The Study of Concrete Durability with PPC Premium and PPC Non Premium Cement

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Abstract. Concrete structures reinforced with steel formed an important part of recent infrastructures. Today, the rate of use of cement is higher than 40 years ago. An approximation amount of 11 billion metric ton of cement per year has been consumed in the whole world. The aims of this research are: (1) to obtain the durability value of concrete with PPC Premium Cement and PPC Non-Premium Cement, (2) to obtain the degree of comparison of concrete durability, (3) to obtain the durability parameters. This research based on ASTM International standards, conducts in 224 days non-stop, to obtain following data: (1) compressive strength, (2) rebound number, (3) pulse velocity number, (4) modulus of rupture, and (5) corrosion rate. The test result: (1) PPC Premium cement give a relatively good performance rather than PPC Non-Premium cement. This is based on both destructive and non-destructive test, (2) the modulus of rupture’s value also giving the PPC Premium cement act relatively good than PPC Non-Premium cement, (3) test on severe environment, concrete treatment by mean of waterproofing proved to be effective to reduce the rate of steel destruction., (4) on a practical use, cement with high fineness modulus can give a better performance.

Keywords: cement, durability, severe environment

1. Introduction
On an article published by [1], two famous scientists on cement and concrete wrote “The most widely used construction material is concrete, commonly made by mixing Portland cement with sand, crushed rock, and water. Last year in the U.S. 63 million tons of Portland cement were converted into 500 million tons of concrete, five times the consumption by weight of steel. In many countries the ratio of concrete consumption to steel consumption exceeds ten to one. The total world consumption of concrete last year is estimated at three billion tons, or on ton for every living human being. Man consumes no material except water in such tremendous quantities”

Today, the rate of concrete use worldwide is higher than 40 years ago. It is assumed that 11 million tons per year have been consumed. It shows that concrete is still a chosen and favourite material in worldwide construction [2].

The U.S. used approximately 180 million metric cubic of ready mixed concrete each year. It is used on highways, roads, parking lot, bridges, high-rise buildings, dams, houses, sidewalks, etc. It is supported by the fast-growing development of cement industry. The cement industry is one of kind of
industry that support the concrete industry. In the U.S., the cement production is supported by 97 cement factories spread out on 36 states [3].

In Indonesia, the national consumption of cement can be shown on following chart.

![Cement consumption in Indonesia](image)

**Figure 1.** Cement consumption in Indonesia [4]

It is shown that following the recent acceleration on infrastructure development, it is triggered the development of cement industry in Indonesia. It is strengthening by the statement of The Director General of Chemical, Textile and Miscellaneous Industry of the Ministry of Industry in Indonesia that the Ministry of Industry predicted that the total national cement capacity on 2017 will be 102 million tons from the total required 70 million tons each year, following the high-investment realization on domestic cement industry [5].

This statement is strengthened by the new investors in cement industry to Indonesia. The Indonesian Cement Association (ASI – *Asosiasi Semen Indonesia*) has been gathered data from many sources regarding the cement producer in Indonesia on following table [6][7].

**Table 1.** Cement factory in Indonesia

| Investor                                      | Capacity per Year | Location                     |
|-----------------------------------------------|-------------------|------------------------------|
| China Anhui                                   | 10 million tons   | South-East-West Borneo, West Papua |
|                                               | 2.5 million tons  | Tanjung, South Borneo        |
| China Trio Int. Engineering Co. Ltd. (SDIC)   | 1.5 million tons  | Subang, West Java            |
| State Development and Investment Cooperation  | 1.0 million tons  | Papua                        |
| Siam Cement Group – Thailand                  | 1.8 million tons  | Sukabumi, West Java          |
|                                               | 1.2 million tons  | Bayah, Banten                |
| Pakubumi / Semen Karawan / PT. Jui Shin Indonesia | 2.5 million tons | Karawang, West Java          |
| PT. Semen Grobogan / Gajah Tunggal (China Triumph Int. Eng. Co. Ltd. – CTIEC) | 1.5 million tons | Grobogan, Central Java       |
| Wilmar Group                                  | 2.0 million tons  | Banten                       |
| Ultra Tech Cement - India                     | 4.0 million tons  | Wonogiri, Central Java       |
Along with this newly cement industries, bring hope to the cement availability on both domestic and export requirements. With this industry the adequacy of cement to support the national infrastructure development can be provided.

2. Methods
The research method can be describe as follow:

![Research flowchart](image1)

**Figure 2.** Research flowchart

![Modulus of rupture specimen](image2)

**Figure 3.** Modulus of rupture specimen
3. Result and Discussion
The compressive strength is the first shown parameter on this research. From the compressive strength, it can be referred into other parameters. The compressive strength test then compared with other two non-destructive testing, Schmidt rebound hammer test and ultrasonic pulse velocity. The result can be shown as follow:
Figure 7. Compressive strength test

Figure 8. Schmidt hammer test 0 deg

Figure 9. Schmidt hammer test 90 deg
The bending test on beam is intended to get the modulus of rupture value, which can be used as a parameter for a specimen before rupture. The modulus of rupture of the beam for two different cement type, as follow.

![Figure 10. Ultrasonic pulse velocity test](image)

The test on severe environment was conducted to model the environment of sea water, which has particular salt content. On this test, the specimens were treated with waterproofing layer to examine the effectiveness of corrosion rate resistance on concrete reinforcement [11].

![Figure 11. Bending test on the beam](image)
According to test result, it is shown that the premium cement has the relatively better performance rather than cement non-premium, generally. This indication is shown from the early compressive strength which have the more stable curvature. This result is also strengthen with the reading of Schmidt hammer test and ultrasonic pulse velocity, which are shown the similar behaviour. Regarding the collapse of the beam, whether concrete with premium cement or non-premium cement behave the same and have almost similar performance, and when dealt with severe environment, the waterproofing treatment also give a significantly better performance rather than non-waterproofing treatment. Even the damage still happen, but the rate of damage is reduced into significant level.

4. Conclusion
According to discussion, there are conclusions as follow:

- The PPC Premium cement give relatively better performance rather than PPC non-premium cement. It is shown from the concrete quality of both destructive and non-destructive testing
- On the bending strength test, the PPC Premium cement also give the modulus of rupture relatively better performance rather than PPC non-premium
- The waterproofing treatment on severe environment can resist the damage process on the reinforcement. It can be shown from the corrosion rate and weight loss of the reinforcement

Figure 12. Reinforcement loss weigh measurement

Figure 13. Corrosion rate measurement
For practical application, cement with high finess modulus can give better performance

5. References

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