CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Discussion

5.1.1 Manufacturing Condition and Procedure

Prior to the experiment which gives the results in Chapter 4, preliminary experimental study was done in order to set up exact manufacturing procedure. During this preliminary study, great effort was spent to find the obtimum condition and procedure to eliminate bubbles in the product caused by side reactions. Finally, the best condition and procedure were obtained as described in Chapter 3. Reacting mixture of less than 200 grams was used in each batch.

During the prepolymer period, a typical temperature rise in the reaction mixture is shown in Figure 5.1.

In this Figure, the temperature reaches a plateau of about 57 °C in about 20 minutes as shown characteristic of exothermic reaction. So a period of 30 minutes was used for prepolymer reaction. It was found that the suitable temperature of the water bath was about 60 °C which was close to that used by R.F. Harris et. al.

The chain extending reaction is rapid as indicated by the step rising temperature of the reacting mixture from 57 °C to about 85 °C in less than one minute.

Table 5.1 Relation of temperature and time

Time (min)	0	1	2	4	5	6	7	8	9	10	11	12	13	14	16	18	20	22	24	26	28
Temp (°C)	54	39	43	47	48	49	50	51	52	53	54	54	55	55	56	56	57	57	57	57	57

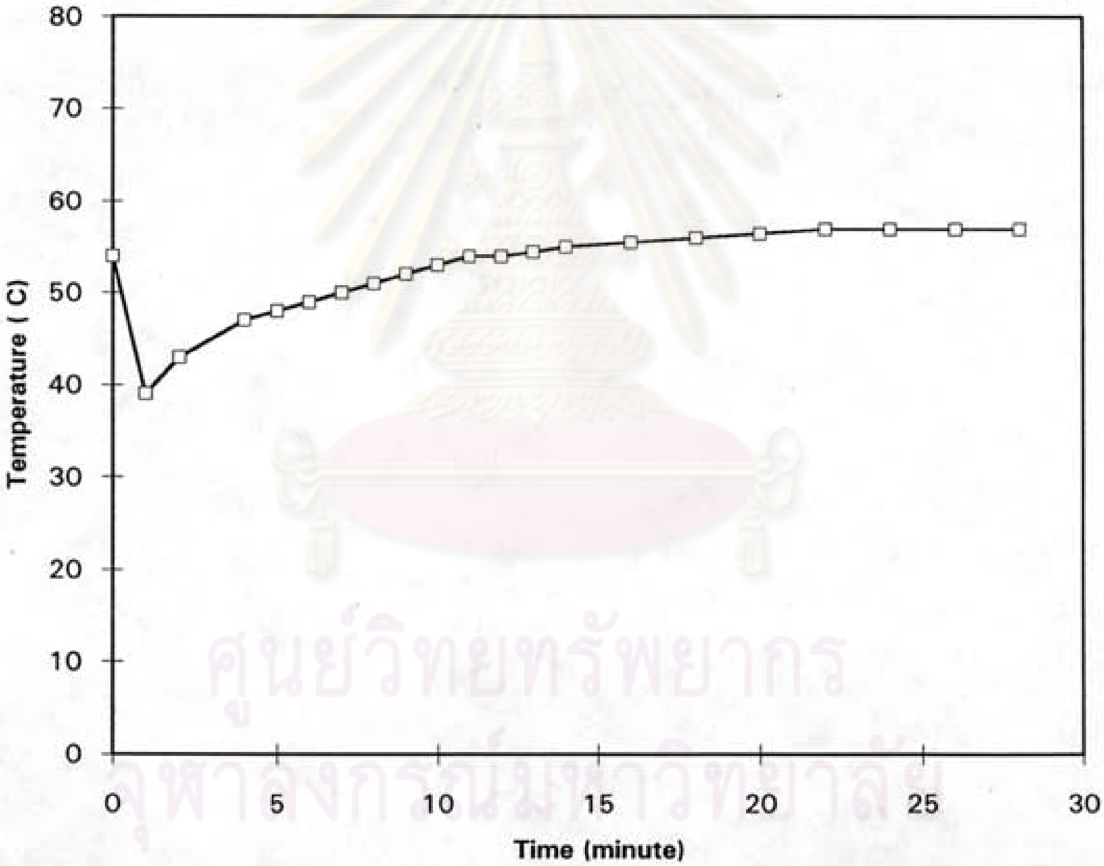

Figure 5.1 Relation of temperature and time

5.1.2 Composition of filled-polyurethane

5.1.2.(a) Raw materials

The raw materials used in the work are selected based on the following criteria :

- locally available
- low cost

The polyol used is produced by a local plant. Brick and used tire are found easily at low cost.

5.1.2 (b) Suitable composition

First, the NCO/OH ratio is chosen based on the best mechanical properties. A value of 1.09 for NCO/OH ratio was chosen because it obtained maximum tensile strength and maximum hardness (Table 4.1). Then, at this NCO/OH ratio of 1.09, molar ratio of polyol : MDI : BDO of 1:4:3 was chosen because it obtained the highest values of tensile strength and elongation at break (Table 4.2).

After the composition of unfilled polyurethane is obtained, the type of filler is determined. According to Table 4.3, all fillers do not participate in the reaction but effect on decrease properties. The filled-polyurethane with 5% of brick obtain properties not slightly different when compare with other fillers. The price of silica is 90 Baht/kg, Calcium carbonate is 5 Baht/kg and brick is 1.5 Baht/kg. Therefore, brick is chosen as the suitable filler because of its cheapness, color and abundance.

The percentage of brick in the filled-polyurethane was then determined. According to the patent pol.P.L. No. 141,631, polyurethane for covering sport facilities, should have a tensile strength in excess of 1.5 N/mm^2, % elongation at break in excess of 100 and a hardness Shore °A of 45-60. These values of the properties will be used

Table 5.2 Relation between properties and cost by various weight percent brick at NCO/OH ratio 1.09

%Brick	Tensile strength (N/mm^2)	Elongation (%)	Cost (Baht/kg)
0	17.6353	118.57	122.25
5	12.0494	109.90	116.46
9	10.1815	90.89	111.39
13	8.9827	81.76	106.56
17	7.8466	80.32	101.65
20	7.2777	59.33	98.08
23	6.3514	54.68	93.08

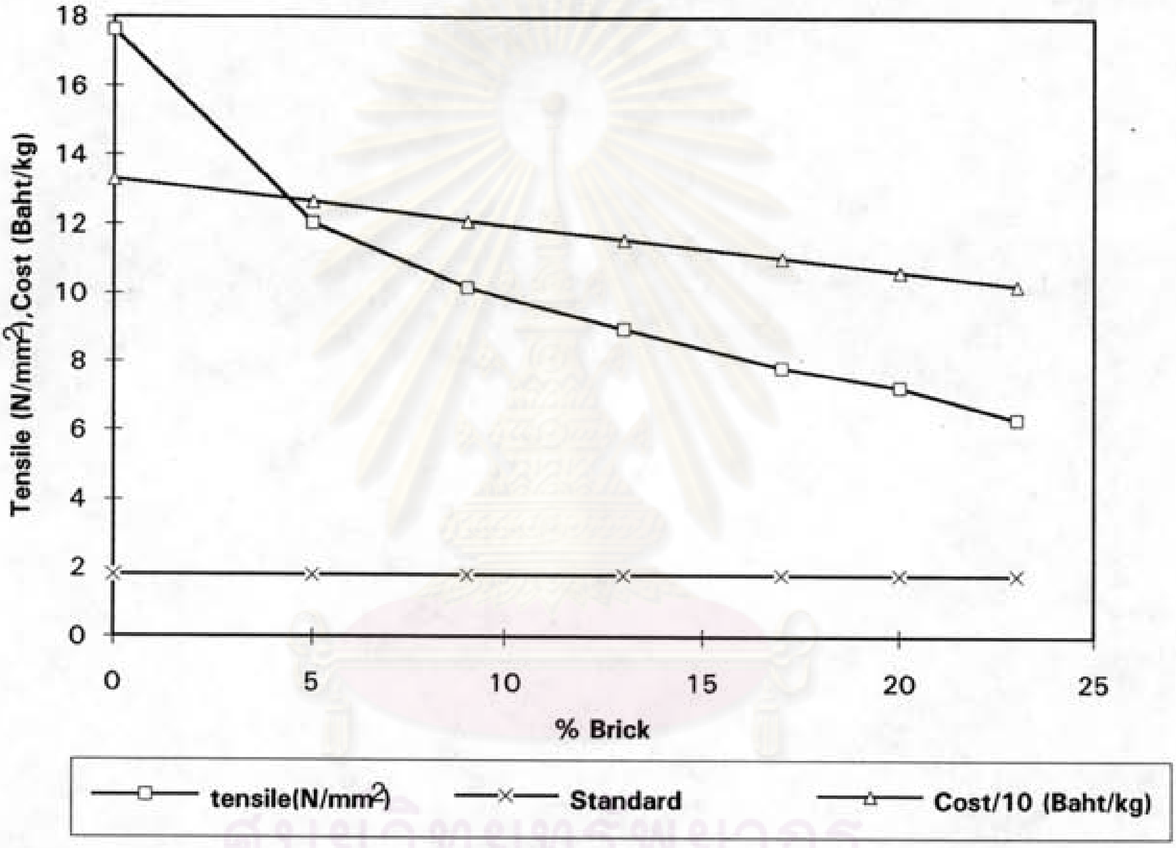

Figure 5.2 Relation between tensile strength, cost and standard value of filled-polyurethane at NCO/OH ratio 1.09

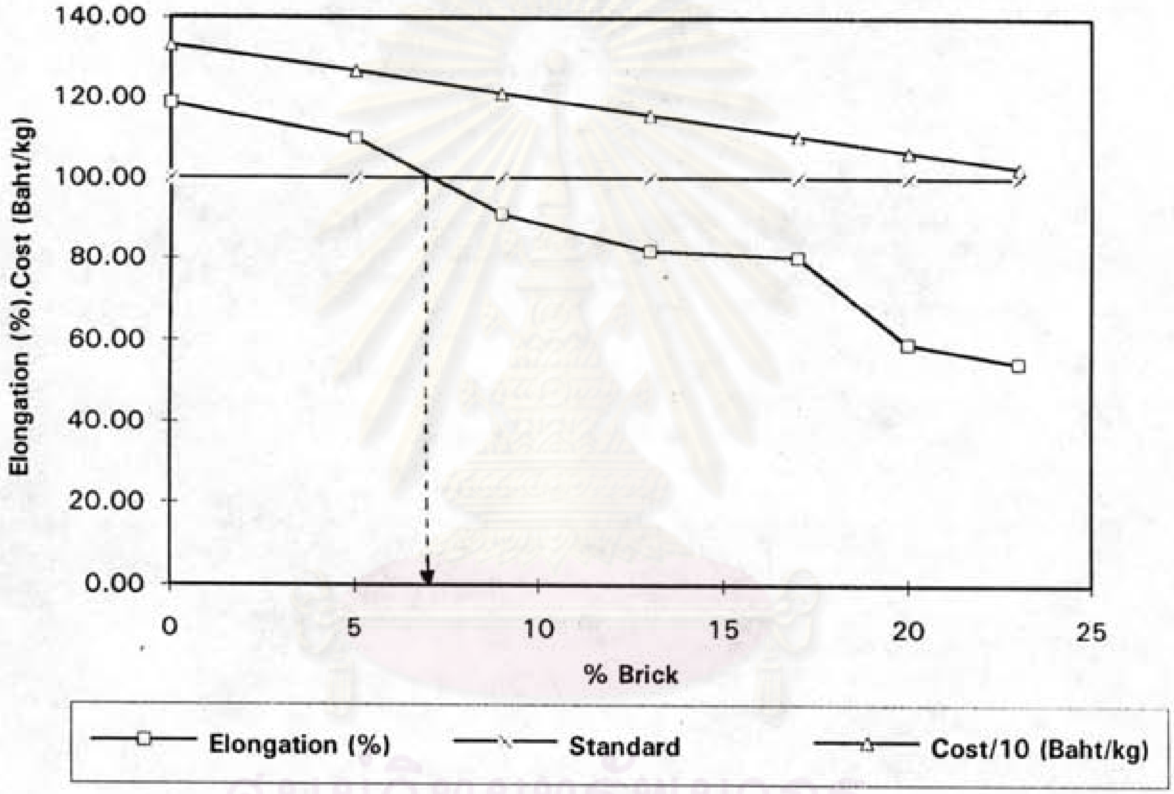

Figure 5.3 Relation between %elongation at break, cost and standard value of filled-polyurethane at NCO/OH ratio 1.09

Table 5.3 Relation between properties and cost by various weight percent brick at NCO/OH ratio 1.03

%Brick	Tensile strength (N/mm^2)	Elongation (%)	Cost (Baht/kg)
0	12.7117	144.97	123.43
5	11.0099	112.50	117.35
10	10.4832	100.67	111.23
15	9.0606	90.23	105.15
20	7.2364	79.71	99.03

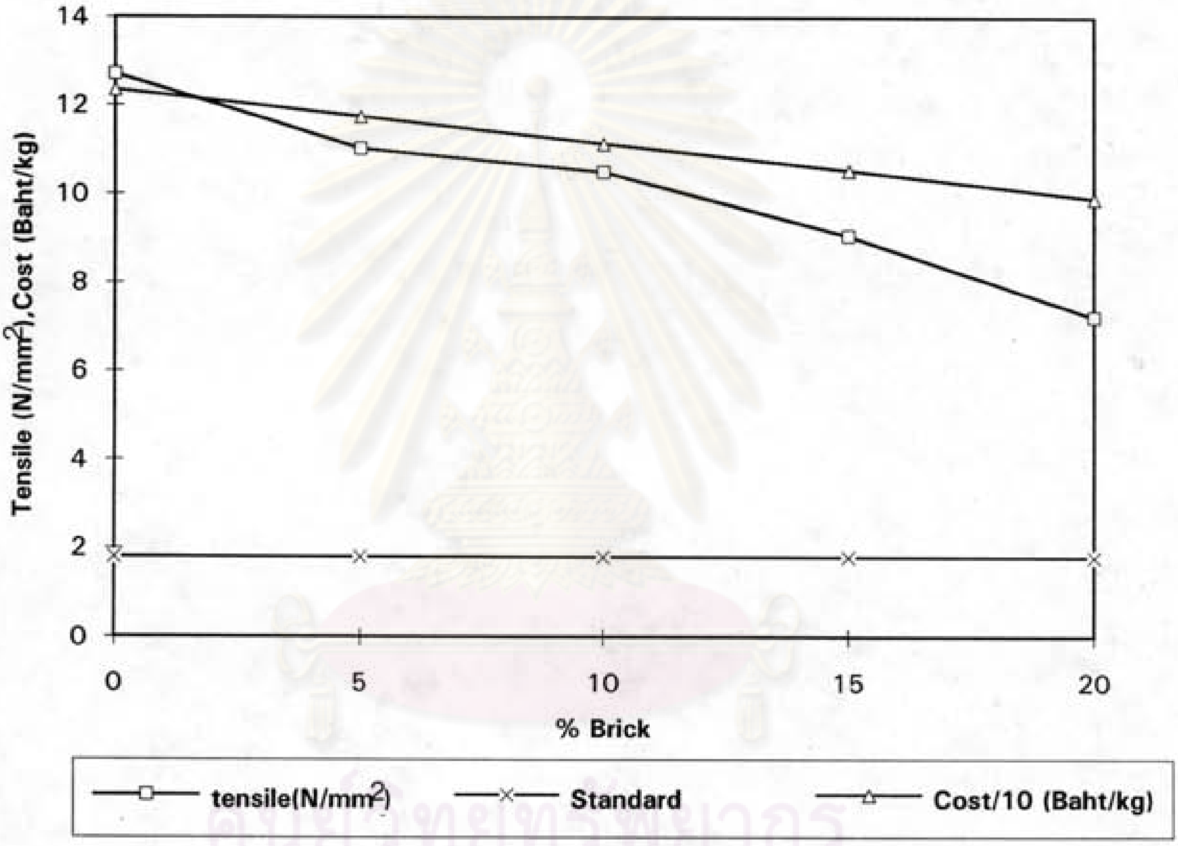

Figure 5.4 Relation between tensile strength, cost and standard value of filled-polyurethane at NCO/OH ratio 1.03

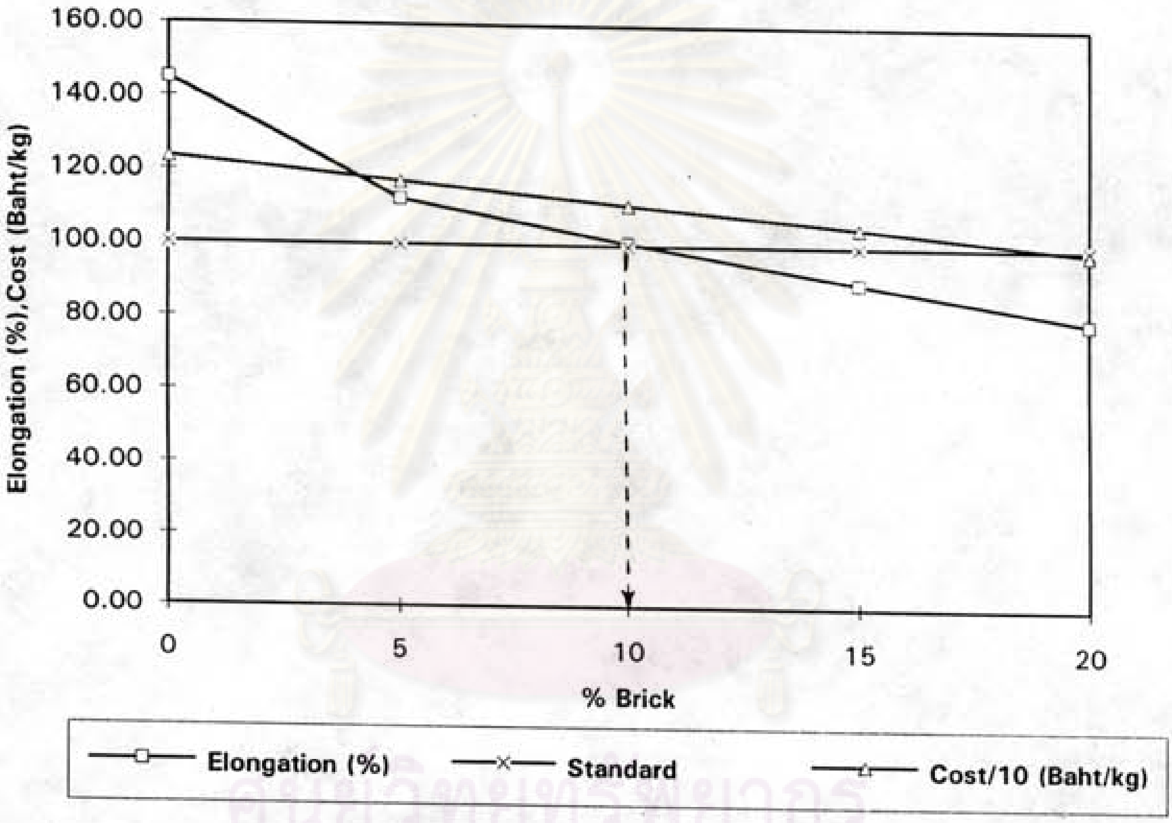

Figure 5.5 Relation between %elongation at break, cost and standard value of filled-polyurethane at NCO/OH ratio 1.03

as a standard in determining the suitable composition. Thus, based on Table 4.5, a 5% of brick was chosen. As a higher percentage of brick is desirable, tensile strength is over the standard value (Figure 5.2) but the percentage elongation at break of this production will be below that of the standards (Figure 5.3).

Additional experiment was carried out for NCO/OH ratio of 1.03 because of its higher elongation at break and the results are presented in Table 4.4, Table 4.6, and Figure 5.4, respectively. Table 4.4 indicates that brick is still the best choice. Moreover according to Figure 5.4 and 5.5, the brick content of filled-polyurethane can be increased to 10 % and the % elongation still lies above the standard value.

5.1.3 Preparation of finished paving surface

After the suitable composition of the filled-polyurethane has been obtained, the paving surface is prepared in further step (Figure 5.6).

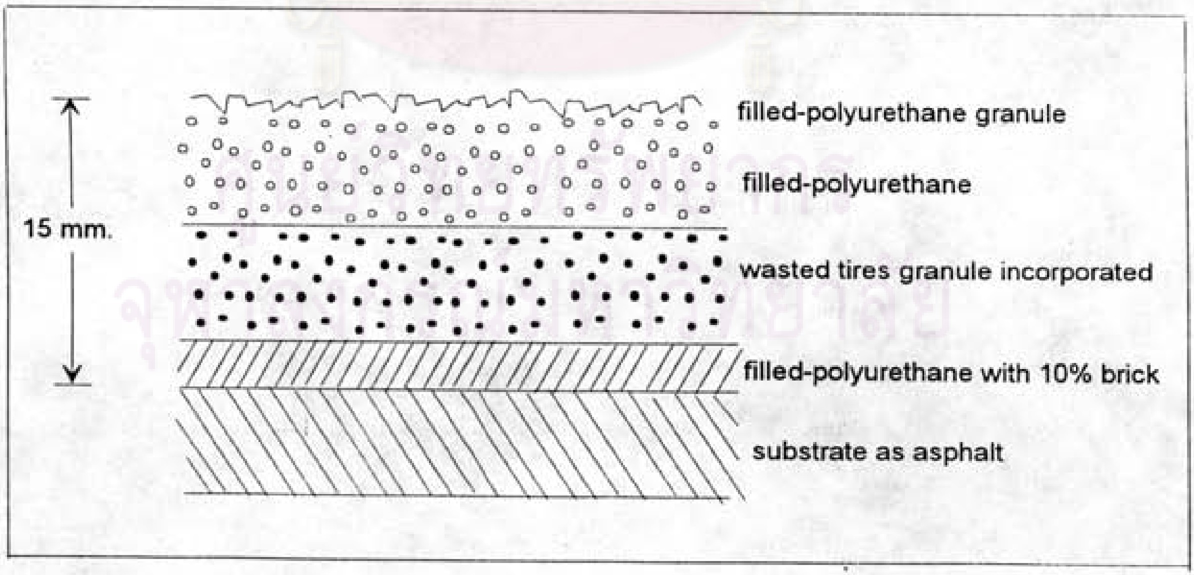

Figure 5.6 Cross-sectional view of running track

Figure 5.6 illustrates the detail of cross-sectional view of running track which filled-polyurethane (10% brick) is applied over substrate including asphalt, concrete and other substructure as the base layer. After that, waste rubber granules are incorporated in second layer. On the top layer, filled-polyurethane particle can be applied to the surface before it cures in order to increase the traction of paving surface. Figure 5.8 and Figure 5.9 show the comparison of experimental and industrial synthetic paving surface, respectively.

5.1.4 Cost of paving surface

Table 5.4 and Figure 5.6 showed estimation material cost of the finished paving surface as a function of weight percentage of waste rubber particle used. Table 5.5 showed estimation overall cost of the finished paving surface as the same function. The basis used in this cost calculation is as follows :

Composition of filled-polyurethane :

polyol	53.45 weight percent
MDI	29.32 weight percent
BDO	7.20 weight percent
brick powder	10.0 weight percent
catalyst	0.03 weight percent

Material cost :

polyol	85	Baht/kg
MDI	60	Baht/kg
BDO	666.66	Baht/kg
brick powder	1.5	Baht/kg
waste rubber particle	5.0	Baht/kg

Table 5.4 Relation between filled-polyurethane, weight percentage of rubber and cost

% filled-PU	%Rubber	Cost (Baht/kg)
100	0	111.23
90	10	100.61
80	20	89.98
70	30	79.36
60	40	68.74
50	50	58.12

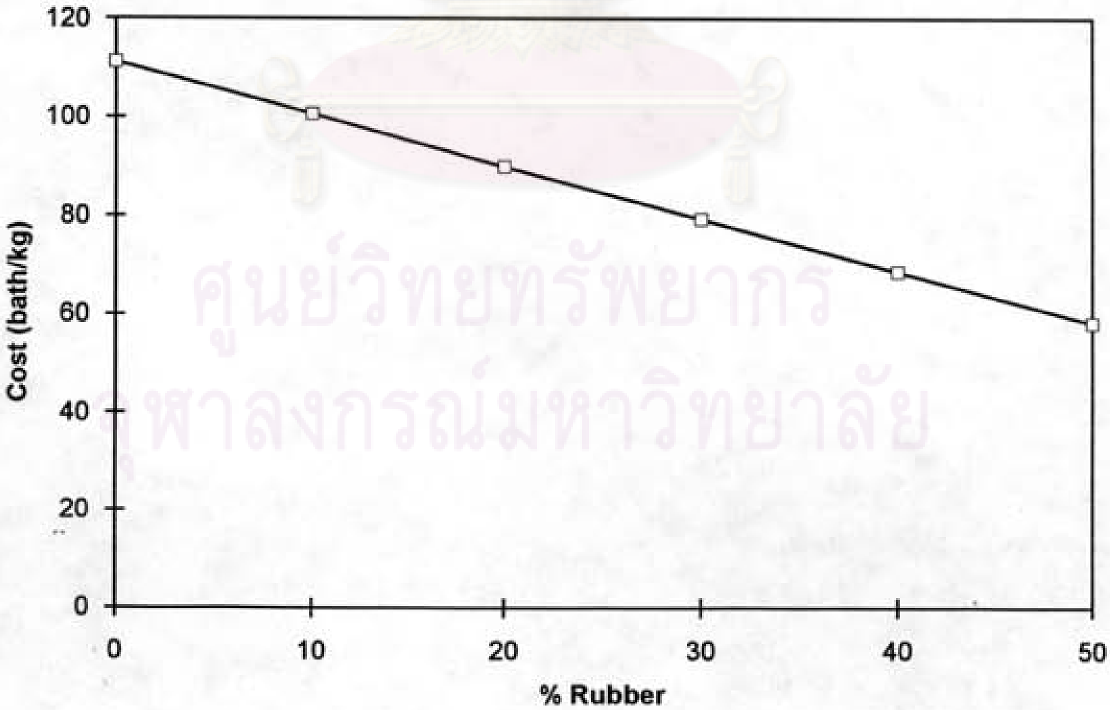

Figure 5.7 Relation between filled-polyurethane, weight percentage of rubber and cost

Table 5.5 Overall cost of the produced paving surface as a function of % waste rubber particle.

% filled-PU	%Rubber	Material Cost (Baht/m^2)	Overall Cost (Baht/m^2)
100	0	2508.87	3010.64
90	10	2269.28	2723.14
80	20	2029.60	2435.52
70	30	1789.99	2147.99
60	40	1550.39	1860.47
50	50	1310.79	1572.95

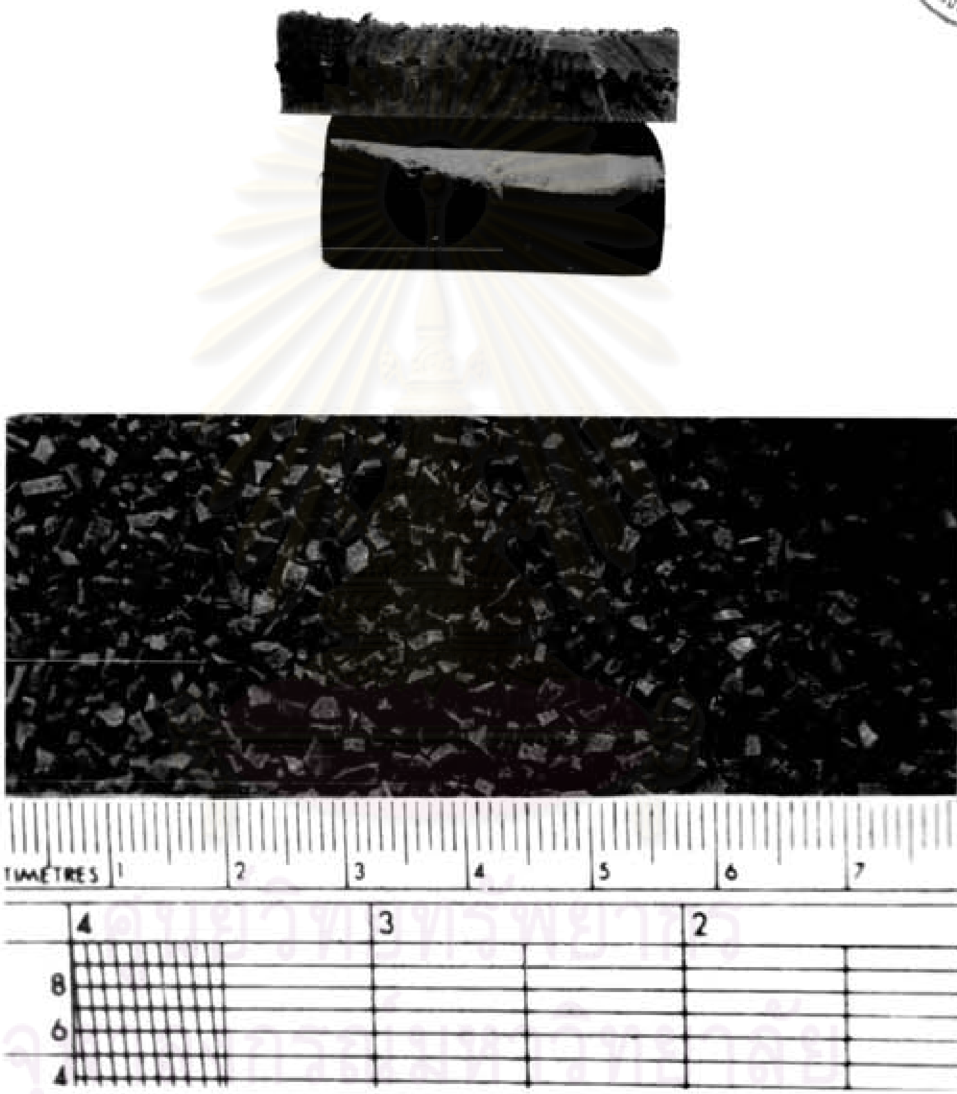

Figure 5.8 Experimental synthetic paving surface

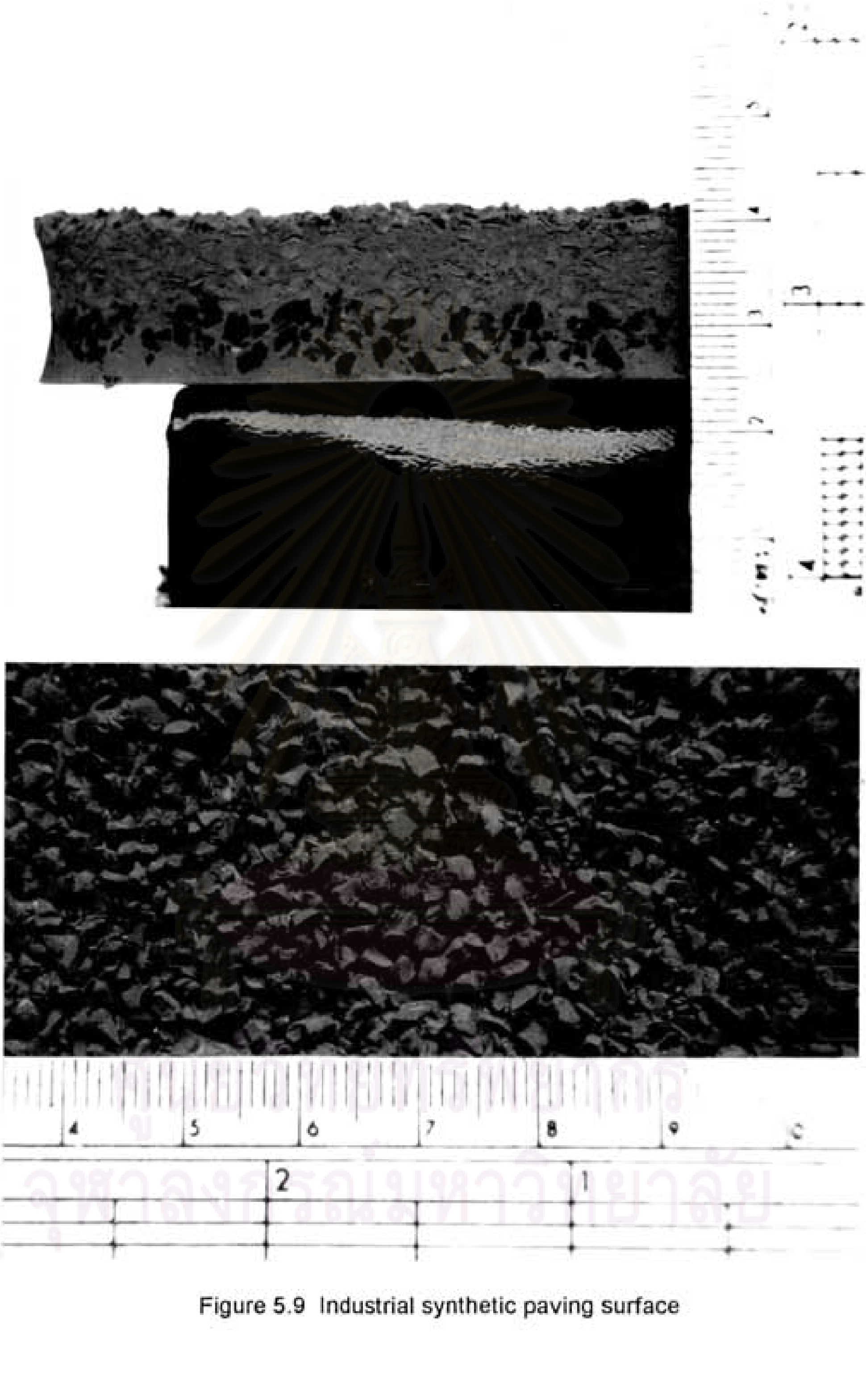

Figure 5.9 Industrial synthetic paving surface

5.2 Conclusion

A sample of finished paving surface of polyurethane was made. On the basis of this work, the suitable composition of the paving surface is : the NCO/OH ratio at 1.03, the molar ratio of polyol : MDI : BDO at 1:4:3 and 10 weight percentage of brick. Brick powder is a suitable filler for polyurethane surface because of its cheapness and its red colour from Fe_2O_3 that requires no addition of pigments. The cost of polyurethane paving material can be reduced by incorporating local cheap brick and substantial amount of waste tire particles in filled-polyurethane.