

Load Analysis on The Bridge Structure According to RSNI T 02-2005 and SNI 1725-2006

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ABSTRACT

The rapid development of infrastructure in civil engineering must be compensated with the latest regulations to adapt to the current conditions, especially in the construction of bridge infrastructure, and therefore the government issued the latest loading regulation on bridge structure that is SNI 1725-2016. The bridge is important because it serves as a liaison between two separate places due to several conditions. This research is conducted to find out whether existing bridge can still meet the criteria of stress, deflection, and deformation based on load value factor, load action, and load combination on SNI 1725-2016. The earthquake load used is a response spectrum using SNI 2833: 2013 regulations[1]. This research uses finite element method using software midas civil software program. In this analysis it is found that the value of stress, deflection, and deformation on the bridge structure according to SNI 1725-2016 is greater than RSNI T 02-2005.

Key words : Bridge, Deflection, Deformation, Voltage

1.INTRODUCTION

A bridge is a construction structure that functions to connect two parts of a road that are cut off by obstacles such as deep valleys, river courses, irrigation channels and dumps. This road that crosses the same plot and not others. Bridges are often a critical component of a road section, because as a determinant of the maximum load of vehicles passing through these roads [2]. This paper will show the calculation of the loading on the bridge structure according to [3]and [4]. Loads calculated are those that are used in accordance with the function of the bridge as a highway bridge. Charges are grouped into 3 load groups namely girder's own weight, additional dead load, and live load. For additional dead load analyzed, the load plate, asphalt, and diaphragm. As for the live load, that is D load which consists of distributed load (uniformly distributed load) and Knife Edge Load (KEL) load.

Calculation analysis of the two types of loading on the bridge structure using the same bridge modeling. The length of the girder is 40 m, the distance between girders is 1.75 m, and

plate thickness is 0.2 m. The compressive strength of concrete for girder is 40 MPa, while for pier and foundation it uses 35 MPa. The pre-stressed cable used is uncoated stress relieve 7 wires strand with an ultimate tensile strength of 18700 kg / cm², diameter of 12.7 mm, effective area of 0.987 cm², and modulus of elasticity 1.960.000 kg/cm².

As for the purpose of this paper is as follows: (1) find out the results of a comparative analysis of the effect on the bridge girder; (2) find out the results of the analysis of influence on the bridge pillars; (3) find out the results of comparative analyses of effects on bridge abutments; (4) find out the results of analysis of influence on the bridge foundation.

2. RESEARCH METHODOLOGY

The burden on building structures is one of the most important things in building planning. Errors in load planning or application of loads in calculations will result in fatal errors in the results of the building design [5]. Based on this, it is important to update the loading regulations on this bridge. So the government issued a loading regulation on the latest bridge, SNI 1725-2016, to replace the RSNI T 02-2005. As for some differences between SNI 1725-2016 regulations with RSNI T 02-2005 in Table 1 and the research flow diagram in Figure 1 are as follows.

Table 1: Difference RSNI T 02-2005 and SNI 1725-2016

No	Description	RSNI T 02-2005	SNI 1725-2016
1	Lane load "D"		
	Load evenly distributed	8 kPa	9 kPa
	Centered line load	44 kN/m	49 kN/m
	Load intensity	100% load intensity for line width ≤ 5.5 m and additional "D" loads must be placed on the remaining width of tracks with 50% intensity.	Distribution of loads spread across the entire width of the beam (not including parapets, curbs, and sidewalks) with 100% intensity.
2	Truck load		
	Truck load plan	450 kN	500 kN

Wheel load plan	10 Tons	11,25 Tons
3 Wind load	$T_{EW} = 0,0012 C_W (V_w)^2 A_b$	$V_{DZ} = 2,5 V_0 \left(\frac{W_{10}}{W_b}\right) \ln\left(\frac{Z}{Z_0}\right)$
4 Earthquake load	$T_{EQ} = K_h \cdot I \cdot W_t$	$E_Q = \frac{C_{SM}}{R_d} \times W_t$
5 Load combination	The combination of the load consists of Service and Ultimit.	The combination of the load consists of Service, strong, and extreme.

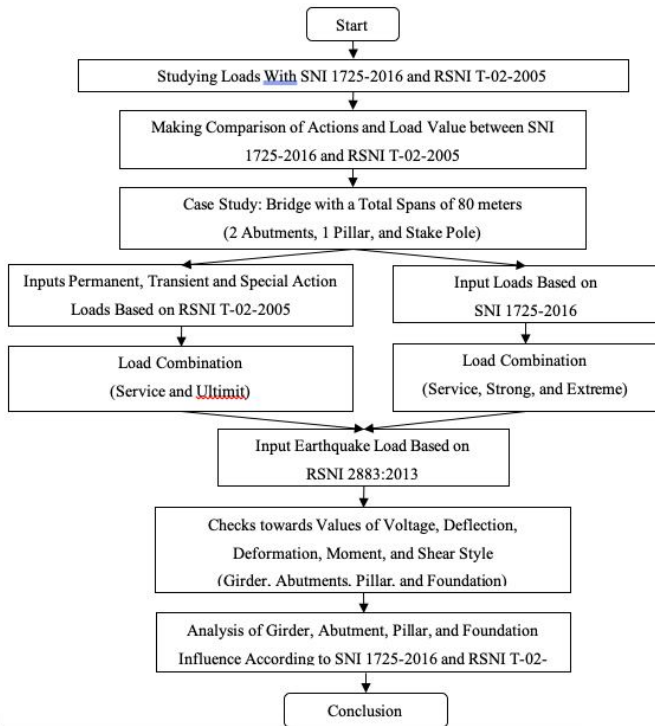


Figure 1: Research Flow Diagram

The factor of loading combination must be chosen in such a way as to produce extreme conditions due to the workload. For each combination of loading, the maximum and minimum drinking conditions must be investigated. The following is the combination of loading according to [3] regulations in Table 2 and the combination of loading according to SNI 1725-2016 in Table 3.

Table 2: Load Factor According to [3]

Combination	Along Weight	Additio nal Dead Load	Lane Load "D"	Bra ke Styl e	Wi nd Load	Earthqu ake Load
Service 1	1	1	1	1	-	-
Service 2	1	1	0,5	0,5	-	-
Service 3	1	1	0,5	0,5	0,5	-
Ultimit 1	2	2	2	1	0,6	-
Ultimit 2	2	2	1	1	-	-
Ultimit 3	2	2	1	1	0,6	-

Ultimit 4	2	2	1	1	1,2	-
Ultimit 5 Pontianak	2	2	-	-	-	1
Ultimit 6 Jayapura	2	2	-	-	-	1

Table 3: Load Factor According to SNI 1725-2016

Combination	Along Weight	Additio nal Dead Load	Lane Load "D"	Bra ke Styl e	Wi nd Load	Earthqu ake Load
Service 1	1	1	1	1	0,3	-
Service 2	1	1	1,3	0,3	-	-
Service 3	1	1	0,8	0,8	-	-
Service 4	1	1	-	-	0,7	-
Strong 1	1,2	2	1,8	1,8	-	-
Strong 2	1,2	2	1,4	1,4	-	-
Strong 3	1,2	2	-	-	0,4	-
Extreme 1 Pontiana k	1,2	1,2	0,5	0,5	-	1
Extreme 1 Jayapura	1,2	1,2	0,5	0,5	-	1

3. RESULT AND DISCUSSION

The geometry of the bridge structure for calculation analysis is the same. With geometrical data the bridge structure is longitudinal is 40 m with transverse direction width of 9 m, bridge height is 7 m and foundation depth is 10 m. the number of girder I in the transversal direction is 5 units with a distance of girder 1.75 m and additional length at the left and right girder is 1 m. Here is a picture of the geometry of the bridge structure (figure 2).

3.1 Bridge Material Technical Specification

Technical specifications of girders, pillars, foundations, and pre-stressed cables along with the arrangement of pre-stressed cable configurations as described in Tables 4-7. For the geometry of bridge structures found in Figure 2 below.

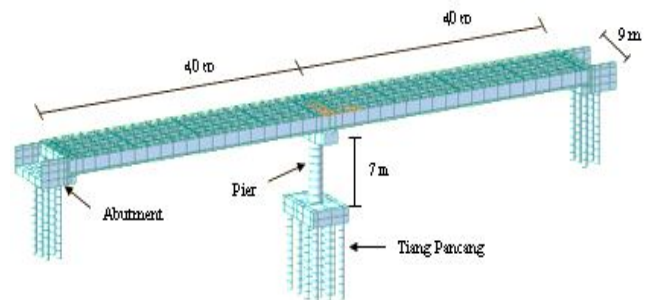


Figure 2: Geometry of Bridge Structures

Table 4: Technical Specifications of Girder I and Pre-stressed Cables

Girder I		Pre-stressed Cable	
Girder Height	2,3 m	Nominal Diameter	12,7 mm
Distance between Girders	1,75 m	Nominal Area	0,987 cm ²
Plate Thickness	20 cm	Ultimate Tensile Strength	18700 kg/cm ²
Girder Compressive Strength	40 MPa	Low Relaxation	
Plate Compressive Strength	20 MPa	Number of Pre-Stressed Cables	58 strand

Table 5: Bridge Pillar Technical Specifications

Description	Value	Unit
Concrete Compressive Strength (f_c')	30	MPa
Concrete Elastic Modulus (E_c)	25742,96	MPa
Pier Height	7	m
Pier Diameter	2	m
Pier Head Width	9	m

Table 6: Bridge Foundation Technical Specification

Description	Value	Unit
Concrete Compressive Strength (f_c')	30	Mpa
Concrete Elastic Modulus (E_c)	25742,96	MPa
Foundation Length	10	m
Foundation Diameter	0,8	m

Table 7:Pre-stressed Cable Configuration Arrangement

Tendon Number	Number of Strand	Strand Height From Below (cm)	
		Edge	Middle
1	15	1650	200
2	19	1350	100
3	12	550	100
4	12	300	100

3.2 Loads that Works

Loads that work on the bridge according to [3]and [4]regulations as in Table 8 below.

Table 8: Loads that Works

Load	RSNI T 02-2005 (kN/m)	SNI 1725-2016 (kN/m)	%
Alone Weight	33,835	33,835	0
Additional Dead	11,8	11,8	0
Brake Load	50	27,06	45
Wind Load	1,2	4,4	73

Lane Load

Line Load	48,4	68,6	30
Loads Evenly Divided	7,7	11,03	30

Earthquake Loads

Pontianak	2,35	2,35	0
Jayapura	107,24	107,24	0

3.3 Voltage Value Results

In the discussion of the comparison of the value of the voltage on the girder will be obtained the results of the comparison of the maximum voltage value in the middle of the girder span based on calculations according to [3]and [4]. The following results are the comparison of the value of the voltage on the girder.

Table 9: Voltage Comparison in Girder

Situation	Voltage Limit (Mpa)	RSNI T 02-2005		SNI 1725-2016	
		Voltage (Mpa)	Check	Voltage (Mpa)	Check
Initial Condition					
Upper Fiber	2,82	2,56	OK	2,56	OK
Fiber Bottom	-19,2	-11,28	OK	-11,28	OK
Service Conditions					
Upper Fiber	-18	-6,5	OK	-7,6	OK
Fiber Bottom	3,16	1,6	OK	2,5	OK

3.4 Deflection Analysis Results in Girder

In this sub chapter will explain the stress value that occurs in the middle span due to axial force, latitude, bending moment and torque which have been analyzed with the help of the Midas civil program. The following results of deflection values on the girder reviewed in the middle of the span according to [3]and [4].

Table 10: Deflection Value of RSNI T 02-2005

x	Lane "D"	Load	Service 1	Service 2	Service 3
0	0		0	0	0
2	-1,1		-6,1	-5,4	-4,9
4	-2,1		-9,2	-7,8	-7,1
6	-2,9		-12,1	-10,2	-9,5
8	-3,7		-14,7	-12,2	-11,6
10	-4,3		-16,1	-14,1	-13,3
12	-4,9		-17,2	-15,3	-14,9
14	-5,4		-18,4	-16,5	-16,1
16	-5,7		-19,3	-17,1	-16,7

18	-5,9	-20,2	-17,6	-17,1
20	-6,1	-20,7	-17,8	-17,4

Table 11: Deflection Value of SNI 1725-2016

x	Lane "D"	Load	Service 1	Service 2	Service 3	Service 4
0	0		0	0	0	0
2	-3,1		-7,6	-8,5	-7,1	-4,5
4	-5,3		-11,9	-13,5	-10,8	-6,5
6	-7,5		-15,9	-18,2	-14,2	-8,9
8	-9,5		-19,6	-22,4	-17,7	-10,1
10	-11,3		-22,8	-26,7	-20,4	-11,1
12	-12,8		-25,3	-29,1	-22,7	-12,4
14	-14,3		-27,2	-31,4	-24,4	-13,1
16	-15,2		-28,5	-33,2	-25,5	-13,5
18	-15,7		-29,2	-33,8	-26,1	-13,8
20	-16,1		-29,8	-34,2	-26,8	-14,2

3.5 Result of Moment Value and Shear Style

In the sub chapter comparison of the moment value and shear style in the girder will be obtained the results of the comparison of the maximum moment value in the middle of the girder span based on calculations according to [3] and [4]. The results of the comparison of moment and shear style values as shown in Table 12 to Table 15 below.

Table 12: Moment Value of RSNI T 02-2005

Load	Span (m)										
	0	2	4	6	8	10	12	14	16	18	20
Alone Weight	0	1609,3	3088,2	4397,5	5537,2	6507,4	7284,3	7891,6	8328,8	8506,1	8694,2
Additional Dead	0	275,2	713,1	874,9	998,6	1138,3	1240,3	1304,2	1315,6	1320,4	1330,9
Lane Load "D"	0	370,2	556,1	737,2	914,5	1002,6	1085,4	1163,2	1237,2	1306,5	1306,7
Brake Load	0	4,6	9,2	13,7	18,3	22,9	27,5	32,1	36,6	41,2	45,8
Wind Load	0	36,6	54,9	73,2	91,5	109,7	128,0	146,3	164,6	182,9	201,2
Pontianak Earthquake	0	432,0	647,9	863,9	1079,9	1295,9	1511,9	1727,9	1943,8	2159,8	2375,8
Jayapura Earthquake	0	1591,6	2387,4	3183,2	3979,0	4774,9	5570,7	6366,5	7162,3	7958,1	8753,9
Ultimit 1	0	2904,7	5635,8	7635,4	9381,7	10812,1	11963,2	12858,5	13471,0	13801,1	14015,2
Ultimit 2	0	2534,5	5079,7	6898,2	8467,2	9809,5	10877,8	11695,3	12233,8	12494,6	12708,5
Ultimit 3	0	2556,4	5112,6	6942,1	8522,1	9875,3	10954,6	11783,1	12332,6	12604,4	12829,2
Ultimit 4	0	2578,4	5145,5	6986,0	8577,0	9941,2	11031,4	11870,9	12431,4	12714,1	12949,9
Ultimit 4 Pontianak	0	2591,7	5162,3	7011,2	8614,3	10079,9	11276,8	12227,9	12903,8	13306,7	13731,8
Ultimit 4 Jayapura	0	3751,3	6901,8	9330,5	11513,4	13558,9	15335,6	16866,5	18122,3	19105,0	20109,9

Table 13: Shear Style Value of RSNI T 02-2005

Load	Span (m)										
	0	2	4	6	8	10	12	14	16	18	20
Alone Weight	835,1	824,2	781,9	697,1	612,3	527,5	430,7	345,9	261,1	174,5	0,0
Additional Dead	149,8	128,5	109,5	90,4	81,4	79,6	60,3	41,5	22,4	15,7	0,0
Lane Load "D"	143,7	115,5	100,9	95,8	87,3	81,4	66,2	50,6	35,2	19,8	22,0
Brake Load	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9
Wind Load	20,2	18,4	16,5	14,7	12,9	11,0	9,2	7,3	5,5	3,7	1,8
Pontianak Earthquake	23,6	21,4	19,3	17,1	15,0	12,9	10,7	8,6	6,4	4,3	2,1
Jayapura Earthquake	107,2	97,2	87,2	77,2	67,2	57,2	45,0	38,3	21,8	10,3	0,3
Ultimit 1	2270,2	2148,3	1995,4	1776,3	1570,6	1384,5	1120,8	881,3	641,6	423,1	46,0
Ultimit 2	2114,4	2021,8	1884,6	1671,7	1475,6	1296,5	1049,1	826,3	603,1	401,1	22,9
Ultimit 3	2126,5	2032,8	1894,5	1680,5	1483,3	1303,1	1054,6	830,7	606,4	403,3	24,0
Ultimit 4	2138,6	2043,8	1904,4	1689,3	1491,0	1309,7	1060,1	835,1	609,7	405,5	25,1
Ultimit 4 Pontianak	1993,4	1926,8	1802,1	1592,1	1402,4	1227,1	992,7	783,4	573,4	384,7	2,1
Ultimit 4 Jayapura	2077,0	2002,6	1870,0	1652,2	1454,6	1271,4	1027,0	813,1	588,8	390,7	0,3

Table 14: Moment Value of RSNI T 02-2005

Load	Span (m)										
	0	2	4	6	8	10	12	14	16	18	20
Alone Weight	0	1609,3	3088,2	4397,5	5537,2	6507,4	7284,3	7891,6	8328,8	8506,1	8694,2
Additional Dead	0	275,2	713,1	874,9	998,6	1138,3	1240,3	1304,2	1315,6	1320,4	1330,9
Lane Load "D"	0	488,1	931,5	1331,0	1686,4	1997,8	2264,1	2486,3	2664,7	2799,2	2889,3
Brake Load	0	5,1	7,6	10,1	12,7	15,2	17,7	20,3	22,8	25,3	27,9
Wind Load	0	91,4	137,1	182,9	228,6	274,3	320,0	365,7	411,4	457,1	502,9
Pontianak Earthquake	0	432,0	647,9	863,9	1079,9	1295,9	1511,9	1727,9	1943,8	2159,8	2375,8
Jayapura Earthquake	0	1591,6	2387,4	3183,2	3979,0	4774,9	5570,7	6366,5	7162,3	7958,1	8753,9
Strong I	0	2403,7	4969,5	6802,3	8377,8	9804,4	10958,5	11855,2	12466,0	12828,6	13129,2
Strong II	0	2206,4	4593,9	6265,9	7698,2	8999,2	10045,7	10852,6	11391,0	11698,8	11962,4
Strong III	0	1552,6	3334,0	4461,4	5410,9	6290,8	6979,2	7489,6	7793,0	7927,3	8079,5
Extreme 1 Pontianak	0	1976,9	3829,9	5227,9	6456,4	7580,4	8520,6	9291,3	9875,0	10272,9	10661,9
Extreme 1 Jayapura	0	3131,5	5561,8	7537,1	9342,9	11044,2	12561,7	13909,6	15070,6	16045,8	17012,2

Table 15: Shear Style Value of SNI 1725-201

Load	Span (m)										
	0	2	4	6	8	10	12	14	16	18	20
Alone Weight	835,1	824,2	781,9	697,1	612,3	527,5	430,7	345,9	261,1	174,5	0,0
Additional Dead	149,8	128,5	109,5	90,4	81,4	79,6	60,3	41,5	22,4	15,7	0,0
Lane Load "D"	258,5	232,7	210,7	188,7	166,5	144,2	122,2	100,1	78,2	56,2	34,2
Brake Load	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Wind Load	50,3	45,7	41,2	36,6	32,0	27,4	22,9	18,3	13,7	9,1	4,6
Pontianak Earthquake	23,6	21,4	19,3	17,1	15,0	12,9	10,7	8,6	6,4	4,3	2,1
Jayapura Earthquake	107,2	97,2	87,2	77,2	67,2	57,2	45,0	38,3	21,8	10,3	0,3
Strong I	1769,7	1667,6	1539,2	1359,7	1200,0	1054,5	860,1	681,0	501,6	344,7	64,3
Strong II	1665,7	1573,9	1454,4	1283,6	1132,8	996,2	810,6	640,3	469,7	321,6	50,0
Strong III	1321,8	1264,3	1173,7	1032,0	910,4	803,2	646,6	505,4	363,6	244,5	1,8
Extreme 1 Pontianak	1335,4	1281,8	1195,1	1057,2	931,4	814,2	661,8	524,2	386,5	261,4	20,0
Extreme 1 Jayapura	1419,1	1357,6	1263,0	1117,3	983,7	858,6	696,1	553,9	401,8	267,3	18,1

3.6 The Value of Inner Style on the Pillar

In this sub chapter will explain the results of the ultimate load on the pillars and bridge abutments resulting from a combination of loading according to [3] and [4] regulations. Following are the results of the calculation of the value of internal forces on the pillars and bridge abutments which can be shown in Table 12 to Table 15.

Table 16: Inner Styles on Pillars of RSNI T 02-2005

No	Combination	Axial Load P (kN)	M Moment (kN)	Horizontal Style T (kN.m)
1	Ultimit 1	16234,8	1367,6	433,45
2	Ultimit 2	15387,2	1035,8	80,2
3	Ultimit 3	15298,5	1367,5	333,4
4	Ultimit 4	15298,5	1835,1	566,9
5	Ultimit 5 Jayapura	14128,1	8360,9	7028,7
6	Ultimit 5 Pontianak	14128,1	1337,4	1123,5

Table 17: Inner Styles on Pillars of SNI 1725-2016

No	Combination	Axial Load P (kN)	M Moment (kN)	Horizontal Style T (kN.m)
1	Strong I	18705,5	986,2	543,5
2	Strong II	18705,5	635,7	389,4
3	Strong III	14128,1	754,6	130,1
4	Jayapura Extreme	14333,6	9234,5	8475,2
5	Pontianak Extreme	14333,6	1458,4	2223,7

Table 18: Inner Styles on Abutments of RSNI T 02-2005

No	Combination	Axial Load P (kN)	M Moment (kN)	Horizontal Style T (kN.m)
1	Ultimit 1	8117,4	633,78	266,72
2	Ultimit 2	7693,6	517,9	40,1
3	Ultimit 3	7649,25	633,7	166,7
4	Ultimit 4	7649,25	1067,5	273,45
5	Ultimit 5 Jayapura	7064,05	4180,4	3014,35
6	Ultimit 5 Pontianak	7064,05	668,7	561,75

Table 19: Inner Styles on Abutments of SNI 1725-2016

No	Combination	Axial Load P (kN)	M Moment (kN)	Horizontal Style T (kN.m)
1	Strong I	9352,75	580,1	271,75
2	Strong II	9352,75	317,85	194,7
3	Strong III	7064,05	377,3	75,05
4	Jayapura Extreme	7166,8	4617,25	4237,6
5	Pontianak Extreme	7166,8	729,2	1121,85

3.7 The Value of Inner Styles on the Foundation

In this sub chapter will explain the ultimate value of load that occurs on the foundation due to the axial force and moment style that have been analyzed with the help of the Midas civil program. The following results are the value of ultimate load on the foundation according to [3] and [4].

Table 20: Inner Styles on the Foundation of RSNI T 02-2005

No	Combination	Axial Load V (kN)	M _x Moment (kN.m)	M _y Moment (kN.m)
1	Ultimit 1	16234,8	922,4	97,4
2	Ultimit 2	15387,2	922,4	97,4
3	Ultimit 3	15298,5	922,4	97,4
4	Ultimit 4	15298,5	922,4	196,6
5	Ultimit 5 Jayapura	14128,1	3795,6	4871,6
6	Ultimit 5 Pontianak	14128,1	1892,7	2145,9

Table 21: Inner Styles on the Foundation of SNI 1725-2016

No	Combination	Axial Load V (kN)	M _x Moment (kN.m)	M _y Moment (kN.m)
1	Strong I	18705,5	786,9	126,3
2	Strong II	18705,5	573,2	126,3
3	Strong III	14128,1	131,5	396,3
4	Jayapura Extreme	14333,6	5693,4	7307,4
5	Pontianak Extreme	14333,6	2271,24	2575,08

4. CONCLUSION AND SUGGESTION

From the analysis conducted on the bridge structure, can be concluded several things as follows:

- The value of the style in shear and moment due to the "D" lane load for SNI 1725-2016 is greater than RSNI T 02-2005. However, due to the brake load at SNI 1725-2016 is lower than RSNI T 02-2005;
- Deflection value due to vehicle life load for SNI 1725-2016 is greater than RSNI T 02-2005. This is because the distribution factor of the "D" lane load in SNI 1725-2016 is greater;
- The style on the bridge pillar in SNI 1725-2016 is greater than that of the 02N 2005 RSNI. An increase in axial style, moment style, and horizontal style;
- The style on the bridge foundation on SNI 1725-2016 is greater than that of RSNI T 02-2005. An increase in axial style, moment style, and horizontal style;
- The value of voltage and deflections in SNI 1725-2016 is an increase compared to RSNI regulation T 02-2005, but the voltage value is still below its permit limit value.

Based on the results of the analysis of this study, then to get better results, the authors provide the following advice:

- a. For further analysis it is necessary to review for bridges that have a span of more than 40 m, looking at the results of the voltage value on the bridge which is approaching the value of the voltage permit limit;
- b. Henceforth it needs to be reviewed for bridges in addition to using girder I.

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