

# Evaluation of the Properties Magnesium Phosphate Cement with Emulsified Asphalt

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**Abstract.** Three type mixtures of magnesium phosphate cement with emulsified asphalt for evaluation their properties. The mixtures of the samples were fabricated and allowed them 2 hours, seven and twenty eight days curing before tested by compressive strength, Marshall stability and indirect tensile strength to probe into their engineering properties. The test results show that all tests have the greatest values at the 28 days curing and too much asphalt emulsion may cause too soft as result of low stability. The compressive strength of Type-III mixture has the greatest value, no matter what curing time is. The Marshall stability test and indirect tensile strength of the Type-III mixture are qualified by the specification required for fast maintenance. The more asphalt emulsion added, the less compressive strength has.

## 1. Introduction

A variety of pavement patching materials have been developed due to material engineer effort. The use of either hot mix asphalt or hydraulic cement for pavement patching materials has some deficiencies which are mentioned in my researches [1].

For rapid asphalt patching material series, cold patch asphalt repair materials are common used for emergency pothole repair. However, these materials are typically used to make temporary repairs until proper maintenance can be done. In addition, their qualities are often criticized by the government agencies. Because of too soft or too much binder, the mixture can face instability problems in summer [2]. The pavement distress such as pushing or shoving, raveling, and dishing is the most frequently encountered in-service failure when cold patch asphalt repair materials are used.

Dishing occurred during compaction under traffic that leaves a depression in the repaired surface; it is a result of improper compaction or installation techniques. Other failure mechanisms may include freeze-thaw deterioration, poor skid resistance, and lack of adhesion to the side or bottom of the pothole [3].

In the early 1980s, hydraulic cement series had been developed for fast hardness of early strength concrete such as "one-day cement" from Japan, "Swiftcrete" from British, "Draifach" from Germany, "Supercement" from Italian, "Pyrament" and "phosphate cement" from American, and aluminate cement [4]. However, magnesium phosphate cements (MPC) formed through an acidbase reaction between MgO and a soluble acid phosphate (typically an ammonium or potassium phosphate) were developed considerably greater compressive and tensile strengths than hydraulic cement, and given they could take less energy to produce. It is a wonder why they are not more commonly used these days because the promotion and proliferation of hydraulic cement occurred when energy was cheap and health concerns of the public were simply not an issue [5, 6].

If a cheap source of potassium hydrogen phosphate could be found, then MPCs could make a valuable



contribution to reducing global warming and improving building biology from the point of view of occupant health [6].

Asphalt series, is a mainstream of pavement, but the properties of patching materials are still insufficient which is mentioned above. On the contrary, the hydraulic cement used has the advantage of long service life, high strength and low price for maintenance. However, its rigid characteristic results in brittle failure, especially, damage occurred in the angle corner and on the edge, and the noise is also loud when driving a vehicle.

Based on the energy conservation and carbon reduction, pavement patching materials should admit to the requirement of green environmental protection, and fast maintenance is necessity under the restriction of the construction time in conformity with the traffic environment demanded in Taiwan. Thus, the objects of this study are to evaluate the properties of nonpoisonous and harmless MPC with emulsified asphalt (MPC-EA) mixture.

## 2. Materials and Methods

MPC typically comprises an alkaline earth phosphate salt, magnesium oxide and type F fly ash. MPC tend to cure rapidly, and exhibit high chemical stability, high compressive strength, low porosity and permeability to water. Due to the rapid cure at room temperature, MPC is considered for fast maintenance.

Cationic rapid setting (CRS-1) asphalt emulsion used for this study was met the specification requirement of the ASTM D2172. The properties of river sand used as fine aggregate and CRS-1 were tested listed in Table 1 and Table 2, respectively. The mixtures of the samples were fabricated by the ratios as shown in Table 3 for test and were allowed them curing 2 hours, seven and twenty eight days before tested by compressive strength, Marshall stable test, and indirect tensile strength for their engineering properties evaluated.

Table 1 The properties of fine aggregate

| Materials      | Specific gravity | Water absorption | FM   |
|----------------|------------------|------------------|------|
| Fine Aggregate | 2.66             | 0.81%            | 2.18 |

Table 2 CRS-1 test results

| Properties                       | Specification | CRS-1    |
|----------------------------------|---------------|----------|
| Specific gravity                 | -             | 1.03     |
| Viscosity, saybolt furol at 50°C | 20-100        | 92       |
| Particle charge test             | Positive      | Positive |
| Sieve test, %                    | 0.1 max       | 0.08     |
| Residue by distillation, %       | 60 min        | 65.8     |
| Sieve content, %                 | 0.3 max       | 0.25     |
| Penetration at 25°C (100g, 5s)   | 100-250       | 120      |
| Stability (1 day)                | 1% max        | 0.43     |
| Storage stability (5 days)       | 5% max        | 1.06     |
| Ductility at 25°C, cm            | 40 min        | 49.4     |

Table 3 Mixture ratios of mortar

| Materials        | Type-I | Type-II | Type-III |
|------------------|--------|---------|----------|
| MPC              | 450    | 450     | 450      |
| Fine Aggregate   | 1000   | 1000    | 1000     |
| Fly Ash          | 45     | 45      | 45       |
| Asphalt Emulsion | 27%    | 7%      | 7%       |
| water            | 7%     | 7%      | 10%      |

### 3. Results and Discussion

#### 3.1. Compressive Strength

Using 2" or 50 mm cube specimens were tested by MTS with a constant loading rate of 5 cm/min, in accordance with ASTM D109. The results of compressive test are shown in Figure 1. As it can be seen, the curing time increases with the compressive strength values increased because MPC is a kind of hydraulic cement which compressive strength developed depends on curing time. The more asphalt emulsion added, the less compressive strength has, as a result, the Type-I have the minimum values. The Type-III mixture has the maximum compressive strength values, regardless of the curing time of 2-hour, 7-day and 28-day. This situation may be explained that enough water added can provide a better chemical reaction and produce a higher compressive strength.

#### 3.2. Marshall Stability Test

In accordance with ASTM D6927, the Marshall stability is the resistance to plastic flow of cylindrical specimens of an asphalt mixture. A load is applied to the specimen at a constant strain rate of 50.8 mm/min until the maximum load is reached. The maximum force (called stability) at that force are read and recorded. The test results as shown in Figure 2 indicate that the Type-III has a very high value above 800 kg at 2-hour curing which means that the stability satisfies the specification required for heavy traffic [7]. Moreover, too much asphalt emulsion may cause too soft as result of low stability like Type-I mixture.

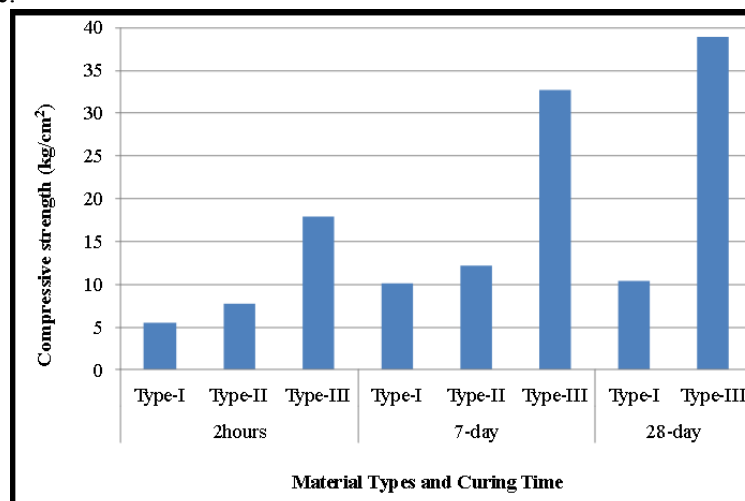


Figure 1 Compressive strength test results

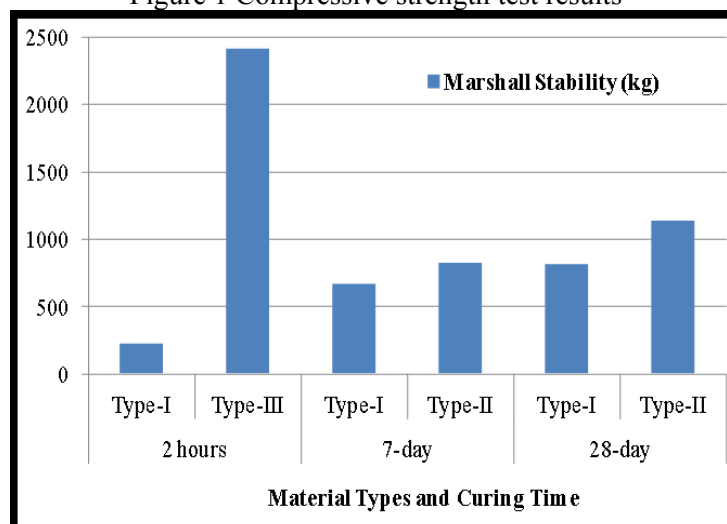


Figure 2 Marshall stability test results

### 3.3. Indirect Tensile Strength

The test of indirect tensile strength, in accordance with ASTM D6931, may use to evaluate the relative cohesion of the MPC-EA mixtures in conjunction with laboratory mix design testing and to estimate the potential for rutting or cracking. The results can also be used to determine the potential for field pavement moisture damage when results are obtained on both moisture-conditioned and unconditioned specimens. The results of test for Type III mixture, due to its better compressive strength and stability than Type I and II, are shown in Figure 3. The curing time increases with the indirect tensile strength increased. Compared with cold patch asphalt repair materials w, the strength is reasonable [8].

## 4. Conclusions

Based on the results from the laboratory test using MPC-EA, the following conclusions are made:

- The compressive strength of Type-III mixture has the greatest value, no matter what curing time is. The more asphalt emulsion added, the less compressive strength has.
- For Marshall stability test and indirect tensile strength, the Type-III mixture is qualified by the specification required for fast maintenance.

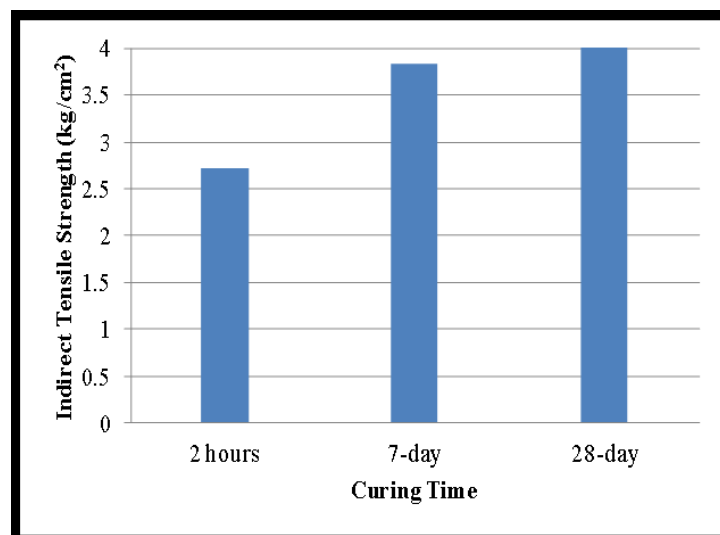


Figure 3 Type-III mixture indirect tensile strength test results

## 5. References

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