Performance of Asphalt Concrete with Chrome and Hot Rolled Sheet with Chrome Using Portland Cement Filler and Prevent Exfoliation by Empirical Mechanism

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Abstract. A fine aggregate fraction that passes No. 200 is filler that affects the performance of a hot asphalt mixture. The usual Portland cement used on the asphalt mixture is Portland cement type 1. It will be tested using Portland cement type 1, type 2, type 3, and type 5. The chance of road damage is greater in wet than dry. The loss of asphalt or adhesion attachment can lead to weak bond between the asphalt/binder and the strength of interlocking and friction on the aggregate. If the binding strength is reduced or weak, the damage occurs on the aggregate and the asphalt consequently the structural value becomes reduced. Reduced structural values of weak bonds are often referred to as stripping processes. Aggregate attachment level with asphalt can be increased by adding anti stripping. The results showed that the best filler expression of Portland cement type 1, type 2, type 3 and type 5, was the highest stability filler. This is owned by type 1 and type 5 filler. Portland cement type 1 type stabiltas value is 1,296.10 kg while the type 5 value has a stability of 1317.20 kg.

1. Introduction
The construction of flexible pavement is a pavement type with asphalt as a binding material that has been widely used in the construction of pavement in Indonesia. Asphalt Concrete is one type of pavement construction of flexible pavement and Latissone Thins or Hot Roll Sheets (HRS) with different gradations of parallel to continuous gradual (AC) asphalt [1].

The number of fine aggregate fractions passes the no. 200 affects the performance of hot asphalt mixtures. This aggregate can serve as filler or mortar when united with asphalt binder. The use of aggregate passing through 200 sieves that is too large may affect the use of asphalt and may have negative effects of flow and bleeding. Usable fillers include rock ash, dust, dolomite dust, fly ash, high cement blast furnaces or inorganic mineral materials, Portland cement (PC), and others [2].

The chance of road damage is greater in wet than dry. Another factor that results in damage is the vehicle load that puts pressure on the road surface layer which will result in cracks on the surface. The loss of asphalt bonding power can lead to weak bond between the asphalt / binder and the strength of interlocking and friction on the aggregate. If the binding strength is reduced or weak, the damage occurs on the aggregate and the asphalt consequently the structural value becomes reduced. Reduced
structural values of weak bonds are often referred to as stripping processes on the type of pavement bending.

Aggregate attachment level with asphalt can be increased by adding anti stripping. Several anti-stripping have been developed such as surface active compounds which were used in the 1950s and chemical compounds such as amidomines, imadozolines, cement (Portland cement) and hydrated lime.

The design of a paved mixture that relies solely on Marshall Parameters is not sufficient. In this decade, the Strategic Highway Research Program (SHRP), U.S.A has conducted research to obtain a fairly rigid asphalt mixture to withstand deflection but still flexible enough to withstand cracks [3].

2. Literature Review

2.1. Heat Resistant Mixture to Water
Water on the pavement is very influential on the service life of paved construction. Some of the factors causing pavement damage due to water effects can be caused by aggregate conditions, asphalt, mixed type, weather and environmental influences, and drainage conditions. The presence of fine plastic material in the fine aggregate fraction of the asphalt concrete mixture may cause stripping in the mixture when it is affected by water or moisture.

2.2. Anti Stripping
The adhesion between aggregate and asphalt is thought to be closely related to the service life of asphalt mixtures. The damage that is often encountered when the stick is less is stripping on the aggregate which can cause damage to loose on the surface. Furthermore, if not immediately addressed will cause more widespread damage such as holes.

2.3. Combined Aggregate Gradation

| The size of the sieve (mm) |  |  |
|---------------------------|---|---|
|                           | WC | Base | WC | BC |
| 37.5                      | 100 | 100 | 100 | 100 |
| 25                        | 100 | 90-100 | 90-100 | 90-100 |
| 19                        | 90-100 | 65-90 | 77-90 | 66-82 |
| 12.5                      | 75-85 | 53-69 | 33-53 | 30-49 |
| 9.5                       | 75-85 | 53-69 | 33-53 | 30-49 |
| 4.75                      | 50-723 | 35-553 | 21-40 | 18-38 |
| 2.36                      | 50-723 | 35-553 | 21-40 | 18-38 |
| 1.18                      | 50-723 | 35-553 | 21-40 | 18-38 |
| 0.600                     | 35-60 | 15-35 | 14-30 | 12-28 |
| 0.300                     | 35-60 | 15-35 | 14-30 | 12-28 |
| 0.15                      | 35-60 | 15-35 | 14-30 | 12-28 |
| 0.075                     | 35-60 | 15-35 | 14-30 | 12-28 |

2.4. The Marshall Properties of Hot Asphalt Mixes
General Spesification of Bina Marga revised 3 [4], Asphalt Concrete (AC) and Hot Rolled Sheet (HRS) characteristics can be measured by Marshall testing which will generate parameters: Density, Voids In the Mix (VIM), Voids Filled With Asphalt (VFWA), stability, flow, and Marshall Quotient.
2.5. Mixed Asphalt Mechanized Parameters

2.5.1. Mixture of asphalt Modulus Resillient. Huang Yang [5][6] said that the modulus of asphalt mixture commonly used in planning is the Resillient Modulus. The flexural resillient modulus is the elastic modulus used in elastic theory. Figure 1 shows the stretching of the specimens that occur on the asphalt mixture in the repeated load test. At the start of the load, the specimen will suffer a high enough deflection, indicated by its plastic strain. This strain will increase in line with the increased repetition of the load given. But after a relatively long load, the subsequent strain will be fully reversed which is referred to as a resilient ($\varepsilon_r$).

![Figure 1. Void that occurs on the Repeated Load Test](image)

2.5.2. Permanent Deformation. NCHRP [7], permanent deformation of asphalt mixtures occurs gradually in line with the amount of traffic load through it. The general form of deformation occurring in the asphalt mixture is the formation of elongated grooves on the wheel trajectories of vehicles without or with the jembul on both sides of the groove. The two causes of the flow on the asphalt layer are the presence of advanced compaction and shear deformation caused by traffic.

2.5.3. Resilience to Fatigue. NCHRP [8], fatigue of an asphalt mixed material is a decrease in material performance due to receiving recurrent loads. Fatigue resistance of asphalt mixture is one of the main factors causing failure in pavement layer structure. In order for pavement age to be in accordance with the planning age of the service plan, the resilience of the asphalt mixture to the recurrent load should be included in the planning.

3. Methodology
This study aims to analyze the effect of anti stripping with filler Portland cement type 1, type 2, type 3, and type 5 on asphalt concrete mixture using empirical mechanistic method.

The goal to be achieved in this research as follows:

a) Obtaining the best type of Marshall Filler Portland cement type 1, type 2, type 3, and type 5 types, the highest stability of Asphalt Concretee with Chrome (AC-WC) and Hot Rolled Sheet with Chrome (HRS-WC).

b) Obtain performance of Marshall (Stability) and Empirical Mechanisms (flexural stiffness modulus, permanent deformation, and fatigue), using the best portland cement filler with and without the addition of anti stripping to Asphalt Concretee with Chrome (AC-WC) mixture and Hot Rolled Sheet With Chrome (HRS-WC).
Seeking performance relationships of Marshall (Stability) and Empirical Mechanisms (modulus of flexural rigidity, eternal deflection, and fatigue), using the best Portland cement filler with and without peel-off for Asphalt Concrete with Chrome (AC-WC) mixture and Hot Rolled Sheet with Chrome (HRS-WC).

Figure 2. Flow of Research

Stage I:
1. The problem formulation is the performance of AC-WC and HRS-WC mixtures using a portland cement filler and anti stripping with Marshall tests. The next step sets the hypothesis, and sets the variables to be studied.
2. The research design is based on the variables to be studied and the determination of the number of samples.

Stage II:
1. Mixed planning aims to obtain the best stability of Asphalt Optimum (KAO) on AC-WC and HRS-WC mixtures by using variations of filler type portland cement, type 1, type 2, type 3, and type 5.
2. Mixed planning is to design aggregate gradation mixtures and set an estimate of optimum asphalt content.
3. After obtaining the best stability on the Optimum Asphalt Level (KAO) on variations of filler type portland cement type 1, type 2, type 3, and type 5 mixed AC-WC and HRS-WC, the next 2 (two) filler portland cement highest Its stability value for phase III research.

Stage III :
1. Preparation of AC-WC and HRS-WC mixed test specimens is the highest filler portland cement of stability. Then added to anti stripping respectively 0%, 0.2%, 0.3%, and 0.4%, then tested Marshall to obtain stability value and stability Marshall residual.
2. Measuring the best mixed AC-WC and HRS-WC mixture mechanistic values, plus anti-stripping addition of 0%, 0.2%, 0.3% and 0.4%, respectively, an indirect tensile strength test Flexible rigidity modulus, Wheel Tracking Machine testing to determine mixed resistance to eternal deflection or measuring dynamic stability due to recurrent wheel load, and fatigue testing to obtain fatigue life that is the amount of repetition of load until collapse (Number of failure =Nf).
3. After obtaining stability values and remaining Marshall stability, flexible stiffness modulus, permanent deformation, and mixed fatigue of AC-WC and HRS-WC, then analyzed to make conclusions and suggestions.

After the researchers got the data, the researchers tested the data with statistical tests. In this study, the statistical approach was more emphasized on the level of relationship between dependent variable and independent variable expressed as correlation analysis in regression. This is done considering that in the implementation of this research is not done randomly from the source material, the variables in this study have been controlled on each specimen.

4. Result and Discussion

4.1. Marshall Testing and Best Portland cement Filler Selection

| Table 2 Test Result of AC-WC with Marshall Test |
|-----------------------------------------------|
| No   | Mixed characteristics                      | AC-WC                  |
|      | Filler PC Type 1 | Filler PC type 2 | Filler PC type 3 | Filler PC type 5 | Filler Ash Stone | Requirements |
| 1.   | Optimum bitumen content (%)                 | 5.28                  | 5.40             | 5.35             | 5.30             | 5.48         | -            |
| 2.   | Density (t/m³)                               | 2.520                 | 2.517            | 2.500            | 2.525            | 2.482        | -            |
| 3.   | Void Filled With Asphalt (FVB) (%)           | 77.64                 | 77.21            | 75.35            | 77.45            | 73.58        | Min.63       |
| 4.   | Void in Mix (VIM) Marshall (%)               | 3.43                  | 3.58             | 3.91             | 3.77             | 4.37         | 3.5 - 5.5   |
| 5.   | Void In Mineral Aggregate (VMA) (%)          | 15.25                 | 15.70            | 15.81            | 15.37            | 16.50        | Min. 14      |
| 6.   | Void in Mix (VIM) PRD (%)                    | 2.48                  | 2.82             | 2.83             | 2.43             | 2.96         | Min. 2.5    |
| No | Mixed characteristics | AC-WC |  |
|----|------------------------|-------|---|
| 7. | Marshall Stability(Kg) | 1.296,10 | 1.264,40 |
| 8. | Melting (mm) | 3.40 | 3.60 |
| 9. | Marshall Quotient (Kg/mm) | 381.06 | 351.22 |
| 10. | Stability of Marshall leftover (%) after Soaking for 24 hours. 60 °C | 94.30 | 93.20 |

Table 3. Test Result of HRS-WC with Marshall Test

| No | Mixed characteristics | HRS-WC |  |
|----|------------------------|-------|---|
| 1. | Optimum bitumen content (%) | 6.25 | 6.40 |
| 2. | Density (t/m³) | 2.449 | 2.444 |
| 3. | Void Filled With Asphalt (FVB) (%) | 75.20 | 75.20 |
| 4. | Void in Mix (VIM) Marshall (%) | 4.80 | 5.10 |
| 5. | Void In Mineral Agreggate (VMA) (%) | 19.30 | 20.00 |
| 6. | Void in Mix (VIM) PRD (%) | 3.70 | 3.80 |
| 7. | Marshall Stability(Kg) | 1.137,40 | 1.128,40 |
| 8. | Melting (mm) | 3.60 | 3.50 |
| 9. | Marshall Quotient (Kg/mm) | 315.75 | 322.40 |

Table 3. Test Result of HRS-WC with Marshall Test
From Marshall Test would get the best portland cement filler value that was the highest stability value, hence the highest stability was portland cement filler was type 1 and type 5. For further research to be used filler portland cement type 1 and type 5 which would be supplemented by preventing exfoliation to find the value of stability, modulus resilience, permanent deformation and fatigue.

4.2. Characteristics of Marshall with Prevented Peel Levels

| No | Mixed characteristics | Filler PC Type 1 | Filler PC Type 2 | Filler PC Type 3 | Filler PC Type 5 | Filler Ash stone |
|----|-----------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|    | Stability of Marshall leftover (%) after Soaking for 24 hours. 60 °C | 95,80 | 93,90 | 91,70 | 96,80 | 90,50 | Min. 90 |

**Table 4. Result of Characteristics of Marshall AC-WC**

| No | Characteristics of Marshall | AC-WC (kg) |
|----|-------------------------------|------------|
|    |                               | Filler PC type 1 With anti stripping levels (%) | Filler PC type V With anti stripping levels (%) |
|    |                               | 0 % | 0,2 | 0,3 | 0,4 | 0 % | 0,2 | 0,3 | 0,4 |
| 1  | Stability Kg)                 | 1.296,1 | 1.362,36 | 1.345,38 | 1.350,99 | 1.317,20 | 1.366,60 | 1.338,82 | 1.355,35 |
| 2  | Melting (mm) Marshall Quotient (Kg/mm) Marshall leftover (%) | 3,40 | 3,50 | 3,50 | 3,60 | 3,50 | 3,50 | 3,60 | 3,60 |
| 3  | 381,06 | 389,24 | 384,39 | 375,28 | 376,40 | 390,46 | 371,89 | 376,49 |
| 4  | 94,30 | 95,10 | 96,30 | 95,90 | 96,40 | 96,40 | 98,40 | 97,20 |

**Table 5. Result of Characteristics of Marshall HRS-WC**

| No | Characteristics of Marshall | HRS-WC (kg) |
|----|-------------------------------|------------|
|    |                               | Filler PC type 1 With anti stripping levels (%) | Filler PC type V With anti stripping levels (%) |
|    |                               | 0 % | 0,2 | 0,3 | 0,4 | 0 % | 0,2 | 0,3 | 0,4 |
| 1  | Stability Kg)                 | 1.137,4 | 1.180,37 | 1.169,44 | 1.175,49 | 1.164,80 | 1.192,64 | 1.181,76 | 1.18657 |
| 2  | Melting (mm) Marshall Quotient (Kg/mm) Marshall leftover (%) | 3,60 | 3,60 | 3,70 | 3,60 | 3,40 | 3,50 | 3,60 | 3,50 |
| 3  | 315,75 | 327,88 | 316,07 | 326,53 | 343,06 | 340,75 | 328,27 | 339,02 |
| 4  | 95,80 | 96,30 | 97,20 | 96,70 | 96,80 | 97,80 | 96,70 | 98,30 |
4.3. The Test of Modulus Resilience

Table 6. The Test Result of Indirect Tensile Strength

| Mixture    | Temperature Testing | Modulus of Bending Strength of AC-WC and HRS-WC (MPa) |
|------------|---------------------|-----------------------------------------------------|
|            |                     | Filler PC type 1 | With anti stripping levels (%) | Filler PC type V | With anti stripping levels (%) |
|            |                     | 0 %   | 0.2  | 0.3  | 0.4  | 0 %   | 0.2  | 0.3  | 0.4  |
| AC-WC      | 25°C                | 3.346 | 3.808| 3.441| 1.770| 3.757 | 3.881| 3.201| 2.130|
|           | 35°C                | 698   | 640  | 731  | 585  | 576   | 655  | 736  | 585  |
|           | 45°C                | 234   | 179  | 294  | 205  | 171   | 199  | 234  | 105  |
|           | 60°C                | 140   | 163  | 271  | 183  | 151   | 117  | 160  | 94   |
| HRS-WC     | 25°C                | 2.000 | 2.910| 3.184| 1.753| 1.560 | 2.569| 2.633| 1.723|
|           | 35°C                | 476   | 506  | 514  | 452  | 410   | 444  | 433  | 553  |
|           | 45°C                | 225   | 401  | 271  | 289  | 212   | 237  | 458  | 269  |
|           | 60°C                | 125   | 151  | 251  | 163  | 131   | 107  | 150  | 84   |

The Resilient Modulus value was strongly influenced by the temperature factor. With increasing temperature, it would decrease the modulus of flexural rigidity. The effect of temperature on the mechanistic properties of asphalt mixture was mainly due to the change of asphalt. It was due to the viscoelastic asphalt that could change from viscous to elastic or vice versa caused by temperature change.

4.4. Testing Resilience to Permanent Deformation

Table 7. Test Result of Whell Tracking Machine AC-WC

| Load                    | Sample AC-WC  | Filler PC type 1 | With anti stripping levels (%) | Filler PC type V | With anti stripping levels (%) | Unit  |
|-------------------------|---------------|------------------|--------------------------------|------------------|--------------------------------|-------|
| Early Deformation       | 2,16          | 2,43             | 2,33                           | 2,21             | 2,18                           | 2,08  | 2,14 | 2,12 | mm   |
| Dynamic Stability       | 1,167,0       | 1,400,0          | 1,909,1                        | 1,750,0          | 1,909,1                        | 2,032,3 | 2,333,3 | 2,172,4 | track/mm |
| Deformation speed       | 0,036         | 0,03             | 0,022                          | 0,024            | 0,022                          | 0,027 | 0,018 | 0,0193 | mm/minute |


Table 8. Test Result of Wheel Tracking Machine HRS-WC

| Load                     | Filler PC type 1 | Filler PC type V | Unit       |
|--------------------------|------------------|------------------|------------|
|                          | With anti stripping levels (%) | With anti stripping levels (%) |            |
|                          | 0 %     | 0.2     | 0.3     | 0.4     | 0 %     | 0.2     | 0.3     | 0.4     |
| Early Deformation        | 3.52    | 3.88    | 4.28    | 3.92    | 2.07    | 2.29    | 2.41    | 2.18    |
| Deformation speed        | 0.094   | 0.089   | 0.078   | 0.0847  | 0.073   | 0.068   | 0.060   | 0.0613  |
| Dynamic Stability        | 446,8   | 473,7   | 538,5   | 496,1   | 572,7   | 617,6   | 700,0   | 684,8   |

The Wheel Tracking Machine was used to know the asphalt mixture was resistant to permanent deformation due to heavy and repetitive loads. This tool simulated the flow of wheels caused by heavy vehicles at high temperatures on a flat road to evaluate the rate of deformation that occurs. The value of the depth of the path associated with the number of passes through which the load (dynamic stability, tract / mm) or Dynamic Stability (DS). The greater the value of dynamic stability, the asphalt mixture was more resistant to receiving the traffic load.

4.5. Resilience to Fatigue

Table 9. Test Results Resilience to Fatigue AC-WC and HRS-WC

| No. | Control Strain | AC-WC Cycle (Nf) | HRS-WC Cycle (Nf) |
|-----|----------------|------------------|-------------------|
|     |                | Filler PC type 1 | Filler PC type V  |
|     |                | With anti stripping levels (%) | With anti stripping levels (%) |
|     |                | 0 %     | 0.2     | 0.3     | 0.4 | 0 %     | 0.2     | 0.3     | 0.4 |
|     | cycle (Nf)     | cycle (Nf) | cycle (Nf) | Cycle (Nf) | cycle (Nf) | cycle (Nf) | cycle (Nf) | cycle (Nf) |
| 700 | 4.770          | 9.850     | 8.540     | 6.160     | 8.900     | 9.280     | 10.320    | 29.120    |
| 600 | 10.220         | 25.300    | 24.460    | 20.860    | 20.002    | 21.010    | 22.560    | 31.740    |
| 500 | 13.710         | 36.360    | 44.150    | 57.610    | 40.500    | 43.000    | 43.350    | 38.450    |
| 700 | 28.010         | 41.870    | 37.670    | 17.870    | 16.001    | 16.490    | 43.290    | 23.860    |
| 600 | 50.200         | 57.480    | 47.980    | 37.790    | 30.200    | 32.780    | 71.670    | 49.240    |
| 500 | 128.660        | 128.890   | 161.080   | 80.270    | 68.900    | 697.80    | 122.750000| 65.590    |

In order for the flexible pavement layer to function properly to receive recurrent loads, the pavement of the structure should be made to the required properties of the internal pavement required. The most closely approximated field testing method to find out the mixed bending stiffness modulus was the test using Beam Fatigue Apparatus.
The use of shrub-proofing was a material that will increase the aggregate aggregation in hot asphalt mixtures AC-WC and HRS-WC which in amount of its use would affect fatigue resistance. Types of mixed gradations could also affect. The result showed that the HRS-WC mixture was more resistant to receiving recurrent loads from AC-WC mixtures.

5. Conclusion
The research found that the best filler of Portland cement Type 1, Type 2, Type 3 and Type 5, which was the highest stability filler, it was owned by Type 1 and Type 5 Filler. Thus, the Type 1 and Type 5 filler Portland cement had a high stability value in improving the mixed Asphalt Concretee with Chrome (AC-WC) and Hot Rolled Sheet with Chrome (HRS-WC).

The results showed that the use of the Type 1 and Type 5 filler Portland cement (best Portland cement) and the addition of exfoliate materials could increase the stability value of Asphalt Concretee with Chrome (AC-WC) and Hot Rolled Sheet with Chrome (HRS-WC). It was stated by the calculation of the AC-WC asphalt mixture with the Type 1 filler Portland cement plus a 0.4% peel prune having the highest stability value of 1,350.99 kg then the AC-WC mixture with the Type 5 flyland cement filler plus a peel of 0.4% with a stability value of 1,355.35 kg. While the mixture of HRS-WC with Portland cement Type 1 filler plus shave 0.4% had the highest stability value that is 1,175.49 kg. Then mix HRS-WC with filler Portland cement Type 5 plus shred peel 0.4% with stability value 1,186, 57 kg. While the mixture of HRS-WC with filler Portland cements Type 1 plus avoids 0.1% peel had the lowest stability of 1,136.70 kg. Then, a mixture of HRS-WC filler Portland cement Type 5 with a 0.1% peeled peel has the lowest stability of 1,166.40 kg.

The results showed that the mixture of AC-WC Filler portland cement type 5 by preventing peel 0.2%. The mixture has the highest flexural rigidity modulus of 3,881.00 Mpa at 25°C, 655 Mpa at 35°C, 199 Mpa at 45°C and 117 Mpa at 60°C. The AC-WC uses a filler portland cement type 1 plus a 0.2% peel absorbance modulus of the highest flexural rigidity of 3,808.00 Mpa at 25°C, 640 Mpa at 35°C and 179 Mpa at 45°C and 163 Mpa at a temperature of 60°C. Then, a mixture of HRS-WC filler portland cement type 5 plus a 0.4% shredded peel of mixture had the lowest modulus of bending stiffness of 1,723.00 Mpa at 25°C, 553 Mpa at 35°C, 269 Mpa at 45°C and 84 Mpa at 60°C.

The results showed that filler Portland cement type 1 and type 5 and the addition of exfoliate materials can increase the value of deflection eternal. The AC-WC mixture with a filler portland cement type 1 plus avoids 0.3% peel has the greatest dynamic stability value of 1,909.00 trajectory / mm with a rate of deformation rate of 0.022 mm / min. The asphalted mixture of HRS-WC filler Portland cement type 1 plus avoids 0.3% peel with the lowest dynamic stability rung of 539.00 traje / mm and a deformation rate rate of 0.078 mm / min.

The test results showed that the HRS-WC mixture with the type 1 Portland cement filler plus the 0.2% peeled shave had the number of repetitions of loads up to the highest Number of failures, which means more resistant to recurrent loads of 128,890.00 cycles. Furthermore HRS-WC mixture with filler Portland cement type 5 plus avoids 0.3% peel with fatigue lifespan of 122,750.00 cycles compared to AC-WC hot paved mixture with filler Portland cement type 1 plus the lowest peel 0.4% For 6,160.00 cycles.

The results showed that the use of the Type 1 and Type 5 filler Portland cement could increase the empirical mechanistic value. It was proved by regression analysis obtained correlation modulus flexural and stability Modulus:

\[ 3.543 \text{of stability - 184.66 of bitumen content - 2781.17 of prevent peel.} \]

From the regression analysis, the correlation between flexural and stability modulus is:

\[ \text{Dynamic Stability} = 3.18 \text{of stability -349.94 of bitumen - 225.39 of prevent peel.} \]

From the regression analysis obtained fatique and Stability relations are:

\[ \text{Cycles} = 37.24 \text{of stability} + 10388.32 \text{of bitumen} + 23507.61 \text{of prevent peeling.} \]
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