The Effect of Iron Powder Waste as a Replacement of Amount of Fillers on HRS (Hot Rolled Sheet)

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Abstract. Hot Rolled Sheet (HRS) HRS is used on roads with moderate traffic loads, Hot Rolled Sheet is flexible and has high durability, this is due to the mixture of HRS with large gradations having a large cavity in the mixture, so as to absorb the amount of asphalt large amounts (7-8%) without bleeding, due to the nature of the HRS above, the author chose the HRS pavement type to be modified so that the stability and flow value increased. This study was aimed to determined how much influence iron waste have on stability and flow. This study was used an experimental method that is with a laboratory experiment to get the results, thus the effect of the utilization of iron powder waste on HRS (hot rolled sheet) pavement with variations of 0%, 5%, 10%, 15%, and 20% of filler weight. From the results of this study was found that: Iron powder based on gradation and specific gravity test and water absorption has fulfilled the requirements as fillers as regulated in SNI 03-4142-1996. From the Marshall test data obtained, variations that meet the requirements for the properties of Marshall parameters for HRS-WC pavement are variations of 5% and 10%. Percentage of addition of iron powder variation from filler weight which results in the highest stability and flow and fulfills all characteristics the Marshall parameter is a variation of 10%.

1. Introduction

Roads are the basic and main infrastructure in moving the wheels of the national and regional economies. Road damage in Indonesia is generally caused by overloading, heavy flow of vehicles as a result of rapid growth in the number of vehicles, especially commercial vehicles and environmental changes or due to poor drainage function, the researchers conclude the need to increase the stability and flow of a road pavement by increasing the quality of its constituent materials, one of which is the filler where the filler used is modified with variations in the number of fillers with iron powder [1].

Hot Rolled Sheet (HRS) is used on roads with moderate traffic load, Hot Rolled Sheet is flexible and has a high durability, this is due to the mixture of HRS with large gradations having a cavity in a mixture that is large enough, so it can absorb the amount of asphalt in the amount many (7-8%) without bleeding [2]. By looking at the nature of HRS above, the authors choose the type of HRS pavement to be modified so that the stability value increases.

Broadly speaking the problems that exist are: Does the use of iron powder waste with different levels of variation as a substitute for some fillers in the HRS asphalt pavement mixture can meet the requirements of the characteristics of the Marshall parameters?. What is the composition of the best iron powder waste mixture produced from the Marshall test.
The purpose of this study is to determine how much influence the use of variations of iron powder waste on the characteristics of Marshall parameters in the asphalt pavement mixture. To get the composition of variations in the mixture of iron powder waste with the best results using Marshall parameters.

The benefits of holding this research are as follows: Can be used as a reference for asphalt mixing research by using variations of iron powder waste as a filler in asphalt pavement mixture, Can provide information about asphalt pavement innovation, Can give knowledge to readers about the use of iron powder waste, The existence of this study is expected to be able to provide insights and add insight into the effect of the use of iron powder waste as an alternative filler material in lataston mix (HRS).

Research purposes is to find out how much influence the use of variations of iron powder waste on the characteristics of Marshall parameters in the asphalt pavement mixture, and to get the composition of variations in the mixture of iron powder waste with the best results using marshall parameters.

While the benefits of research are as follows:
- Can be used as a reference for asphalt mixing research by using variations of iron powder waste as a filler in asphalt pavement mixture[3] [4]
- Can provide information about asphalt pavement innovation [5].
- Can give knowledge to readers about the use of iron powder waste[5].
- The existence of this study is expected to be able to provide insights and add insight into the effects of the use of iron powder waste as an alternative filler material in lataston mix (HRS)

2. Research Methods

![Flowchart Research Steps](image)

Figure 1. Flowchart Research Steps
2.1. Material Preparation

Materials used include:

a. Iron powder waste obtained from several lathe workshops in Purwokerto
b. Aggregate, including [6]:
   - Coarse aggregate of size ½ Coarse aggregate comes from the Klawing river and is obtained from the results of a stone crusher from PT. AW Patikraja, Banyumas Regency, Central Java.
   - Fine aggregate comes from the Kalierang river Bumiayu.
   - The filler aggregate comes from the Klawing river and is obtained from the results of a stone crusher from PT. AW Patikraja, Banyumas Regency, Central Java.

c. Asphalt material using Pertamina asphalt penetration 60/70.

Material inspection is intended to determine the quality of the material to be used in research, whether by the specified requirements or not. The aggregate examination is carried out at the Jalan Raya Muhammadiyah University Laboratory in Purwokerto.

2.2. Mixed Planning

Making the Mixed Working Formula (FCK)

Mixed testing in the laboratory must be carried out in three basic steps, namely: Obtaining an appropriate aggregate gradation, making a mixture of plans, obtaining approval of mixed plans as a work plan mix[7].

Calculate the estimated asphalt level of the plan (Pb)

\[ Pb = 0.035 \times (\% \text{ CA}) + 0.045 \times (\% \text{ FA}) + 0.18 \times (\% \text{ FF}) + k \]

Where:
- \( Pb \) = Initial plan asphalt level is % of the weight of the mixture
- \( CA \) = Coarse aggregate is % of aggregate held by filter no. 8
- \( FA \) = Fine aggregate is % retained by aggregate passing filter no. 8 and retained sieve no. 200
- \( FF \) = Fillers or fine aggregates pass filter no. 200
- \( K \) = Constants ranging from 1-2

Manufacture of test specimens[7].

Based on SNI 06-2489-1991 testing on asphalt mixture testing methods using Marshall tools, it is planned to carry out at least 5 variations of asphalt mix testing with iron powder waste, and each variation of at least 3 test pieces is made. Testing is carried out on the asphalt and powder waste mixtures iron with a percentage variation of 0%, 5%, 10%, 15%, 20% made as many as three pieces of test specimens for each variation, so the total test pieces as many as 15 pieces.

3. Results and Discussion

Testing gradation and aggregate physical properties

a. Rough aggregate testing
   - Testing of coarse aggregate in the form of gravel from the Serayu river with a stone size of ½ meets SNI requirements.

b. Testing fine aggregate gradation
   - The testing of fine aggregate in the form of sand from the Kalierang Bumiayu river meets SNI requirements.

c. Grading gradation [8].

| Filter Size (ASTM) | Original Gradation | Combined Gradation | Mixed Gradation Requirements |
|--------------------|---------------------|--------------------|-----------------------------|
|                    | A       | C       | D       | A       | C       | D       | HRS-WC |
| ¾”                 | 100,00  | 100,00  | 100,00  | 100,00  | 100     | 100     |
| ½”                 | 97,00   | 100,00  | 100,00  | 98,95   | 87-100  |
d. Testing the aggregate physical properties [9] [10].

**Table 2. Results of Aggregate Physical Examinations**

| No | Testing                  | Method         | Requirement | Result | Description |
|----|--------------------------|----------------|-------------|--------|-------------|
|    | Coarse aggregate         |                |             |        |             |
| 1  | Water Absorption         | SNI 03-1969-1990 | ≤ 30        | 1,7    | satisfy     |
| 2  | Bulk Specific Gravity    | SNI 03-1969-1990 | ≥ 2,5       | 2,6    | satisfy     |
| 3  | Pseudo Specific Gravity  | SNI 03-1969-1990 | ≥ -         | 2,72   | satisfy     |
| 4  | Los Angeles Wear         | SNI 03-2417-1991 |            |        |             |
|    | Agregat Halus            |                |             |        |             |
| 1  | Water Absorption         | SNI 03-1970-1990 | ≤ 30        | 2,88   | satisfy     |
| 2  | Bulk Specific Gravity    | SNI 03-1970-1990 | ≥ 2,5       | 2,63   | satisfy     |
| 3  | Pseudo Specific Gravity  | SNI 03-1970-1990 | ≤ 30        | 2,84   | satisfy     |
|    | Filler                   | SNI 15-2531-1991 | ≥ 1         | 2,82   | satisfy     |

**Determination of asphalt levels**
PB = 0.035 (%CA) + 0.045 (%FA) + 0.18 (%FF) + K
= 1.357 + 2.4852 + 1.08 + 1.5
= 6.42 

**e. Sample making**

| Material               | Percentage of material + iron powder waste (%) | weight of material + iron ore waste (grams) |
|------------------------|-----------------------------------------------|--------------------------------------------|
| iron powder waste 0%   |                                               |                                            |
| Joint gradation        | 50                                            | 638.53                                     |
| *Filler*               | 50                                            | 561.47                                     |
| Iron powder waste      | 0                                             | 0                                          |
| Amount                 | 100                                           | 1200                                       |
| iron powder waste 5%   |                                               |                                            |
| Joint gradation        | 50                                            | 638.53                                     |
| *Filler*               | 47.5                                          | 533.39                                     |
| Iron powder waste      | 2.5                                           | 28.07                                      |
| Amount                 | 100                                           | 1200                                       |
| iron powder waste 10%  |                                               |                                            |
| Joint gradation        | 50                                            | 638.53                                     |
| *Filler*               | 45.25                                         | 505.32                                     |
| Iron powder waste      | 4.75                                          | 56.15                                      |
| Amount                 | 100                                           | 1200                                       |
| iron powder waste 15%  |                                               |                                            |
| Joint gradation        | 50                                            | 638.53                                     |
| *Filler*               | 43.21                                         | 477.25                                     |
| Iron powder waste      | 6.79                                          | 84.22                                      |
| Amount                 | 100                                           | 1200                                       |
| iron powder waste 20%  |                                               |                                            |
| Joint gradation        | 50                                            | 638.53                                     |
| *Filler*               | 41.36                                         | 449.17                                     |
| Iron powder waste      | 8.64                                          | 112.29                                     |
| Amount                 | 100                                           | 1200                                       |

**f. Calculation of sample-specific gravity [9] [10]**

1. Bulk Specific Gravity (Gmb)

| No | Test Objects | Iron powder | Score BJ Bulk Mix (Gmb) |
|----|--------------|-------------|-------------------------|
| 1  | A            | 0%          | 2,220                   |
|    | B            | 0%          | 2,223                   |
|    | C            | 0%          | 2,206                   |
|    | **Average**  |             | **2,216**               |

| No | Test Objects | Iron powder | Score BJ Bulk Mix (Gmb) |
|----|--------------|-------------|-------------------------|
| 2  | A            | 5%          | 2,189                   |
|    | B            | 5%          | 2,213                   |
|    | C            | 5%          | 2,218                   |
|    | **Average**  |             | **2,207**               |
3. Maximum Mixed Specific Gravity (GMM)

Table 5. Calculation Results Maximum density of the mixture (Gmm)

| No | Test Objects | Iron powder | Score BJ Bulk Mix (Gmb) |
|----|--------------|-------------|-------------------------|
| 4  | A            | 15%         | 2,278                   |
|    | B            | 15%         | 2,284                   |
|    | C            | 15%         | 2,272                   |
|    | Average      |             | 2,278                   |
| 5  | A            | 20%         | 2,284                   |
|    | B            | 20%         | 2,282                   |
|    | C            | 20%         | 2,282                   |
|    | Average      |             | 2,283                   |

| Bottle Weight + sample | a               | 2821                  | 2825                  |
| Bottle Weight         | b               | 1654                  | 1654                  |
| Example Weight        | c = a - b       | 1167                  | 1171                  |
| Bottle + water weight | d               | 5782                  | 5782                  |
| Bottle Weight + Water + Example | e | 6447                  | 6445                  |
| Fill in the Example   | f = c+d-e       | 502                   | 508                   |
| Specific gravity      | g = c/f         | 2.32                  | 2.31                  |
| Water Temperature (C) | h               | 25                    | 25                    |
| Temperature Correction| l               | 1                     | 1                     |
| Specific gravity      | G = g x l       | 2.32                  | 2.31                  |
| BJ Average            |                | 2.315                 |
g. Marshall test results

![Graphs of Marshall Test Results](image)

**Figure 3.** Graphs of Marshall Test Results (with a mixture of iron powder waste)

4. Conclusions and Suggestions
From the research results of the influence of iron powder waste as a substitute for some fillers, the following conclusions can be drawn:

a) Iron powder based on gradation test and specific gravity and water absorption have fulfilled the requirements as a filler as regulated in SNI 03-4142-1996

b) From the Marshall test data obtained, variations that meet the requirements of the characteristics of Marshall parameters for HRS-WC pavement are 5% and 10% variations.

c) The percentage increase in the variation of iron powder from the weight of the filler which produces the highest stability and meets all the criteria characteristics of the Marshall parameters is a variation of 10% content with a stability value achieved of 1519.89 kg

Some things that can be suggested in connection with the results of this study are as follows:

a) For further research, other types of pavement should be used, including AC-BC, HRS-BASE, and LATASIR.
b) Future research should consider conducting field tests so that it can prove whether the research in the laboratory is proven to improve road stability or not.

References

[1] Sugianto, Gito 2008. Study of Characteristics of Hot Rolled Asphalt Mixture Due to Addition of Used Tire Powder Waste. General Sudirman University

[2] Bahri, Samsul 2010. Effect of Iron Powder Waste as a Substitute for a Fine Aggregate of Asphalt Mixtures. Bengkulu University

[3] Ministry of Public Works. Directorate General of Highways of 2010 General Specifications HRS Revised 2. Jakarta

[4] Ministry of Public Works Directorate General of Highways, 2010. Division 6 General Specifications HRS Revised 3. Jakarta.

[5] Priambodo, Sam 2003. Laboratory studies of the effect of the use of iron sand as fine aggregate on a mixture of hot rolled asphalt HRA (HOT ROLLED ASPHALT) on marshal properties and durability. Diponegoro University

[6] Pasaribu, Iffah Fathaniah 2015 "The Effect of Use of Iron Powder Waste on Ac-Wc Hot Asphalt Mixture. University of Northern Sumatra

[7] Indonesian national standard no. RSNI m-01-2003 about the method of testing hot asphalt mixtures with marshall tools.

[8] SNI 03-1968-1990 concerning the testing method of fine aggregate and coarse aggregate sieve analysis.

[9] SNI 03-1969-1990 concerning the method for testing specific gravity and absorption of coarse aggregate water

[10] SNI 03-1970-1990 concerning the method for testing specific gravity and absorption of fine aggregate water.