Construction technology and treatment effect of RoadMesh reinforcement in joint section between new and existing asphalt pavement

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Abstract. In order to verify the application effects of pavement reinforcement technology with RoadMesh steel wire mesh, and relied on the S415 Reconstruction and Extension Project from Xiapuzhen to Jietoutang in Tongshan County, Xianning City, Hubei Province, the application researches on construction technology and treatment effect of RoadMesh reinforcement were carried out for the joint section between new and existing asphalt pavement through scheme design, field construction, tests and analysis and economic comparison. The results show that the tensioning and fixing of RoadMesh are the key construction processes, and the anchoring and rolling of RoadMesh should be strictly prohibited during its construction. The asphalt pavement performances of RoadMesh reinforcement is better than that of unreinforcement, and the reinforcement effect between lower surface layer and base layer is better than that between base layer and subbase layer. The RoadMesh can effectively improve the integral bearing capacity of asphalt pavement structure and the resistances of reflection cracking and differential settlement in the joint section between new and existing pavement. Compared with the traditional reinforcement of geotechnical synthetic materials, the RoadMesh has higher performance price ratio and better long-term pavement performances. Therefore, the pavement reinforcement technology of RoadMesh can be widely popularized and applied.

1. Introduction
Due to the rapid development of road transport accompanied by the rapid socio-economic development, the large and loaded vehicles and the traffic volume have increased exponentially, which made it hard to meet the transportation demands for many early constructed highways. Under the combined effects of complex climatic and environmental factors, the distresses of pavement structure become more and more serious, so the reconstruction and extension projects are imperative. However, the problems of reflective cracking and uncoordinated deformation in the joint section between new and existing pavement have been one of the key technical problems in road engineering. According to many researches and applications, the reinforcement treatment technology is one of the most commonly used technologies to solve such problems [1-2]. Among them, the pavement reinforcement technology with RoadMesh steel wire mesh is a new type of pavement reinforcement technology that has been developed and applied to the highway reconstruction and extension projects in China over the past decade [3-4].

The RoadMesh steel wire mesh has a larger opening structure with unique hexagon braided steel mesh and penetrated transverse reinforced steel bar. The successful applications at home and abroad show that the unique three-dimensional occluding and wedging structure could be formed between the
RoadMesh and the mixtures of pavement structure layer. When the RoadMesh is laid between the structure layers of asphalt pavement, it can effectively enhance the capacities for cracking resistance, rutting resistance, fatiguing resistance and interlayer binding etc. in asphalt pavement structure. Its reinforcement performance is better than that of traditional geotechnical materials such as geotextile, geotechnical grid and glass fiber grid etc. Then the asphalt pavement performances can be significantly improved to extend the service life of asphalt pavement [5-7]. Therefore, China has gradually paid attention to the reinforcement technology since 2009, and achieved excellent application effect. Especially in recent years, the RoadMesh reinforcement technology has been applied more and more widely in the projects of directly repaving asphalt surface layer on the joint section between new and existing pavement and the existing cement concrete pavement [8-10].

Although the researches and applications of pavement reinforcement technology with the RoadMesh have been carried out at home and abroad, and some meaningful research results have been obtained, but it is still not deep enough and comprehensive enough. In order to further promote the popularization and application of this technology, and by relying on the S415 Reconstruction and Extension Project from Xiapuzhen to Jietoutang in Tongshan County, Xianning City, Hubei Province, the test road section of pavement reinforcement with the RoadMesh had been paved. The construction technology and the treatment effect for reinforcing the joint section between new and existing asphalt pavement were researched to hope providing a scientific reference for similar projects.

2. Design scheme of RoadMesh reinforcement in joint section between new and existing asphalt pavement

In order to determine the reasonable design scheme for pavement reinforcement with the RoadMesh and effectively control the longitudinal reflection cracking and the transverse uncoordinated deformation in the joint section between new and existing pavement, and relied on the S415 Reconstruction and Extension Project from Xiapuzhen to Jietoutang in Tongshan County, Xianning City, Hubei Province, the test road section with a total length of 300 m with the RoadMesh reinforcement was determined to pave in the joint section between new and existing pavement. The highway is a connection line of ordinary dart and an important channel connecting Tongshan County and Chongyang County. The technical standard of the existing highway is a third class highway with a roadbed width of 7 m, and it will be widened and reconstructed to a second class highway with a roadbed width of 10 m. It adopts the asphalt pavement structure. Among them, the newly repaving structure layers are “3 cm AC-13C upper surface layer + 5 cm AC-20C lower surface layer + 18 cm base layer with cement stabilized macadam”, and an additional 20 cm subbase layer with cement stabilized macadam is paved on the newly built roadbed in the widening parts to keep flush with the surface of existing pavement. The existing pavement structure layers are “5 cm AC surface layer + 20 cm base layer with cement stabilized macadam”.

Generally, because the total thicknesses of pavement structure layer on the RoadMesh reinforced layer must not be less than 6 cm, according to the fact that the upper surface layer is thinner (only 3 cm) and the field construction conditions, the reinforcement scheme between surface layers is not adopted. Meanwhile, due to the differential settlement in the embankment widening section is more obvious than that in the excavation widening section, the embankment widening section with a 3 m unilateral widening is selected as the test road section for reinforcement treatment. For this reason, two design schemes of pavement reinforcement with the RoadMesh are applied. One is to reinforce between the additional paving base layer with cement stabilized macadam and the subbase layer composed of the newly paved cement stabilized macadam and the existing asphalt pavement, i.e. reinforce between the base layer and the subbase layer (existing pavement) (Scheme 1: reinforcement between base layers), with the section of length 150 m. Another is to reinforce between the additional paving lower surface layer of AC-20C and the base layer with cement stabilized macadam, i.e. reinforce between the lower surface layer and the base layer (Scheme 2: reinforcement between base and surface layers), with the section of length 150 m. The pavement structure design drawings of the two reinforcement schemes are shown in figure 1. The specifications of RoadMesh are the length of...
25 m and width of 3.6 m each roll, and the mesh size is 8 cm × 12 cm, as shown in figure 2. Its transverse direction is horizontally paved across the joint section between new and existing pavement with the width of 1.8 m on both sides of the new and existing pavement. In order to drive construction machinery conveniently and prevent the RoadMesh from being rolled up, a bonding coat with cement paste and crushed stone is added between the base layers in the Scheme 1, and a seal coat with emulsified asphalt and crushed stone is added between the base and surface layers in the Scheme 2. So as to compare the reinforcement effect with the RoadMesh, one unreinforcement section of original design for each scheme is selected as the comparison section near the test road section. The stack numbers of each section are shown in table 1.

| Existing pavement | Widening |
|--------------------|----------|
| 3 cm AC-13C upper surface | Scheme 2 |
| 5 cm AC-20C lower surface | Scheme 1 |
| RoadMesh 18 cm cement stabilized macadam | |
| 5 cm existing AC surface | 20 cm cement stabilized macadam subbase layer |
| 20 cm existing cement stabilized macadam base | |

**Figure 1.** Design schemes of RoadMesh reinforcement in joint section between new and existing pavement

### 3. Construction technology of RoadMesh reinforcement in joint section between new and existing asphalt pavement

#### 3.1. Reinforcement construction process between base layers

The construction processes of RoadMesh reinforcement for the Scheme 1 between base layers are mainly divided into the three major steps: laying RoadMesh, spreading bonding coat of cement paste and crushed stone and paving base layer of cement stabilized macadam. According to the actual situation of the test road, the specific construction techniques include the following five steps.

**Figure 2.** RoadMesh structure (the size unit: mm)
Table 1. Test section of RoadMesh reinforcement in joint section between new and existing asphalt pavement

| No. | Origin and final stack number | Length (m) | Types of reinforced materials | Reinforced location |
|-----|-------------------------------|------------|-------------------------------|---------------------|
| 1   | K3+250~K3+400 (right range)  | 150        | RoadMesh                      | Scheme 1: between base layers |
| 2   | K2+980~K3+180 (right range)  | 200        | Unreinforced                  | Comparison section 1 |
| 3   | K2+725~K2+875 (left range)   | 150        | RoadMesh                      | Scheme 2: between base and surface layers |
| 4   | K2+320~K2+550 (left range)   | 430        | Unreinforced                  | Comparison section 2 |

1. Clean the underlayer. The distresses of existing asphalt pavement should be checked out. The structural diseases such as ravelling, pit slot etc. are dug and repaired in accordance with the technical requirements of maintenance. The newly paved subbase layer with cement stabilized macadam is cured at least 7 days. It should be ensured that the underlayer surface is smooth, dense without potholes, and the loose aggregates on the surface are cleaned up. Meanwhile, it should be ensured that the surface is flush and tidy between the existing asphalt pavement and the newly paved subbase layer with cement stabilized macadam.

2. Lay the RoadMesh. The artificial method is used to lay the RoadMesh along the longitudinal direction of the route, and it should be ensured that the longitudinal joints in the joint section between new and existing asphalt pavement is located in the middle of the RoadMesh. Since the finished product of RoadMesh is in the form of a roll, the RoadMesh surface will be some bending. When laying, the curved surface should be installed downwards so that the RoadMesh surface is close to the underlayer surface. After laying, the entire RoadMesh surface should be rolled and levelled twice round trip with the small medium-sized rubber roller, loader or truck at a uniform speed of 10 km/h, then manually adjusted.

3. Tension and fix the RoadMesh. Firstly, the beginning of RoadMesh about a length of 4 m is fixed with the high-density clamp nails consisting of steel nails and clips. The another end is tensioned by fixing on a tension rod and connecting to the small medium-sized vehicle, and also it is fixed with the high-density clamp nails. Lastly, the middle of RoadMesh is fixed with the clamp nails to eliminate the slack and fold of RoadMesh. Among them, the length of steel nail used for the asphalt surface layer and the semi-rigid base layer should be 6 cm and 10 cm respectively, and the density of clamp nail should be at least 1 per square meter. Then, the next roll of RoadMesh is laid, and the length of longitudinal lap joint is not less than 30 cm. Accordingly, the fixed RoadMesh is shown in Figure 3.

![Figure 3. Fixed RoadMesh](image)

4. Spread the bonding coat of cement paste and crushed stone. In order to improve the interlayer bonding capacity and prevent the construction machinery from pushing the RoadMesh, the bonding...
coat of cement paste and crushed stone of “cement paste + 5~10 mm crushed stone” is spread on the fixed RoadMesh. So as to facilitate construction, the cement paste coat is taken the spreading method of “firstly sprinkling water, secondly sprinkling ash, and lastly sprinkling water” in site. Among them, the sprinkling amount of cement and crushed stone should be 0.5~1 kg/m² and 7~9 kg/m² respectively.

5. Pave the base layer of cement stabilized macadam. The base layer of cement stabilized macadam is paved and rolled in accordance with the technical requirements of “Technical Guidelines for Construction of Highway Roadbases” (JTG/T F20-2015). In order to avoid the larger disturbance to the reinforced layer and the bonding coat during the construction process, the driving speed of dumper and paver should be strictly controlled to not exceed 10 km/h, and the rolling speed of roller should not exceed 5 km/h.

3.2. Reinforcement construction process between base and surface layers

The construction processes of RoadMesh reinforcement for the Scheme 2 between base and surface layers are mainly divided into the three major steps: laying RoadMesh, spreading prime coat of emulsified asphalt and seal coat of crushed stone and paving asphalt lower layer. Among them, the technical requirements of construction process for cleaning the underlayer and laying, tensioning and fixing the RoadMesh are basically the same with the above mentioned reinforced section between base layers. The other two construction processes are as follows:

1. Spread the prime coat of emulsified asphalt and the seal coat of crushed stone. The prime coat and seal coat of “emulsified asphalt + 5~10 mm crushed stone” are spread on the fixed RoadMesh, where the spraying amount of emulsified asphalt is 1~1.5 L/m² for covering the entire RoadMesh surface. The travelling speed of asphalt sprayer is strictly controlled within the range of 4~6 km/h to prevent the RoadMesh from being pushed or rolled up. The crushed stone is manually spread with the spreading amount of 7~9 kg/m², and it is evenly distributed and blackened while spreading. It should be ensured that the crushed stone is evenly embedded into the RoadMesh meshes. The finished prime coat and seal coat are shown in Figure 4.

2.

![Figure 4. Finished prime coat and seal coat](image)

3. Pave the asphalt lower layer. The lower layer of AC-20C is paved and rolled in accordance with the technical requirements of “Technical Specifications for Construction of Highway Asphalt Pavements” (JTG F40-2004). The paving speed of paver shall be less than 3 m/min to prevent disturbing severely the RoadMesh. The rolling speed of roller should be under 2~3 km/h slowly and evenly. When semi-range constructing, it should be noted the roller to avoid rolling the exposed RoadMesh near the central line of road. The following precautions should be noted during the construction of RoadMesh.
1. Strictly control the tensioning and fixing of RoadMesh. Tensioning and fixing are the important steps for reinforcing asphalt pavement with the RoadMesh. The tensioning quality and the fixing effect of the RoadMesh should be strictly guaranteed. If the tensioning and the fixing are poor, the RoadMesh reinforcement effect will be seriously influenced.

2. Strictly prohibit the arching and rolling up of RoadMesh. The RoadMesh arching would cause the upper layers on the reinforced layer, especially the asphalt surface layers, to be difficult to compact, additionally the thicknesses would become thinner. The rolling up can lead to the damage of RoadMesh. As a result, it is easy to cause early distresses such as rutting, swelling and loosening for the pavement at the places of arching and rolling up, and affect the integral reinforcement performance of RoadMesh.

Accordingly, for the purpose of improving the construction quality of RoadMesh reinforcement, the following preventive measures should be taken.

1. The number of clamp nails should be increased at the both ends, edges and laps of RoadMesh, the bends and the up and down slopes.

2. The seal coat or bonding coat of crushed stone should be added on the reinforced layer of RoadMesh to protect the RoadMesh from being directly damaged by the construction machinery.

3. After fixing the RoadMesh, the construction machinery should be strictly forbidden to accelerate, emergency brake, turn and U-turn to prevent damage to the RoadMesh.

4. The crawler paver should be strictly prohibited for paving the upper structure layers to prevent the track shoe from damaging the RoadMesh because of hooking up.

5. The paver paving speed and the roller rolling speed should be strictly controlled during the construction of upper structure layers to prevent the moving and arching of RoadMesh.

4. Treatment Effect of RoadMesh reinforcement in joint section between new and existing asphalt pavement

In order to evaluate the treatment effect of RoadMesh reinforcement in joint section between new and existing asphalt pavement, the field detection, core drilling observation, tracking observation and economic comparison were carried out on the reinforced test section and the comparison road section after completion.

a. Field detection

The test results of pavement performance such as deflection, smoothness, pendulum value and water permeability coefficient in each section are shown in table 2. For convenience of comparison, the two comparison road sections were merged to analyze.

| Road section | Representative deflection (0.01mm) | Maximum clearance (mm) | Pendulum value (BPN) | Water permeability coefficient (mL min⁻¹) |
|--------------|----------------------------------|-----------------------|---------------------|-----------------------------------------|
| Scheme 1     | 32.4                             | 1.7                   | 64                  | 512                                      |
| Scheme 2     | 17.4                             | 1.9                   | 64                  | 1381                                     |
| Comparison section | 40.1                  | 1.7                   | 63                  | 1872                                     |
| Technical requirements | ≤ 41.6               | ≤ 5                   | /                   | /                                       |

As can be seen from Table 2:

1. All the representative deflections in each section meet the design requirements of strength, and the representative deflection of Scheme 2 is the smallest, which is 46.3% and 56.6% lower than that of Scheme 1 and the comparison section respectively. The representative deflections in both reinforced sections are smaller than that of the unreinforced comparison section. The results show that the joint section between new and existing pavement reinforced by the RoadMesh can obviously improve the integral bearing capacity and uniformity of asphalt pavement structure, and the reinforced effect between base and surface layers is better than that between base layers.
2. All the maximum clearances with the three-meter ruler in each section meet the design requirements of smoothness. Among them, Scheme 1 has the same test results as the comparison section, while the maximum clearance of Scheme 2 is increased by 11.8%. It indicates that the RoadMesh reinforcement between base layers has almost no influence on the pavement surface smoothness. The reinforcement between base and surface layers has a certain adverse effect on the pavement surface smoothness, but the driving comfort and safety would not be affected.

3. Although the pendulum value of RoadMesh reinforced section is slightly increased, it is basically consistent with the pendulum value of the comparison section, which indicates that the RoadMesh reinforcement will not affect the surface skid resistance of asphalt pavement.

4. Although the second class highway has no specific requirements for the impermeability of pavement surface, the test results of water permeability coefficient in each section are larger and obviously more than 300 mL/min. From the field detection situation, the main reason for the larger water permeability coefficient is the larger air voids of AC-13C in the upper surface layer to cause the reverse seepage phenomenon, but it is not directly related to the RoadMesh reinforcement. In general, the joint section of new and existing asphalt pavement reinforced by the RoadMesh can obviously improve the bearing capacity of asphalt pavement structure, and has no obvious adverse effect on the pavement surface performances such as smoothness, skid resistance and impermeability.

b. Core drilling observation

For analyzing the interlayer reinforcement distribution of the RoadMesh, two core samples were drilled for each road section. Due to the height limitation of drill bit, the complete core sample reinforced between base layers could not be drilled. Wherein, the core samples in the comparison section were disconnected between the lower surface layer and the base layer, but the core samples in Scheme 2 show that there are completely bonded between the surface layer and the base layer, as shown in figure 5.

![Core drilling samples](image)

Figure 5. Core drilling samples

The cross-sections of transverse reinforced steel bar and ordinary steel wire in the RoadMesh and the aggregate particles embedded in the RoadMesh can be clearly observed from figure 5. It shows that there are no gaps between the asphalt mixture and the RoadMesh, and the contacts are tight and evenly full. The results indicate that the RoadMesh hoops the asphalt mixture into its meshes in a three-dimensional way, and the asphalt mixture is evenly and compactly embedded in the RoadMesh meshes to form a whole structure which can effectively resist the reflective cracking and the differential settlement. Thus its excellent reinforcement effect is verified.

c. Tracking observation

To further verify the long-term pavement performances reinforced by the RoadMesh in joint section between new and existing asphalt pavement, the test road section has been tracked and observed in site after completion and opening to traffic for one year. The results are shown in figure 6 and figure 7.
It can be seen from figure 6 and figure 7 that after the comprehensive effect of vehicle loads and environmental factors for more than one year, the common distresses such as cracking and rutting etc. in the widening projects have been not found on the asphalt pavement of reinforced test section with the RoadMesh, but there are multiple longitudinal and transverse cracks and more obvious ruts on the unreinforced section. It shows that the unreinforced asphalt pavement is difficult to resist the stress concentration and the surface layer displacement caused by uncoordinated deformation, while the joint section between new and existing asphalt pavement reinforced by the RoadMesh can effectively disperse the stress concentration in the structure layers of asphalt pavement and improve the flexural tensile strength and intergral performance for the structure. The generation and development of typical longitudinal and transverse cracks for the asphalt pavement structure can be effectively delayed, prevented and treated in the widening projects. Therefore, the pavement reinforcement technology with RoadMesh has an excellent long-term performance for resisting the reflective cracking and differential settlement.

**Figure 6. Reinforced test section**

**Figure 7. Unreinforced comparison section**

d. Economic comparison

By calculation, for the reinforcement treatment in joint section between new and existing asphalt pavement, the unit cost of RoadMesh is about 5~15 RMB/m$^2$ higher than that of the traditional geosynthetic materials such as geotextile, geogrid and glass fiber grid etc. According to the calculation of laying reinforcement material of 3600 m$^2$ per kilometer in an unilateral widening project, the cost per kilometer has only increased by about 18~54 thousands RMB. However, the RoadMesh has excellent effect of pavement reinforcement which can effectively improve the long-term pavement performances and service ability of asphalt pavement structure, extend the service life and reduce the maintenance and repair costs. From the perspective of the total life cycle, the RoadMesh has higher performance price ratio to be worth popularizing and applying.

5. Conclusions

According to the actual conditions of test section in the entititative project, the two design schemes were proposed for reinforcing the joint section between new and existing asphalt pavement with the RoadMesh, including the reinforcement between base layer and subbase layer, and between lower surface layer and base layer. The field construction and detection were carried out. Thus the following conclusions can be obtained.

1. The construction processes of pavement reinforcement with the RoadMesh can be mainly divided into the three major steps: laying RoadMesh, spreading bonding coat or seal coat and paving upper structure layers. Among them, the tensioning and the fixing of RoadMesh are the key processes. During the process of construction, the RoadMesh should be strictly prohibited from arching and rolling up, and the paving and rolling speed of upper structure layers should be strictly controlled.
2. The treatment technology of RoadMesh reinforcement can effectively improve the integral bearing capacity of asphalt pavement structure and the abilities of reflective cracking resistance and differential settlement resistance in the joint section between new and existing pavement, but there is almost no effect on the performances of pavement surface such as smoothness, skid resistance and impermeability etc. The reinforcement effect between lower surface layer and base layer is better than that between base layer and subbase layer.

3. The long-term pavement performances of asphalt pavement with the RoadMesh reinforcement is better than that without reinforcement. Compared to the reinforcement with other traditional geosynthetic materials, although its cost is slightly higher, its comprehensive performance price ratio is superior. Therefore, the RoadMesh has broad promotion and application prospects.

Acknowledgments
This work was supported by National Natural Science Fundation of China (No. 51878077).

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