INVESTIGATING OF USING OF WASTE WATER-PROOFING MATERIALS AS BITUMEN IN ASPHALT MIXTURES

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ABSTRACT

The majority of waste will be produced when a building reaches the end of its life. At present, the majority of insulation waste, whether from manufacturing, installation or end-of-life will be landfilled. Although some manufacturers offer take-back facilities for clean/uncontaminated products, this practice is not common and is likely to continue to be underexploited in the long term due to contamination of the product during use (e.g. with mortar or bitumen). The majority of insulation products do not currently require any special treatment if landfilled.

In this study, the usability of bitumen as bitumen-based water-proofing materials in asphalt mixtures was investigated. Marshall Samples prepared for this purpose included various amounts of waste material. The Standard Marshall testing method for the stability of these wastes was investigated.

Keywords: Marshall Stability, Water-proofing materials, Waste, Aggregate, Flexible Pavement

1. INTRODUCTION

In recent years, some environmental and economic concerns, such as the reduction of natural source, and energy resources have led to the implementation of new techniques and processes. For this aim, highway engineering has used the application of new techniques that contribute to a development that is more environmentally friendly (e.g. pavement recycling, use of waste material in bituminous mixes, low-temperature mixes that reduce emissions, etc.) [1].

Bitumen has been used in road construction and in many other applications for a long time. The material can be produced from crude oils or found in nature as natural asphalt [2].
Bitumen and bituminous mixes are modified in order to improve the performance of hot mix asphalts. There are two main objectives. The first aim is to increase the performance of the asphalt mixture. The cost is increasing because of the polymers used in this method. The second aim is the evaluation of waste materials. A lot of material can be used for modified bitumen: polymer [3] waste polymer [4], waste plastic bottles [5], recycled asphalt shingles [6], polymer-modified emulsions [7,8], crumb rubber [9], wax [10].

The amount of bitumen used on highways, and the percentage of total production in Turkey (Table 1). Table 2 shows the used modified bitumen amount in that time. As shown in the tables, the modified bitumen ratio is very low compared to the amount of total production.

Table 1: Bitumen amount produced and used in highways [11]

Year	Produced amount (1000 ton)	Used in highways amount (1000 ton)	Percent
2003	1.404	1.193	84.97%
2004	1.389	1.326	95.46%
2005	1.753	1.453	82.89%
2006	2.179	1.555	71.36%
2007	2.292	1.876	81.85%

Table 2: Used Polymer Modified Bitumen Amount (Ton) [11]

Year	2000	2001	2002	2003	2004	2005	2006	2007	Total
Amount	3.700	4.350	14.950	5.572	19.098	11.994	34.392	23.661	117.717

In this study, the availability of water-proofing material instead of bitumen in asphalt concrete mixtures was investigated.

2. MATERIALS AND EXPERIMENTS

2.1. Materials

Crushed limestone was obtained from quarries around Isparta which are mainly used for highway construction. The aggregate properties are given in Table 3.

Table 3: Properties of aggregate used in the tests

Properties	Standard	Limestone
Specific gravity (g/cm^3)	(ASTM C 127-88, 1992)	2.660
Saturated specific gravity		2.652
Water Absorption (%)		0.130
Specific gravity (g/cm^3)	(ASTM C 128-88, 1992)	2.329
Saturated specific gravity		2.428
Water Absorption (%)		2.800
Abrasion Loss (%) (Los Angeles)	ASTM C 131(1996)	20.38

In the study, aggregate grading curves for asphalt mixtures were obtained from Turkish Highway specifications. It was seen that the available aggregates grading curve was close to the binder layer specification, as shown in Figure 1. 75-100 penetration asphalt cement was used to prepare the Marshall Samples.

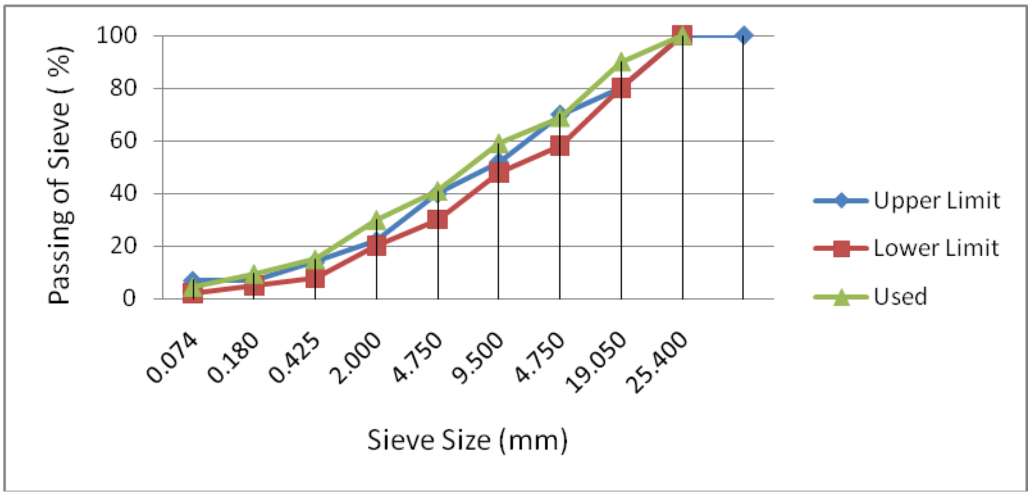

Figure 1: Grading curves of aggregate

2. Water-proofing Membrane

In this study, a fiberglass or polyester and plastomeric (with polyolefinic polymeric base) bitumen membrane was used, the upper and lower surfaces were covered with a polyethylene film, and the torch applied waterproofing membrane. The material was used in Marshall Tests after applied to extraction experiments as the rate of bitumen amount. Table 4 shows the use of water-proofing material over the years.

Table 4: The use of water-proofing material over the years [15]

	2004	2005	2006	2007	2008
Bituminous Coverings (m^2)	25.000.000	31.000.000	40.000.000	93.000.000	80.000.000
Synthetic Covers (m^2)	2.500.000	3.000.000	4.000.000	6.000.000	6.000.000
Coat Based Covers (m^2)	5.500.000	8.000.000	17.000.000	23.233.000	26.000.000
Total (m^2)	33.000.000	42.000.000	61.000.000.	122.233.000	122.000.000

Table 5 shows the extraction test results. As seen in this table, there is an important amount of fiberglass in water-proofing material. This material was directly used in the asphalt mixtures samples production.

Table 5: Extraction test results

Material Area (m^2)	Bitumen (gr)	Fiberglass (gr)	Total (gr)
1	2924.151	724.434	3648.585

3. MARSHALL TESTS

3.1. Mixtures with Limestone Aggregate and Limestone Mineral Filler

Mixtures with Limestone Aggregate and Limestone Mineral Filler were prepared with a 4, 5, 6, 7, and 8 percent rate of bitumen content. As shown in Figure 2, stability reduces whereas bitumen content increases.

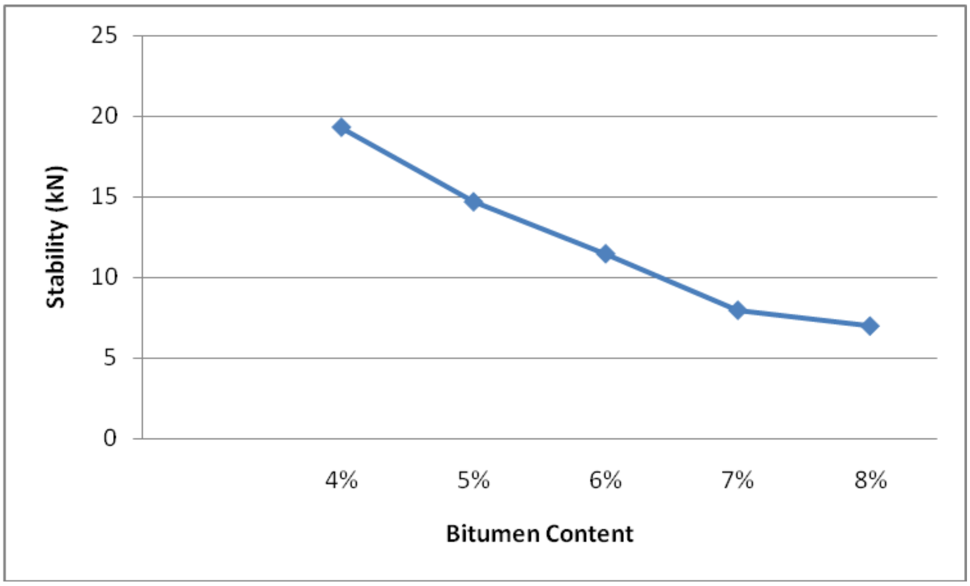

Figure 2: Relationship of stability and bitumen content

For a given asphalt and aggregate mixture, the durability is enhanced if adequate film thickness is attained. For the given effective asphalt content, the film thickness will be greater if the aggregate gradation is coarser. This can most effectively be accomplished by decreasing or minimizing the percentage of fines. Establishing adequate Voids in Mineral Aggregate (VMA) during mix design, and in the field, will help establish adequate film thickness without excessive asphalt bleeding or flushing [16].

In this study, limestone aggregate and limestone mineral filler mixtures gave reductions whereas bitumen content increases after 5 %, as shown in Figure 3. Also, voids filled with bitumen increase while bitumen content increases (Figure 4).

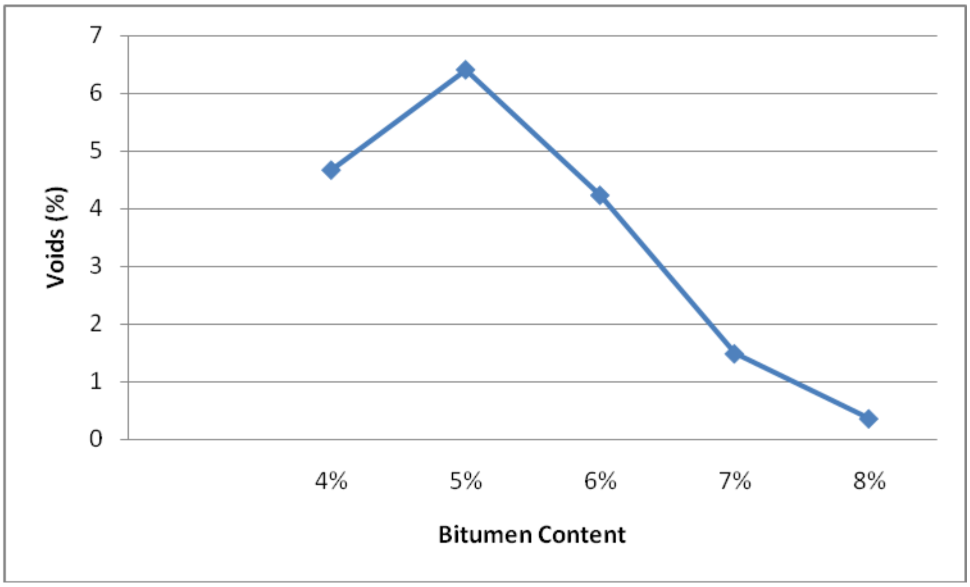

Figure 3: Relationship between air voids and bitumen content

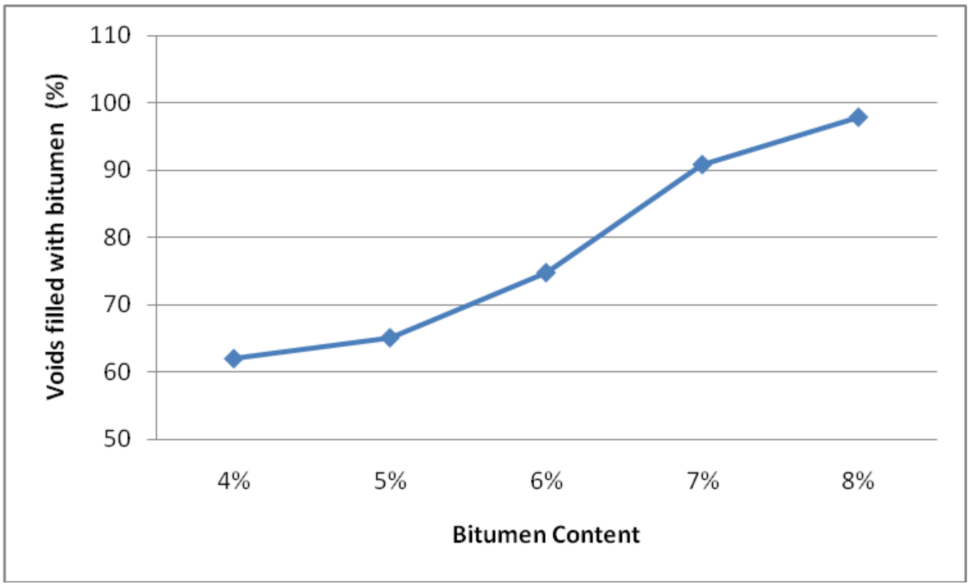

Figure 4: Relationship between voids filled with bitumen and bitumen content

The flow value reflects the properties of plasticity and flexibility of asphalt mixtures. Marshall Samples corresponding to the deformation of the load are broken, which represents a measure of the flow, and also the value of mixing and flow with the value of the internal friction. Flow has a linear inverse relationship with internal friction [17]. Figure 5 shows the relationship between flow and bitumen content. The flow of the mixture with asphalt bitumen, as a result of the experiment showed a linear relationship. Increasing the asphalt bitumen percentage also increases the flow value.

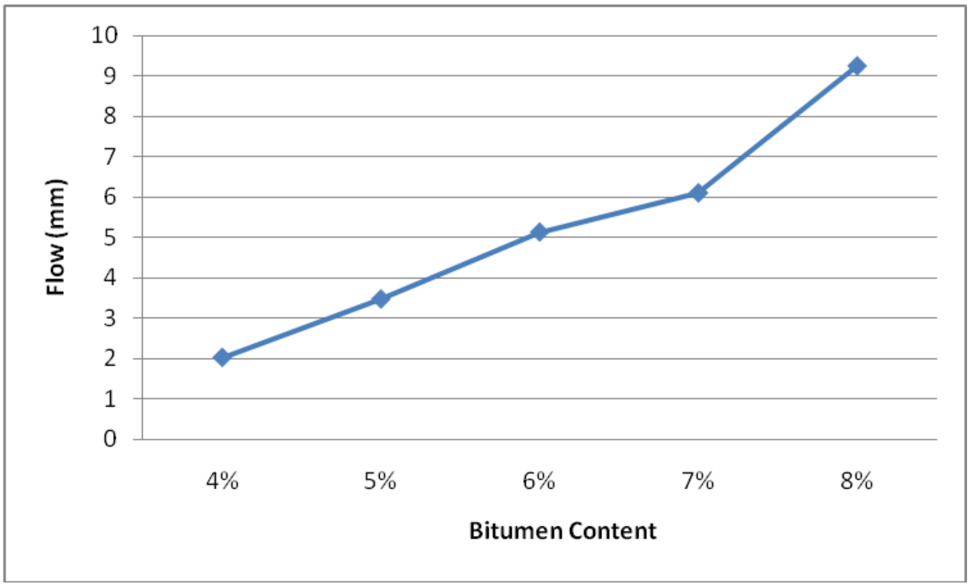

Figure 5: Relationship between flow and bitumen content.

We determined the optimum bitumen content for the mix design by taking the average value of the following three bitumen contents taken from the above graphs.

1. Bitumen content corresponding to maximum stability
2. Bitumen content corresponding to maximum bulk specific gravity
3. Bitumen content corresponding to the median of designed limits of percentage air voids in the total mix (i.e. 4%)
4. Bitumen content corresponding to the median of designed limits of percentage voids filled with bitumen in the total mix (i.e. 80 %)

Limestone aggregate optimum bitumen content: $\frac{4.0+4.0+6.4+6.1}{4}=5.125$

The flow value corresponding to this ratio is 3.6, which is under the maximum values in the specification.

3.2. Mixtures with Normal Bitumen and Waste-proofing Bitumen

Using optimum membrane percent in asphalt cement, the same limestone aggregate and aggregate gradation (Figure 1) with the same bitumen, the mixtures were prepared and the stability values determined. The membrane content ratio was changed 25%, 50%, 75%, and 100% rate in asphalt cement.

With the increasing of the membrane ratio, the stability value increased up to 50 % then decreased as seen in Figure 6.

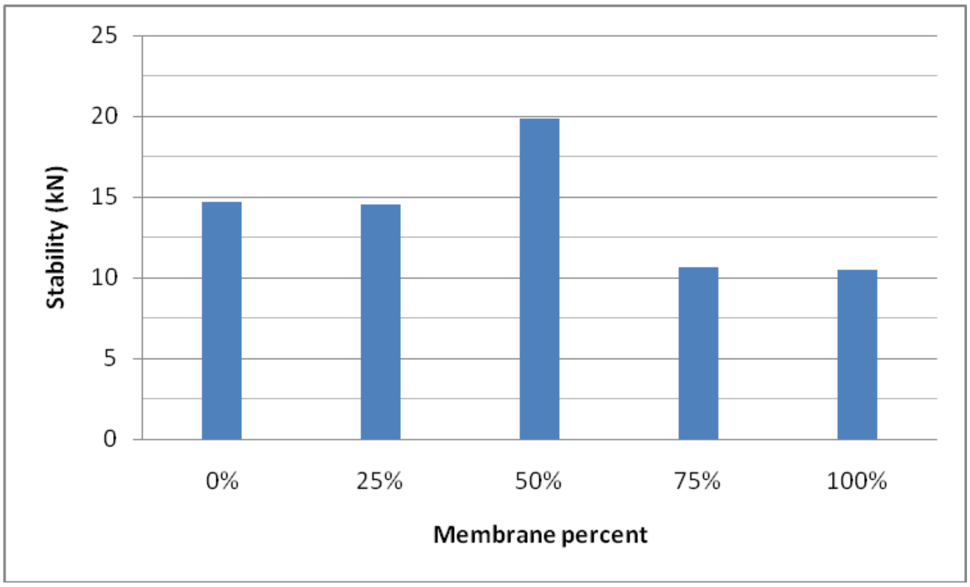

Figure 6: Relationship of stability and membrane ratio

The mixtures gave reduced void percentages whereas membrane percent increases after 25%, as shown in Figure 7. Also, voids filled with bitumen increased while membrane percent increases (Figure 8). However, no membrane percent mixtures gave similar results for 50% percent membrane percent mixtures.

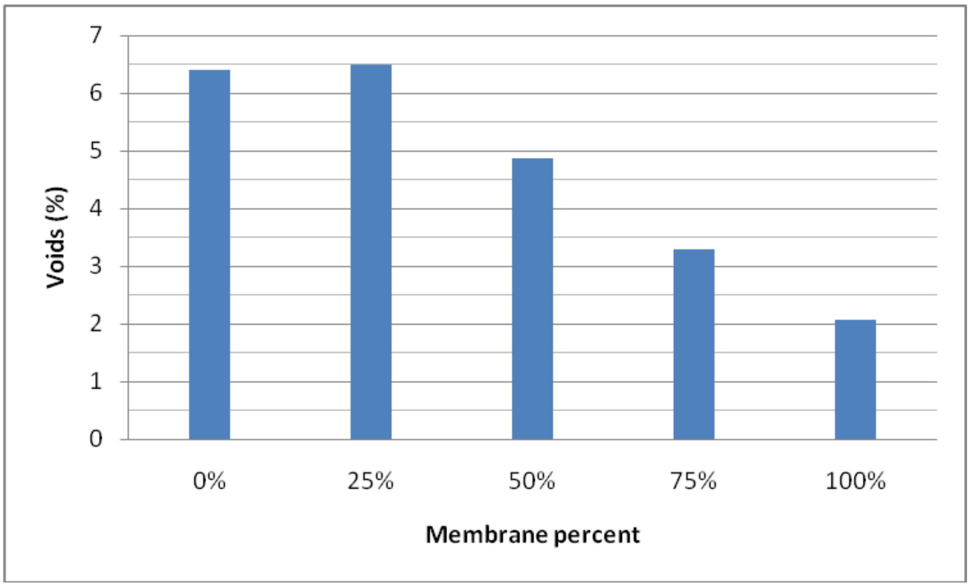

Figure 7: Relationship between air voids and membrane ratio

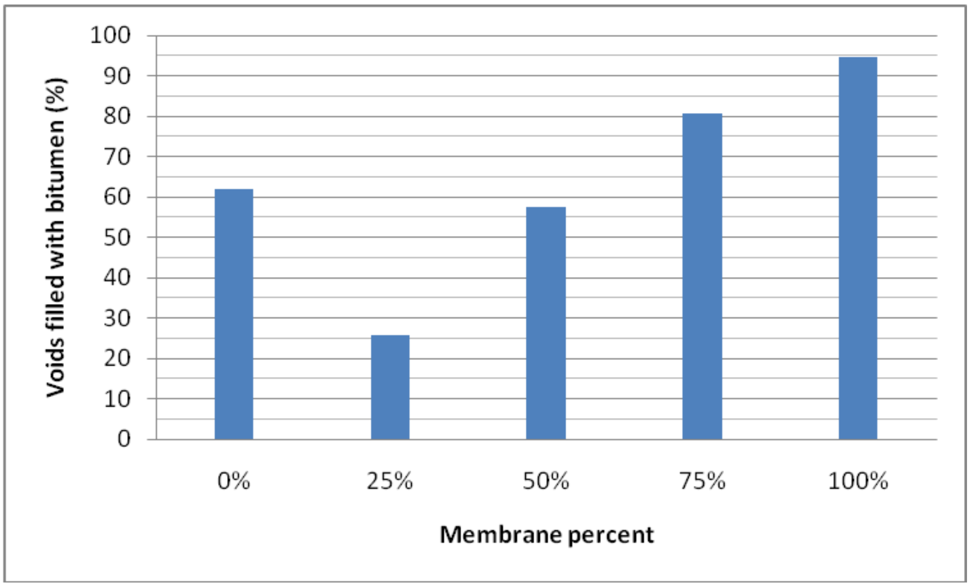

Figure 8: Relationship between voids filled with bitumen and mineral filler ratio

The flow of the mixture with different ratios of mineral filler showed a nonlinear relationship (Figure 9). Increasing the membrane percent in asphalt cement percentage also increases the flow value. However, flow values of mixtures with 75 and 100 % membrane rose above the maximum values in the specification.

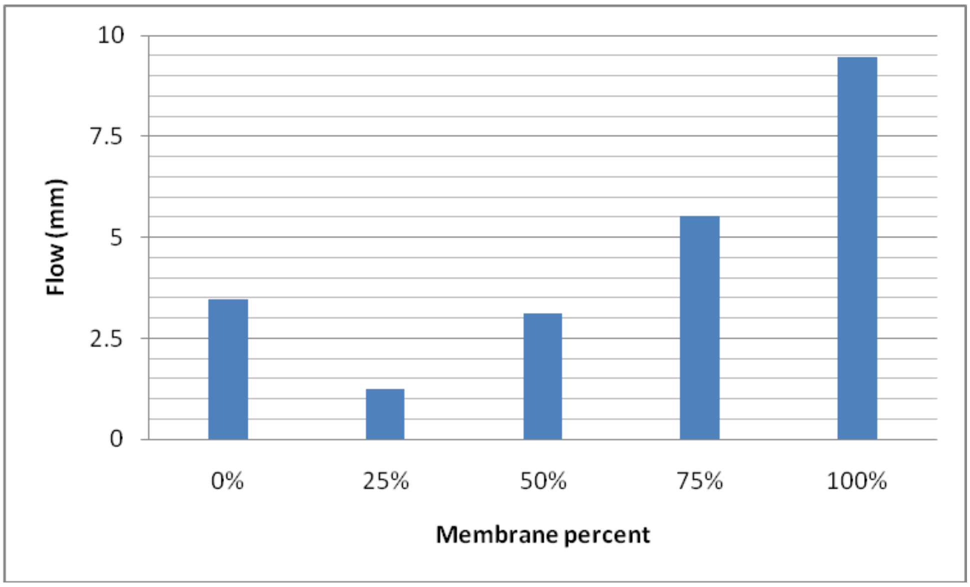

Figure 9: Relationship between flow and membrane percent.

4.CONCLUSIONS

Waste from bitumen-based water-proofing materials is a major environmental problem. Therefore, the evaluation of these materials in pavements will bring an important contribution to the economy and the environment.

The results of experimental studies have shown that waste bitumen -based water-proofing materials using in 50 percent in total bitumen amounts in asphalt mixtures gives a significant positive difference in the Marshall test. Therefore, these materials can be evaluated asphalt concrete mixtures. Directly the use of bitumen-based waste water-proofing materials in bituminous mixtures is economical.

If the construction factories are stocked with bitumen-based water-proofing materials on a regular basis, they can be more easily used in the binder or base layer of hot mix asphalt as bitumen. But, it is not guarantee to use in wearing layer because of they may be decrease of quality and performance for a long time.

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