

Problems and Optimization Countermeasures of Stone Paving in Landscape Construction Engineering

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Abstract: In various landscape construction projects in Shenyang, granite stone paving is widely used in commercial plazas, municipal pedestrian paths, and residential landscape sites. With the advantages of neat appearance, heavy texture, and easy cleaning, it has become a common method to improve space quality and reflect site positioning. However, in the long-term use, affected by multiple factors such as construction technology, material selection, later maintenance, and regional climate, stone paving generally suffers from surface crushing, bottom void, foundation settlement, freeze-thaw damage and other problems, which not only affect pedestrian experience and the integrity of landscape, but also lead to high maintenance costs. This is inconsistent with the development requirements of high-quality, long-term, and low-cost operation and maintenance of landscape engineering. Combined with field cases such as Shenyang Tiexi Vientiane Hui, Evergrande Green Town, and municipal roads in Shenbei and Yuhong Districts, this paper compares the paving experience of the Historical and Cultural Block of Zhongshan Road in Quanzhou, sorts out typical problems of stone paving, analyzes the root causes, puts forward an optimization idea of using modified asphalt as the main material and decorating with stone at important nodes, and briefly describes the implementation path and effect combined with domestic practical cases, so as to provide practical reference for similar landscape construction projects in Shenyang.

Keywords: Landscape Construction; Stone Paving; Modified Asphalt; Construction Specification; Later Maintenance; Shenyang Engineering Cases; Practical Implementation

1. Introduction

In recent years, the urban renewal process in Shenyang has been accelerated. As an important

carrier to improve urban quality and living environment, the construction standard of landscape construction has been continuously improved. Because of its advantages of aesthetics, practicality and texture, stone paving is widely used in commercial plazas, municipal pedestrian paths, residential garden roads and other scenarios, becoming a key element to enhance the grade of the site. Commercial plazas create a high-end atmosphere through stone paving, municipal paths improve urban style with stone, and residential areas highlight the quality of the community through stone to meet residents' leisure and travel needs.

However, on-site visits and case comparisons show that most stone paving projects in Shenyang have the problem of "beautiful in the early stage but difficult to use in the later stage". After 1-5 years of use, different degrees of diseases appear, especially in high-frequency use areas such as commercial plazas and municipal paths. These problems destroy the integrity of the landscape, reduce traffic safety, lead to rising maintenance costs year by year, forming a vicious circle, which is in sharp contrast to the long-term stable effect achieved by standardized construction in the historical block of Zhongshan Road in Quanzhou.

Based on this, this paper takes the local stone paving problems in Shenyang as the starting point, sorts out the phenomena and digs deep the root causes combined with field cases, focuses on the optimization direction of "modified asphalt as the main body + local stone decoration", expounds the implementation details combined with domestic practical cases, strives to solve the pain points of easy damage and high maintenance cost of stone paving, and provides practical solutions for landscape paving projects in Shenyang and other cold northern regions.

2. Typical Problems of Local Stone Paving in Shenyang

In various landscape and municipal engineering

in Shenyang, the quality problems of stone paving are universal and different, covering the main application scenarios. Affected by use frequency, load, maintenance level and climate, the problems are different in different scenarios, but the overall common feature is "short-term beauty, long-term deterioration", which is in sharp contrast to the stability of Zhongshan Road paving in Quanzhou. The details are as follows:

In the commercial plaza scenario, stone damage is the most prominent and deteriorates rapidly, typified by the square in front of Shenyang Tiexi Vientiane Hui. In the early stage of completion, the square adopted 30–50mm thick light gray granite stone paving, which was flat and neatly textured, in line with the high-end commercial positioning. However, after five or six years of use, affected by pedestrian and non-motor vehicle rolling, rainwater and freeze-thaw, a large area of diseases appeared: stone cracking, corner missing, fragmentation, partial slab void, hollow sound when stepped on, and bumps when riding; the gap filler aged and fell off, resulting in water accumulation on rainy days and icing in winter, which had potential safety hazards and lowered the commercial image. The maintenance adopts local replacement, which is a temporary solution, leading to high maintenance costs and a vicious circle.

The paving problems in residential areas are greatly affected by operation and maintenance levels, and the problems are the most serious in unfinished and poorly maintained communities, typified by Shenyang Evergrande Green Town. In the early stage, the community adopted 30mm thick granite paving, which was clean and neat, improving the living quality. However, due to project stagnation and lack of property management in the later stage, the paving was out of control for a long time, with slabs loosening, voiding, breaking, and gravel scattering, affecting the appearance and traffic safety; dust and dirt accumulated on the stone surface, and road undulation was caused by foundation settlement in some areas. Even in normally operated communities, maintenance is often delayed due to cost control, and small problems expand into large-area damage.

The stone damage of pedestrian paths on municipal roads is more common, typified by many roads in Shenbei and Yuhong Districts. These paths generally adopt 30mm ultra-thin

granite. Affected by pedestrian trampling, rainwater and freeze-thaw, the stones loosen, warp, and have corner damage. Uneven settlement occurs in some road sections due to insufficient compaction of the base course, posing a tripping risk; the gaps are not densely filled, and rainwater infiltration aggravates damage. Municipal maintenance focuses on motor vehicle lanes, with insufficient inspection and maintenance of paths, and small damages accumulate into contiguous diseases, affecting urban style and traffic experience.

Compared with the Historical and Cultural Block of Zhongshan Road in Quanzhou, which adopts 100mm thick granite paving and maintains good stability and low maintenance cost after long-term use. The gap between the two places is not only reflected in stone thickness, but also highlights the shortcomings of Shenyang in material selection, construction control and later management, providing a reference direction for paving optimization.

3. Main Causes of Frequent Problems in Stone Paving

The large-area quality diseases such as damage, void, settlement and freeze-thaw damage of stone paving in Shenyang are not caused by a single factor, but the result of the superposition and interaction of multiple factors such as non-standard construction technology, unreasonable material selection, inadequate later maintenance and the influence of regional climate. Among them, extensive operation, simplified processes and illegal operations in the construction link are the core inducements of various problems, which directly determine the basic quality of paving engineering. The other factors further aggravate the development of diseases and shorten the service life of paving. The specific analysis is as follows:

First, extensive construction technology and common illegal operations lay hidden dangers for diseases. According to the relevant requirements of landscape engineering, manual excavation must be carried out within 300mm of the stone paving base to avoid mechanical disturbance of the undisturbed soil and ensure the compactness and bearing capacity of the soil foundation [1]. However, affected by construction period and cost pressure, most construction units are eager for quick success and conduct illegal operations, directly using excavators to excavate to the design elevation,

resulting in loose undisturbed soil structure and reduced compactness, laying hidden dangers for later settlement and void. Inadequate rolling and compaction of the base course is also prominent. In low-cost projects such as municipal paths and residential garden roads, manual simple compaction is often used instead of mechanical compaction, and the compactness fails to meet the specification requirements. Uneven settlement is easy to occur under long-term load, resulting in stone void and fragmentation [2]. In addition, there are defects in stone paving technology, such as insufficient mortar laying and dense gap filling. Rainwater and ice-snow melt water easily infiltrate into the slab bottom, softening the base course, damaging the structure, aggravating stone damage and loosening, forming a chain reaction [3].

Second, unreasonable material selection, mismatched with use requirements, shortens service life. Material quality determines the durability of paving. There are obvious shortcomings in material selection of local stone paving in Shenyang, mainly reflected in two aspects. On the one hand, the stone thickness is too thin: only 50mm for commercial plazas and road edges, and only 30mm for municipal paths and residential garden roads, with insufficient strength and stiffness to withstand long-term load and winter freeze-thaw damage [4]. The 100mm thick granite used on Zhongshan Road in Quanzhou has stronger bending and freeze-thaw resistance, greatly extending the service life. On the other hand, some construction units choose inferior stone with soft texture and poor frost resistance to control costs. Such stone has high porosity and obvious congenital defects. Under the freeze-thaw cycle environment in Shenyang, the internal water freezes and thaws repeatedly and expands, which is prone to peeling, chalking and cracking, further aggravating damage and shortening service life [5].

Third, the lack of later maintenance, with prominent emphasis on construction over maintenance, turns minor problems into major ones. Most construction and operation units only pay attention to early construction and appearance effect, ignoring later maintenance, forming a common misunderstanding. All kinds of stone paving lack a perfect regular inspection mechanism, no special maintenance team and process, and fail to deal with early diseases such as stone loosening, minor damage and aging of

joint filler in a timely manner. Small problems gradually expand into large-area damage, greatly increasing maintenance cost and difficulty [6]. Especially in unfinished buildings, the paving has zero maintenance for a long time, and the diseases develop rapidly, eventually losing service function and can only be renovated in a large area, resulting in waste of resources. In addition, deicing salt is frequently used in Shenyang in winter, which is highly corrosive. If the residue is not cleaned in time, it will cause spots, whitening and cracking on the stone surface, accelerate aging and damage, and further reduce service life [7].

Fourth, the special regional climate aggravates paving damage. Shenyang is a typical cold northern region with long and cold winters, the minimum temperature can reach below -20°C , and frequent freeze-thaw cycles, which puts forward higher requirements for the durability of stone paving and is also an important natural factor aggravating damage [8]. During freeze-thaw cycles, the water inside the stone freezes and thaws repeatedly and expands, producing internal stress, resulting in damage to the internal structure, cracking and peeling; after rainwater and ice-snow melt water infiltrate into the slab bottom and freeze, the volume expands, aggravating base course deformation and stone void, leading to stone loosening and fragmentation [9]. In addition, Shenyang has windy sand in spring and rainy in summer. Wind and sand erosion and rainwater soaking will wear and erode the stone surface, further reducing durability and aggravating damage.

4. Optimization Countermeasures and Implementation Path of Landscape Paving (Combined with Practical Cases)

In view of the problems and root causes of stone paving in Shenyang, combined with the advantages of modified asphalt, the experience of Zhongshan Road in Quanzhou and domestic practical cases, an optimization scheme of "modified asphalt as the main body and stone decoration at important nodes" is proposed, supported by standardized construction and strengthened maintenance, to realize the unity of aesthetics, practicality and economy. The specific paths are as follows:

First, comprehensively promote modified asphalt as the main paving material. By adding modifiers, modified asphalt has good flexibility, crack resistance and frost resistance, can adapt

to slight foundation settlement, avoid void and cracking, and has fast construction, simple maintenance and low cost, suitable for various landscape construction scenarios in Shenyang [10]. Select materials according to scenario needs: for main traffic areas such as commercial plazas and paths, choose dark gray, dark red and other colored modified asphalt, close to stone texture to improve landscape grade; for vehicle traffic areas, choose high-modulus modified asphalt to improve rutting resistance; for landscape paths in parks and residential areas, choose ordinary colored modified asphalt, balancing aesthetics and economy.

Domestic practical cases can provide reference: the original 50mm thick stone paving of Cihu Tiandi Commercial Plaza in Huangshi, Hubei was damaged in a large area after 3 years of use. In 2020, it was renovated with dark gray colored modified asphalt, the construction period was shortened by 2/3, no obvious damage occurred after 4 years of use, and the maintenance cost was reduced by more than 60%; the Central Square of Anting New Town in Shanghai adopted the mode of "colored modified asphalt + stone lines", dividing functional areas and decorating landscape nodes, balancing aesthetics and durability, becoming a local leisure hotspot. Shenyang projects can learn from their experience and replace stone with modified asphalt to solve core pain points.

Second, appropriately decorate with stone at important nodes to balance landscape quality. Do not completely abandon stone, decorate with high-quality stone in key areas to form visual focus and improve space grade. Specifically, pave 80–100mm thick high-quality granite at key positions such as commercial plaza entrances and around LOGO walls, adopting the "dry hanging + grouting" process to enhance stability; decorate with stone at intersections of municipal roads, bus stops and other areas to improve landscape and identification; pave stone at core landscape nodes of residential areas and parks to balance quality and aesthetics.

The practical case of "modified asphalt as the main body + local stone decoration" can be referred to: the commercial plaza around Huafa International Financial Center in Hengqin, Zhuhai takes dark gray colored modified asphalt as the main body, and decorates with 80mm thick sesame black granite at the entrance and LOGO area. The overall effect is good after 4

years of use, and the maintenance cost is only 1/3 of that of full stone paving; in the renovation of Hubushan Commercial Street in Xuzhou, SBS modified asphalt was used to replace the original damaged stone, and 100mm thick granite was paved on pedestrian paths and landscape nodes, retaining historical texture and solving damage problems. Shenyang Tiexi Vientiane Hui and Shenbei municipal paths can learn from this mode to realize the unity of aesthetics and durability.

Third, process optimization to improve the aesthetics of asphalt paving. In addition to stone decoration, a variety of processes can be used to make up for the visual shortcomings of asphalt paving: first, asphalt embossing and grooving process, pressing natural texture similar to stone and coloring, with visual effect close to natural stone, convenient construction and simple maintenance, suitable for multiple scenarios; second, colored asphalt divides functional areas, matched with stone lines to outline boundaries, improving visual hierarchy and safety; third, combined with landscape lighting and greening to weaken the monotony of asphalt. Shenyang projects can select appropriate processes according to scenarios.

Fourth, standardize construction processes and strengthen process control. Standardize base course treatment: manual cleaning within 300mm of the base, layered rolling and compaction, compactness not lower than specification requirements, sand and gravel replacement for weak soil foundation, improve drainage slope and set blind ditches; standardize paving technology: control temperature and thickness for modified asphalt paving and rolling, ensure full mortar and dense joints for stone paving; strengthen side supervision, train construction personnel, strictly accept, and do not enter the next process if unqualified, so as to control quality from the source [11].

Fifth, establish a regular maintenance mechanism to extend service life. Establish a regular inspection system, repair small problems such as asphalt cracks and stone loosening in a timely manner; do a good job in daily cleaning, give priority to environmentally friendly deicing salt in winter, and regularly apply protective agent to stone areas; establish maintenance files and formulate targeted maintenance plans to ensure standardized and sustainable maintenance [12].

Sixth, optimize frost and corrosion resistance

according to regional climate. Select frost-resistant materials such as SBS modified asphalt, and add frost and corrosion inhibitors to asphalt; select frost and corrosion resistant granite for stone and do a good job in protective treatment to meet the needs of cold climate and deicing salt use in Shenyang.

5. Conclusion

This paper takes the local landscape construction stone paving in Shenyang as the research object, sorts out typical problems such as surface damage and slab bottom void through multi-scenario field research, analyzes the core causes such as non-standard construction, unreasonable material selection, inadequate maintenance and climate impact, puts forward the optimization countermeasure of "modified asphalt as the main body + local stone decoration", and expounds the implementation path combined with domestic practical cases.

Practice shows that this mode can effectively solve the pain points of stone paving. Modified asphalt adapts to foundation settlement and is convenient for maintenance, local stone retains high-end texture. Combined with standardized construction and regular maintenance, it can improve paving durability, reduce life-cycle cost, and realize the unity of aesthetics, practicality and economy.

In the future, Shenyang landscape construction projects can further promote this mode, optimize materials and processes according to regional climate and scenario needs, strengthen construction and maintenance control, combine intelligent technology to achieve precise maintenance, promote the development of landscape construction engineering towards refinement, long-term and economic, and help improve urban landscape quality and living environment.

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