific Data, 6(1), 1–8. https://doi.org/10.1038/s41597-019-0177-4
Beausoleil-Morrison, I. (2019). Learning the fundamentals of building performance simulation through an experiential teaching approach. *Journal of Building Performance Simulation*, 12(3), 308–325. https://doi.org/10.1080/19401493.2018.1479773

Black, A. D. (2018). Wor (d)-building: Simulation and metaphor at the mars desert research station. *Journal of Linguistic Anthropology*, 28(2), 137–155. https://doi.org/10.1111/jola.12183

Brunelli, A., de Silva, F., Piro, A., Parisi, F., Sica, S., Silvestri, F., & Cattari, S. (2020). Numerical simulation of the seismic response and soil-structure interaction for a monitored masonry school building damaged by the 2016 Central Italy earthquake. *Bulletin of Earthquake Engineering*, 19(2), 1181–1211. https://doi.org/10.1007/s10518-020-00980-3

Dodd, T., Yan, C., & Ivanov, I. (2020). Simulation-based methods for model building and refinement in cryoelectron microscopy. *Journal of Chemical Information and Modeling*, 60(5), 2470–2483. https://doi.org/10.1021/acs.jcim.0c00087

Endo, N., Shimoda, E., Goshome, K., Yamane, T., Nozu, T., & Maeda, T. (2019). Simulation of design and operation of hydrogen energy utilization system for a zero-emission building. *International Journal of Hydrogen Energy*, 44(14), 7118–7124. https://doi.org/10.1016/j.ijhydene.2019.01.232

Gibeaux, S., Thomachot-Schneider, C., Eyssautier-Chuine, S., Beatrice, M., & Partica, V. (2018). Simulation of acid weathering on natural and artificial building stones according to the current atmospheric SO2/NOx rate. *Environmental Earth Sciences*, 77(9), 1–19. https://doi.org/10.1007/s12665-018-7467-6

Guerra-Santin, O., & Silvester, S. (2017). Development of Dutch occupancy and heating profiles for building simulation. *Building Research & Information*, 45(4), 396–413. https://doi.org/10.1080/09613221.2016.1160563

Hanson, K., Hernandez, L., & Banaski, J. A., Jr. (2018). Building simulation exercise capacity in Latin America to man-age public health emergencies. *Health Security*, 16(S1), S98-S102. https://doi.org/10.1089/hs.2018.0091

Imam, S., Coley, D. A., & Walker, I. (2017). The building performance gap: Are modelers literate? *Building Services Engineering Research and Technology*, 38(3), 351–375. https://doi.org/10.1177/0143624416684641

Lee, C. W., & Cho, S. J. (2017). The development of converting program from sealed geological model to Gmsh, COMSOL for building simulation grid. *Journal of the Korean Earth Science Society*, 38(1), 80–90. https://doi.org/10.5467/IKESS.2017.38.1.80

Miller, C., Thomas, D., Kämpf, J., & Schluter, A. (2018). Urban and building multiscale co-simulation: Case study implementations on two university campuses. *Journal of Building PerformanceSimulation*, 11(3), 309–321. https://doi.org/10.1007/19401493.2017.1354070

Pei, J. S., Carboni, B., & Lacarbonara, W. (2020). Mem-blocks as building blocks for simulation and identification of hysteretic systems. *Nonlinear Dynamics*, 100(2), 973–998. https://doi.org/10.1007/s11071-020-05542-5

Petursson, G., Mavrogiani, A., Symonds, P., Anastasiou, M., Dane, V., Rokia, R., & Mike, D. (2019). Can the choice of building performance simulation tool significantly alter the level of predicted indoor overheating risk in London flats? *Building Services Engineering Research and Technology*, 40(1), 30–46. https://doi.org/10.1177/0143624418792340

Remmen, P., Lauster, M., Mans, M., Fuchs, M., Osterhage, T., & Muller, D. (2017). TEASER: An open tool for urban energy modelling of building stocks. *Journal of Building Performance Simulation*, 11(1), 84–98. https://doi.org/10.1080/19401493.2017.1283539

Wati, E. K., & Widiamsyah, N. (2020). Design of learning media: Modeling & simulation of building thermal comfort optimization system in building physics course. *Jurnal Pendidikan IPA Indonesia*, 9(2), 257–266. https://doi.org/10.15294/jpii.v9i2.23504

Xie, X., & Gou, Z. (2017). Building performance simulation as an early intervention or late verification in architectural design: Same performance outcome but different design solutions. *Journal of Green Building*, 12(1), 45–61. https://doi.org/10.3992/1552-6100.12.1.45

Xiong, C., Huang, J., & Lu, X. (2020). Framework for city-scale building seismic resilience simulation and repair scheduling with labor constraints driven by time–history analysis. *Computer-Aided Civil and Infrastructure Engineering*, 35(4), 322–341. https://doi.org/10.1111/mice.12496