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ALTERNATIVE GEOMETRY ROAD TRASE AND FLEXIBLE PAVEMENT OF THE SOUTH TRANSJAVA ROADS LOT 2

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ABSTRAK

Jalan merupakan infrastruktur yang menghubungkan suatu daerah dengan daerah lainya dan sangat penting dalam sistem pelayanan masyarakat dari berbagai aspek. Proyek Pembangunan Jalan Lintas Selatan (JLS) merupakan salah satu proyek strategis nasional yang menghubungkan berbagai kota di Pulau Jawa bagian selatan, salah satunya adalah pembangunan Jalan Lintas Selatan Lot 2 Bululawang – Pangi yang menghubungkan Kabupaten Tulungagung bagian selatan dengan perbatasan Kabupaten Blitar. Diketahui proyek tersebut mempunyai jarak sepanjang 5.041 KM dan memiliki lebar jalan 7.2 m. Untuk itu, tujuan dari skripsi ini adalah untuk menghitung perencanaan geometrik dengan menggunakan metode (PDGJ) 2021 dan mencoba menghitung tebal perkerasan lentur dengan pedoman MDP 2024 dengan umur rencana 20 tahun. Berdasarkan hasil Perencanaan Geometrik dan Perkerasan Lentur pada Proyek JLS. Lot 2 (STA 5+100 – 9+889) diperoleh 7 tikungan berupa tikungan SCS dan ada 10 lengkung vertikal yang terdiri dari 6 lengkung vertikal cembung, dan 2 lengkung vertikal cekung. Perencanaan perkerasan kaku dengan Manual Desain Perkerasan Tahun 2024 (MDP 2024) diperoleh nilai ESA4 dan ESA5 2.789.378 dan 3.053.134 serta dengan design perkerasan dengan ketebalan CTB 150mm, AC-BC 60mm dan AC-WC 40mm. Didapatkan hasil total biaya untuk seluruh pekerjaan adalah Rp 68.120.084.027.55-.

Kata kunci : Perencanaan Jalan, Geometrik Jalan, Perkerasan Lentur, Bill of Quantity

ABSTRACT

Roads are infrastructure that connects one region to another and are very important in the community service system from various aspects. The Southern Cross Road Development Project (JLS) is one of the national strategic projects that connects various cities in southern Java, one of which is the construction of Lot 2 Bululawang - Pangi South Cross Road which connects southern Tulungagung Regency with the border of Blitar Regency. It is known that the project uses flexible pavement with a distance of 5,041 KM and has a road width of 7.2m. Therefore, the purpose of this thesis is to calculate geometric planning using the 2021 (PDGJ) method and try to calculate the thickness of flexible pavement with the 2024 MDP guidelines on the grounds of a 20-year plan life. Based on the results of Geometric Planning and Flexural Pavement on the JLS Project. Lot 2 (STA 5+100 - 9+888) obtained 7 bends in the form of SCS curve and there are 10 vertical curves consisting of 6 sag vertical curves, and 2 crest curves. Rigid pavement planning with the 2024 Pavement Design Manual (MDP 2024) obtained ESA4 and ESA5 values of 2.789.378 and 3.053.134 and with a pavement design with a thickness of CTB 150mm, AC-BC 60mm and AC-WC 40mm. The total cost for all work is Rp 68.120.084.027.55.

***Keywords** : Road Design, Road Geometry, Flexible Pavement, Bill of Quantity*

1. INTRODUCTION

Lot 2 Transjava Road Bululawang - Pangi is a road that connects Tulungagung Regency with the border of Blitar Regency. Its main function is as one of the accesses to the south coast and connects between cities in the southern region of Java Island. With the existence of JLS LOT 2, hopefully it can develop the tourism sector and the economy of the surrounding community. In its planning, this road is planned to use flexible pavement and currently the project has not been completed. This thesis intends to provide planning using flexible pavement that has a 20-year plan design, because at STA 5 + 900 and 8 + 700 has a soil foundation with a low bearing capacity value. Therefore, the author makes planning with flexible pavement using the Road Pavement Design Manual method (MDP 2024) and road geometrics using (Bina Marga Road Geometric Design Guidelines 2021) with the hope that in the future it can be useful for readers

2. METHOD

Collecting data for geometric planning and rigid pavement in the form of topographic data, road class and function data, traffic data (LHR), soil data (CBR), and work unit price data (HSPK Blitar City). Road geometric planning begins with determining the main design criteria in accordance with the PDGJ guidelines (2021), then determining the technical design criteria according to the planned road location, then planning horizontal alignments and vertical alignments, and checking coordination between alignments.

Flexible pavement thickness planning begins with determining the age of the plan, then proceeds to determine the traffic growth rate factor (i), and traffic on the plan lane, then calculates the vehicle axis group and field CBR using the graph method, after completing all calculations, the structure of the pavement thickness and its connection can be determined according to the table in MDP (2024) and calculations.

The calculation of the cost budget plan begins with calculating the entire volume of work, then calculating the Analysis of Unit Prices of Work (AHSP), and recapitulating the cost budget plan in accordance with the unit price in HSPK Blitar City

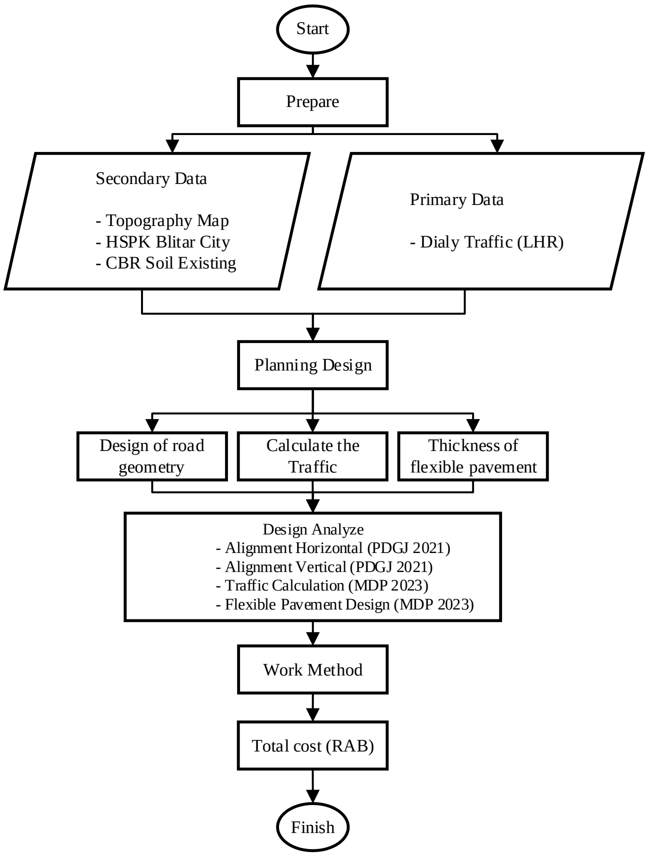

Figure 1. Flowchart Diagram
Source: *Personal Document*

3. RESEARCH FINDING AND DISCUSSION

Road Geometry Design

A. Road Design Criteria

After conducting a literature study and the collected traffic data has been completed, the next step is to determine the road design criteria based on the status of the road and road terrain. Road design criteria will be used in geometric planning which includes vertical and horizontal alignments. Here are the road design criteria.

Table 1. Road Design Criteria

No	Element of Road Geometric Criteria Design		Criteria
1	VD, Km/hour		60
2	Grade max, %		6
3	f max		0.15
4	e max, %		8
5	Type and Dimension of Road	Road Type	2/2-UD
6		Lane Width, m	3.60

No	Element of Road Geometric Criteria Design		Criteria
7		Shoulder Width, m	1.5
8		Median Width, m	-
9		Verge Width, m	-
No	**Element of Road Geometric Criteria Design**		**Criteria**
10	Transverse Slope	Lane	2
11		Shoulder	6
12	Pavement		Flexible
13	Road Area	Rumaja, m	25
14		Rumija, m	25
15		Ruwasja, m	15

Source: *PDGJ 2021*

B. Horizontal Alignment Design

Example of horizontal alignment at point PI. 1

- Azimuth (α)

  $\alpha_{PI\ 2-PI\ 3} = 360 + arc\ tg\ (\frac{619582 - 618321}{9082029 - 9082145})$
- Deflection Angle (Δ)

  $\Delta_{PI\ 3} = \alpha_{PI\ 3-PI\ 4} - \alpha_{PI\ 2-PI\ 3}$

  $\Delta_{PI\ 3} = 275.256 - 8.636$

  $\Delta_{PI\ 3} = 266.620^0$
- Length of Minimum Radius (Rmin)

  Rmin = 60^2 / {127 (10% + 0.153)}

  Rmin = 121.659 m
- Minimum Length of Spiral (Ls) or Transition Length

  L_S = (0.5 x (6 sec x V_D)

  L_S = (0.5 x (6 sec x 60)

  L_S = 50 m
- Straight Lane (LL)

  $S_L \leq$ 2.5 seconds x 60 km/hoir

  $S_L \leq$ 2500 m
- Distance Between curve (Overlap)

  0.7 x V_D

  0.7 x 60 = 42 meter
- Off Tracking (p)

  $p_1 = \frac{50^2}{24 \text{ x } 150}$

  $p_1 = 0.694$ (S-C-S)
- Length of Curve (Lc)

  $\text{Lc} \leq 6 \text{ sec x } 60\text{km/ jam } = 100 \text{ m}$
- Detail Calculation PI. 1 (S-C-S)
  - Distance from TS to SC Straight distance of transition curve (Xc)

    $\text{Xc} = 50 \text{ x } (1 - \frac{50^2}{40 \text{ x } 150^2})$

    $\text{Xc} = 49.861$
  - Perpendicular distance from tangent to SC (Yc)

    $yc = \frac{50^2}{6\ x\ 150}$

    $yc = 2.778$
  - Length of Circle, from SC to CS (Lc)

    $Lc = \frac{(84.345 - 2\ x\ 9.549)}{180°}\ x\ \pi\ x\ 150$

    $Lc = 170.815$ m
  - Length of Tangen, from PI to TS or ST (Ts)

    $Ts = (150 + 0.694) tan\ ^1/_2\ 84.345 + 25.1147$

    $Ts = 170.293$
  - Distance from PI to Lc (Es)

    $Es = 150 + 0.694\ x\ sec\ \frac{84.345}{2} - 150$

    $Es = 53.332$
  - Spiral Curve Angle (θs)

    $\theta s = \frac{90\ x\ 50}{\pi\ x\ 150}$

    $\theta s = 9.549$
  - Radius Circle (Radius Design) (Δc)

    $\Delta c = 84.345 - 2\ x\ 9.549$

    $\Delta c = 65.25$
  - Absis from p in tangent spiral (K)

    $\text{k} = 50 - 150. \text{Sin } 9.549$

    $\text{k} = 25.115$

Table 2. Calculation Recap Horizontal Alignment

PI	1	2	3	4
Δ	84.35	86.62	58.57	83.98
Xc	49.86	49.86	49.86	49.86
yc	2.78	2.78	2.78	2.78
Θs	9.55	9.55	9.55	9.55
Δc	65.25	67.52	39.47	64.88
p	0.69	0.69	0.69	0.69
k	25.11	25.11	25.11	25.11
Lc	170.82	176.77	103.33	169.86
Ts	170.29	166.89	168.55	168.99
Es	53.33	57.10	22.77	52.75

Curve	S-C-S	S-C-S	S-C-S	S-C-S

PI	5	6	7
Δ	32.71	56.32	50.35
Xc	49.80	49.80	49.82
yc	3.33	3.33	3.21
Ѳs	11.46	11.46	11.02
Δc	9.79	33.40	28.31
p	0.83	0.83	0.80
k	25.16	25.16	25.15
Lc	21.36	72.87	64.23
Ts	146.60	145.88	150.19
Es	6.14	17.73	14.53
Curve	S-C-S	S-C-S	S-C-S

Source: *Data Calculation*

B. Vertikal Alignment Design

- Slope Algebraic Difference

  A1 = g2 - g1 = -0.81— 2.75 = -3.56%

  $A_{Absolute}$ = 3.56%

  Table 3. Point Gradien from Civil 3D Design

Point	Gradien	A	A Absolute	Profile Type Curve
G1	2.75%	3.56%		Crest
G2	-0.81%		2.89%	Crest
G3	-3.70%	3.54%		Sag
G4	-0.16%		0.67%	Crest
G5	-0.83%	1.12%		Crest
G6	-1.95%		3.31%	Sag
G7	1.36%	2.14%		Sag
G8	3.50%		3.50%	Crest
G9	0.00%	1.50%		Crest
G10	-1.50%			Sag

Source: *Civil 3D Profil*

- Lv minimum
  - Lv by OSD

    $$Lv_{min} = \frac{140^2}{405}$$

    Lv_{min} = 48.4 m
  - Lv by SSD

    $$Lv_{min} = \frac{50^2}{405}$$

    Lv_{min} = 6.2 m
- Lv Comfort

  $$Lv = \frac{40}{3.6}\ x\ 3$$

  Lv = 55.6 m
- Dexterity

  $Lv\ =\ 0.6\ x\ 40km/jam$

  Lv = 24 m
- Drainage G1

  $Lv_1\ =\ 40\ x\ 3.56\%$

  Lv_1 = 1.4 %
- Shock Reduction

  $$Lv_1 = \frac{40^2\ x\ 3.56\%}{360}$$

  Lv_1 = 0.16 m
- Crest Curve
  - Because SSD < Lv

    $$Lv_1 = \frac{3.56\%\ x\ 50^2}{412}$$

    Lv_1 = 21.6 m
  - Because OSD > Lv

    $$Lv_1 = \frac{3.56\%\ x\ 140^2}{1000}$$

    Lv_1 = 69.8 m

- Sag Curve

  Because SSD < Lv

  $$Lv_3 = \frac{3.54\%\ x\ 50^2}{150 + 3.5\ x\ 50}$$

  Lv_3 = 27.23 m

C. Cut and fill Volume

Cut and fill volume is the calculation of the difference between the volume of soil that must be excavated (cut) and the volume of soil needed for hoarding (fill) in construction work. This process is important to ensure land stability and the efficiency of the use of soil materials in infrastructure development as well as determine the total soil disposal area. From calculation that has been modelled in Autodesk Civil 3D, the volume is:

- Cut/Excavation Area : 1.521.939.26 m^3
- Fill/Embankment Area : 440.259.60 m^3
- Disposal Area : ± 1.081.679.66 m^3

Flexible Pavement

A. Road pavement design criteria

Road pavement design criteria is according to location of pavement design to measure the UR, growth of vehicle (i %), lane distribution factor DD and DL:

- i (Growth) : 4.80% (East Java)
- Way factor distribution (DD) : 0.50
- Lane factor distribution (DL) : 0.80
- Plan Design (UR) : 20 Years

B. Calculate of CESA4 and CESA5

Calculate of CESA4 and CESA5 is vehicle with 5B class in below, with vehicle damage base on location project (East java – Southern Road). For example, Vehicle type 5B

- Vehicle 5B Class:
  - LHR 2025 = 8
  - LHR 2026:

    $\text{LHR } 2026 = 8 \text{ x } (1 + \frac{4.8\%}{100})^1$

    $\text{LHR } 2026 = 8$ (Round up)
  - LHR 2029:

    $\text{LHR } 2026 = 8 \text{ x } (1 + \frac{4.8\%}{100})^4$

    $\text{LHR } 2026 = 10$ (Roundup)
- Vehicle Damage Factor (E)

Table 4. Ekivalen Value

Vehicle Type	VDF4		VDF5	
	Factual	Normal	Factual	Normal
5B	1.2	1.2	1.3	1.3
6A	0.5	0.5	0.4	0.4
6B	1.7	0.6	2.1	0.5
7A1	4.9	2.1	7.4	2.4
7A2	14.6	4.8	27.9	6.5
7A3	-	-	-	-
7B1	17.8	6.4	29.1	7.5
7B2	-	-	-	-
7B3	-	-	-	-
7C1	9.9	6.5	14.2	8.4
7C2A	15.1	7.9	26.3	10.9
7C2B	15.4	7.2	27.9	10.6
7C3	29.4	10.7	59.1	16.0
7C4	-	-	-	-
8	-	-	-	-

Source: *MDP 2024*

- **3 Years:**

  $$\frac{(1 + 0.01\, x\, i)^3 - 1}{0.01\, x\, i}$$

  $$\frac{(1 + 0.01\, x\, 4.8)^3 - 1}{0.01\, x\, 4.8} = 3.15$$
- **17 Years:**

  $$\frac{(1 + 0.01\, x\, i)^{17} - 1}{0.01\, x\, i}$$

  $$\frac{(1 + 0.01\, x\, 4.8)^{17} - 1}{0.01\, x\, 4.8} = 25.39$$

- **CESA 4 (2026 - 2029)**
  - Factual:

    LHR 2026 x VDF4 Factual x DD x DL x 3 Years

    8 x 1.2 x 0.5 x 0.8 x 3.15 = 4622
  - Normal:

    LHR 2029 x VDF4 Normal x DD x DL x 17 Years

    10 x 1.2 x 0.5 x 0.8 x 25.39 = 42934
- **CESA 5 (2029 - 2045)**
  - Factual:

    LHR 2026 x VDF5 Factual x DD x DL x 3 Years

    8 x 1.3 x 0.5 x 0.8 x 3.15 = 5007
  - Normal:

    LHR 2029 x VDF5 Normal x DD x DL x 17 Years

    10 x 1.3 x 0.5 x 0.8 x 25.39 = 46512

after calculating each class of vehicles, the values of CESA4 and CESA5 are 2.789.378 and 3.053.134

C. Determine the Flexible Pavement

With a planned design (UR) of 20 years, and by obtaining a CESA4 and CESA5 value 2.789.378 and 3.053.134, by MDP 2024 a pavement design with a thickness of *CTB* 150mm, *AC-BC* 60mm, and *AC-WC* 40mm was selected base on

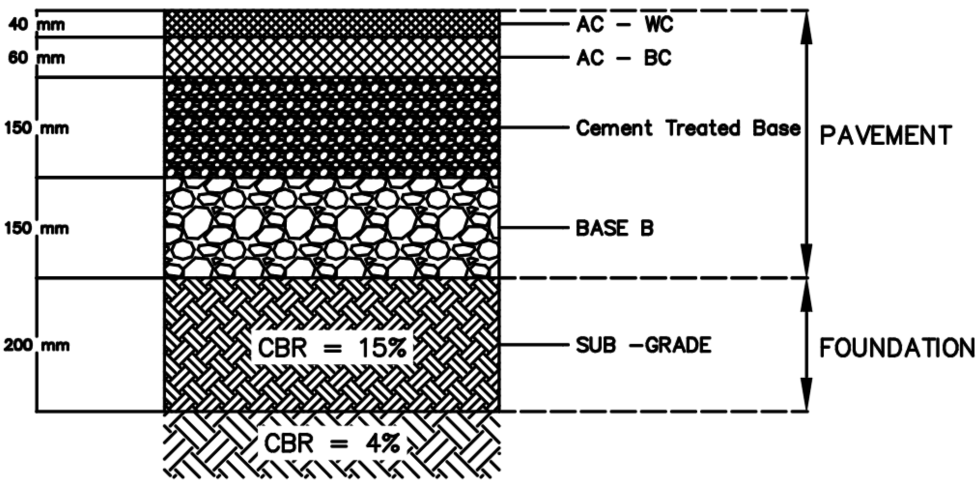

Figure 2. Pavement Design

Source: *MDP 2024*

Cost Estimate

Cost Estimation is a breakdown of the total estimation cost of the project during its implementation intended to complete the construction project contract. The table below is the bill of quantities of the planned road construction works (Works Volume x AHSP)

Table 5. Volume of Work

NO	DESCRIPTION	UNIT	QTY
1	**Bill No. 1: General**		
	Mobilization	ls	1
2	**Bill No. 2: Earth and Geosynthetic Works**		
	Excavation	m3	152194
	Embankment	m3	44026
	Disposal	m3	107803
	Sub - grade Preparation	m3	3651.12
	Land Clearing and Stripping	m2	50710
	Cutting Selected Trees	pcs	1000
3	**Bill No. 3: Granular Pavement**		
	Aggregate Base Course Class B	m3	7302.24
4	**Bill No. 4: Asphalt Pavement & CTB**		
	Prime Coat	lt	3651.12
	Track Coat	lt	3651.12
	Cement Treated Base 150 mm	m3	5476.68
	Asphalt Concrete Binder Course	ton	5715.531
	Asphalt Concrete Wearing Course	ton	3833.381
5	**Bill No. 5: Day Works and Miscellaneous Works**		
	Thermoplastic Road Marking	m2	507.1
	Guide Post	pcs	10
	Kilometer Post	pcs	20

Source: *Data Calculation*

Table 6. Units Price of Work

NO	DESCRIPTION	UNIT	UNIT PRICE	
1	**Bill No. 1: General**			
	Mobilization	ls	Rp 1.501.049.000	
2	**Bill No. 2: Earth and Geosynthetic Works**			
	Excavation	m3	Rp	171.708
	Embankment	m3	Rp	120.120
	Disposal	m3	Rp	120.120
	Sub - grade Preparation	m3	Rp	120.120
	Land Clearing and Stripping	m2	Rp	26.662
	Cutting Selected Trees	pcs	Rp	68.129
3	**Bill No. 3: Granular Pavement**			
	Aggregate Base Course Class B	m3	Rp	138.042
4	**Bill No. 4: Asphalt Pavement & CTB**			
	Prime Coat	lt	Rp	37.196
	Track Coat	lt	Rp	37.196
	Cement Treated Base 150 mm	m3	Rp	617.451
	Asphalt Concrete Binder Course	ton	Rp	931.517
	Asphalt Concrete Wearing Course	ton	Rp	975.497
5	**Bill No. 5: Day Works and Miscellaneous Works**			
	Thermoplastic Road Marking	m2	Rp	909.600
	Guide Post	pcs	Rp	500.000
	Kilometer Post	pcs	Rp	300.000

Source: *HSPK Blitar*

Table 7. Total Cost

NO	DESCRIPTION	TOTAL	
1	**Bill No. 1: General**	Rp	1.501.049.000
	Mobilization	Rp	1.501.049.000
2	**Bill No. 2: Earth and Geosynthetic Works**	Rp	46.229.262.259
	Excavation	Rp	26.132.932.955
	Embankment	Rp	5.288.378.215
	Disposal	Rp	12.949.229.605
	Sub - grade Preparation	Rp	438.570.867
	Land Clearing and Stripping	Rp	1.352.021.355
	Cutting Selected Trees	Rp	68.129.262
3	**Bill No. 3: Granular Pavement**	Rp	1.008.015.058
	Aggregate Base Course Class B	Rp	1.008.015.058
4	**Bill No. 4: Asphalt Pavement & CTB**	Rp	12.716.764.638
	Prime Coat	Rp	135.806.934
	Track Coat	Rp	135.806.934
	Cement Treated Base 150 mm	Rp	3.381.582.535
	Asphalt Concrete Binder Course	Rp	5.324.115.168
	Asphalt Concrete Wearing Course	Rp	3.739.453.067
5	**Bill No. 5: Day Works and Miscellaneous Works**	Rp	472.258.160
	Thermoplastic Road Marking	Rp	461.258.160
	Guide Post	Rp	5.000.000
	Kilometer Post	Rp	6.000.000
	TOTAL	Rp	61.927.349.116
	PPN 11%	Rp	6.812.008.403
	GRAND TOTAL	Rp	68.739.357.519

Source: *HSPK Blitar*

From the bill of quantities has been calculated, that the implementation of the road construction project requires a cost of Rp. Rp. 68.739.357.519 million

4. CONSLUSION

Based on the results of the calculation, the following conclusions can be concluded that:

- The results of the geometric planning calculation using the *"Pedoman Desain Geometrik Jalan 2021"* obtained 7 curves in the form of S-C-S curve and 10 vertical curves consisting of 6 crest vertical curves, and 4 sag vertical curves.
- The results of the calculation of flexural pavement planning using the Bina Marga method *"Manual Desain Perkerasan Jalan 2024"* with a planned design (*UR*) of 20 years, and by obtaining a CESA4 and CESA5 value

2.789.378 and 3.053.134, a pavement design with a thickness of *CTB* 150mm, *AC-BC* 60mm, and *AC-WC* 40mm was selected.
- The Work Method applied in this construction work consists of several main step, where is: Land Clearing, Earthwork (cut and fill), Granular, Pavement Work, Day Works, and Miscellaneous Works. Each step has characteristics and method procedures that are adapted to field conditions and bill of quantity
- The results of the calculation of the cost budget plan for Road planning work obtained Rp. 68.739.357.519-,

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