The effect of crystalline material addition to concrete quality

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Abstract. To improve the moisture susceptibility of concrete structure that will be exposed to water, an admixture should be added. One of the additives that can be added is Xypex C-1000 NF, which is a crystalline material. A number of past studies have shown that this additive is effective in improving the moisture resistance of concrete structure. However, the application of this additive in Indonesia was found to be challenging as the performance of the concrete mixture was not as good as expected. This research aims to evaluate the effect of adding various percentages of this additive, various amount of water to be added to the concrete mixture, and the methods of mixing the materials, which are wet and dry methods, by looking at both the slump value and the compressive strength of the concrete specimens. From the research results, it was found that the methods used to mix the additive matter to produce a desirable concrete quality. The wet mix method is the preferable method as it produces less variations in compressive strength test results regardless of the additional water amount. It was also found that, by using both dry and wet mix methods, the usage of Xypex C-1000 NF can improve the compressive strength value.

Keyword: concrete, optimum water content, slump value, compressive strength, wet mix, dry mix

1. Introduction

Admixture is commonly added onto concrete mixture when the engineer would like to improve the performance of concrete mixture. A number of admixtures that is commonly used to improve the compressive strength of concrete mixture includes fly ash, expanded polystyrene, polycarboxylate-ether-based superplasticizer, and other materials [1], [2].

For concrete structure that would be exposed to water in a large scale, it is necessary to add an admixture to ensure that the structure is waterproofed and can last until its designed life. This research used a crystalline-based material, namely the Xypex C-1000NF and this research project is a continuation of previous research study [3], which found that this additive was effective in reducing the permeability of the concrete structures, but it was important further study the effect that the Xypex C-1000 has on the compressive strength of concrete structures. This finding was in contrary to the other studies, where it was found that this additive is able to improve the compressive strength of aggregate [4]. One of the observations made during past experiences was the it is crucial to ensure that
the crystalline-based admixture is mixed properly and according to the product specification in field, as wrong or improper methodology could lead to the decreasing compressive strength of the concrete. This research aims to find the effect of optimum water content and concrete mixing method using various percentages of Xypex C-1000NF. The mixing process that will be done in this research is using concrete mixer with wet mix and dry mix method. The water content of concrete is set in this research are 100%, 110%, 120%, and 130% for dry mix. The dosage of crystalline material that used is 0.8%, 1.0%, and 1.2%.

2. Experimental Design

2.1. Materials

There were four materials mixed to prepare the concrete specimens, including aggregates, cement, water, and Xypex C-1000 NF. The concrete mix design was designed to be 25 MPa.

It is necessary to assess the suitability of both fine and coarse aggregates to be used in the concrete mixture as they have to satisfy the requirements stated by Standar Nasional Indonesia (SNI) 7656:2012 [5]. Table 1 and Table 2 show the results for the required tests for fine and coarse aggregates, respectively and it can be seen that the aggregates used satisfy the standards.

| Test               | Standard     | Unit   | Result | Limit |
|--------------------|--------------|--------|--------|-------|
| Loose Unit Weight  | SNI 03-4804-1998 | kg/m³  | 1103.380 | >1100 |
| Dense Unit Weight  | SNI 03-4804-1998 | kg/m³  | 1158.265 |       |
| Water Content      | SNI 03-1971-2011 | %      | 7.296   |       |
| Organic Content    | SNI 03-2816-1992 | -      | 2       | 3     |
| Dry Specific Gravity | SNI 03-1970-2008 | -      | 2.071   |       |
| SSD Specific Gravity | SNI 03-1968-1990 | -      | 17.892  | ≤40   |

| Test               | Standard     | Unit    | Result | Limit |
|--------------------|--------------|---------|--------|-------|
| Clay Lumps         | ASTM C142    | %       | 0.90   | ≤1    |
| Dry Specific Gravity | SNI 03-1969-2008 | -      | 2.52   |       |
| SSD Specific Gravity | SNI 03-2147-2008 | -      | 3.23   | ≤5    |

2.2. Sample Construction

Table 3 shows the research matrix that represents the variations used for this study. For each variation, there were six specimens constructed by using a cylindrical mould.
### Table 3. Research Matrix

| Xypex (%) | 0 | 0.8 | 1.0 | 1.2 |
|-----------|---|-----|-----|-----|
| **Method** | **Wet** | **3Xypex:2Water** | **3Xypex:1Water - 3Xypex:4Water** | **3Xypex:2Water** |
| **Dry**    |       |     |     |     |
| 100%-130%  | 100%-130% | 100%-130% | 100%-130% |

In this research project, there were two methods used to mix all the materials, which are the wet mix and dry mix methods. The wet mix method was conducted by mixing coarse aggregate, fine aggregate, cement, and water in a concrete mixer. After the mixture is evenly mixed, the admixture and the additional water were then added. For the dry mix method, the coarse aggregate, fine aggregate, and the admixture were mixed first in the concrete mixture. After those materials were mixed evenly, cement and water were then added to be mixed.

### 2.3. Laboratory Test

There were two laboratory tests conducted to evaluate the effect of varying the percentage of additive and water and using different mixing method, which are the slump test, which was done according to [6] and the compressive strength test, which was conducted according to [7].

### 3. Results & Discussion

#### 3.1. Slump test results

Figure 1 shows the slump test results for the concrete specimens that were prepared by using dry mix method. The x-axis shows the variation of water content percentage to the concrete samples and the y-axis shows the slump test results in centimeter unit. For all percentages of additive, it can be seen that the higher the percentage of water content, the higher the slump value will be. This shows that the workability of the concrete mixture is improved. It can also be seen that the higher the percentage of additive added, the slump values are generally higher.

![Slump test results](image-url)  

**Figure 1.** The effect of various percentage of additive and water content on slump values of concrete specimens prepared by using dry mix method
Figure 2 shows the slump test results for the concrete specimens that were prepared by using wet mix method. Similar to Figure 1, the x-axis shows the amount of additional water to the concrete samples and the y-axis shows the slump test results in centimeter unit. It can be seen that the higher the amount of additional water added and the higher the percentage of Xypex C-1000 NF used, the higher the slump value will be.

**Figure 2.** The effect of various percentage of additive and water content on slump values of concrete specimens prepared by using dry mix method

### 3.2. Compressive strength results

Figure 3 shows the compressive strength test results for the concrete samples that were prepared by using the dry mix method according to the dry mix method. The x-axis shows the variation of water content percentage to the concrete samples and the y-axis shows the compressive strength results in mega Pascal (MPa) unit. From Figure 3, it can be seen that the higher the percentage of water, the lower the compressive strength of the concrete specimens will be.

For the concrete specimens mixed with the Xypex C-1000 NF, the addition of the percentage of water content can be known for the optimum water content suitable for each dosage of Xypex C-1000 NF. For the concrete with used 0.8% of Xypex C-1000 NF, the maximum value for compressive strength test was achieved with 110% of water content. For the concrete specimens mixed with 1.0% and 1.2% of Xypex C-1000 NF, the maximum value for compressive strength test was achieved with 120% of water content.

Figure 3 also shows that the higher the percentage of Xypex C-1000 NF, then the compressive strength values will increase at the right amount of water content.
Figure 3. The effect of various percentage of additive and water content on compressive strength test values of concrete specimens prepared by using dry mix method

Figure 4 shows the compressive strength test results for the concrete samples that were prepared by using the wet mix method according to the dry mix method. The x-axis shows the variation of water content percentage to the concrete samples and the y-axis shows the compressive strength results in MPa unit. For all concrete sample variations, it was found the higher the amount of additional water added, the compressive strength test results remain to be similar. This suggests that wet mix method is the preferable method as it shows less variation in the compressive strength test results despite the fact that the additional water amount varied. It can be seen that adding more of Xypex C-1000 NF was able to improve the compressive strength of the concrete specimens.
4. Conclusions

Based on the slump test and the compressive strength test results it can be concluded that the methodologies used to mix the additive matters in determining the quality of the concrete mixture. For the dry mix method, it can be seen that the additional water affects both slump and compressive strength of concrete mixture. When the dry mix method is used, if the concrete is mixed with 0.8%, 1.0%, and 1.2% of Xypex C-1000 NF, the maximum compressive strength value will be achieved when using 110%, 120%, and 120% water content, respectively. For the wet mix method, it can be learned that, while the percentage of water affects the slump value, but it did not affect the compressive strength of the concrete. This research result suggests that wet mix method is the preferable method as it shows less variation in the compressive strength test results despite the fact that the additional water amount varied.

Moreover, it can also be seen that the Xypex C-1000 NF was able to improve the compressive strength by using both wet and dry mix method. However, this suggests that the additive should be mixed with a certain manner to obtain a more desirable result.

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