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Development of Asphalt Mixing Plant Information System at PT. X Jabodetabek Asphalt Mixing Plant Production Unit to Reduce Material Waste

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ABSTRACT

This study aims to develop a web-based AMP Information System at PT. X Jabodetabek Production Unit to reduce material waste in the asphalt production process. The existing condition shows significant deviations in material usage, including screening (9.28%), split (15.38%), asphalt (6.84%), and diesel (9.07%), all exceeding the company's waste tolerance limit of 5%. The research employs a descriptive method with both quantitative and qualitative approaches, involving archival analysis, literature review, questionnaires, interviews, and expert validation to address three research questions (RQ1–RQ3): identifying waste-related problems, developing the AMP information system, and evaluating the system's effect on material waste reduction. The findings indicate that the main causes of material waste include frequent material rejection, mixing errors, and equipment damage, with the highest Relative Importance Index (RII) value of 0.88. The developed system features a three-layer strategic dashboard comprising monthly accumulation, daily monitoring, and real-time monitoring that visualizes sensor status, temperature, material usage, and deviations from the JMF. Based on a comparative case study between two AMPs, applying the information system reduced material waste from 4.28% to 4.14% in AMP 1 and from 4.84% to 4.79% in AMP 2. The study concludes that developing an integrated AMP information system plays a vital role in improving operational efficiency and production quality control.

KEYWORDS *Asphalt Mixing Plant (AMP); Waste Material; Information Systems; Materials Management*

INTRODUCTION

An Asphalt Mixing Plant, often referred to as an AMP, is a collection of machines or equipment designed to produce asphalt mixtures and aggregates (Sowolino, 2023). An AMP Equipment Conformity Inspection is required to verify the condition of each AMP component to ensure it is suitable for use (Carter & Mancini, 2017). Meanwhile, according to Direktorat Jenderal Bina Marga (2023), the AMP is the main unit responsible for maintaining the quality of asphalt mixtures used in road and bridge construction works. Therefore, it is necessary to have guidelines for inspecting the condition of the AMP so that it can be categorized as operationally and production-worthy.

PT. X is a subsidiary of a state-owned enterprise mandated to participate in the completion of the Trans Sumatra Toll Road (JTTS), which has a length of 2,765 kilometers and is a National Strategic Project (PSN) entrusted by the government to PT. Hutama Karya (Persero). In 2022, PT. X had 14 AMPs spread throughout Indonesia (Dameanti et al., 2023). However, in 2024, PT. X only has 6 AMPs remaining due to declining performance, which led to the closure of some units (Ma et al., 2023). One major cause of this decline is the high material waste (Song, Li, & Zeng, 2015). Table 1 explains the amount of waste material.

Table 1. Data of Waste Material

No.	Material	Unit	Usage Vol.	Production Vol.	JMF	ARP's Vol.	Dev.	% Dev.
1	Stone Dust	Ton	17.279,10	28.829,10	0,6	17.297,46	18,36	0,11%
2	Screening	Ton	9.451,23	28.829,10	0,3	8.648,73	(802,50)	-9,28%
3	Split 1-2	Ton	3.326,29	28.829,10	0,1	2.882,91	(443,38)	-15,38%
4	Split 2-3	Ton	-	28.829,10	0	-	-	0,00%
5	Addictive	Kg	1.353,94	28.829,10	0,171	4.929,78	3.575,84	72,54%
6	Asphalt	Kg	1.848.000,26	28.829,10	60	1.729.746,29	(118.253,97)	-6,84%
7	Cement	Kg	102.961,20	28.829,10	9	259.461,94	156.500,74	60,32%
8	Emulsion	Kg	86.682,97	28.829,10	3,5	100.901,87	14.218,90	14,09%
9	Diesel	Liter	440.200,45	28.829,10	14	403.607,47	(36.592,98)	-9,07%

Source: Author's Report 2025

As shown in Table 1, there are significant deviations in the use of materials, with screening at 9.28%, split at 15.38%, asphalt at 6.84%, and diesel at 9.07%. These deviations exceed the Company's waste material tolerance of 5%. This issue arises because the existing Asphalt Mixing Plant (AMP) lacks a tool to monitor material waste, resulting in delayed management intervention when high levels of waste material are detected (Praticò, 2017).

With the development of information technology, it can also automate the information processing, starting from input, storage, and update directly, so that everyone can access the most up-to-date information and analyze it with ease (Florén et al., 2013). The role of Information Technology (IT), which is part of Information Systems (SI), has undergone many dramatic changes. It is no longer expected only to support organizational activities but has become part of the organization's strategy in achieving its goals (Sevrani et al., 2011).

Along with the development of information technology, the development of information systems at the AMP has become very relevant (Kashikar-Zuck et al., 2016). An integrated information system can help in various operational aspects, ranging from raw material management and production processes to finished product distribution, and even help monitor waste materials (Pandowo et al., 2023).

Thus, this research aims to develop an AMP Information System to reduce material waste (Xu, Shi, Xie, & Zhao, 2019). The information system will be useful for monitoring the use of the Job Mix Formula (JMF) in AMP so that if there is a discrepancy in the production process, the operator will immediately know and can take corrective action (Prasetyo, Sugiarto, & Rosyidi, 2018).

An Asphalt Mixing Plant (AMP) is a combination of mechanical and electronic equipment used to mix aggregate and asphalt fractions to produce hot mix asphalt for flexible road structures (D. P. K. B. Aceh, 2020). The AMP consists of several components that are essential for its operation, and if any one of these components fails, it will impact the production results. The components of the AMP include: 1) Cold bin, 2) Cold bin door, 3) Cold elevator, 4) Dryer, 5) Dust collector, 6) Chimney for smoke, 7) Hot elevator, 8) Sieve, 9) Hot bin, 10) Tub for weighing, 11) Mixing tub (Mixer/Pugmill), 12) Filler reservoir, 13) Asphalt heater oil tank, 14) Asphalt scales, and 15) Power generation (Gen Set). The AMP used in this research is from the Greater Jakarta Production Unit, manufactured in 2017, with a production capacity of 60 tons per hour and a daily production capacity of 800 tons, serving the Greater Jakarta area. Figure 1 illustrates the sequence of the production procedures as outlined in the following flow chart (Ruiz, 2015).

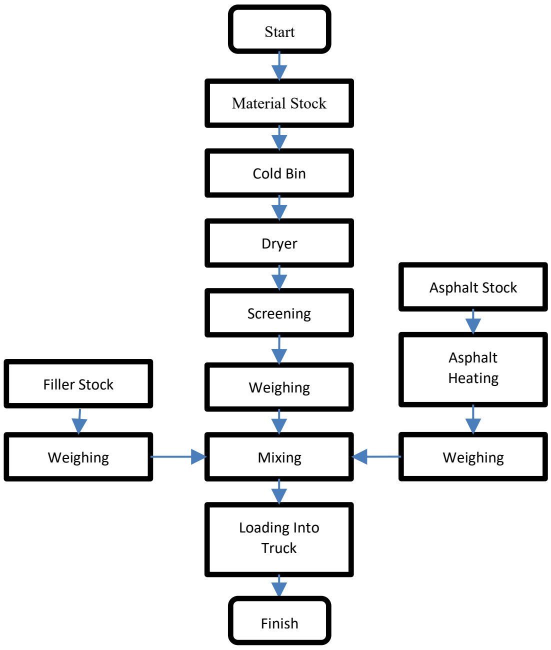

Figure 1. Production SOP Flowchart

The image above shows the flow of the hot asphalt mixture production process (hot mix) at the *AMP*, which starts from the preparation of aggregate material in the cold bin, drying in the dryer, filtering by size, and weighing according to the composition of the *JMF*. In parallel, the asphalt is heated in the boiler and stored in a hot asphalt tank, while the filler is also weighed as needed (Prasetyo et al., 2018). All components—aggregate, filler, and hot asphalt—are then mixed in a pugmill until homogeneous to form a hot mix mixture that is ready to be poured onto a transport truck for shipment to the overlay site, marking the completion of the production process (Mallick & El-Korchi, 2017).

Waste material can be in the form of residual material that can no longer be used due to excess or damage. The material can be asphalt, iron, coarse aggregate, filler, and others (Cao, Zhou, Zhou, Dong, & Tian, 2022). Residual materials are often produced from leftover production, construction, building demolition, and other sources (Sormunen & Kärki, 2019). Waste materials on a large scale can adversely affect the surrounding environment, so they must be managed properly (Papamichael et al., 2023).

Waste materials can be categorized into two categories based on their type (Formoso et al., 2002; Okonkwo et al., 2023), namely: 1) Direct waste is residual material that appears in the project due to damage, loss, or disuse. Examples include shipping residue, site storage waste, conversion waste, cutting waste, criminal waste, wrong use waste, and management waste; 2) Indirect waste is residual material in the project because the volume used exceeds the plan, so it does not become physical residual material in the stockyard but affects hidden costs.

Examples of indirect waste include substitution waste, production waste, and negligence waste (residual material that occurs due to faults on site).

A system is a unit of components or subsystems interacting with each other, interdependent, and difficult to separate in order to achieve its goals. As conveyed by Tata Sutabri (2005), a system can be interpreted as a collection of elements, components, and variables that are neatly arranged, interacting, interdependent, and integrated. A dashboard is a visual display of important information needed to achieve a goal by describing and linking layers to present information that can be monitored more easily. Dashboards are clarified into three types (Few, 2006): a) Operational dashboards provide direct information requiring quick responses; b) Tactical dashboards analyze the cause of incidents and assist in finding causes of certain conditions; c) Strategic dashboards provide information for decision-making, direction, and strategic achievements focused on performance measurement. The information conveyed is easy to understand and presented in real time.

The dashboard used in the *AMP* is more likely a strategic dashboard because it requires data for rapid decision-making to continue production or stop for checks and repairs in unplanned events, and the data must be real-time. To support the *AMP* Dashboard's performance, sensors in the *AMP* play a very close and complementary role in forming a real-time, accurate, and data-based information system to support production efficiency and material control. Sensors serve as the main data collection devices in the field, while dashboards serve as a medium for data visualization and analysis that assists operators and management in making quick and accurate decisions. Technically, different types of sensors are installed at each stage of the *AMP* process such as load cells to measure aggregate and filler weights, flowmeters to calculate the volume and flow rate of diesel and gas, and temperature sensors to monitor the temperature of burners, dryers, and pugmill mixers.

The data captured by these sensors is automatically sent to the control system and displayed on a digital dashboard. The dashboard then displays production parameters such as mixing ratio, material temperature, aggregate moisture level, and deviation from the Job Mix Formula (*JMF*). This allows operators to detect irregularities early, optimize material usage, and prevent material waste due to overdoses or process errors. In addition to monitoring, the integration of sensors and dashboards also improves transparency and accountability of the production process. Historically stored sensor data allows analysis of material usage trends, fuel efficiency, and mix quality stability. Thus, the dashboard functions not only as a visualization tool but also as an Internet of Things (IoT)-based quality control and material efficiency system that supports the principles of lean construction and green production (Antunes & Poshdar, 2018; Pandowo et al., 2023).

The dashboard in an *AMP* plays a strategic role in supporting material control during the asphalt mixture production process. Through a dashboard system integrated with sensors and automation devices such as load cells, bitumen flowmeters, and temperature sensors, operators can monitor the entire process in real time, from aggregate weighing and asphalt heating to final mixing. The data visualization on the dashboard helps detect deviations from *JMF* and other production parameters, allowing errors in dosage or composition to be corrected immediately before generating waste material. In addition, the *AMP* dashboard also plays a role in analyzing material performance and production efficiency. By using an information system that records and displays historical data on material usage, production, and quality test results, *AMP* management can evaluate material consumption patterns and potential waste. This aligns with the principles of lean construction, which aim to reduce non-value-added activities through integration of information technology (Antunes & Poshdar, 2018; Pandowo et al., 2023).

METHOD

This study used a descriptive method with a qualitative and quantitative approach. Table 2 explains the research strategy.

Table 2 Research Strategies

No	Research Questions	Strategy
1	What are the problems with the existing AMP related to waste materials? (RQ1)	Archive analysis, literature studies, Questionnaires
2	How is the Development of Information Systems in AMP? (RQ2)	Expert Validation
3	Does Information System Development have an effect on reducing material waste? (RQ3)	Archives, Case Studies, Interviews

Based on the table above, the research method can be formulated as in Table 3

Table 3 Research Methods

No	Research Question	Input	Process	Output
1	What are the problems in the existing AMP related to waste material?	Existing AMP's SOP	Identifying existing problems in the AMP related to waste material	List of recommendations to solve the problems
2	How is the information system development at the AMP?	Existing AMP's SOP	Evaluating the implementation of Information System Development at the AMP	List of methods and tools to be used in information system development
3	What is the effect of the information system on waste material?	Existing AMP's SOP	Identifying the effect of Information System Development on waste material	Assessment of AMP information system effectiveness in reducing waste material

The research methods and strategies used to answer the research questions (RQs) included the following: 1) Expert validation, which was used to obtain research data directly from related subjects by validating with relevant experts (Johansen, 2023); 2) Surveys, which involved collecting data directly from related subjects using questionnaires and interviews to obtain information from sources (Boateng et al., 2018).

To optimize understanding and avoid misinterpretations of the research focus, the scope of the study was limited. The process began with problem identification, followed by problem formulation and the establishment of research objectives. Subsequently, a literature study was conducted to determine the research variables and the operational methods to be applied. The initial stage also included a preliminary survey to obtain an overview of the existing conditions at the *AMP*. This research addressed two main questions (RQ1 and RQ2) through archive analysis, literature review, questionnaires, and expert validation to collect and analyze data related to issues and variables influencing waste material in the *AMP*.

The next stage focused on evaluating conditions and developing solutions based on the results of the analyses of RQ1 and RQ2. These results served as the foundation for formulating improvement strategies and developing a model, which was subsequently validated by experts. After refining the model, trials or case studies were conducted to assess the effectiveness of the proposed strategy. In the final stage, the study identified the effect of the information system on reducing waste material (RQ3), then drew conclusions and provided recommendations for further implementation within the *AMP* environment to achieve improved production efficiency and material management. Figure 2 shows the sequence of the research process described in the following flow chart:

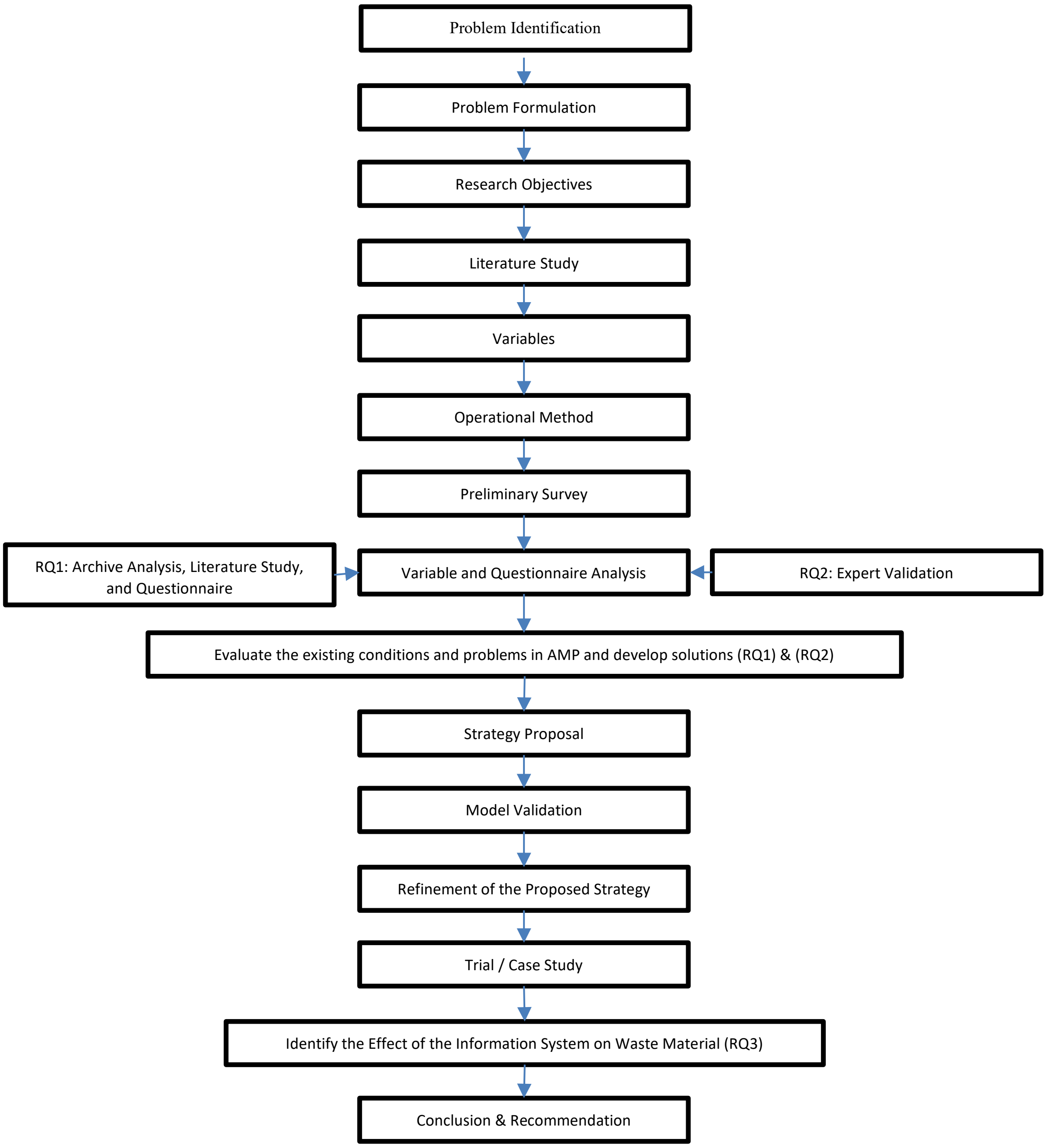

Figure 2 Research Process

This study used instruments including questionnaires, interviews, and literature studies. Table 4 explains the Respondent Criteria to be used:

Table 4 Respondent Criteria Respondent Criteria

No	Respondent Criteria	Description
1.	Health	Physically and Mentally Healthy
2.	Number of Respondents	5 people
3.	Educational Background	Bachelor's Degree (S1)
4.	Academic Background	Asphalt Mixing Plant/Hot mix Field
5.	Length of Experience	5 Years

RESULT AND DISCUSSION

Results and Discussion of RQ 1

This RQ 1 data collection was validated to identify problems in the existing AMP related to waste materials. After the results of the questionnaire were obtained from each expert, the data obtained was analyzed. From these results, there will be indicators that are eliminated, at least 3 experts disagree with these indicators. The following are the results of expert validation. Table 5 explains the results of the experts' validation of problems in AMP related to waste materials.

Table 5 Expert Validation Recap

No	Problems	Check
1	AMP produces waste material in every material fraction	✔
2	Material rejection frequently occurs at AMP	✔
3	AMP produces a lot of dust from the screening process	✔
4	AMP produces residual asphalt from production	✔
5	AMP produces aggregate residue that does not meet specifications	✔
6	AMP produces liquid waste	✔
7	Non-conformity of raw materials from the quarry	✔
8	Rejected material must be disposed of	✔
9	AMP experiences errors in mixing	✔
10	Waste material processing at AMP is poor	✔
11	Operators and staff lack training	✔
12	AMP experiences equipment damage	✔
13	AMP exceeds production capacity	✔
14	AMP does not have facilities to manage waste	✔
15	There is no information system to monitor waste material	✔
16	Equipment maintenance at AMP is poor	✔

To find out the level of importance or priority in the problem that has been identified, the researcher uses the RII (Relative Importance Index) method. Where this method is a quantitative method that is often used to determine the level of importance or priority of a factor based on respondents' perceptions. This method is often used in survey research, particularly in the fields of construction management, civil engineering, and risk management, to rank factors based on their degree of significance.

The calculation formula is:

$$\text{RII} = \frac{\sum W}{AN}$$

Information:

W = The weight given by the respondents for each factor (e.g. scale 1–5 or 1–10).

ΣW = The total weight given by all respondents to a factor.

A = The highest weighted value on the rating scale (e.g., if it is a scale of 1–5 then A = 5).

N = Number of respondents.

The scale of assessment is:

1 = Very Unimportant

2 = Not Important

3 = Important Enough

4 = Important

5 = Very Important

The weight of experts related to RII for AMP problems related to waste materials is explained in Table 6 as follows:

Table 6 Weighting of RII

No	Problems	RII
1	Material rejection frequently occurs at AMP	0.88
2	AMP experiences errors in mixing	0.88
3	AMP experiences equipment damage	0.84
4	Equipment maintenance at AMP is poor	0.84
5	AMP produces residual asphalt from production	0.76
6	AMP produces waste material in every material fraction	0.72
7	Non-conformity of raw materials from the quarry	0.72
8	AMP does not have facilities to manage waste	0.72
9	There is no information system to monitor waste material	0.72
10	AMP exceeds production capacity	0.68
11	Operators and staff lack training	0.64
12	AMP produces a lot of dust from the screening process	0.60
13	Waste material processing at AMP is poor	0.60
14	AMP produces liquid waste	0.48
15	AMP produces aggregate residue that does not meet specifications	0.44
16	Rejected material must be disposed of	0.40

Based on the results of the calculation of the RII, various problems can be identified that cause waste material in the production process at AMP. The value of RII obtained ranges from 0.40 to 0.88. The problems with the highest level of importance are material rejection that often occurs in AMP and errors in the mixing process, each with an RII value of 0.88. These findings indicate that product quality that does not meet specifications and errors in mixing are the main contributors to the occurrence of waste material. In addition, the factor of tool damage and poor tool maintenance also occupies a high priority with an RII value of 0.84. This suggests that suboptimal equipment conditions contribute directly to production inefficiencies and increased volumes of wasted materials.

Results and Discussion of RQ 2

Development begins with a needs analysis where the observation of the production process is carried out directly, the identification of critical points that cause inefficiency and waste, then the documentation of what system needs to be monitored (temperature, scales, fillers, production time, etc.), and what sensors are needed. After the need is identified, then design a system design in the form of designing a user interface that is easy to understand and according to the AMP flow.

Sensors are one of the keys in modern technology, which makes it easier for us to detect, measure and monitor various physical phenomena. Sensors can be devices or elements that can know the state of the surrounding environment and can be converted into signals that can be measured or interpreted by the operator or electronic system. Sensors can act as an interface between the physical world and the digital world and provide the necessary information about the conditions of the surrounding environment. Sensors can also convert physical stimuli into measurable signals.

The development of information systems in AMP involves the use of various types of sensors, including: 1) Temperature sensor at the dryer drum outlet, 2) Temperature sensor in the bitumen tank, 3) Temperature sensor in the pugmill (mixer), 4) Weight sensor in the aggregate scales, 5) Weight sensor on the bitumen scales, 6) Weight sensor on the filler scales, 7) Weight sensor on the weighing bridge, 8) Flowmeter sensor in the diesel tank, and 9) Flowmeter sensor in the storage gas. AMP is an asphalt production facility that requires precise control over material flow, temperature, mixture composition, and distribution. Based on observations, the manual recording system has several risks, including: a) Information delays, b) Out-of-sync communication leading to inaccurate data, c) Lack of integration between production, logistics, and quality control departments, and d) Lack of real-time visibility into material stock data.

With the risk of manual recording, a dashboard is needed, the dashboard referred to here is a visual display of information / computer interface that displays many diagrams, reports, visual indicators, and data aggregation to make it easier for readers to analyze the report. With this dashboard, it is hoped that it can improve data accuracy, reduce the potential for errors, speed up decision-making, and can reduce material waste.

The main features of the AMP dashboard are as follows: 1) Temperature monitoring: Displays the temperature of the burner and mixture in the pugmill 2) Material Measurements: Shows actual comparisons and plans for aggregates, bitumen, and fillers. 3) Daily production: Number of asphalt mixture produced per shift/day. 4) Tool Status: Main tool operational indicators such as burner, mixer, elevator. 5) Production history: Graphical display of production trends and material usage over a period of time

From the required features, a visual appearance design of the system is made which includes layouts, colors, icons, graphics, and other supporting elements. The purpose of this design is to make it easier for operators and managers to understand the operational situation in a short period of time, increase the speed of response to technical issues, and increase convenience and accuracy in daily production supervision. Here's the design of the AMP dashboard plan:

The dashboard design is divided into 3 parts:

1. The first part is monthly accumulation, in this section there is information about production history or data about production that has been produced before, then the summary part which summarizes the total production, production plan and total waste material in one month, there is also a comparison diagram between the plan, realization, and production waste. In this section there is also a month selection option, where users can choose the month to be reviewed.
2. The second part is daily, in this section there is information about daily production, daily material use, daily job mixes formula and daily material waste. In this section there is also a day selection option, where users can choose the day to be reviewed.
3. The third part is real time, in this section there is information about the status of the active device, the status of the active sensor and live temperature monitoring.

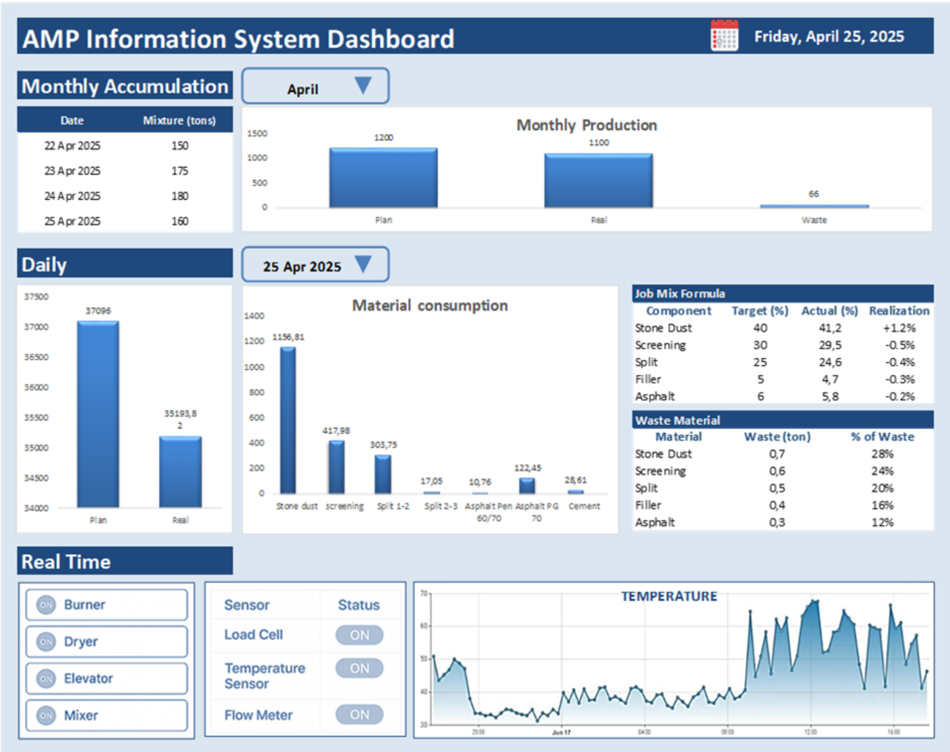

Figure 3 AMP Dashboard

Results and Discussion of RQ 3

The development of the information system in this study is still in the design stage and has not been fully implemented. This condition presents methodological challenges in the validation process, because the effectiveness of information systems in reducing material waste cannot be directly tested on systems that are still in the form of designs. Therefore, this study uses a comparative approach through sampling on two other AMPs that have previously implemented production information systems. To determine the influence of information systems on material degradation, the researcher used data on AMPs that had used information systems, the data used were from two different AMPs, the two AMPs were used as samples to measure the extent to which the application of information systems contributed to reducing waste levels. Thus, the results of the analysis can provide an initial overview of the effectiveness and potential benefits of the information system that is being developed data from the use of materials before the information system is used compared to the use of material materials after the information system is used. The data used for material use before the information system is used is material usage data in 2023. As for the data on the use of material materials after the information system is used, namely the data on material use in 2024. Data is taken from the logistics department which records income and expenses as well as material stocks on a regular basis.

The information system under study is designed with a superior, complete, and integrated range of features compared to the information system used by the two AMP comparative samples. This difference arises because the developed system not only adopts best practices from existing AMPs, but also adds innovative components to address specific problems related to waste materials.

Broadly speaking, the difference can be explained as follows:a) The scope of the information system features studied is equipped with a real-time material waste control module, JMF data integration, and deviation data between the target and the realization of material use. b) Data integration where the system being studied prioritizes the concept of an integrated dashboard, where all production data, material use, sensor performance, and waste reporting can be accessed in one platform. c) Focus on Waste Reduction where the system studied is specifically directed to reduce material waste, with performance indicators that can be monitored directly through the dashboard

To answer RQ 3, the researcher compared waste before and after the use of information systems in AMP 1 and AMP 2, the use of materials in 2023 was compared to 2024. The results of the study show that the application of information systems in the production unit of the AMP contributes to the reduction of the level of waste material, although the percentage is not very significant. From the data obtained, AMP 1 experienced a decrease in material waste from 4.28% to 4.14%, while AMP 2 experienced a decrease from 4.84% to 4.79.

This decline indicates an improvement in the effectiveness of the production process after the integration of information systems. The information system allows operators to: 1) Real-time monitoring where the production process can be monitored through the dashboard so that any deviation from the JMF can be detected immediately. 2) Material input control where sensors integrated with the system help maintain a balance of aggregate and asphalt proportions, thereby reducing excess doses that have the potential to become waste. 3) Improved data accuracy where historical production data stored in the system can be used for evaluation, reducing human error in manual recording. 4) Speed of decision-making where operators and management can immediately take corrective action when potential quality discrepancies are detected.

In AMP 1, the decrease in material waste was relatively greater (0.14%) than in AMP 2 (0.05%). This can be caused by differences in internal factors, such as the operator's level of competence, equipment conditions, and production intensity. In AMP 2, although the information system has also been implemented, the reduction achieved is smaller. This shows that the effectiveness of information systems is greatly influenced by organizational readiness, machine conditions, and the discipline of implementing standard operating procedures (SOPs). Conceptually, these results support the theory that information system development can play a role in improving operational efficiency. Although the rate of reduction in material waste may seem small, in the context of large-scale AMP production, a difference of as small as 0.05% or 0.14% can have a significant impact on cost savings and optimization of resource use.

CONCLUSION

The analysis using the RII method from expert questionnaires identified key problems causing waste in the AMP, including frequent material rejection, mixing errors, equipment damage, poor maintenance, and asphalt residue. To address these issues, a web-based information system with strategic dashboards was developed, offering three layers of information: monthly waste trends, daily production and waste data, and real-time equipment and sensor monitoring. The system features material stock management, process monitoring, automated reporting, sensor integration, and material quality analysis, enabling early detection of deviations from the JMF. Implementation of this system led to measurable waste reductions in two case studies—from 4.28% to 4.14% and from 4.84% to 4.79%—which, although numerically small, translate into significant operational savings in material and cost. By enabling rapid anomaly detection, corrective action, and precise material planning based on historical data, the system enhances production efficiency. Future research could explore scaling the system across multiple plants and integrating predictive analytics to further optimize waste reduction and resource management.

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