Development of Concrete Admixtures and Their Application in Road Bridges

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Abstract. Concrete admixtures, which is in order to distinguish mineral admixtures such as fly ash. In cement concrete, the technical and economic benefits of admixtures can be maximized. This technology has attracted attention at home and abroad and is now an indispensable part of concrete. The admixture can reduce the use of cement concrete in engineering, make concrete have more practical functions, and maintain good quality under various concrete engineering construction procedures to meet the individual needs of concrete during construction. Reduce the use of cement and reduce construction costs. This thesis is to study the types, properties, advantages and disadvantages of concrete admixtures, and applies the professional knowledge to studying the application of various concrete admixtures in road and bridge engineering to solve various concrete admixtures in real life. Some of the problems have made various concrete admixtures more widely used in road and bridge engineering.

1. Introduction to concrete admixture
Concrete admixtures (often referred to as admixtures), also known as chemical admixtures, play an important role in concrete. In road and bridge engineering, the technical and economic effects of using admixtures are obvious and have received extensive attention from relevant people in various countries. In recent decades, the types of admixtures have become more and more effective, and the effects have become more and more obvious. It has become the most important component in the concrete, including water, cement, fine sand and stone.

2. Name and type of concrete admixture
The concrete admixture is a substance which is added at the same time or in advance as the concrete is mixed, and the basic amount is within 5\% of the mass of the cement, which can enhance the use efficiency of the concrete. At present, a total of named air-entraining water reducing agent, quick-setting agent, retarder, air-entraining agent, high-efficiency water reducing agent, retarding water reducing agent, early strength agent, air entraining agent, ordinary water reducing agent, expansion agent, waterproof Agent, antifreeze, rust inhibitor, pumping agent, early strength water reducing agent, coloring agent 16 kinds of admixture.

Concrete admixtures are divided into two categories, as shown in Table 1.

| Classification basis | Admixture type |
|----------------------|----------------|
| Classified by admixture function | Improve the rheological properties of concrete: water retention agent, water reducer and pumping agent, etc. |
| | Improve concrete durability: water repellents and mineral admixtures, etc. |

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Adjust the gas content in concrete: foaming agent, air entraining agent, defoaming agent and air entraining agent, etc.

Adjust concrete setting time or hardening speed: quick setting agent, early strength agent and retarder

Special properties for concrete: colorants, waterproof and antifreeze admixtures and bulking agents

Inorganic compounds: early strength agents CaCl2 and Na2SO4

Organic compound admixtures: surfactants and organic compounds

Inorganic composite admixture

3. Selection of admixtures in concrete engineering - taking water reducing agent as an example

The water reducing agent refers to an admixture for reducing the mixing water of the concrete under the premise that the workability of the concrete is not affected. The main performance is to increase the durability and strength of the concrete.

The main functions of the water reducing agent: (1) By adding the water reducing agent, the water-cement ratio is reduced, the workability of the concrete is unchanged, but the strength of each age is increased. (2) the concrete composition is not Under variable conditions, the strength of the concrete is unchanged, but the workability is improved. (3) Under the condition of maintaining the workability and strength properties, the water reducing agent is added to reduce Cement usage and water consumption.

Water reducing agent is suitable for reinforced concrete, prestressed concrete, hydraulic concrete, mass concrete, pumped concrete and cast-in-place concrete.

3.1. Selection of concrete admixture

Admixtures are selected according to the actual engineering requirements for concrete functions, such as concrete cohesiveness, strength, impermeability, fluidity, and seasonal changes in construction, construction techniques and specifications, and engineering requirements. Materials such as the type and quality of cement, fine aggregates and coarse aggregates. It is necessary to select concrete admixtures that are compatible with the construction of this project.

The choice of admixture should be consistent with the performance requirements of engineering use, and the admixture should be used reasonably to better play the role of admixture. For example, the different water-reducing effects of different water-reducing agents on the concrete: as can be seen from Table 2, when the workability and the dosage are constant, the second type of water-reducing agent, the second type of water-reducing effect Preferably, the fourth type has the worst water reduction.

Table 2. Water-reducing rate of different types of common water reducers when workability and dosage are constant

| Serial number | Ordinary water reducer | Slump/mm | Water cement ratio | Water reduction rate /% |
|---------------|------------------------|----------|--------------------|------------------------|
| 1             | blank                  | 95       | 0.68               | -                      |
| 2             | Sodium gluconate       | 100      | 0.61               | 10.3                   |
| 3             | glucose                | 95       | 0.63               | 7.3                    |
| 4             | Sugar-free wood sodium | 100      | 0.65               | 4.4                    |

3.2. The amount of concrete admixture

The best effect of the project depends on the optimum amount of admixture. The concrete admixtures that best match the performance of the concrete and their optimum dosages are determined through experiments. All in all, as long as the compatibility and variation of concrete and admixtures are known, the proportions are obtained through experiments to achieve the desired results.
Taking ordinary water-reducing agents with different contents as an example, Table 3 is a mixture of different dosages of ordinary water-reducing agent in concrete with a ash-to-ash ratio (aggregate/cement ratio) of 5.85, a water-cement ratio of 0.55, and a slump of 50 mm. Water reduction effect. It can be seen that if the slump is certain, the more the amount of ordinary water reducing agent is, the larger the water reduction rate is. When the dosage exceeds a certain value, the trend will tend to be gentle.

Table 3. Water reducing effect of different water reducing agent dosage

| Common water reducer type | Dosage        | Water-cement ratio |
|---------------------------|---------------|--------------------|
|                           | constant      | 0.51               |
| wood calcium              | 2 times constant | 0.49              |
|                           | 5 times constant | 0.47              |
| hydroxy carboxylate       | 2 times constant | 0.48              |
|                           | 5 times constant | 0.46              |

3.3. Admixture incorporation method

There are four ways to incorporate admixtures:
- Dry powder first mixing method
- Solution mixing method
- Water retention method
- Post-mixing method.

Admixtures are added in different ways, and their effects are greatly different. Only by selecting a suitable incorporation procedure can the effect of the admixture be more exerted to improve the construction effect. For example, the method of mixing ordinary water reducing agents is different, and the water reducing effect is also different. It can be seen from Table 4 that the same ordinary water reducing agent can obtain better water reducing effect than the same mixing method.

Table 4. Effect of ordinary water reducing agent incorporation on concrete workability and water reduction rate

| Incorporation method                | Water-cement ratio | Slump/mm | Water reduction rate/\% |
|-------------------------------------|--------------------|----------|-------------------------|
| No mixing                           | 0.59               | 100      | -                       |
| Incorporation with mixing water     | 0.55               | 88       | 6.8                     |
| Incorporation 2 min in advance      | 0.55               | 163      | 6.8                     |
| Incorporation 2 min in delay        | 0.51               | 81       | 13.6                    |

4. Application of 4 concrete admixtures in road bridges

With the development of road and bridge engineering construction in China, the role of concrete admixtures has become increasingly important, and the requirements for it have become higher and higher. At present, the application of concrete admixtures in road and bridge engineering is as follows.

4.1. applied to reduce costs

Concrete is composed of four kinds of materials, namely cement, fine sand, water and stone. In the whole concrete engineering cost, cement occupies a large proportion, and the amount of cement also determines the compressive strength and ease of performance of concrete. The scientific use of concrete admixtures can reduce the proportion of cement occupied in the project, thereby reducing the cost of construction. For example, MF superplasticizer:

Table 5. Experimental results of cement saving with mf superplasticizer

| Cement type | Cement dosage/ (kg/m3) | MF dosage/ (C×%) | Slump/ cm | Compressive strength/MPa | Saving cement/ % |
|-------------|------------------------|-----------------|-----------|--------------------------|-----------------|
| Ordinary    | 380                    | 0               | 11.0      | 3.8                      | 21.5            | 30.4            | -              |
|             | 360                    | 0.05            | 9.7       | 3.5                      | 22.2            | 31.2            | 5.0            |
|             | 350                    | 0.1             | 9.2       | 3.3                      | 20.0            | 30.9            | 7.9            |
|             | 325                    | 0.3             | 13.0      | 3.1                      | 20.9            | 30.4            | 14.5           |
|             | 306                    | 0.5             | 15.2      | 3.4                      | 20.5            | 28.3            | 19.5           |
It can be concluded from Table 5 that under the same strength requirement, the water-cement ratio and workability are kept unchanged, the superplasticizer is added, the concrete strength is increased, and the more the superplasticizer is added, the cement will be phased. Correspondingly reduced. The experimental results of MF superplasticizer show that 0.3% MF can save 50~55kg/m$^3$ of cement, 0.5% MF can save 74kg/m$^3$, and 0.7% MF can save 84~86kg/m$^3$.

### 4.2. Applied to improve the performance of concrete

The main role of admixtures is to improve the performance of concrete in road and bridge engineering. According to the performance requirements of concrete in different projects, the construction process also has different standards. It is different retarder and the amount of addition is different. The setting time of concrete will also have different effects. Table 6 lists the effects of various retarders on concrete setting time.

| Name                   | Dosage/ (C× %) | Setting time/min | Initial setting | Final setting | Initial and final setting interval |
|------------------------|----------------|------------------|-----------------|---------------|-----------------------------------|
| Basis (blank)          | 0              | 440              | 610             | 170           | 205                               |
| Wood calcium           | 0.3            | 630              | 835             | 205           |                                   |
| Calcium sugar          | 0.3            | 1135             | 1435            | 300           |                                   |
| Sucrose                | 0.05           | 685              | 890             | 215           |                                   |
| Carboxymethyl cellulose| 0.05           | 590              | 895             | 305           |                                   |
| Sodium tripolyphosphate| 0.1            | 590              | 990             | 400           |                                   |
| Polyvinyl alcohol      | 0.1            | 480              | 670             | 190           |                                   |

### 4.3. Applied to improve construction

In the construction of road and bridge engineering, the engineering process is particularly important. The process can save time and cost, and the quality can be ensured. The slow construction process will result in the opposite ending. Taking the early strength effect of triethanolamine and sodium chloride as an example, it can be seen from Table 7 that under the same temperature conditions, the incorporation of early strength agent can greatly reduce the construction time of concrete construction and speed up the engineering process.

| Early strength agent dosage/ (C× %) | Curing temperature (°C) | Compressive strength ratio at different ages/% | Number of days required to reach 70% strength of concrete 28d/d |
|-------------------------------------|-------------------------|-----------------------------------------------|-------------------------------------------------------------|
| NaCl N(C$_2$H$_4$OH)$_3$            | 20~25                   | 10d                                           | 10                                                          |
| 0.5                                 | 100                     | 100                                           | 100                                                         |
| 0.5                                 | 100                     | 100                                           | 100                                                         |
| 0.5                                 | 156                     | 157                                           | 143                                                         |
| 0.5                                 | 150                     | 144                                           | 135                                                         |
| 0.5                                 | 150                     | 144                                           | 135                                                         |

### 4.4. Experimental analysis of the application of admixtures in road and bridge engineering

The most important indicator of the mechanical properties of concrete after admixture in road and bridge engineering is the concrete compressive strength. In order to study the basic compressive strength of concrete after adding admixture, the concrete compression test results were obtained by using the water reducing agent concrete to carry out the cubic compression test when the ratio of water to cementing material was 0.42, 0.47, 0.52, 0.57 respectively, as shown in Table 8.
Table 8. Concrete cube compression test results

| Test | Water-to-binder ratio | Aggregate replacement rate/% | Fly ash content/% | Silica fume content/% | Mineral powder content/% | Water Reducing Agent dosage/% | Compressive strength /MPa |
|------|-----------------------|------------------------------|------------------|-----------------------|-------------------------|-----------------------------|--------------------------|
| 1    | 0.42                  | 25                           | 5                | 2                     | 2                       | 1.5                         | 44.2                     |
| 2    | 0.42                  | 50                           | 10               | 4                     | 4                       | 1.5                         | 31.2                     |
| 3    | 0.42                  | 75                           | 15               | 6                     | 6                       | 1.5                         | 40.2                     |
| 4    | 0.42                  | 100                          | 20               | 8                     | 8                       | 1.5                         | 32.7                     |
| 5    | 0.47                  | 25                           | 10               | 6                     | 8                       | 1.5                         | 34.8                     |
| 6    | 0.47                  | 50                           | 5                | 8                     | 6                       | 1.5                         | 43.6                     |
| 7    | 0.47                  | 75                           | 20               | 2                     | 4                       | 1.5                         | 37.6                     |
| 8    | 0.47                  | 100                          | 15               | 4                     | 2                       | 1.5                         | 37.9                     |
| 9    | 0.52                  | 25                           | 15               | 8                     | 4                       | 1.5                         | 27                       |
| 10   | 0.52                  | 50                           | 20               | 6                     | 2                       | 1.5                         | 26.8                     |
| 11   | 0.52                  | 75                           | 5                | 4                     | 8                       | 1.5                         | 32.1                     |
| 12   | 0.52                  | 100                          | 10               | 2                     | 6                       | 1.5                         | 33.4                     |
| 13   | 0.57                  | 25                           | 20               | 4                     | 6                       | 1.5                         | 28.5                     |
| 14   | 0.57                  | 50                           | 15               | 2                     | 8                       | 1.5                         | 30.4                     |
| 15   | 0.57                  | 75                           | 10               | 8                     | 2                       | 1.5                         | 23.8                     |
| 16   | 0.57                  | 100                          | 5                | 6                     | 4                       | 1.5                         | 33                       |

In order to more clearly understand the change of compressive strength performance of concrete after admixture, the aggregate substitution rate is x-axis and compressive strength is y-axis, and the water-to-binder ratio is 0.42, 0.47, 0.52, 0.57, respectively. Compressive strength properties.

![Figure 1. Compressive strength properties of concrete admixture](image-url)

It can be seen from figure 1 that when the admixture is incorporated into the concrete, the compressive strength of the concrete with a water-cement ratio of 0.42 and 0.52 shows a trend of first decreasing and then increasing, and the water-to-binder ratio is 0.47 and 0.57, which shows a tendency of increasing first and then decreasing. This is because when the water-to-binder ratio is 0.47 and 0.57, the admixture is added to the concrete to reduce the moisture, thereby increasing the compressive strength of the concrete. In the case of ratios of 0.42 and 0.52, the aggregate replacement rate is gradually increased, resulting in an increase in aggregate ratio. Some small drawbacks, that is, the increase of the gap, so that the water gradually penetrates into the crack, so that the strength of the aggregate becomes lower, which leads to the lowering of the concrete strength grade, and the increase in the later period is because the reasonable amount of the admixture increases the concrete. Compressive strength.

The test results show that the admixture has a significant effect in the road and bridge engineering. Reasonable use of admixture can not only reduce the construction cost of the project, speed up the
construction process, but also strengthen the function of concrete in the project and lengthen the use time. Therefore, we must make rational use of admixtures to allow admixtures to perform their best in road and bridge engineering.

5. Conclusion
Admixtures play an important role in the quality of concrete, which in turn will indirectly affect the overall quality of road and bridge engineering. The incorporation of admixtures can reduce the cost of road and bridge engineering, while at the same time obtaining the desired concrete function, in the unfavorable mixing. In the case of transportation, pouring and curing, the quality of concrete works is guaranteed. The special needs of concrete are met during the construction of roads and bridges, the amount of cement is reduced, and the engineering cost is reduced. Therefore, when using admixtures in road and bridge engineering with a reasonable admixture. Accompanied by the most suitable amount and operation during the construction process. In addition, one of the most important points to consider is the degree of matching between cement and admixture. Solving this problem can make road and bridge engineering have good engineering quality.

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