Properties of Para-Rubber Plates Using as the Capping on Concrete Specimens for Compression Test Instead of Molten Sulphur

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Abstract

This paper aims to study the using para-rubber plate for transferring the force on concrete specimens instead of capping with sulphur. Four formulas for mix design of para-rubber plate are setup. Each formula is mixed in two rolls mill machine and formed the para-rubber plate by Compression Molding. After obtaining the para-rubber plate specimens, the measuring of compression set, tensile strength, % strain, tear strength, hardness of para-rubber plate are performed. Consequently, the para-rubber plates are taken into capping the concrete and tested the compressive strength. These results are compared to that with sulphur capping. From the results, it is found that adding carbon black over 60 phr affects to develop the hardness but the other properties are declined. In testing the compressive strength of concrete with para-rubber plate, it is found that the formula having the results close to that using of sulphur is the formula that using latex at 100 phr, carbon black (grade N330) at 100 phr and calcium carbonate at 50 phr. In this formula, the compressive strength is larger than using sulphur at 7%. This indicates that there is possibility in developing the formula of para-rubber plate for capping material in the future.

Keywords : para-rubber, compressive test, concrete, capping material

1. Introduction

Normally, there are 2 types of compressive tests of the concrete. One is test on the cubic of size 15x15x15 cm (BS 1881 part 108 [1]). This method uses widely in Europe. Another method which extremely uses in America, France, Canada, Australia and New Zealand performs on cylinder at diameter 15 cm and height 30 cm according to ASTM C192 [2]. The tested concrete must be capped with cement paste or plaster cement or sulphur [3]. Among three types of capping materials, the sulphur is mostly exploited. However the sulphur is the toxic substance which can harm the

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respiratory system of the users, then many organizations replace the using of sulphur in capping concrete with the other materials such as synthetic-rubber plate with steel case (see Fig.1). We can find the synthetic-rubber plate from both aboard (see Fig. 2) and in the country. However the price of synthetic-rubber from aboard is relatively high, then there is an attempt on research the new materials for capping the concrete instead of sulphur [4-7]. The results from those studies are still unsatisfied. Thus this research aims to find the formulae of para-rubber (from latex in Thailand) plate. The compressive strengths of purposed rubber plate will be compared to those with sulphur for finding the suitable formula which gives the results close to those using the sulphur.

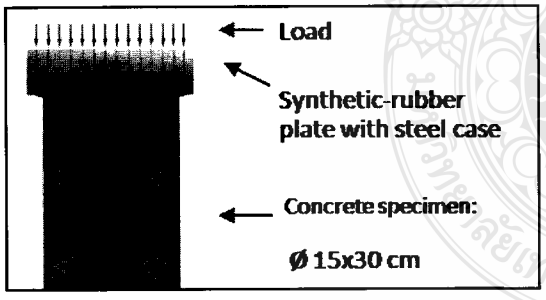

Fig. 1 Loading of para-rubber plate with steel case

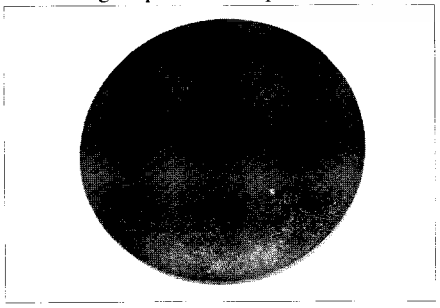

Fig. 2 Fiber reinforced synthetic rubber-plate from aboard

2. Materials and Equipments

1) Para-rubber no.STR20: the characteristics of this type of para-rubber are i) there is the double bond ii) There is the alpha-methylene which makes the vulcanizing reaction with sulphur. The properties of this para-rubber are shown in Table 1.

Table 1. Specifications of STR20 rubber [8]

Specification	Standard value
The contaminations that are larger than 44 micron (max%wt)	0.16
Ash (max % wt)	0.80
Nitrogen (max % wt)	0.60
Vaporous matter (max % wt)	0.80
Initial plasticity (PO) (min)	30
Plasticity Retention Index (PRI) (min)	40
Mark color	Red on with surface
Color of film (LDPE)	Transparency
Color of polyethylene	White

2) Sulphur that serves as vulcanizing agent (or curing agent). The benefit of adding sulphur is to make the link between molecules of rubber.

3) Carbon black of four grades according to ASTM D1765 (N220, N330, N550 and N660). The properties of carbon black in each grade are summarized in Table 2.

Table 2. Properties of Carbon black

Fundamental properties	Carbon black			
	N220	N330	N550	N660
Iodine absorption (g/kg), ASTM D1510	121	82	43	36
Nitrogen absorption (m/g), ASTM D3037	119	83	42	35
DBPA (cm/100g), ASTM D2414	114	102	121	90
DBPA of compressed sample (cm/100g), ASTM D3493	100	88	88	75
CTAB (m/g), ASTM D3765	111	83	42	35

4) Calcium carbonate ($CaCO_3$)

5) Two-roll mill

6) Compression Molding

7) Tension machine

8) Shore durometer

9) Universal testing machine

10) Steel case

3. Research Methodology

The methodology is divided into three sections: i) By using only carbon black as a major component in producing the para-rubber plate, the most suitable grade of carbon black will be selected according to the fundamental properties of carbon black (Table 2) and mechanical properties from testing under ASTM standard [9]. ii) By using calcium carbonate ($CaCO_3$) and carbon black, the $CaCO_3$ is added for reducing the cost of carbon black. The 3 ratios of carbon black to $CaCO_3$ are given and tested similar to the first case. iii) The para-rubber plates from sections 1 and 2 are taken into capping the concrete specimens with steel cases and examined the compressive strength under ASTM C39 [10]. The results from two types of para-rubber plates are compared for selecting the appropriate formula. Before explaining the step of forming para-rubber plate, it is important to note that the unit of defining the quantity of substances in this paper is phr or pphr (part per hundred of rubber). For example, carbon black 50 phr means there are 50 parts of carbon black per 100 parts of rubber. The steps of forming the para-rubber plate are shown below.

1) Mastication in open system and at temperature 30-70 degree Celsius, the chemical substances such as carbon black, $CaCO_3$ and sulphur were added respectively. After complete mixing, the rubber compound is obtained.

2) The rubber compound was formed by hot rolling at temperature 160 degree Celsius.

3) The para-rubber plate was cooled down and then the para-rubber plate having 15 cm in diameter and 1 cm in thickness is formed.

4) The following mechanical properties of Para-rubber plate were evaluated using the ASTM standard [9].

- Compression strength (ASTM D395)
- Tensile strength (ASTM D412)
- Strain (ASTM D412)
- Hardness (ASTM D1415)
- Tear strength (ASTM D624)

5) The concrete specimens were capped with para-rubber plates and tested the compressive strength of the concrete. The results were compared to those with sulphur capping. Each formula had 30 specimens for finding the average value of compressive strength. The strength of concrete in mix design is 280 ksc.

The symbols for testing are listed in Table 3. The readers should keep in mind that all of quantities in Table 3 are compared with 100 parts of para-rubber.

Table 3. The symbols in this research

Symbol	Definition
S	Sulphur
60N: 0C	Carbon black 60 parts per $CaCO_3$ 0 part
60N: 50C	Carbon black 60 parts per $CaCO_3$ 50 parts
80N: 50C	Carbon black 80 parts per $CaCO_3$ 50 parts
100N: 50C	Carbon black 100 parts per $CaCO_3$ 50parts

4. Results and Discussion

The mechanical properties of para-rubber mixed with carbon black are shown in Table 4 and Fig. 3.

Table 4. Mechanical properties of para-rubber plate

Mechanical Properties	Grades of Carbon black			
	N220	N330	N550	N660
Compression set (%)	76	74	62	66
Tensile strength (MPa)	14	13	13	12
Strain (%)	478	451	474	428
Hardness (Shore D)	64	65	64	60
Tear strength (N/mm)	64	53	43	36

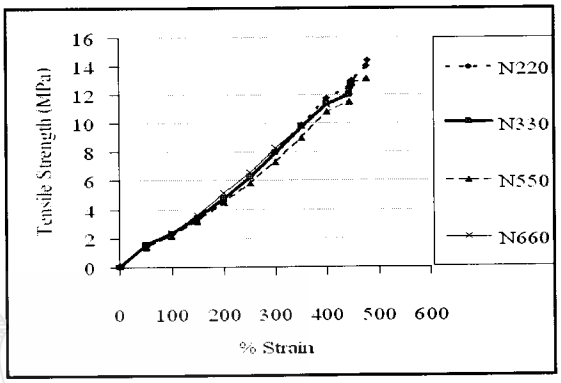

Fig. 3 Stress strain relationship of para-rubber plate

The important property of para-rubber plate is the hardness so it is considered as a major property in selecting the para-rubber plate. From Table 2, para-rubber plate with carbon black N330 gives the maximum hardness (measures from Shore D [11]) and the other properties are in acceptable range (see Fig. 3), then the carbon black grade N330 is selected as a filter in this research.

The mechanical properties of para-rubber plate with carbon black and $CaCO_3$ are shown in Table 5. The $CaCO_3$ is added for reducing the cost of para-rubber plate.

Table 5. Mechanical properties of para-rubber plate

Mechanical Properties	Carbon black : $CaCO_3$			
	60N: 0C	60N: 50C	80N: 50C	100N: 50C
Compression set (%)	63	74	46	54
Tensile strength (MPa)	14	13	12	10
Strain (%)	404	451	327	219
Hardness (Shore D)	60	66	72	77
Tear strength (N/mm)	60	53	33	25

From Table 5 and focusing on formulae 60N:0C and 60N:50C, it is found that $CaCO_3$ makes higher in compression set, strain and hardness. However the tear and tensile strengths are a little bit decreased. By considering formulae 60N:50C, 80N:50C and 100N:50C, the compression set, tensile strength, strain and tear strength are inversely proportional to amount of carbon black. In contrast with the hardness, it is proportional to amount of carbon black.

Normally, the content of carbon black should not excess 60 phr [12] but the main objective is to find the formula that gives the maximum hardness. Then in this study, the range of carbon black is extented to 100 phr. The results of formula 100N:50C indicate that the hardness reaches the highest value but the other properties are lowest. These results from lose of dispersion and distribution of carbon black's particles, and then rubber cannot bind the filters effectively [12] and leads to low values in many properties. While many properties have low values when using carbon black 100 phr but the hardness gives the highest value since higher density of the para-rubber plate.

The results of compressive strength of concrete capping with para-rubber plate and steel case are compared to that with sulphur and shown in Fig. 4.

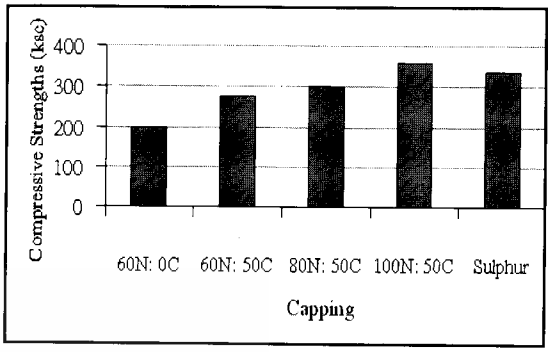

Fig. 4 Compressive strengths of concrete specimens

From Fig. 4, it reveals that the using of $CaCO_3$ can reduce not only the cost of para-rubber plate but also give the higher value of compressive strength (for case 100N:50C). Thus the suitable formula from this research is 100N:50C. With this formula, the higher compressive strength than capping with sulphur around 7% is obtained. The lower compressive strengths, in descending order, are 80N:50C, 60N:50C and 60N:0C.

5. Conclusions

From the testing, it was found that the most suitable formula of para-rubber plate is 100N:50C. At this formula, the compressive strength is in good agreement with those from sulphur capping (larger than sulphur capping around 7%). In view of cost, the cost of para-rubber plate from this research is not over than 50 baths/sheet. In comparison with para-rubber plates that produce aboard and in the country, the costs of these para-rubber plates are 500-800 baths/sheet and 180 baths/sheet respectively. Thus the proposed formula of para-rubber plate has the potential in developing into large scale of economic.

6. Suggestions

The results from this formula should be compared with the para-rubber plate from aboard and in the country.

In order to reduce the cost, the formula should be modified for capping without steel case.

7. Acknowledgment

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8. References

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