

Original research article

Road construction and quality control

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Abstract: Cement concrete is widely used in civil engineering construction because of its convenient construction, performance can be adjusted according to design, high compressive strength, good durability, and good coordination with steel and other materials. In modern roads and bridges, cement concrete pavement is a common pavement structure. However, due to the construction quality, climatic conditions, and with the rapid growth of heavy cargo vehicles, many cement concrete pavement has been broken, local subsidence and other structural damage; therefore, cement concrete pavement disease, has been affected and troubled cement surface use and development. Some opinions are put forward through the analysis and management of some problems in the construction of highland cement concrete pavement.

Keywords: hydraulically settling; concrete pavement; construction quality; construction control; pavement fracture; plate fracture

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1. Introduction

Cement concrete is a non-homogeneous brittle mixture, its biggest disadvantage is poor toughness, low tensile strength (with its compressive strength ratio). Prevention and disposal of various types of road cracks and the occurrence and development of the phenomenon is to maintain and ensure cement concrete pavement use and durability of the most basic requirements, but due to construction technology and quality control and other aspects of the reasons, so that some cement concrete pavement in the construction will encounter a variety of problems, the following combined with my internship: the concrete cement concrete surface construction has made some discussion and analysis on some problems encountered in the construction of cement concrete.

2. Quality control of two cement concrete materials

Usually in the cement concrete pavement construction, were generally more emphasis on gravel, sand, water and other raw materials quality, the cement only requires its strength and stability. In order to improve the crack resistance of cement concrete, in addition to the quality of gravel, sand, water and other materials, cement concrete pavement should be used for cement, concrete water-reducing agent and curing agent to make more stringent quality control.

Material quality control was the basis of engineering quality control, good quality raw materials, engineering quality will be guaranteed. Because of our highland line in the mountains of the characteristics of traffic inconvenience, we decided to use the road construction materials used by our local suppliers through the procurement, procurement of materials from different sand fields, each car to the material

specifications have a certain difference, raw materials and its bad control. These conditions made management difficult. To this end, our laboratory in strict accordance with the design of the material on the outsourcing of cement, gravel and other raw materials to carry out the necessary test, inspection before use, inspection did not meet the origin, did not meet the specifications of the materials are not allowed to approach, had been approach to resolutely retreat, the complete elimination of the quality of raw materials from the hidden dangers. We had imported sand in between, stone has appeared too much mud, crushing value was not enough, grading was not enough and so on, we deal with it one by one. The content of soil, mud and stone powder in aggregate had a great influence on the flexural strength of concrete, which would increase the probability of splitting and shrinkage. The current national standards: coarse aggregate soil content $\leq 1\%$, sand soil content $\leq 3\%$. In practice, due to the processing of aggregate production units, raw material origin and environmental differences, the quality of the aggregate used for the project is difficult to control, mud content is often exceeded. Therefore, the control of the amount of soil containing aggregates should pay attention to the source management, strengthen the construction screening, remove the stone powder, soil, and prohibit the processing of gravel in the rainy season, so as not to adhere to the stone powder and clay surface and mixed with the aggregate; treatment of sand and gravel material, and should take tarpaulins cover measures to actively prevent the secondary pollution of the aggregate; is required for the use of sand in the project, all sieves (8 mm) washed use, thoroughly screen sand in the soil, stone. Aggregate (sand, stone) gradation and technical requirements: aggregate (sand, stone) should choose the amount of mud, organic matter content in the specification within the allowable range of materials, coarse aggregate size is larger than the concrete bending strength is not high, and the strength of the variance is large, the choice of gravel maximum particle size should not be greater than 19 mm, crushed gravel maximum particle size shall not be greater than 26.5 mm, gravel maximum particle size shall not exceed 31.5 mm, super diameter content shall not exceed 5%, the content of not less than 10%, gravel or gravel particle size of less than 75 mm stone powder content should not be greater than 1%. Fine aggregate with continuous gradation, fine modulus of 2.5 to 3.2 in the partial coarse sand. Cement quality: cement is a concrete cementing material, the performance of concrete depends largely on the quality of cement. Rural roads can be used Portland cement and ordinary Portland cement, the proposed large traffic volume of county and township roads using 42.5 cement, for the smaller traffic volume of village roads can be used 32.5 grade cement. Cement approach, each batch should be accompanied by a full range of chemical composition and physical and mechanical indicators of qualified quality inspection certificate. Cement grinding must be stable, and the cement storage period shall not exceed 3 months, different varieties, grades, strength level, the manufacturers of cement could not be mixed and mixed use.

3. Cement concrete pavement construction

3.1. Cement concrete slab control

Concrete thickness is to ensure that the basic indicators of life, so the thickness should have more security reserves, not because the grass-roots thicker, high strength, free to reduce the surface layer. In fact, increasing the strength and rigidity of the base layer has little effect on reducing the stress on the surface layer or the thickness of the thinned layer. And the service life of the pavement is proportional to the thickness of the cement concrete surface layer. The slight change of the thickness of the surface layer has obvious influence on the service life of the road surface, such as 20cm thick layer, thinning 1cm, service life will be shortened by 23%, thinning 2 cm, shortening 41%. Therefore, to strengthen the control of the thickness.

- 1) Cement concrete pouring before the template to be checked. First check the size of the template, the

height must be consistent with the thickness of the concrete slab design; followed by checking the template stiffness, the template should adopt steel mold, prohibit the use of large deformation, the top of the uneven steel mold; and then check the safety and quality of the template to ensure a solid, straight, flat, no fluctuation between the piles and the adjacent template height difference is greater than 3 mm, there are dislocation and uneven template to be re-installed, do not sink in the vibrating, no deformation, and no displacement; the final detection of mold after the template height, usually by the pull line method, every 5 m longitudinal detection of a place, each with a small steel ruler 3 o'clock horizontal measurement, once found a high height of the template should be timely on the base surface treatment, or adjust the steel mold until qualified.

2) To control the top of the grass-roots elevation and cross slope, according to the straight line every 20 m, the curve set every 10 m center pile, every 150 m or so set a temporary leveling point in order to check the review. At the same time should be polished to check the thickness of concrete pouring (line and the top of the base of the distance), the thickness of the location of the use of artificial or mechanical chisel part of the base to ensure that the thickness of concrete pavement, In the concrete pouring, supervision and quality inspection personnel should be in the field inspection and supervision.

3.2. Grass-roots control

Cement concrete pavement construction process to the quality of the grassroots level, in accordance with the norms of testing. To achieve grass-roots level, dense, stable, grass-roots elevation control in the design requirements. To avoid the uneven elevation of the thickness of the cement layer caused by the uneven thickness of the grass-roots level, resulting in the impact of traffic under the action of the thin part of the fracture, in the pouring of cement concrete before the work surface to reach the saturated water to prevent the grass-roots moisture cement concrete in the water, so that cement concrete plastic shrinkage.

(1) Grass-roots compaction

As the characteristics of mountain roads, in order to fully use the building materials, the current high-line cement concrete pavement base is basically used sand and gravel grass-roots structure. In the construction process, if the mixing mixture is not uniform, easy to produce coarse and fine particles segregation phenomenon, rolling equipment or rolling process improper, will inevitably affect the compaction effect of the grassroots. Therefore, the construction unit is required to adopt a centralized mixing method for spices, due to the conditions of the restrictions, paving is generally artificial paving, paving and integer mixture should be immediately in the full width of the compaction, should use of more than 12 t three-wheel rolling machine, thickness of each layer should not exceed 15–18 cm, and in the mixture of water content is equal to or greater than about 1% of the best water when the rolling immediately; straight and no high level curved section, from the edge of the rolling, in the set of ultra-high flat curve, from the inside out rolling, rolling are in accordance with the first light after heavy, the first slow and fast after the principle of a rolling pressure 6 to 8 times, so that no obvious surface of the track, the road should be on both sides of the pressure 2 to 3 times, until the provisions of the requirements of the degree of compaction so far.

(2) Base surface flatness

The flatness of the base layer directly affects the thickness of the surface layer, and it is also an important factor to prevent the fracture of concrete pavement. The surface of the grass-roots surface uneven, not only will make the friction between the panel and the base layer increases, and the friction below the panel to form a non-uniform sheet area, so that the uneven edge of the chip area and friction resistance concentrated area easy to form a broken plate; the other hand, when the grass-roots level is low, the pouring

of concrete panels on the thick side, and the depth of the slit is carried out according to the normal thickness of the concrete coagulation process in the role of tensile stress, it will produce irregular cracks in the relatively thin part of the panel. Therefore, to control the elevation of the grassroots level, so that the flatness of the grass is controlled within the allowable deviation range

3.3. Site construction

Cement concrete after mixing to the scene after the expected fall to be flattened vibrations, leveling mainly by self-arranged vibrator and three-axis pulp leveling machine to complete the row of vibrators mainly by a row of spacing 407, the power of 1.1 kW vibration rod (mechanical lift) formed by the mechanical automatic forward. As a result of automatic mechanical operation, thus avoiding the previous cement concrete construction leakage vibration, lack of vibration and other human factors, so that the vibrating effect is effectively improved and guaranteed. At the time of vibrating, the concrete cement surface is flat and slightly higher than that of the top of the template. As the width of the construction plate is generally 7.5 m or 8.5 m, the longitudinal rod must be set according to the design. In the row of vibrator truss on the corresponding longitudinal position of the installation of a rod installation machine, in the row of vibrator at the same time can be accurately embedded longitudinal rod.

After the vibration, is the three-axis leveling machine pulp leveling process. Three-axis leveling machine with the previous manual construction with vibration beam and artificial drag roller-type pulp and other equipment, which is mainly composed of three axes, the first axis for the vibration axis, from rolling, vibrating and pulp role, after the two axes are mainly rolling, leveling effect. It is a paving speed of 15–30 m per hour, the general one day can be spread around 200 m. The specific operation of the three-axis leveling machine should be back and forth rolling 3–4 times, during the artificial shovel pulp to fill the flat, and then three-axis leveling. From the use of the scene, the effect of pulp leveling is better. But only by the three-axis leveling machine leveling, cannot meet the requirements of the flatness requirements, it is only for the smooth process to create a better basic condition. Then use a large wiping board (usually wide body arc aluminum plate) repeatedly plaster surface to the cement concrete surface after no water, and then three meters and four meters scratch scale 2–3 times back and forth, after three meters straight ruler after the fine, immediately with artificial plastic plate grant surface, remove surface pores, floating sand, scratch marks, and as required to wipe out a certain degree of roughness, and large flat, to avoid sharp edges and ears. Finally, you can properly carry out the artificial pulp plaster, artificial wiping and 3 m ruler inspection, the per capita cannot step on the cement concrete surface, but should stand on the mobile work bridge operation, so as not to affect the flatness and appearance, after this treatment, the use of the instrument to detect flatness is generally about 1 mm, cement concrete pavement flatness pass rate of 90%–95% or more.

3.4. Construction impact prevention measures

1) The choice of lime-fly ash or poor concrete to do the cushion will ease the development of cement concrete pavement cracks. Lime-fly ash mixed with paving after a certain pore, water stability is good, a small amount of water can be absorbed when filled, the bottom of the plate and lime-fly ash interface does not save water, pulp disease will not happen. 20 cm thick lime-fly ash gravel cushion, even if the water poured into the bottom of the interface gap is small, the upper and lower stiffness are higher, even if there is a small amount of water and no pulp can be.

2) In order to prevent the edge of the board cracks, concrete plate longitudinal, horizontal free edge part of the reinforcement. Generally, use two $\phi 12$ – $\phi 16$ of the steel, arranged in the lower part of the board, run the bottom of the board is generally $1/4$, not less than 5 cm, spacing 10 cm in general, both ends of the steel

should bend down, layer should be not less than 5 cm.

3) In order to prevent the deformation of cement concrete slabs, road slits should be divided between 4 m × 5 m, to reduce the impact of temperature stress on the plate.

4) To prevent the corner angle fracture, the corner reinforcement, the choice of two diameter <12–<14 of the rebar layout in the upper part of the board, from the top of the board should not be less than 5 cm, from the edge of the board is generally 10 cm.

5) Road and bridge joints part of the roadbed, the use of water-permeable material backfill, according to the provisions of the thickness of each layer and to achieve the required degree of compaction. Back to the back of the building should be set up drainage pipes and geogrids. Drainage pipe spacing is not greater than 2 m, geogrid spacing of 50–80 cm.

3.5. Cement concrete pavement board strength control

Cement concrete strength assessment indicators are to use anti-bending strength to ensure that. Mainly should control the following aspects:

1) Aggregate (sand, stone) gradation and technical requirements: aggregate (sand, stone) should choose the amount of mud, organic matter content in the specification within the allowable range of materials, coarse aggregate size, such as larger concrete maximum particle size is not more than 31.5 mm, the diameter of the diameter should not be greater than 5%, the maximum size of the gravel cannot be greater than the maximum particle size of not more than 19 mm, the diameter of the path should not be greater than 10%, gravel or gravel particle size of less than 75 mm stone powder content should not be greater than 1%. Fine aggregate with continuous gradation, fine modulus of 2.5 to 3.2 in the partial coarse sand.

2) Cement quality: cement is a concrete cementing material; the performance of concrete depends largely on the quality of cement. Rural roads can be used Portland cement and ordinary Portland cement, the proposed large traffic volume of county and township roads using 42.5 cement, for the smaller traffic volume of village roads can be used 32.5 grade cement. Cement approach, each batch should be accompanied by a full range of chemical composition and physical and mechanical indicators of qualified quality inspection certificate. Cement grinding must be stable, and the cement storage period shall not exceed 3 months, different varieties, grades, strength level, the manufacturers of cement cannot be mixed and mixed use.

3) With the ratio: the ratio is to ensure the quality of the project key, only with the ratio to do a good job, the quality of the project will be guaranteed. According to the experience of construction of cement concrete pavement in rural areas in recent years, it is suggested that the coarse aggregate of concrete should refer to the recommended ratio of 28%–34%, the amount of cement is 305–350 kg/m³, the water-cement mass ratio is 0.4 to 0.55. The construction unit must be done according to the requirements of the mix design, and the distribution ratio in the mixing machine, so that all the construction workers are clear. If the raw material changes, you should adjust the mix ratio, cannot use a mix of uniform.

4. Maintenance and maintenance of four cement concrete pavement

1) On the cement concrete pavement material off the maintenance. First remove the shrinkage between the packing and other debris, with a wire brush to clean the wall, and then blower will be lit inside the lime, with diluted asphalt brushing wall, with a good joint material for filling, shrink seam or horizontal has been pulled out of the longitudinal seam, the gap is wide, in the lower part of the seam can be filled with 25–30 mm foam caulking. Most of the materials used for caulking are polyurethane or asphalt.

2) For the cement concrete pavement slab width of less than 3 mm non-spreadable cracks in the broken plate can be directly poured with adhesive solution, can repair with same method if there is sewing material dropped off. Expanded cracks can be temporarily filled with asphalt sand filler, to avoid the infiltration of rain and increase damage. When the cracks are no longer extended, the cracks are cut and the filling material is filled. In order to increase the bonding area between the joint and the slit, the temperature and the temperature of the diffusion and the fracture are cut into triangular sections. The depth and width are 1/6 of the thickness of the plate. The high elastic material is easy to fill sewing material, perfusion of the top surface of the joints should be slightly higher than the road and the width is greater than the width of the chisel mouth 2 cm.

3) Cement concrete pavement medium fracture, due to the wide cracks (usually 3–25 mm) accompanied by a slight peeling, the fracture should be on both sides of the crack to a width of not less than 20 cm lofting, chisel all seam edge damage concrete into a groove, chisel edge to be neat, standardized, depth to thickness of 2/3. The tank should be perpendicular to the center line, washed with water, the use of strength and the same level of the same level of concrete pouring, elevation and the same as the original road. Pouring at the same time, in the thickness of 1/3, placed 20 cm length, 10 mm diameter of 20 cm × 30 cm steel mesh, pouring concrete to join a certain proportion of admixture. The most thorough way is to chisel the groove to penetrate the thickness, that is, the whole depth of plate maintenance.

5. Analysis of cement concrete pavement problems

5.1. Analysis of the causes of broken plate and broken plate

(1) Longitudinal and transverse fracture of cement concrete pavement.

Longitudinal fracture refers to the cement concrete slab, parallel to the direction of the line through the thickness of the cracks; transverse fracture refers to the cement concrete plate perpendicular to the line through the thickness of the cracks. The causes of the two cracks are basically the same, there are differences, the technical performance of cement concrete, the ambient temperature, the role of the vehicle and the roadbed foundation, the pavement base strength is the main reason. Subgrade deformation is the main cause of longitudinal fracture, the uneven settlement of the roadbed, lack of strength or poor stability of the grassroots caused by vertical settlement, lateral slip, so that roadbed distortion.

(2) Cement concrete pavement surface fracture.

Surface fractures are commonly referred to as cracking. Cement concrete pavement surface irregular short and small cracks, crack depth does not run through to the bottom of the board, the cracks in the process of driving will continue to increase and even through the bottom of the board. The fracture of the surface is caused by the shrinkage and deformation of the cement concrete. The shrinkage of the concrete can cause the internal stress of the concrete, and the micro-cracks are generated inside the concrete, which can damage the microstructure of the concrete and reduce the durability of the concrete.

5.2. Mixing of cement concrete

Carefully control the water-cement ratio of concrete mix, the ratio of slurry and sand. If the water-cement ratio is inconsistent, paving will form a different water-cement ratio of the plate. In the combination of cross-site, due to solidification shrinkage and heat expansion rate of the formation of different cracks or broken plate. Cement slurry in the concrete, both filling the gap between the aggregate, and wrapped in the aggregate surface to reduce the friction between the aggregate, so that the concrete with mobility. Compared with the small content of aggregates, the content of aggregates will decrease, and the cohesion and water

retention of concrete will change, which will reduce the strength and durability of concrete. The change in the rate of the aggregate can lead to a change in the specific surface area of the aggregate void, which affects the workability of the cement concrete. So, in the construction of concrete control of the water-cement ratio, the ratio of slurry and sand in order to ensure the technical characteristics of cement concrete in order to achieve the reduction of cement concrete slab fracture.

6. Conclusions

From the construction practice point of view, to strengthen the raw materials and construction process of technical management control, refine the cement concrete design mix ratio, to improve the cracking performance of cement concrete are very effective. Coping with existing experience has been summed up and exchanged, developed, thereby improving our cement concrete construction technology level.

1) To improve the construction unit of the technical and management level, to strengthen the project quality management, the use of high-tech is to reduce the cement concrete pavement and other diseases important basis.

2) The reason why cement concrete pavement is broken is that the strength of cement concrete itself is low, and the selection of high standard raw materials and optimized concrete can effectively prevent the fracture of concrete pavement.

3) Strictly control the cement concrete pavement construction technology, reduce the temperature deformation and shrinkage deformation of the concrete plate adverse effects, in order to effectively reduce the cement concrete pavement disease.

Conflict of interest

The authors declare no conflict of interest.

References

1. JTG B01-2003. Highway Engineering Technology Standard. The ministry of transport of the people's republic of China.
2. JTG D40-2004. Code for Design of Highway Cement Concrete Pavement. The ministry of transport of the people's republic of China.
3. JTG D60-2004. General specification for design of highway bridge and culvert. The ministry of transport of the people's republic of China.