

# Traffic Assessment for Unsignalized Intersection Under Influence for Side Friction on Padang Lawas, North Sumatera

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## Abstract

An unsignalized intersection is a part of a road where currents from different directions or directions meet. There was a conflict between currents from the opposite direction and intersecting each other, resulting in congestion along the arms of the intersection. Likewise, at the intersection of four arms without a signal at Sibuhuan Market, Padang Lawas Regency, North Sumatera, there is a congestion caused by the reduction in the effective width of the road due to parking on the road. At the intersection of four arms without a signal at Sibuhuan Market, Padang Lawas Regency, North Sumatera, there is a congestion caused by side obstacles, a high vehicle population that is not matched by the availability of adequate infrastructure so this research aims to analyze the performance of the four-arm intersection without a signal. based on Indonesian Highway Capacity Manual (MKJI 1997) and analyzes them to improve the performance of these unsignalized intersections. The analysis of the results showed that the intersection performance for the unsigned intersection conditions in the existing condition with the parking on the side of the road which reduced the effective width, the maximum total flow was 2341 pcu / hour, capacity (C) = 2707.06 pcu / hour, and the degree of saturation (DS) = 0.86, intersection delay (D) = 14.62 seconds / pcu and queuing opportunity (QP) 30.03 - 59.32%. Therefore, it is necessary to recalculate with various alternatives so that the DS value meets the requirements of the Indonesian Highway Capacity Manual, which is < 0.75.

**Keywords:** intersection, degree of saturation, MKJI 1997, Padang Lawas

## 1. Introduction

Roads are land transportation facilities that have an important role in smoothing economic relations and social activity relations, and play a major role in the progress and development of an area. This traffic was very important to increase more about the social mobility for people [1]. Every time people continue to grapple with traffic with various interests [2]. Traffic volume in North Sumatera has been developed to increase more about regional growth and development as well as the rate of population growth. Recently, traffic volume is not accompanied

by additional road infrastructure often results in congestion. Traffic congestion was still a major problem in big cities, which is especially felt during rush hours, morning, afternoon and evening [3].

Development of traffic volume in Padang Lawas Regency, especially in the Sibuhuan Market, was still in high congestion rate. This was happened because there is a market which is a trading center right on Jl. Sibuhuan-Gunung Tua and Jl. Prof. H. M Yamin SH with high side friction [4]. This is due to market activity, vehicles parked on the road and vehicles in and out of the intersection lane [5].

From the above problems, it can be concluded that the intersection with no signal at the Sibuhuan Market needs to be evaluated and analyzed both on the performance of traffic management, road widening, the existing condition from an unsigned intersection to a signalized intersection to be able to solve existing problems optimally [6].

The purpose of this study was determining about performance of existing traffic at the intersection at the Sibuhuan Market, Padang Lawas Regency, North Sumatra. It is necessary to define the problem, namely the research was carried out at the intersection of Sibuhuan Market, Padang Lawas Regency, North Sumatra. This study was divided into 3 (three) sessions for peak hours, namely 06.00-08.00 WIB, 12.00-14.00 WIB, and 16.00-18.00 WIB for two working days (Monday and Tuesday) and Saturday for the weekend.

## 2. Theoretical Background

Basically, in conducting research on an object it is important to understand the mindset of the research to be carried out. The mindset will help direct the research to be carried out. The compilation in this research focuses on the volume of traffic flow that passes through the intersection of the intersection of Sibuhuan Market, Padang Lawas Regency, North Sumatra, population data of Padang Lawas Regency, and measures the intersection arm and looks at the condition of the intersection.

This study used a field observation method, namely the main survey by means of manual recording per 2 (two) hours and by direct measurement using a meter to obtain the intersection arm width and parking width, then analyzed the data obtained. The survey was carried out on working days, namely Monday and last Tuesday on a non-working day, namely Saturday, with the consideration that these days represent peak hours and the traffic volume is expected to differ greatly. Another very influential consideration is the research location which is the most visited trade area, especially on weekdays. The research location is an unsigned intersection with 4 (four) arms without a median, which is then carried out by observation for 3 (three) sessions for 2 (two) hours, namely 06.00-08.00 WIB, proceed to the next session at 12.00-14.00 WIB, and the last session 16.00-18.00 WIB, observations made at 5 minutes intervals.

The input variables for the width of the approach and the type of intersection can be seen in Tables 1 and 2, as follows.

**Table lanes and the average**

width of the minor and main approaches $W_{AC}$ and $W_{BD}$	Number of lanes (total for two directions)
$W_{BD} = (b + d / 2) / 2$	2
$< 5.5$	4
$\geq 5.5$	
$W_{AC} = (a / 2 + c / 2) / 2$	2
$< 5.5$	4
$\geq 5.5$	

**Table 2. Intersection Type**

IT Code	Number of intersection arms	Number of minor	lane lanes Number of minor road lanes
322	3	2	2
324	3	2	4
342	3	4	2
422	4	2	2
424	4	2	4

### 2.1 Capacity (C)

Value of basic capacity ( $C_o$ ) can be seen based on the type of intersection contained in Table 3. as follows,

**Table 3. Basic Capacity ( $C_o$ )**

IT Junction Type	Basic Capacity (pcu / hour)
322	2700
342	2900
324 or 344	3200
422	2900
424 or 444	3400

Ways Calculation of Capacity (C) can be calculated with the provisions of MKJI 1997 with the formula of Capacity (C) as follows:

$$C = C_o \times F_w \times F_M \times F_{CS} \times F_{RSU} \times F_{LT} \times F_{RT} \times F_{MI} \quad (1)$$

Description :

C = Capacity (pcu / hour)

$C_o$  = Basic capacity (pcu / hour)

$F_w$  = Approach width adjustment factor

$F_M$  = Main road median adjustment factor

$F_{CS}$  = City size adjustment factor

$F_{RSU}$  = Road environment type adjustment factor, side friction and non-motorized vehicles  
 $F_{LT}$  = Left turn adjustment factor  
 $F_{RT}$  = Right turn adjustment factor  
 $F_{MI}$  = minor road current adjustment

factor 2.2 Adjustment factor

a. Approach width adjustment factor ( $F_w$ )

Approach width adjustment factor ( $F_w$ ) is calculated based on the type of intersection, using equation (2), as follows:

$$F_w = 0.70 + 0.0698 W_1 \quad (2)$$

Description:

$F_w$  = Approach width adjustment factor

$W_1$  = Average width of approach (m)

Input variables for the main road median type are shown in Table 4, for city size adjustment factors are listed in Table 5 and for adjustment factors for road environment type, side obstacles, and vehicles Non-motorized is shown in Table 6, below:

**Table 4.** Main road median adjustment factor

Description	Type M	Adjustment factor Main road median ( $F_M$ )
No main road median	None	1.00
There is a main road median, width <3 m	Yes	1, 05
There is a median of the main road, width $\geq 3$ m	There is	1.20

**Table 5.** Adjustment factor for City Size City

Size (CS)	Population (million)	Adjustment factor for City Size ( $F_{CS}$ )
Very Small	<0.1	0.82
Small	0, 1 - 0.5	0.88
Medium	0.5 - 1.0	0.94
Large	1.0 - 3.0	1.00
Very large	> 3.0	1.05

**Table 6.** Adjustment factors for road environment types, side barriers and non-motorized vehicles

Class RE road environment	Class SF side obstacle class	Non-motorized vehicle factors					
		0.00	0.05	0.10	0.15	0.20	$\geq 0.25$
Commercial	High	0.93	0.88	0.84	0.79	0.74	0.70
	Medium	0.94	0.89	0.85	0.80	0.75	0.70
	Low	0.95	0.90	0.86	0.81	0.76	0.71
Settlement	High	0.96	0.91	0.86	0.82	0.77	0.72
	Medium	0.97	0.92	0.87	0.82	0.77	0.73
	Low	0.98	0.93	0.88	0.83	0.78	0.74
Limited access	High or moderate or low	1.00	0.95	0.90	0.90	0.80	0.75

b. Left Turn Adjustment Factor ( $F_{LT}$ )

The left turn adjustment factor ( $F_{LT}$ ) is calculated using equation (3), as follows:

$$F_{LT} = 0.84 + 1.61 P_{LT} \quad (3)$$

Where:

$F_{LT}$  = left turn adjustment factor

$P_{LT}$  = Ratio of left turning current

c. Right turn adjustment factor ( $F_{RT}$ )

The right turn adjustment factor ( $F_{RT}$ ) is determined based on the number of intersection arms, where the number of intersection arms in the research is 4 arms, then it is calculated using equation (4), as follows:

$$F_{RT} = 1.00 \quad (4)$$

d. Minor road ratio adjustment factor ( $F_{MI}$ )

Minor road ratio adjustment factor ( $F_{MI}$ ) is influenced by the type of intersection, where the type of intersection used is 422 then it is calculated using equation (5), as follows:

$$F_{MI} = 1.19 \times P_{MI}^2 - 1.19 \times P_{MI} + 1.19 \quad (5)$$

Where:

$F_{MI}$  = minor road adjustment factor

$P_{MI}$  = Right turning current ratio

2.3 Degree of Saturation (DS)

Value of DS (*Degree Of Saturation*) is obtained by comparing traffic flows total ( $Q_{TOT}$ ) with Capacity (C) using equation (6), as follows:

$$DS = Q_{TOT} / C \quad (6)$$

## 2.4 Delay

### a. The intersection traffic delay ( $DT_I$ )

is the average traffic delay for all motorized vehicles entering the intersection. The intersection traffic delay ( $DT_I$ ) is calculated using the following equation (7):

$$DT_I = \left( \frac{1.0504}{0.2742 - 0.2042 DS} \right) - (1 - DS) \times 2 \quad (7)$$

### b. Main road traffic delay ( $DT_{MA}$ )

Main road traffic delay ( $DT_{MA}$ ) is calculated using the following equation (8):

$$DT_{MA} = \left( \frac{1.05034}{0.346 - 0.246 DS} \right) - (1 - DS) \times 1.8 \quad (8)$$

### c. Minor road traffic delays ( $DT_{MI}$ )

Minor road traffic delays ( $DT_{MI}$ ) are calculated using equation (9), as follows:

$$DT_{MI} = (Q_{TOT} \times DT_I - Q_{MA} \times DT_{MA}) / Q_{MI} \quad (9)$$

Where:

$Q_{MA}$  = Total traffic flow of major roads

$Q_{MI}$  = Total traffic flow of minor roads

### d. Intersection geometric delay (DG)

Intersection geometric delay (DG) includes DS and total turning ratio ( $P_T$ ). Thus, equation (10) is used, as follows:

$$DG = (1-DS) \times (p_T \times 6 + (1-p_T) \times 3) + DS \times 4 \text{ (sec / pcu)} \quad (10)$$

### e. Junction delay (D)

Junction delay (D) is the total delay due to traffic volume and road geometric, where the intersection delay is calculated using equation (11), as follows:

$$D = DG + DT_I \quad (11)$$

### f. Queue Chances

The queue probability range is determined from the empirical relationship between the queue probability and the degree of saturation, for more details can be seen in Figure (1) or equations (12) and (13), as follows.

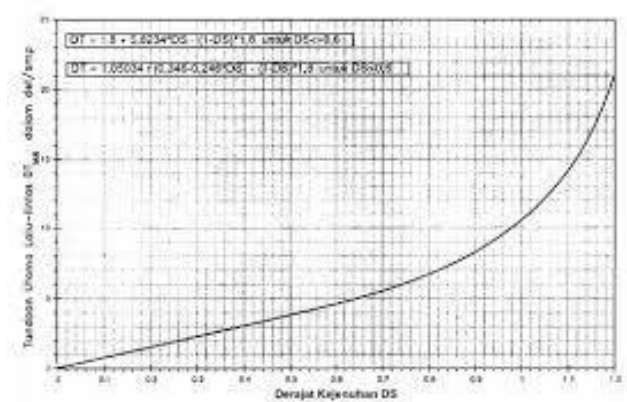


Figure 1. Queue Chance Range (QP%)

$$QP\%_{Upper\ limit} = 47.71DS - 24.68 DS^2 + 56.47 DS^3 \quad (12)$$

$$QP\%_{Lower\ limit} = 9.02DS - 20.66DS^2 + 10.49 DS^3 \quad (13)$$

## 3. Methodology

### 3.1 Procedure

#### a. Primary Data Collection Primary

data is data obtained from the research location. How to get primary data by means of manual recording per 2 hours and by direct measurement using a meter to get the intersection arm width and parking width, then analyzed the data obtained. The survey was conducted on weekdays, namely Monday and last Tuesday on a non-working day, namely Saturday, taking into account that these days represent peak hours and the estimated traffic volume is significantly different. Another very influential consideration is that the research location is a trade and shopping center area which is still widely passed and visited, especially during working hours. The research location is an unsigned intersection with four arms, namely Jl. Sibuhuan-Gunung Tuan (North), Jl. Surapati (South), Jl. Kihajar Dewantara (East) and Jl. Prof. H. M Yamin SH (West). Then the observations were made for 3 (three) diving sessions per 2 hours, namely 06.00-08.00 WIB, 12.00-14.00 WIB, and the last session 16.00-18.00 WIB. Observations were made at 5 minutes intervals, and produced traffic volume data.

#### b. Secondary Data Collection

According to Hasan (2002: 58) secondary data is data obtained by researchers from existing sources or from previous data. This data is used to support the primary data that has been obtained, namely,

from library materials, literature, previous research, books and so on. Secondary data consists of:

- 1) Location Map, which determines the layout where the research will be carried out.
- 2) Geometric intersection, which measures the width of the intersection arm of the
- 3) Population Data, namely to determine the size class of the city of Padang Lawas Regency, North Sumatra from the relevant agency, such as: BPS (Central Statistics Agency)
- 4) Environmental conditions, namely determining the type of road environment based on the side friction classification in Table 6.

## 4. Results and Discussion

### 4.1 Intersection Geometric Results

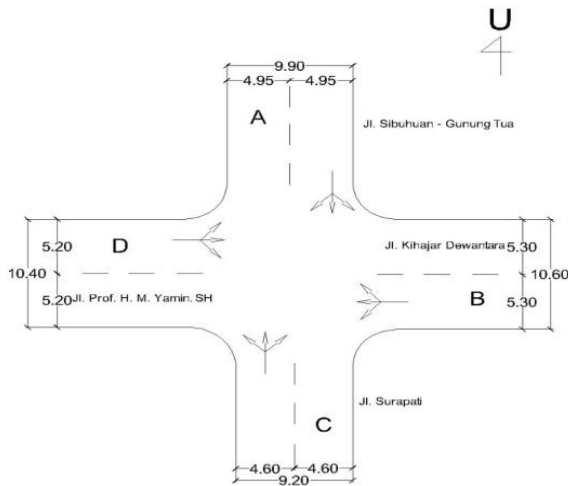


Figure 3. Location Plan

The geometric intersection results are obtained directly from observations and measurements in the field, namely the intersection of four sibuhuan markets. Observations during the survey found that the intersection of the Sibuhuan Market was the intersection of Jl. Kihajar Dewantara - Jl. Prof. H. M Yamin SH as the main road, and Jl. Sibuhuan-Gunung Tua - Jl. Surapati as a minor path. This intersection has 4 arms and each arm 2 lanes and 2 lanes without a median.

The width of the main roads are 10.60 m (East Arm) and 10.40 m (West Arm), while those on minor roads are 9.90 m (North Arm) and 9.20 m (South Arm).

### 4.2 Traffic

Volume The volume of traffic flowing through the Sibuhuan Market is observed 2 (two) days on weekdays (Monday and Tuesday) and 1 (one) non-working day (Saturday) with 3 (three) sessions, namely, 06.00-08.00 WIB, 12.00-14.00 WIB and 16.00-18.00 WIB, the maximum traffic volume results are on Tuesday at 12.00-14.00 WIB with a traffic volume value of 2341 pcu / hour. For more details can be seen in Table 7, as follows:

Table 7. Summary of Traffic Flow Volume

Day	Period	Volume of traffic flow (smp / hour)
Mon	06.00-08.00	2315
	12.00-14.00	2341
	16.00-18.00	2328
Tuesda y	06:00 to 08:00	2298
	12:00-14.00	2333
	16.00-18.00	2311
Saturda y	06.00-08.00	2278
	12.00-14.00	2209
	16.00-18.00	2220

### 4.3 Analysis of Simpang Not signalized

#### Data Input

- a.  $Q_{MI}$  is the sum of all traffic on minor roads, which are known to the current total of 1048 minor road smp / hour .
- b.  $Q_{MA}$  is the total traffic flow on the major road, which is known to be the total flow of minor roads as 1294 pcu / hour.
- c.  $P_{MI}$  is the minor road current divided by the total current ( $Q_{TOT}$ ), where the total current is 2341 pcu / hour. So, the Pvalue is obtained $_{MI}$  as follows:

$$P_{MI} = \frac{Q_{MI}}{Q_{TOT}} = \frac{1048}{2341} = 0.45$$

- d.  $P_{LT}$  and  $P_{RT}$  obtained from the current total turn left ( $P_{LT}$ )= 783 smp / hour and the flow right turn total total ( $P_{RT}$ )= 766 smp / hour

$$P_{LT} = \frac{Q_{LT}}{Q_{TOT}} = \frac{783}{2341} = 0.33 \text{ smp / hour}$$

$$P_{RT} = \frac{Q_{RT}}{Q_{TOT}} = \frac{766}{2341} = 0.33 \text{ pcu / hour}$$

- e. Ratio between non-motorized vehicle flows

$$P_{UM} = \frac{Q_{UM}}{Q_{TOT}} = 0.11 \text{ vehicles / hour}$$

#### 4.4 Traffic Flow Analysis Intest Unsignalized Intersection Capacity

##### a. Approach width ( $W_1$ ) and intersection type (IT)

- 1) Average width of the minor and major approaches  $W_{AC}$  and  $W_{BD}$  and average width of the approximation  $W_1$

$$\begin{aligned} \text{North Approach } (W_A) &= (a - \text{parking width}) / 2 \\ &= (9.90 - 2.00) / 2 \\ &= 3.95 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{South Approach } (W_C) &= (a - \text{parking width}) / 2 \\ &= (9.20 - 2.00) / 2 \\ &= 3.60 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{East Approach } (W_B) &= (a - \text{parking width}) / 2 \\ &= (10.60 - 2.30) / 2 \\ &= 4.15 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{West Approach } (W_D) &= (a - \text{parking width}) / 2 \\ &= (10.40 - 2.20) / 2 \\ &= 4.10 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Width of minor approach } (W_{AC}) &= (W_A + W_C) / 2 \\ &= (3.95 + 3.60) / 2 \\ &= 3.78 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Width of the minor approach } (W_{BD}) &= (W_A + W_C) / 2 \\ &= (4.15 + 4.10) / 2 \\ &= 4.13 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Width of the minor approach } (W_{BD}) &= (W_A + W_C) / 2 \\ &= (4.15 + 4.10) / 2 \\ &= 4.13 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Average width of the approximation } (W_{BD}) &= (W_A + W_B + W_C + W_D) / 4 \\ &= (3.95 + 3.60 + 4.15 + 4.10) / 4 \\ &= 4.13 \text{ m} \end{aligned}$$

Number of lanes  
 $W_{AC} = 2$  lanes  
 $W_{BD} = 2$  lanes

##### Intersection Type

From the table it is found that the type of intersection is 422

##### 2) Capacity Basic ( $C_0$ )

The intersection type is 422, then the basic capacity is 2900 pcu / hour.

##### 3) Approach width adjustment factor ( $F_W$ )

$$\begin{aligned} F_W &= 0.70 + 0.0698 W_1 \\ F_W &= 0.70 + 0.0698 (4.13 \text{ m}) \\ F_W &= 1.04 \text{ m} \end{aligned}$$

##### 4) Main road median adjustment factor ( $F_M$ )

At the study location there is no good median i tu on the main road and minor roads. ( $F_M$ ) = 1.00

##### 5) City size adjustment factor ( $F_{CS}$ )

Total population of Padang Lawas district = 281,239 people, which means small size, so that the value of the city size adjustment factor ( $F_{CS}$ ) = 0.88

##### 6) . side friction, and non-motorized vehicles ( $F_{RSU}$ )

RE = Commercial  
 SF =height  
 PUM = 0.83

##### 7) Left turn adjustment factor ( $F_{LT}$ )

$$\begin{aligned} F_{LT} &= 0.84 + 1.61 P_{LT} \\ &= 0.84 + 1.61 (0.33) = 1.38 \end{aligned}$$

##### 8) Right turn adjustment factor ( $F_{RT}$ )

$$F_{RT} = 1, 00$$

##### 9) Minor road current adjustment factor ( $F_{MI}$ )

$$\begin{aligned} F_{MI} &= (1.19 \times 0.45^2) - (1.19 \times 0.45) \\ &= 0.89 \end{aligned}$$

##### 10) Capacity (C)

$$\begin{aligned} C &= C_0 \times F_W \times F_M \times F_{CS} \times F_{RSU} \times F_{LT} \times F_{RT} \times F_{MI} \\ &= 2900 \times 1.04 \times 1 \times 0.88 \times 0.83 \times 1.38 \times 1 \times 0.89 \\ &= 2711 \text{ pcu / hour} \end{aligned}$$

#### 4.5 Traffic Behavior

##### a. Degree of Saturation (DS)

$$DS = \frac{Q_{TOT}}{C} = \frac{2341}{2711} = 0.86$$

(degree of saturation > 0.75)

##### b. Delay ( $DT_1$ )

$$DT_1 = \left( \frac{1.0504}{0.2742 - 0.2042 DS} \right) - (1 - DS) \times 2$$

$$\begin{aligned} DT_1 &= \left( \frac{1.0504}{0.2742 - 0.2042 \times 0.86} \right) - (1 - 0.86) \times 2 \\ &= 10.49 \text{ sec / pcu} \end{aligned}$$

##### c. Main Road Traffic Delay ( $DT_{MA}$ )

$$DT_{MA} = \left( \frac{1.05034}{0.346 - 0.246 DS} \right) - (1 - DS) \times 1.8$$

$$\begin{aligned} DT_{MA} &= \left( \frac{1.05034}{0.346 - 0.246 \times 0.86} \right) - (1 - 0.86) \times 1.8 \\ &= 7.64 \text{ sec / pcu} \end{aligned}$$

##### d. Minor Road Traffic Delay ( $DT_{MI}$ )

$$\begin{aligned} DT_{MI} &= (Q_{TOT} \times DT_1 - Q_{MA} \times DT_{MA}) / Q_{MI} \\ DT_{MI} &= (2341 \times 10.49 - 1294 \times 7.64) / 1048 \\ &= 14.01 \text{ sec / pcu} \end{aligned}$$

##### e. Geometric Delay Intersection (DG)

$$\begin{aligned} DG &= (1 - DS) \times (\rho_H \times 6 + (1 - \rho_H) \times 3 + DS \times 4) \\ DG &= (1 - 0.86) \times (0.66 \times 6) + (1 - 0.66) \times 3 + 0.86 \times 4 \\ &= 4.13 \text{ sec / pcu} \end{aligned}$$

f. Intersection Delay (D)

$$D = DG + DT_1$$

$$D = 4.13 + 10.46$$

$$D = 14.59 \text{ sec / pcu}$$

g. Chance of Queuing (QP%)

$$\begin{aligned} QP\%_{BA} &= 47, 71 DS - 24.68 DS^2 + 56, 47 DS^3 \\ &= 47.71 (0.86) - 24.68 (0.86) + 56.47 \\ &\quad (0.86^3) \\ &= 30.03\% \end{aligned}$$

$$\begin{aligned} QP\%_{BW} &= 9, 20 DS - 20.66 DS^2 + 10, 49 DS^3 \\ &= 9.20 (0.86) - 20.66 (0.86) + 56.47(0.86^3) \\ &= 59.32\%. \end{aligned}$$

## 5. Conclusion

Based on the results of the research conducted, it can be concluded that there is no signaling intersection of Sibuhuan Market. experiencing a peak traffic flow on a weekday, namely 12.00-14.00 hours with a traffic volume of 2341 pcu / hour. This intersection has 4 (four) arms with a capacity (C) of an intersection of 2707.06 pcu / hour, a degree of saturation (DS) of 0.86 with a service level of C, an intersection delay of 14.62 sec / pcu, and a queue opportunity (QP) 30.03% - 59.32%.

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