

Evaluation and Optimization of Asphalt Production Parameters at the Asphalt Mixing Plant in West Sumbawa

Sulaimansyah¹, Miranti Nur Wulandari^{1*}, Fadli², Sri Wahyuni¹, Suhardi¹

¹Department of Mining Engineering, Cordova University, West Sumbawa 84355, Indonesia

²Department of Mining Engineering, Yogyakarta Institute of Technology, 55198, Indonesia

*Correspondence: manamiwulandari@gmail.com

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Abstract: Asphalt is the main material in highway construction that plays an important role in determining the quality, durability, and comfort of road users. The demand for asphalt in Indonesia continues to increase in line with national infrastructure development, including in the West Nusa Tenggara region. PT Fima Kencana Kerthasari, located in Belo Village, Jereweh District, West Sumbawa Regency, is one of the companies engaged in the production of hot mix asphalt through a mixing plant facility. In practice, the production process often faces challenges in maintaining consistent asphalt quality due to variations in mixing temperature, inaccuracies in aggregate and asphalt measurements, and a lack of real-time process control. Considering the potential for quality improvement through the optimization of production process parameters such as temperature, mixing time, and aggregate-asphalt ratio, a systematic study at the PT Fima Kencana Kerthasari site is required. This optimization not only aims to meet technical specification standards (e.g., SNI 06-2489-1991 and SNI 7394:2008) but also to enhance the company's competitiveness through cost efficiency and operational efficiency.

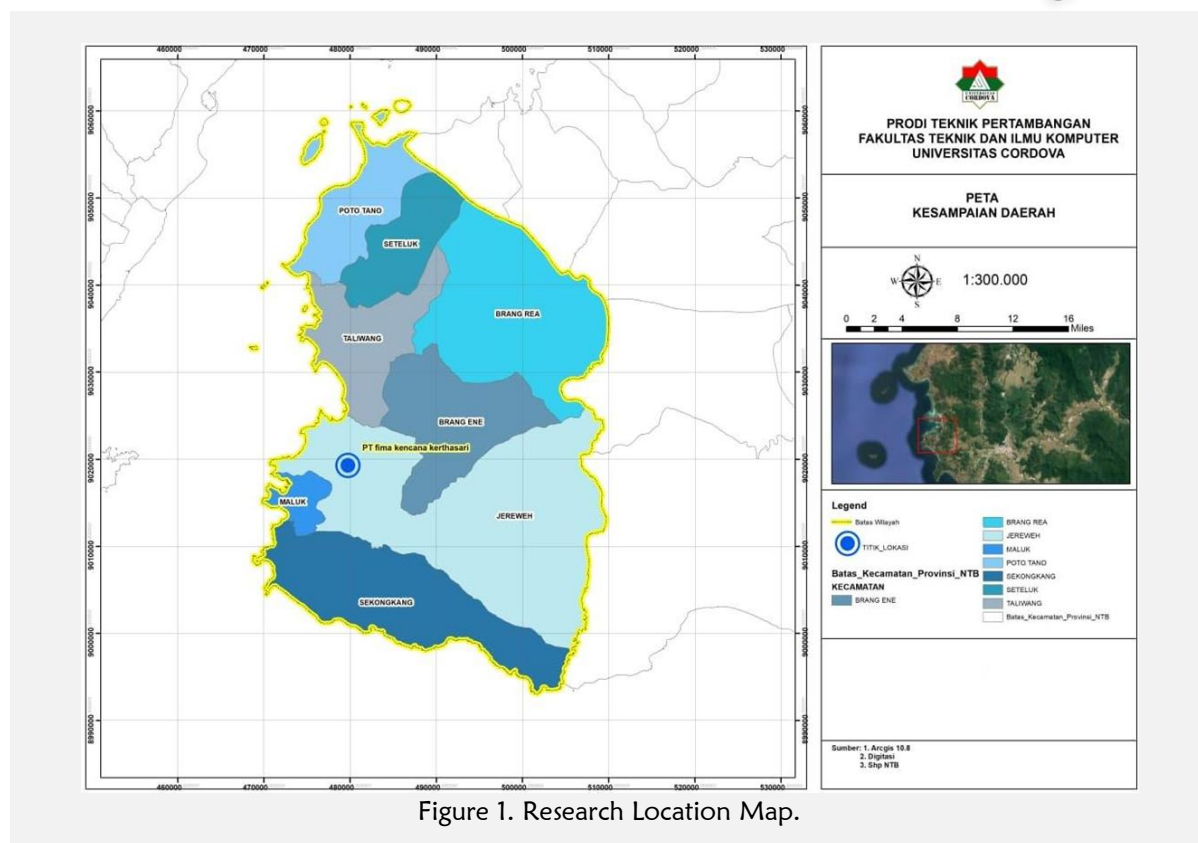
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INTRODUCTION

PT Fima Kencana Kerthasari was established on October 21, 2003, and began operations in early 2004. It is located in Belo Village, Jereweh District, West Sumbawa Regency, West Nusa Tenggara Province. As a company engaged in road and bridge construction services and as a quarry and andesite processing company, it has a mining business license area of approximately 16 hectares and an area that has been mined to date of approximately 6 hectares. The reason for establishing a camp in Jereweh as a center for andesite material production was based on a survey conducted by PT Fima Kencana Kerthasari throughout the islands of Sumbawa and Lombok, which found that only Jereweh met the requirements for andesite stone quality, making it very effective to establish a base camp in that area. This is based on: High-quality andesite stone (meeting technical standards for pavement aggregates), Abundant and sustainable resource availability, a strategic location supporting material distribution to various projects in the West Sumbawa region. The mining site is located far from residential areas, thus not disrupting local residents' activities.

According to Minerba Law No. 3 of 2020, andesite igneous rock is an interlocking collection of silicate mineral aggregates resulting from the cooling and solidification of magma. Andesite is a type of extrusive igneous rock and andesite rock is also a product. The solidification of magma is intermediate to wet on the earth's surface. The minerals produced at PT Fima Kencana Kerthasari are minerals or rocks that are classified as industrial minerals, namely andesite rock. This type of rock has an afanitic porphyritic structure, with plagioclase as the main mineral composition and pyroxene and amphibole as the mafic minerals. This rock is dark in color, ranging from gray to black, and has a specific gravity of 2.3 - 2.6 with a compressive strength of 600 - 2400 kg/cm² (Safi, I, 2010).

In the research area (Figure 1), particularly the stockpile location, quarry, and asphalt mixing plant (AMP) location at PT Fima Kencana Kerthasari, the topography consists of hills with gentle slopes. The research area is covered with tropical plants such as tamarind, srikaya, and teak trees. To the north is a rice field area, and to the west are hills covered with teak trees that were deliberately planted by local residents.



METHOD

Data

Primary and secondary data play an important role in obtaining in-depth and diverse information on the topics studied in this research through standard-based evaluative studies.

Primary Data

Interview

An interview is a conversation with a specific purpose. The conversation is conducted by two parties, namely the interviewer who asks questions and the interviewee, who is the Asphalt Mixing Plant operator himself, who provides answers or responds to the questions.

The interview technique used in this study was in-depth interviews. In-depth interviews are a way of collecting data or information by meeting face-to-face with informants, with the aim of obtaining a complete picture of the topic being studied. Interviews in this study were conducted to obtain data and information about the work activities and the effect of asphalt quality on the Asphalt Mixing Plant at PT Fima Kencana Kerthasari.

Observation

Observation is a technique or method of collecting data by directly observing an ongoing activity. Observation is directed at accurately observing activities, recording phenomena that arise, and considering the relationships between aspects of these phenomena. From observation, data about a problem will be obtained, thereby providing understanding or serving as a means of *rechecking* or verifying the information/details obtained previously.

This observation was conducted by researchers during the study to optimize data on production optimization at the Asphalt Mixing Plant (AMP) at PT Fima Kencana Kerthasari.

Documentation

The data collection technique using the documentation method is a data collection technique that involves compiling and analyzing documents, whether written, pictorial, or electronic. Documentation studies complement the use of observation and interview methods in qualitative research.

The results of research from observation and interviews will be more credible and reliable if supported by documents from the sources.

Secondary Data

Secondary data is data obtained from existing sources, such as company documents, previous research, or other relevant sources.

Company Documents

Documents such as machine maintenance reports, usage reports, technical records, and production data related to the Asphalt Mixing Plant (AMP). This data is important for determining the frequency of damage and the costs incurred for maintenance and repairs.

Previous Study Reports

Previous Reports and Studies Literature studies from journals, books, or other reports discussing Asphalt Mixing Plants (AMPs), particularly related to how they work, the effects of asphalt quality, and machine maintenance. These studies help provide a theoretical basis and a deeper understanding of issues relevant to this research.

RESULTS & DISCUSSION

Pre-Processing & Processing Data

The asphalt production process at PT Fima Kencana Kerthasari is carried out at a mixing plant facility located in Belo Village, Jereweh District, West Sumbawa Regency. This facility is designed to produce hot mix asphalt (HMA) used in road construction projects, both locally and nationally. Field observations and interviews with operators and technical staff showed that the asphalt production process follows standard industry procedures, but there are several aspects that are not yet fully optimized.

The aggregate processing is carried out beforehand by drying it. The dried aggregate in the dryer drum aims to reduce the water content. Therefore, this process is very important to ensure optimal mixing of materials.

After drying, the aggregate is then heated to a certain temperature, usually 150°-170° C. The first objective of aggregate processing is to ensure that the asphalt mixture achieves maximum performance. The second is to reduce unwanted materials such as clay, dirt, or organic matter. The third is to improve the quality of the mixture, and the fourth is to facilitate the construction process in the field.

Next, hot asphalt is added to the mixer in certain proportions according to the required specifications. The stage begins with the preparation of materials in the form of crushed stone aggregate, sand, and filler, prepared according to the planned gradation. Gradation is important to ensure that the mixture has good stability and durability.

The aggregates, which have been grouped according to size, are transported to the dryer drum and heated to the required temperature (around 145-160°C) to remove moisture and ensure optimal bonding later on. After drying, the hot aggregates are transferred using a conveyor or bucket elevator to a hot bin for temporary storage. In the hot bin, the aggregates are separated according to size and are ready to be mixed.



Figure 2. PT Fima Kencana Kerthasari's Asphalt Mixing Plant (AMP).

Mixing Process

In the asphalt mixing process carried out by PT Fima Kencana Kerthasari to determine the quality of the asphalt produced, before the mixing process, the heated asphalt is weighed to achieve the appropriate mixture ratio. The automatic weighing system measures the amount of hot aggregate according to the desired gradation proportion. In the next stage, the hot aggregate is mixed without asphalt for a few seconds to ensure homogeneity in the dry mixing process. Next, in the wet mixing process, hot asphalt is added to the aggregate and stirred until evenly mixed, usually for 30-60 seconds. Sometimes additives or additional fillers are also mixed at this stage.

The homogeneous hot asphalt mixture is transferred to a transport truck via a hopper or storage silo. The truck then transports the mixture to the project site for application to the road surface. Throughout the process, quality control measures are carried out, such as monitoring the temperature of the aggregate and asphalt, the aggregate gradation, and the asphalt content in the mixture. Laboratory tests are conducted periodically to ensure that the mixture meets technical specifications. The main principle in mixing is that the mixture must be homogeneous in order to have uniform strength and durability. The temperature of the aggregate and asphalt must be maintained according to standards so that the asphalt can coat the aggregate perfectly. The proportions of each material, namely aggregate, asphalt filler, and additives, must be weighed accurately to ensure the stability of the mixture.

Table 1. Aggregate Property Test Results.

No	Tests	Aggregate Size (%)			
		1/2"	2/3"	3/8"	Screen
1	Sieve Analysis (% Passing)				
	1/2"	100.00	100.00	100.00	100.00
	2/3"	42.39	100.00	100.00	100.00
	3/8"	0.24	45.28	94.84	88.51
	#4	0.19	17.28	43.40	75.13
	#10	0.16	3.37	10.33	51.74
	#40	0.13	1.05	5.35	17.64
	#200	0.10	0.50	2.01	6.18
2	LA Abrasion	22.50			
3	Coarse Aggregate Specific Gravity				
	Dry	2.615	2.608	2.574	-
	SSD	2.675	2.653	2.609	-
	Apparent	2.781	2.733	2.668	-
	Absorption	2.290	1.750	1.362	-
4	Fine Aggregate Specific Gravity				
	Dry	-	-	-	2.563
	SSD	-	-	-	2.627
	Apparent	-	-	-	2.739
	Absorption	-	-	-	2.512

Asphalt Quality Inspection

The final product is examined through laboratory tests, such as *the Marshall Test*, to ensure that the quality meets the established standards. *The Marshall Test* involves several stages of examination, namely the preparation of test specimens, where the asphalt mixture materials (aggregate, asphalt, and filler) are processed according to the mixture design or *Job Mix Formula (JMF)* or taken directly from the AMP. The mixture is heated to a certain temperature before being molded using a *Marshall* mold, and the sample is stirred. Next, a 63.5 mm cylindrical specimen is molded using a Marshall compactor with a certain number of blows (usually 75 blows on each side for heavy traffic).

The molded specimens are then cooled at room temperature. Before testing, the specimens are immersed in water at 60°C for 30-40 minutes to simulate hot conditions in the field.



Figure 3. Test Sample Molding.

Stability and Flow Testing

Stability measures the specimen's ability to withstand maximum load before damage occurs. The stability value is measured in kilogram-force (kgf) units. Meanwhile, flow measures the deformation of the specimen coating when maximum load is applied. The test is carried out using a Marshall stability testing machine. An additional parameter calculated is void in mix (vim), which is the percentage of air voids and mix. Void in Mineral Aggregate (VMA) is the percentage of voids between aggregate particles filled with asphalt and air. Void filled with asphalt (vfa) is the percentage of voids in the aggregate filled with asphalt, and density is the density of the asphalt mixture.

Table 2. Asphalt Mix Design and Asphalt Mix Testing with the Marshall Test

No.	Test	Parameter	AC-WC Mixture	Unit
1	Composition	3/4"	12.2	%
		3/8"	15.0	%
		1/2"	26.3	%
		Stone Dust	39.4	%
		Sand	0.9	%
		Asphalt	6.2	%
		Total	100.0	%
2	Marshall	Bulk Density	2.213	g/cm ³
		VM	4.32	%
		VMA	20.36	%
		VFB	78.77	%
		Stability	1230	kg
		Flow	3.38	mm
		MQ	357	kg/mm
Marshall Residual Stability			92.32	%

Strengthening the Raw Material Quality Control System

The quality of hot mix asphalt (HMA) is fundamentally determined by the characteristics of the raw materials, particularly the aggregate and asphalt. Therefore, the implementation of a strict raw material quality control system is the first step in the optimization chain. Each aggregate supply must be verified through laboratory tests covering gradation, clay content, Los Angeles Abrasion value, and apparent specific gravity. These values must meet the tolerance limits as stipulated in SNI 03-1737-1989. In addition, aggregate storage must be protected from exposure to extreme weather, especially rain, which can increase moisture content and trigger thermal instability during the drying process.

The use of 60/70 penetration asphalt must also be controlled through routine testing of its rheological properties, such as penetration value, softening point, and viscosity. Fluctuations in asphalt properties due to long-term storage or exposure to high temperatures can result in significant deviations in the performance of the final mixture (Hartono & Putri, 2023). Therefore, it is recommended that each

asphalt tank be equipped with a temperature monitoring system and a regular testing schedule every 30 days of operation.

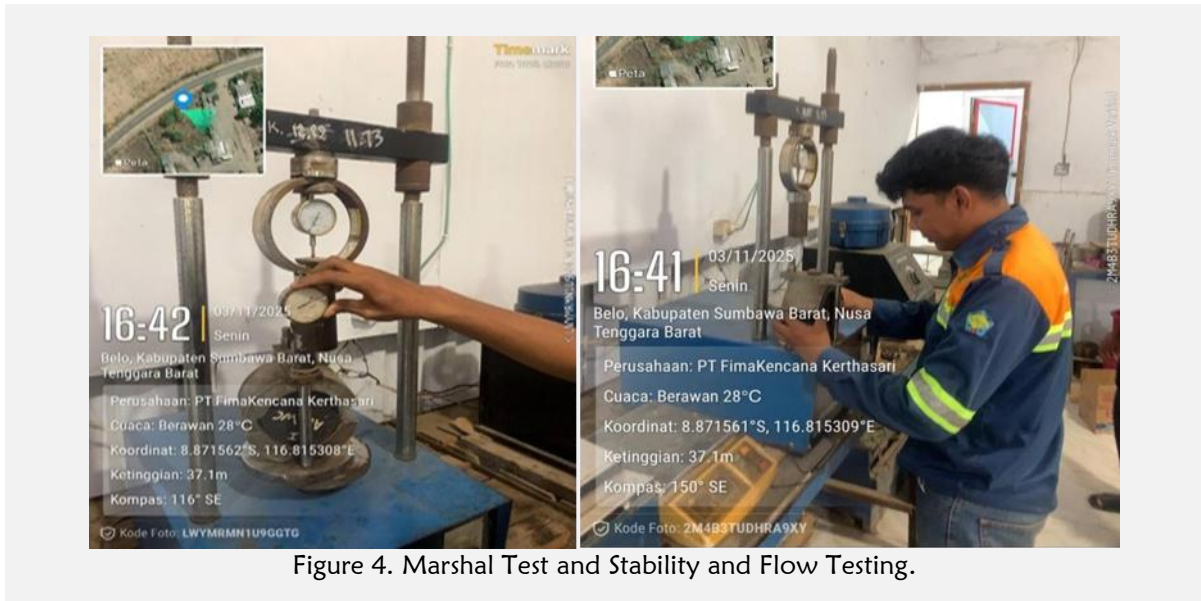


Figure 4. Marshal Test and Stability and Flow Testing.

Standardization of Operational Parameters through SOPs and Automation

Product quality consistency is highly dependent on the accuracy of production process parameters. In the context of mixing plants, critical parameters include aggregate drying temperature (150–170°C), mixing temperature (155–165°C), mixing duration (≥ 45 seconds), and asphalt-aggregate ratio. Field findings show that deviations in these parameters still occur frequently, mainly due to the lack of standardized and documented operational guidelines.

To overcome this, it is necessary to develop comprehensive Standard Operating Procedures (SOPs) specific to the type of mixture being produced (e.g., AC-BC, AC-WC). These SOPs should involve input from technical staff, laboratories, and quality management, and be reviewed every six months. Furthermore, the functionality of the Programmable Logic Controller (PLC)-based control system needs to be improved so that it not only operates automatically but is also capable of recording data in real-time, analyzing quality trends, and providing notifications when deviations outside the control limits occur (Widodo et al., 2024). This approach is in line with the principles of Statistical Process Control (SPC), which has been proven effective in the precision manufacturing industry.



Figure 5. Quality Control Standards.

Implementation of Preventive Maintenance on Production Equipment

The performance of mixing plant equipment has a direct correlation with output quality. Inaccurate temperature sensors, worn mixer paddles, or uncalibrated weighing systems can cause systemic errors in the production process. Therefore, the implementation of a preventive maintenance program is a strategy that cannot be ignored. The program must include three levels, namely daily maintenance (sensor cleaning and visual inspection), weekly maintenance (mechanical inspection of mixers and elevators), and monthly maintenance (calibration of measuring instruments by an accredited party).

All maintenance activities must be documented digitally to ensure accountability and facilitate equipment reliability analysis (reliability-centered maintenance). According to Prasetyo et al. (2021), the disciplined implementation of preventive maintenance can reduce product quality variation () by up to 22% within a six-month period.

In the industrial era, information system integration has become an important pillar of modern quality management. PT Fima Kencana Kerthasari needs to develop an integrated digital platform that connects raw material data, process parameters, laboratory test results, and product distribution. The platform enables traceability of each batch of mixture back to the source of the aggregate, the operator in charge, and the specifications of the destination project.

The existence of an integrated information system not only increases transparency but also speeds up responses to quality non-conformities found in the field. Historical data analysis can also be used to identify failure patterns and formulate preventive corrective actions. This approach is in line with the recommendations of Wijaya & Suryaningsih (2022), who emphasize that the digitization of production processes is the key to efficiency and quality consistency in the medium-scale road construction industry.

Improving Operator Competence

Mixing plant operators are not only required to master operational aspects, but also to understand the principles of road material technology and the interpretation of laboratory test results. Observations show that the theoretical understanding of some operators is still limited, which results in suboptimal decision-making during operations.

To address this competency gap, it is necessary to conduct regular competency-based training that covers understanding of project technical specifications, Marshall test procedures and analysis of VIM, VMA and stability parameters, use of digital control system interfaces, and the principles of continuous improvement in quality management.

Training can be conducted in collaboration with accredited training institutions, such as the West Nusa Tenggara Regional Construction Training Center, or through collaboration with universities. Competency evaluation through written tests and operational simulations must be carried out after training to ensure the effectiveness of knowledge transfer (Haryanto, 2022).



Figure 6. Training in sample testing.

CONCLUSION

Based on the results of observations, data analysis, and practical work activities carried out at PT Fima Kencana Kerthasari, Belo Village, Jereweh District, West Sumbawa Regency, three main conclusions can be drawn that directly answer the research questions in this study.

1. The asphalt production process at the PT Fima Kencana Kerthasari mixing plant generally follows industry standards, but the implementation of the quality control system is not yet fully optimal. There are inconsistencies in the consistency of the mixing temperature, the mixing duration is sometimes below standard, and raw material testing is not carried out regularly. This causes around 30% of products to not meet the technical specification limits according to the Marshall test, especially in terms of stability and VIM (Voids in Mineral Aggregate) parameters.
2. The quality of the asphalt produced is influenced by four dominant factors, namely variations in the quality of local aggregates that do not always meet SNI standards. Fluctuations in production process parameters due to irregular equipment calibration, production equipment conditions that experience wear and tear without adequate preventive maintenance, and the technical limitations of operators regarding road material technology principles. These factors () are interrelated and form a complex system, so that partial improvements are not sufficient to achieve sustainable quality improvement.
3. An effective optimization strategy must be holistic and integrated. Strategic recommendations include: strengthening the raw material quality control system, standardizing operational parameters through data-based SOPs, implementing preventive maintenance programs, improving human resource competencies through competency-based training, and developing a production information system to ensure traceability and evidence-based decision making. The implementation of this strategy not only meets national technical standards, but also supports the principles of sustainable quality management as mandated in the ISO 9001:2015 framework.

Thus, optimizing the asphalt production process at PT Fima Kencana Kerthasari is not merely a technical issue, but a managerial challenge that requires systematic commitment from all levels of the organization.

ACKNOWLEDGMENT

Based on the findings obtained in the field, several suggestions are proposed that are expected to be considered by PT Fima Kencana Kerthasari, including:

1. For the Company
It is recommended to immediately revise and re-socialize the Standard Operating Procedure (SOP) for production, which includes the tolerance limits for critical parameters (temperature, time, material ratio), and require monthly equipment calibration. In addition, the company needs to allocate a special budget for technical training for operators at least every three months, in collaboration with accredited training institutions or local technical universities.
2. For Internal Laboratories
The frequency of quality testing should be increased to 100% for each production batch, especially Marshall tests, asphalt content tests, and gradation tests. The use of simple software for recording and analyzing test data is also recommended to accelerate the early detection of quality non-conformities.
3. For the Community
Especially for road users in Sumbawa Bara District, improved asphalt quality directly impacts comfort, safety, and the service life of road infrastructure. Roads built with high-quality asphalt mixtures will be more resistant to cracking, subsidence, and damage caused by extreme weather. Therefore, the community is expected to participate in participatory monitoring by reporting road damage early and supporting local government policies that encourage the use of construction materials that meet standards. Collective awareness of infrastructure quality is the foundation of sustainable development at the local level.
4. For Future Researchers
It is recommended to develop this research in a more quantitative and experimental direction. First, mix design optimization can be carried out using the Modified Marshall or Superpave methods to adjust the mix formula to the characteristics of local aggregates in West Sumbawa. Second, research can focus on the implementation and evaluation of the impact of the optimization strategies proposed in this report, for example through an action research approach for 6–12 months. Third, further studies on the use of modified asphalt (such as polymer-modified asphalt) or recycled

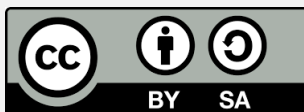
materials (RAP Reclaimed Asphalt Pavement) could be innovative options to improve pavement performance while supporting environmental sustainability principles.

5. For Universities

Mining Engineering study programs are advised to strengthen courses on road material technology and construction quality management, as well as encourage closer collaboration with industry through structured internship programs. This will prepare graduates who not only understand theory, but are also able to solve real problems in the field.

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