The Study of Performance in the Cement Stabilized Crushed Rock without Compression

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ABSTRACT: The need of cement stabilized crushed rock was introduced in the situation that the road roller can’t vibrate in the rural areas through the construction of main road improvement. The gradation of cement stabilized crushed rock was proposed in the reference of all kinds of theoretical and empirical gradations. The optimization of some kinds of water-reducing additives was conducted by the way of normal consistency. Some experiments were conducted to determine how much the water-reducing additive can do in the compaction of cement stabilized crushed rock. At last, exam section was conducted to exam the results in the lab.

Keywords: cement stabilized crushed rock without compression

1. INTRODUCTION

"The Twelfth Five-Year" is the hard time to accelerate the change of economic growth mode in Yunnan Province, is the golden developing period of speeding up construction of "The Tightly around the building a powerful province of green economy strong province, national culture and open to the southwest bridgehead in China", is the critical period of building a well-off society in an all-round way. According to the requirement, Yunnan province transportation hall asked all industry-wide to hasten the province arterial road reconstruction process. Focus on subsequent of grade 2 highways construction project, and strive to start new secondary roads 3000 kilometers. By the end of the 12th five-year, should have strived for the province's highway mileage of 223000 kilometers, the expressways would have reached 16000 kilometers, high-grade highways have accounted for more than 45% of the national and provincial trunk roads. Expect all counties would have been connected by expressways, have built effective high-grade trunk road network covering the entire province.

In the province main transformation process, has a prominent difficulties: too many rural roads across the living area. For decades, local residents living or trading near roads, gradually develop some villages and towns. In the province arterial reconstruction process, a village road roller can’t vibration compaction will happen, in order to prevent damages to the nearby houses. But, the Cement stabilized crushed stone base are especially prone to structural damage because of the vehicles rolling and compaction, and due to can’t normal curing strength at the grass-roots level will be affected.

To solve the above problems, this paper has proposed an effective attempt. Make sure that degree of compaction and the strength of water stable macadam pavement base by non-vibrated compacting.
2. GRADED OPTIMIZATION

The theoretical basis of the optimum gradation is the CAG Weymouth's Theory of Particle Interference, that consider to achieve maximum density, filling of particles between void by secondary particles, remaining voids by more secondary particles filled, but interstitial particle grain size shall not be greater than the gap distance, otherwise between particle size is bound to happen interference phenomenon, lays the foundation for the grading principle.

The principle of graded particle number assigned specific levels, scholar at home and abroad have carried out extensive and a lot of research, put forward many experience tables and calculation method, mainly included Continuous grading, Discontinuous gradation and Breakdown gradation.

Continuous gradation means that gradation curve of composition mixture is sleek. There is a certain weight ratio between adjacent sieve size. This grading is not easy to segregation. Excluded one or several hierarchical graded in Continuous gradation to form a discontinuous graded called gap-graded.

Gap grading was presented on the stage filling theory and particle interfering theory as basis, fraction of fine aggregate in the graded will maintain its cohesion, which based upon the continuous gradation theory. Learned from the filling theory, the voids of coarse aggregate with smaller particle size without secondary aggregate filling will get greater compactness. In theory, the discontinuous gradation is the advantage of the principle of wedging and the principle of grading. Thus, the mixture of coarse aggregate and fine aggregate is discontinuous, which will have the best function including friction resistance, cohesiveness, and compactness.

The gradation of conventional cement stabilized macadam is continuous gradation. On the one hand, continuous grading in line with the general understanding of the grading, more easily accepted; On the other hand, we can use various sizes particle of Stone material factory production, to avoid the waste. Continuous gradation is generally composed of four sizes aggregate, if the aggregate of quarry production remove one or two grade, which will became the gap grading. The first size of aggregate is large material, easy segregation in discontinuous gradation, so it will be removed out. The third graded aggregate is often called interference particles, in the continuous gradation mixture should be less as far as possible, so that can be directly removed in discontinuous gradation. So the remaining sizes of aggregate are the secondary and the fourth sizes in gap-grading. On the following paper, we will discuss the different compaction energy between continuous gradation and discontinuous gradation.

3. OPTIMAL WATER REDUCING AGENT

3.1 The influence of water reducing agent on cement

By the test study on the cement adding water reducing agent, the properties of the material is shown, and the optimum mix amount is on the focus. Material chooses early strength Composite Portland Cement (P.C. 32.5). The test results are listed in table 1.
Table 1. The results of testing cement.

| Types                      | Water-reducer dosage (%) | Cement standard consistency water (g) | Initial setting time (min) | Final setting time (min) |
|----------------------------|--------------------------|--------------------------------------|---------------------------|-------------------------|
| Retarding water reducer    | 0                        | 133.0                                | 233                       | 368                     |
|                            | 0.4                      | 115.0                                | 380                       | 536                     |
|                            | 0.6                      | 106.0                                | 590                       | 832                     |
|                            | 0.8                      | 101.0                                | 653                       | 928                     |
|                            | 1.0                      | 100.2                                | 1348                      | 1476                    |
|                            | 1.2                      | 99.8                                 | 1507                      | 1693                    |
|                            | 1.4                      | 98.9                                 | 1608                      | 1803                    |
| Super-plasticizer          | 0                        | 133.0                                | 233                       | 368                     |
|                            | 0.4                      | 118.5                                | 352                       | 413                     |
|                            | 0.6                      | 107.1                                | 375                       | 439                     |
|                            | 0.8                      | 104.0                                | 385                       | 503                     |
|                            | 1.0                      | 97.5                                 | 400                       | 528                     |
|                            | 1.2                      | 95.8                                 | 435                       | 563                     |
|                            | 1.4                      | 92.3                                 | 447                       | 581                     |

As the results show, the influence of the two water reducer on the initial setting time and the final setting time were big, extended remarkably. With high water-reducer dosage, the water quantity needed for standard consistence decreased, initial and final setting time increased. The initial-set time is the main basis of determining layer intermission time. The length of initial-set time affects the construction techniques and quality control measures. It is assumed that Super-plasticizer is perceived to provide a better quality material than that from Retarding water reducer. Because of construction opportunities, optimal the Retarding water reducer mixed is roughly 0.4% of cement by weight. There does not existing an optimum amount of Super-plasticizer, still need to research it. A subsequent study will be centered on the influence of Super-plasticizer agent on compaction work.

3.2 The influence of water reducing agent on compaction work

Effect of the different gradation types and dosage of Super-plasticizer and compaction energy on the maximum dry density of mixture was studied through test in the lab. We will adopt the method of testing maximum dry density through heavy compaction devices. Striking times of test is 50 times. The mixing content of Super-plasticizer is 0, 1.5%, 3.0%, 5.0% and 7.0% (cement by weight). The mixes with the different gradation types but same maximum normal size, discontinuous grading which aggregate composition is 60/40 (coarse/fine aggregate) has the maximum dry density. The results are shown below in Figure1.
Following information can be derived from the paper shown above in Figure 1: (1) Gap-grading mixtures have bigger Maximum dry density than continuous gradation, when the same maximum normal size and same aggregates. (2) Water reducer agent was helpful to extend Maximum dry density in all test mixtures. (3) It would be the best choice for the Maximum dry density, when the gap-grading aggregate composition is 60/40 (coarse/fine aggregate) and addition of water reducer agent is 5% (cement by weight).

Also, as the Figure 1 show, when Gap-grading mixtures which aggregate radio is 50/50 (coarse/fine aggregate), Maximum dry density decreases as the Super-plasticizer quality ratio increases until the dosage reached 5%. This is due to the voids in coarse aggregate was not sufficient for the fine aggregate, according to the filling theory.

4. COMPACTION EFFORT OPTIMIZATION

This paper probes into the influence of compaction effort on gradation based on the following test. (1) Addition of water reducer agent is 5% (cement by weight); (2) Striking times is 98 times, 50 times and 30 times; (3) Grading types is Continuous gradation, Gap-grading which aggregate composition is 60/40(coarse/fine aggregate), which aggregate composition is 50/50 (coarse/fine aggregate). More details is as follows table 2.
In general, the Maximum dry density will be improved with more Striking times. With the striking times increasing, maximum dry density of Continuous gradation mixtures is improved. The results showed that the Maximum dry density of Gap-grading (60/40) and Gap-grading (50/50) mixtures increases in the beginning and then decreases slightly as striking times increase. Studying its reason, different particle size of aggregate, according to the size distribution of the continuous or discontinuous gradation of gradation composition, can achieve high compactness. The impact load was applied on material to press mixtures, which shear stress induced in Compaction test. Coarse and fine aggregates filling each other make the mixtures denser, form dense framework structure. The larger the aggregate size, the specific surface area will decreases. Since there are limits on the maximum amount of surface area that will limit void of aggregates, maximizing the surface area will increase the maximum dry density.

The maximum dry density of cement stabilized macadam is affected by both the beat numbers and the grading styles. When the striking time amounts to 50 and Gap-grading aggregate ratio is 60/40, the highest maximum dry density is obtained.

5. CONSTRUCTED TRIAL PAVEMENT SECTIONS

Construct the Experiment road section belong the national and provincial trunk roads in Yunnan Province. The gradation of free-vibration water stable layer test road showed as following Table 3. Selection scheme is: (1) Continuous gradation, a paving layer, a layer of RCC, vibration compaction; (2) the Continuous gradation, two layers of paving, two layers of roller compaction and static compaction; (3) Gap grading, two layers of paving, two layers of roller compaction and static compaction.

Table 2. The results of compaction effort.

| Striking times | Continuous gradation | Gap-grading(60/40) | Gap-grading(50/50) |
|----------------|----------------------|-------------------|-------------------|
|                | Maximum dry density (g/cm³) |                  |                  |
| 98             | 2.354                | 2.317             | 2.298             |
| 50             | 2.317                | 3.370             | 2.314             |
| 30             | 2.140                | 2.225             | 2.271             |

Both Continuous Gradation and Gap Gradation, the dosage of cement is 4.5%, the water content is 4.2%, when operate on the site. Reduction agent by artificial added to

Table 3. The gradation of free-vibration water stable layer test road.

| Type of Gradation | Through the following mesh (square hole sieve, mm) quality percentage (%) |
|-------------------|--------------------------------------------------------------------------|
|                   | 31.5 | 19  | 9.5 | 4.75 | 2.36 | 0.6  | 0.075 |
| Continuous gradation | 100  | 80.3| 54.6| 35.7 | 25.8 | 13.6 | 3.5  |
| Gap grading       | 100  | 97.1| 61.3| 52.9 | 35.0 | 18.4 | 7.8  |

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the water tank, then sent to the mixing pot of the Cement stabilized macadam mixer machine by pump, the dosage for 0.5% of cement content.

Construction technology for plan (1): a layer of paving, 22 t Single drum wheel roller static pressures 1 times, 36 t single drum roller vibrates and compacts 4 times, 22t single drum roller vibrates and press 2 times, 22 t single drum roller static pressures 1 times.

Plan (2) Construction technology as follows: the first layer paving, 36 t single drum roller static pressures 7 times, sprinkle water then spray cement paste; the second floor paving, 36 t single drum roller static pressures 7 times.

The Construction process of plan (3) is consistent with plan (2).

All test results about the Experimental road listed in following Table 4 and Figure 3 to Figure 5.

| Program | Number of compaction | Maximum dry density (g/cm³) | Optimum moisture content (%) | Field compactness (%) |
|---------|-----------------------|----------------------------|-----------------------------|----------------------|
| Plan 1  | 98                    | 2.402                      | 3.6                         | 101                  |
| Plan 2  | 50                    | 2.333                      | 4.4                         | 102                  |
| Plan 3  | 50                    | 2.336                      | 4.4                         | 102                  |

Figure 3. The concrete core of Plan (1).

Figure 4. The concrete core of Plan (2).
Figure 5. The concrete core of Plan (3).

All the concrete core samples show: The Plan (3) degree of core sample density is the best. Both Plan (2) and Plan (3) have complete core samples by drilling, compare with Plan (1) core, the strength degradation of cement stabilized macadam layer is less. The compactness of Plan (3) core is lower than Plan (2), the reason was that the gap gradation of Plan (3) was consist of coarse material (2#,3#) and fine aggregate (4#), didn’t achieve the ideal state of discontinuous gradation. Because of low dose of admixture, the compaction energy could not be reduced.

6. CONCLUSIONS
By the above part of the analysis and discussion, make a comprehensive description.
(1) The cement stabilized crushed rock without compression will be a good choice when construct the province trunk through the villages and towns.
(2) Gap-grading of cement stabilized macadam consumes less compaction energy than continuous gradation.
(3) Water-reducing agent takes a good effect on free-vibration compaction when the dosage for 0.5% of cement content.

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