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TINJAUAN STANDART KESTABILAN TOWER NG STANDAR 30 METER TERHADAP BEBAN GEMPA DINAMIS DENGAN BERBAGAI SITUS KELAS TANAH SESUAI SNI 1726-2012

(Study kasus Tower NG Standart 30 m, Kabupaten Jember)

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Abstract

The development of world telecommunications is growing very rapidly occur today, requires the telecommunications provider to provide a means of expanding the reach of mobile phone signal and internet signal in the form of 2G, 3G and 4G. With it the necessary means of supporting specialized tower BTS (Base Transceiver Station) to carry the antenna at a certain height.

In planning the establishment of the BTS tower. The load effect in the form of self weight live load and wind load. But necessary review of the value of the Twist, Sway, and Displacement due to earthquake loads that occur with a variety of site classes of the soil in the form of rock soil, hard soil, medium soil and soft soil in accordance with SNI 1726-2012.

Keywords : *BTS Tower, value of Twist, Sway, and Displacement, SNI 1726-2012*

1. PENDAHULUAN

Perkembangan dunia telekomunikasi yang berkembang sangat pesat terjadi dewasa ini, menuntut para provider telekomunikasi untuk berlomba-lomba merebut hati banyak para konsumen. Salah satu wujud untuk merebut hati para konsumen adalah dengan perluasan jangkauan sinyal telepon seluler dan sinyal internet dalam bentuk 2G, 3G dan 4G. Keberadaan sinyal telepon dan sinyal internet yang kuat dikarenakan adanya antenna pemancar sinyal ataupun antenna penerima sinyal diwilayah jangkauan area tersebut. Antenna Ini akan berfungsi dengan jangkauan yang sesuai dengan kapasitasnya, apabila antenna tersebut terletak diketinggian tertentu. Untuk mensiasati keberadaan antenna yang harus dipasang dalam ketinggian tertentu, mengharuskan pembangunan tower BTS (Base Transceiver Station). BTS adalah bagian dari network element GSM yang berhubungan langsung dengan Mobile Station (MS). Beban yang mempengaruhi Tower BTS adalah beban tower itu sendiri, beban hidup dan beban angin karena pengaruh perbandingan ketinggian dan lebar struktur yang sangat besar. Namun pada pengaplikasian di lapangan dimana penempatan tower BTS yang dilakukan di seluruh wilayah Indonesia dengan situs kelas tanan yang benareka ragam maka perlunya di analisa akibat beban gempa yang terjadi. Sehingga kita bisa mengganalisa berapa besar nilai *Displacement* yang terjadi saat gempa agar tidak melebihi nilai yang di ijinkan. Sehingga dapat ditentukan rumusan masalah Bagaimana pengaruh beban gempa terhadap nilai *Twist, Sway, dan Displacement* yang terjadi pada struktur tower BTS, Bagaimana pengaruh situs kelas tanah yang beraneka ragam terhadap nilai *Twist, Sway, dan Displacement* yang terjadi pada struktur tower BTS saat terjadi gempa dan Berapa besar pengaruh *Displacement pada arah x,y,z* yang terjadi akibat beban gempa.

2. METODE PENELITIAN

Data Umum

Perencanaan struktur baja dan konstruksi tower, antara lain :

1. EIA-222F "Structural Standards for Steel Antenna Tower and Antenna Supporting Structure ."
2. American Institute of Steel Construction (AISC).
3. American Society For Testing And Materials (ASTM).
4. The fabrication and materials of the tower will be according to the relevant Indonesian Standard and/or Japanese Industrial Standard.
5. American Concrete Institute (ACI 318RM-99)
6. SNI 1726-2012 Tata Cara Perencanaan Struktur Bangunan Gedung Dan Non Gedung
7. *Aplikasi Sap 2000 V.14, MS tover V6.02*

Perancangan Struktur Atas

Data – data yang diperlukan, berupa :

1. *Tinggi Menara : 30.00 meter*
2. *Material*
   - ***a.*** *Angle & Plate Fy 245, Fu 400*
   - ***b.*** *Bolt Fy 600, Fu 800*
   - **c.** *Anchor Fy 245, Fu 400*
3. *Elevasi Tower : 0.0 meter Above Ground Level*
4. *Kecepatan Angin Maksimum (V). Dalam desain struktur menara, angin dasar (mil tercepat) kecepatan diambil: V = 120 km/jam = 33.33 m/detik.*
5. *Kecepatan Angin Operasional (V) Untuk analisis Pemindahan, kecepatan angin dasar (mil tercepat) diambil: V = 84 km/jam =23.33m/detik.*
   Twist / puntiran = 0.5°
   Sway / goyangan = 0.5°
   Displacement / Perpindahan = H/200

6. *Beban Antenna*

   a. *Satu Ring Mounting Antena Disk Diameter (-) pada elevasi ± 28 m.*

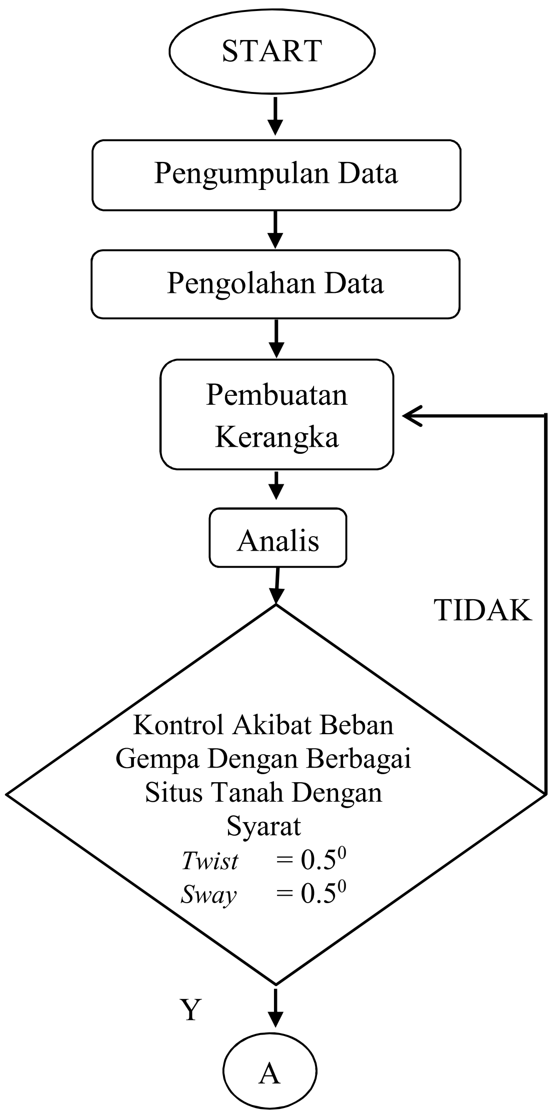
   b. *Sembilan Sectoral Antena Disk Diameter 2.5 m pada elevasi ± 28 m.*

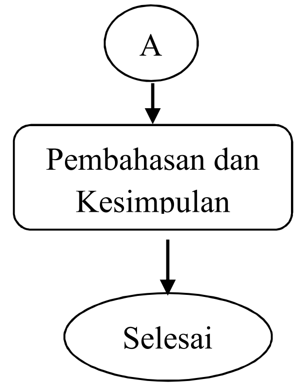
   c. *Sembilan Antenna RRU pada elevasi ± 25.0 m.*

   d. *Enam Antenna Microwave*

   e. *pada elevasi ± 24.0 m.*

Flowchart Tahap Perencanaan





3. HASIL DAN PEMBAHASAN

Data Perencanaan

1. *Tinggi Menara : 30.00 meter*
2. *Material*
   a. *Angle & Plate* *Fy 245, Fu 400*
   b. *Bolt* *Fy 600, Fu 800*
   c. *Anchor* *Fy 245, Fu 400*
3. *Elevasi Tower : 0.0 meter Above Ground Level*
4. Dimensi Profil Menggunakan Baja Siku Sama Kaki

Tabel 1 Profil Baja Siku Sama Kaki

No	[illegible]	Profil		
		h (mm)	b (mm)	[illegible] (mm)
1		[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]
3		[illegible]	[illegible]	[illegible]
4		[illegible]	[illegible]	[illegible]
5		[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]
7		[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]

5. *Beban Antenna*

   a. *Satu Ring Mounting Antena Disk Diameter (-), berat 2.5 kg pada elevasi ± 28 m.*

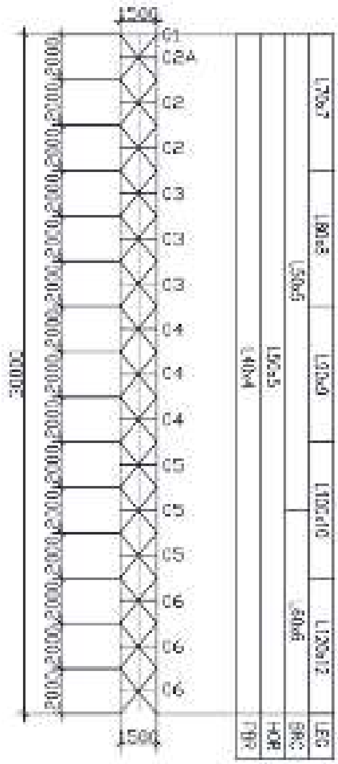
   b. *Sembilan Sectoral Antena Disk Diameter 2.5 m, berat 40 kg pada elevasi ± 28 m.*

   c. *Sembilan Antenna* RRU Disk Diameter(-), *berat 25 kg pada elevasi ± 25.0 m.*

   d. *Enam Antenna* Microwave Disk Diameter (0.6), *berat 30 kg pada elevasi. ± 24.0 m.*

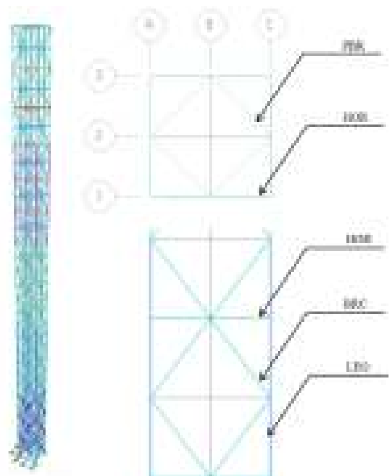
Pemodelan Struktur

1. Penempatan profil profil baja siku sama kaki pada struktur tower.



Gambar 1 Pemodelan Struktur Tower

2. Pemodelan struktur menggunakan aplikasi SAP 2000 V.14



Gambar 2 Pemodelan Struktur Tower Pada Sap 2000V.14

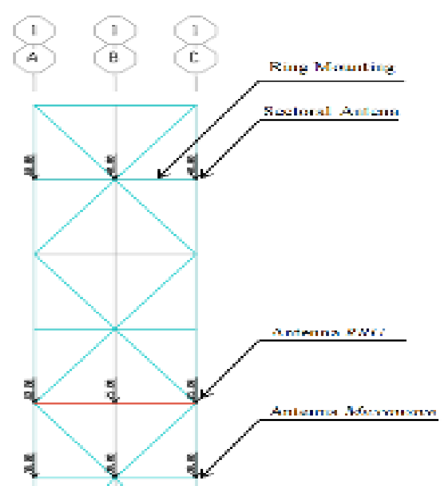
Penempatan Beban Antena

Tabel 2 Penempatan Beban Antena

No.	Elev.	Dish Diameter	Azimuth	Ket.
	(m)	(m)	(deg)	
1	[illegible]	-	-	Ring Mounting
2	[illegible]	2.50	45	Sectoral
3	[illegible]	2.50	90	Sectoral
4	[illegible]	2.50	135	Sectoral
5	[illegible]	2.50	225	Sectoral
6	[illegible]	2.50	270	Sectoral
7	[illegible]	2.50	315	Sectoral
8	[illegible]	2.50	0	Sectoral
9	[illegible]	2.50	225	Sectoral
10	[illegible]	2.50	135	Sectoral
11	[illegible]	-	45	RRU
12	[illegible]	-	90	RRU
13	[illegible]	-	135	RRU
14	[illegible]	-	225	RRU
15	[illegible]	-	270	RRU
16	[illegible]	-	315	RRU
17	[illegible]	-	0	RRU
18	[illegible]	-	225	RRU
19	[illegible]	-	135	RRU
20	[illegible]	0.60	45	Microwave
21	[illegible]	0.60	90	Microwave
22	[illegible]	0.60	135	Microwave
23	[illegible]	0.60	225	Microwave
24	[illegible]	0.60	270	Microwave
25	[illegible]	0.60	315	Microwave

Pembebanan Antena

1. Beban mati berupa berat struktur tower.
2. Beban hidup berupa beban pekerja pada saat pengerjaan sebesar 100 kg.
3. Beban mati tambahan berupa beban antenna :
   - **a.** *Ring Mounting Antena* Disk Diameter (-), *berat 2.5 kg.*
   - **b.** *Sectoral Antena* Disk Diameter *2.5 m, berat 40 kg.*
   - **c.** *Antenna* RRU Disk Diameter (-), *berat 25 kg.*
   - **d.** *Antenna* Microwave Disk Diameter (0.6), *berat 30 kg.*



Gambar 3 Pembebanan Beban Antena

4. Beban Angin

a. *Kecepatan Angin Maksimum (V)Dalam desain struktur menara, angin dasar (mil tercepat) kecepatan diambil : V = 120 km/jam = 33.33 m/sec*

Tekanan angina p $= \frac{V^2}{16}$

V = 33.33 m/s

$P = \frac{33.33^2}{16} kg/m^2 = 69.3 \quad kg/m^2$

Jarak rangka = 1.5 m

Sudut $= 0^0$

Tekanan angin (w)= 69.3 kg/m^2

Koefisien angin tekan untuk rangka (c1) = 1.6

Maka W1 = c1.w.0,3

= 1.6 x 69.3 x 1.6= 33.3 kg/m

b. *Kecepatan Angin Operasional (V).Untuk analisis Pemindahan, kecepatan angin dasar (mil tercepat)diambil : V = 84 km/jam = 23.33m/detik Tekanan angin p =* $\frac{V^2}{16}$

V = 23.33m/s $P = \frac{23.33^2}{16} kg/m^2$

$= 34 \ kg/m^2$

Jarak rangka =1.5 mSudut $= 0^0$

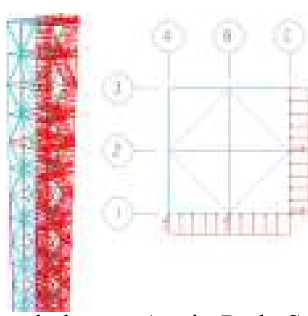
Tekanan angin (w)= 34 kg/m^2

Koefisien angin tekan untuk rangka (c1) = 1.6

Maka W1 = c1.w.0,3

= 1.6 x 34 x 0.3 = 16.3 kg/m

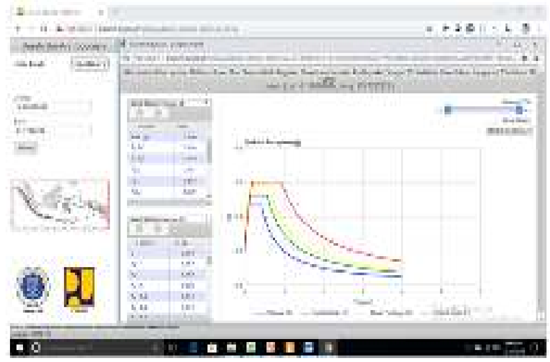
Imput beban angin pada arah $0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0, 315^0$



Gambar 4 Pembebanan Angin Pada Sudut 315^0.

Beban Gempa

Beban Gempa menggunakan Nilai Spektra Gempa pada wilayah Kabupaten Jember dapat diketahui denga menggunakan *web site* http://puskim.pu.go.id/Aplikasi/desain_spektra_indonesia_2011/ dengan Koordinat Kabupaten Jember = *8°10'8"S 113°42'8"E.* . Hasil Analisa Desain Spektra sebagai berikut.

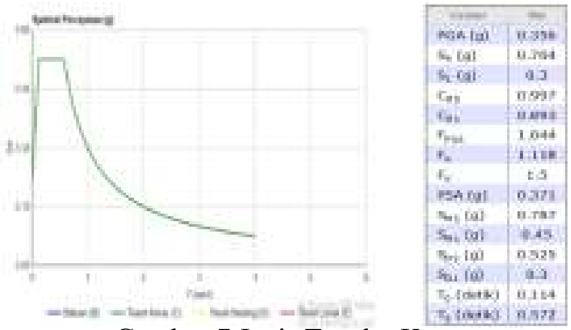


Gambar 5 Desain Spektra Kabupaten Jember

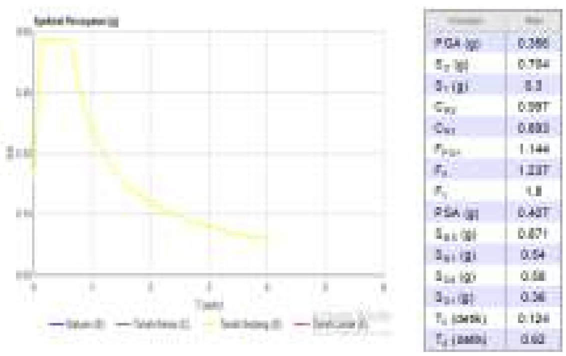
Dari hasil analisa diatas dapat diketahui berbagai situs kelas tanah yang ada sebagai berikut.

Variabel	Nilai
PGA (g)	0.358
S_S (g)	0.704
S_1 (g)	0.3
C_{RS}	0.907
C_{R1}	0.893
F_{PGA}	1
F_a	1
F_v	1
PSA (g)	0.358
S_{MS} (g)	0.704
S_{M1} (g)	0.3
S_{DS} (g)	0.469
S_{D1} (g)	0.2
T_0 (detik)	0.085
T_S (detik)	0.426

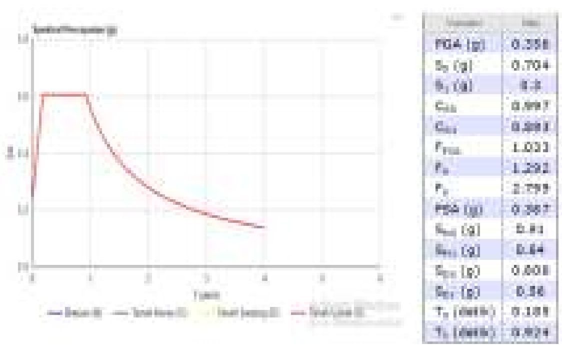
Gambar 6 Jenis Tanah : Batuan



Gambar 7 Jenis Tanah : Keras



Gambar 8 Jenis Tanah : Sedang



Gambar 9 Jenis Tanah : Lunak

Kombinasi Pembebanan

1. 1,4D
2. 1,2D + 1,6L + 0,5 (Lr atau R)
3. 1,2D + 1,6 (Lr atau R) + (L atau 0,5W)
4. 1,2D + 1,0W + L + 0,5 (Lr atau R)
5. 1,2D + 1,0E + L

a. 1,2D + 1,0E (Tanah batuan)+ L
b. 1,2D + 1,0E (Tanah keras) + L
c. 1,2D + 1,0E (Tanah sedang)+ L
d. 1,2D + 1,0E (Tanah lunak) + L

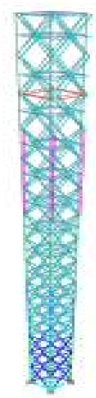
6. 0,9D + 1,0W
7. 0,9D + 1,0E

Dimana :

D = Pengaruh dari beban mati.
L = Pengaruh beban hidup
Lr = Pengaruh beban hidup tambahan
R = Beban air hujan
W = Beban angina
E = Pengaruh beban gempa

Hasil Analisa Struktur Menggunakan SAP 2000 V.14

1. Hasil Analisa Twist yang terjadi pada tower



Gambar 10 Twist Yang Terjadi Pada Tower

Tabel 3 Twist Yang Terjadi Pada Jenis Tanah Batuan

TABLE: Joint Displacements								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	Radians	Radians	Radians	degree	degree	degree	< 0.5°
1	TANAH BATUAN	0.000042	0.000194	4.558E-09	0.0024	0.0111	0.0000003	Ok
2	TANAH BATUAN	0.000042	0.000194	4.558E-09	0.0024	0.0111	0.0000003	Ok
3	TANAH BATUAN	0.000042	0.000194	2.097E-08	0.0024	0.0111	0.0000012	Ok
4	TANAH BATUAN	0.000042	0.000194	2.097E-08	0.0024	0.0111	0.0000012	Ok
829	TANAH BATUAN	0.000042	0.000194	4.734E-08	0.0024	0.0111	0.0000027	Ok
835	TANAH BATUAN	0.000042	0.000194	4.734E-08	0.0024	0.0111	0.0000027	Ok
952	TANAH BATUAN	0.000042	0.000194	4.734E-08	0.0024	0.0111	0.0000027	Ok
958	TANAH BATUAN	0.000042	0.000194	4.734E-08	0.0024	0.0111	0.0000027	Ok

Tabel 4 Twist Yang Terjadi Pada Jenis Tanah Keras

TABLE: Joint Displacements								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	Radians	Radians	Radians	degree	degree	degree	< 0.5°
1	TANAH KERAS	0.000069	0.000227	7.13E-09	0.0040	0.0130	0.0000004	Ok
2	TANAH KERAS	0.000069	0.000227	7.13E-09	0.0040	0.0130	0.0000004	Ok
3	TANAH KERAS	0.000069	0.000227	2.343E-08	0.0040	0.0130	0.0000013	Ok
4	TANAH KERAS	0.000069	0.000227	2.343E-08	0.0040	0.0130	0.0000013	Ok
829	TANAH KERAS	0.000069	0.000227	5.414E-08	0.0040	0.0130	0.0000031	Ok
835	TANAH KERAS	0.000069	0.000227	5.414E-08	0.0040	0.0130	0.0000031	Ok
952	TANAH KERAS	0.000069	0.000227	5.414E-08	0.0040	0.0130	0.0000031	Ok
958	TANAH KERAS	0.000069	0.000227	5.414E-08	0.0040	0.0130	0.0000031	Ok

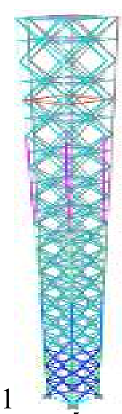
Tabel 5 Twist Yang Terjadi Pada Jenis Tanah Sedang

TABLE: Joint Displacements								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	Radians	Radians	Radians	degree	degree	degree	< 0.5°
1	TANAH SEDANG	0.000076	0.000251	7.803E-09	0.0044	0.0144	0.0000004	Ok
2	TANAH SEDANG	0.000076	0.000251	7.803E-09	0.0044	0.0144	0.0000004	Ok
3	TANAH SEDANG	0.000076	0.000251	2.564E-08	0.0044	0.0144	0.0000015	Ok
4	TANAH SEDANG	0.000076	0.000251	2.564E-08	0.0044	0.0144	0.0000015	Ok
829	TANAH SEDANG	0.000076	0.000251	5.927E-08	0.0044	0.0144	0.0000034	Ok
835	TANAH SEDANG	0.000076	0.000251	5.927E-08	0.0044	0.0144	0.0000034	Ok
952	TANAH SEDANG	0.000076	0.000251	5.927E-08	0.0044	0.0144	0.0000034	Ok
958	TANAH SEDANG	0.000076	0.000251	5.927E-08	0.0044	0.0144	0.0000034	Ok

Tabel 6 Twist Yang Terjadi Pada Jenis Tanah Lunak

TABLE: Joint Displacements								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	Radians	Radians	Radians	degree	degree	degree	< 0.5°
1	TANAH LUNAK	0.00008	0.000262	7.87E-09	0.0046	0.0150	0.0000005	Ok
2	TANAH LUNAK	0.00008	0.000262	7.87E-09	0.0046	0.0150	0.0000005	Ok
3	TANAH LUNAK	0.00008	0.000262	2.586E-08	0.0046	0.0150	0.0000015	Ok
4	TANAH LUNAK	0.00008	0.000262	2.586E-08	0.0046	0.0150	0.0000015	Ok
829	TANAH LUNAK	0.00008	0.000262	5.988E-08	0.0046	0.0150	0.0000034	Ok
835	TANAH LUNAK	0.00008	0.000262	5.988E-08	0.0046	0.0150	0.0000034	Ok
952	TANAH LUNAK	0.00008	0.000262	5.988E-08	0.0046	0.0150	0.0000034	Ok
958	TANAH LUNAK	0.00008	0.000262	5.988E-08	0.0046	0.0150	0.0000034	Ok

2. Hasil Analisa Sway yang terjadi pada tower



Gambar 11 ng Terjadi Pada Tower

Tabel 7 Sway Yang Terjadi Pada Jenis Tanah Batu

TABLE: Joint Velocities - Absolute								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	rad/sec	rad/sec	rad/sec	degree/sec	degree/sec	degree/sec	< 0.5°
1	TANAH BATUAN	0.000668	0.003072	2.772E-07	0.04	0.18	0.00	Ok
2	TANAH BATUAN	0.000668	0.003072	2.772E-07	0.04	0.18	0.00	Ok
3	TANAH BATUAN	0.000668	0.003072	0.000001275	0.04	0.18	0.00	Ok
4	TANAH BATUAN	0.000668	0.003072	0.000001275	0.04	0.18	0.00	Ok
829	TANAH BATUAN	0.00067	0.003082	0.00000277	0.04	0.18	0.00	Ok
835	TANAH BATUAN	0.00067	0.003082	0.00000277	0.04	0.18	0.00	Ok
952	TANAH BATUAN	0.00067	0.003082	0.00000277	0.04	0.18	0.00	Ok
958	TANAH BATUAN	0.00067	0.003082	0.00000277	0.04	0.18	0.00	Ok

Tabel 8 Sway Yang Terjadi Pada Jenis Tanah Keras

TABLE: Joint Velocities - Absolute								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	rad/sec	rad/sec	rad/sec	degree/sec	degree/sec	degree/sec	< 0.5°
1	TANAH KERAS	0.001069	0.003513	3.928E-07	0.06	0.20	0.00	Ok
2	TANAH KERAS	0.001069	0.003513	3.928E-07	0.06	0.20	0.00	Ok
3	TANAH KERAS	0.001069	0.003513	0.00000129	0.06	0.20	0.00	Ok
4	TANAH KERAS	0.001069	0.003513	0.000001291	0.06	0.20	0.00	Ok
829	TANAH KERAS	0.001072	0.003523	0.000002862	0.06	0.20	0.00	Ok
835	TANAH KERAS	0.001072	0.003523	0.000002862	0.06	0.20	0.00	Ok
952	TANAH KERAS	0.001072	0.003523	0.000002862	0.06	0.20	0.00	Ok
958	TANAH KERAS	0.001072	0.003523	0.000002862	0.06	0.20	0.00	Ok

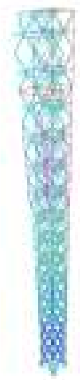
Tabel 9 Sway Yang Terjadi Pada Jenis Tanah Sedang

TABLE: Joint Velocities - Absolute								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	rad/sec	rad/sec	rad/sec	degree/sec	degree/sec	degree/sec	< 0.5°
1	TANAH SEDANG	0.001175	0.003862	4.219E-07	0.07	0.22	0.00	Ok
2	TANAH SEDANG	0.001175	0.003862	4.219E-07	0.07	0.22	0.00	Ok
3	TANAH SEDANG	0.001175	0.003861	0.000001386	0.07	0.22	0.00	Ok
4	TANAH SEDANG	0.001175	0.003861	0.000001386	0.07	0.22	0.00	Ok
829	TANAH SEDANG	0.001179	0.003872	0.000003074	0.07	0.22	0.00	Ok
835	TANAH SEDANG	0.001179	0.003872	0.000003074	0.07	0.22	0.00	Ok
952	TANAH SEDANG	0.001179	0.003872	0.000003074	0.07	0.22	0.00	Ok
958	TANAH SEDANG	0.001179	0.003872	0.000003074	0.07	0.22	0.00	Ok

Tabel 10 Sway Yang Terjadi Pada Jenis Tanah Lunak

TABLE: Joint Velocities - Absolute								
Joint	OutputCase	R1	R2	R3	R1	R2	R3	Kontrol
Text	Text	rad/sec	rad/sec	rad/sec	degree/sec	degree/sec	degree/sec	< 0.5°
1	TANAH LUNAK	0.001206	0.003962	3.914E-07	0.07	0.23	0.00	Ok
2	TANAH LUNAK	0.001206	0.003962	3.914E-07	0.07	0.23	0.00	Ok
3	TANAH LUNAK	0.001206	0.003961	0.000001286	0.07	0.23	0.00	Ok
4	TANAH LUNAK	0.001206	0.003961	0.000001286	0.07	0.23	0.00	Ok
829	TANAH LUNAK	0.001209	0.003972	0.000002848	0.07	0.23	0.00	Ok
835	TANAH LUNAK	0.001209	0.003972	0.000002848	0.07	0.23	0.00	Ok
952	TANAH LUNAK	0.001209	0.003972	0.000002848	0.07	0.23	0.00	Ok
958	TANAH LUNAK	0.001209	0.003972	0.000002848	0.07	0.23	0.00	Ok

3. Hasil analisa displacement yang terjadi pada tower



Gambar 12 Displacement Yang Terjadi Pada Tower

Tabel 11 Displacement Yang Terjadi Pada Jenis Tanah Batuan

TABLE: Joint Displacements							
Joint	OutputCase	CaseType	StepType	U1	U2	U3	Kontrol
Text	Text	Text	Text	mm	mm	mm	H/200
1	TANAH BATUAN	LinRespSpec	Max	3.919099	0.851969	0.145126	OK
2	TANAH BATUAN	LinRespSpec	Max	3.919099	0.851969	0.145126	OK
3	TANAH BATUAN	LinRespSpec	Max	3.919058	0.851978	0.031549	OK
4	TANAH BATUAN	LinRespSpec	Max	3.919058	0.851978	0.031549	OK
829	TANAH BATUAN	LinRespSpec	Max	3.91903	0.851963	0.148499	OK
835	TANAH BATUAN	LinRespSpec	Max	3.91903	0.851963	0.148499	OK
952	TANAH BATUAN	LinRespSpec	Max	3.91903	0.851963	0.148499	OK
958	TANAH BATUAN	LinRespSpec	Max	3.91903	0.851963	0.148499	OK

Tabel 12 Displacement Yang Terjadi Pada Jenis Tanah Keras

TABLE: Joint Displacements							
Joint	OutputCase	CaseType	StepType	U1	U2	U3	Kontrol
Text	Text	Text	Text	mm	mm	mm	H/200
1	TANAH KERAS	LinRespSpec	Max	4.601747	1.400517	0.170215	OK
2	TANAH KERAS	LinRespSpec	Max	4.601747	1.400517	0.170215	OK
3	TANAH KERAS	LinRespSpec	Max	4.601698	1.400532	0.051805	OK
4	TANAH KERAS	LinRespSpec	Max	4.601698	1.400532	0.051805	OK
829	TANAH KERAS	LinRespSpec	Max	4.601666	1.400507	0.177905	OK
835	TANAH KERAS	LinRespSpec	Max	4.601666	1.400507	0.177905	OK
952	TANAH KERAS	LinRespSpec	Max	4.601666	1.400507	0.177905	OK
958	TANAH KERAS	LinRespSpec	Max	4.601666	1.400507	0.177905	OK

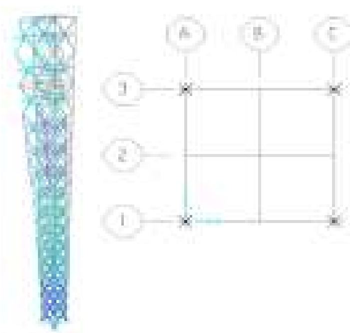
Tabel 13 Displacement Yang Terjadi Pada Jenis Tanah Sedang

TABLE: Joint Displacements							
Joint	OutputCase	CaseType	StepType	U1	U2	U3	Kontrol
Text	Text	Text	Text	mm	mm	mm	H/200
1	TANAH SEDANG	LinRespSpec	Max	5.083739	1.547209	0.188005	OK
2	TANAH SEDANG	LinRespSpec	Max	5.083739	1.547209	0.188005	OK
3	TANAH SEDANG	LinRespSpec	Max	5.083686	1.547225	0.057219	OK
4	TANAH SEDANG	LinRespSpec	Max	5.083686	1.547225	0.057219	OK
829	TANAH SEDANG	LinRespSpec	Max	5.08365	1.547198	0.196499	OK
835	TANAH SEDANG	LinRespSpec	Max	5.08365	1.547198	0.196499	OK
952	TANAH SEDANG	LinRespSpec	Max	5.08365	1.547198	0.196499	OK
958	TANAH SEDANG	LinRespSpec	Max	5.08365	1.547198	0.196499	OK

Tabel 14 Displacement Yang Terjadi Pada Jenis Tanah Lunak

TABLE: Joint Displacements							
Joint	OutputCase	CaseType	StepType	U1	U2	U3	Kontrol
Text	Text	Text	Text	mm	mm	mm	H/200
1	TANAH LUNAK	LinRespSpec	Max	5.311284	1.616461	0.196277	OK
2	TANAH LUNAK	LinRespSpec	Max	5.311284	1.616461	0.196277	OK
3	TANAH LUNAK	LinRespSpec	Max	5.311228	1.616478	0.059737	OK
4	TANAH LUNAK	LinRespSpec	Max	5.311228	1.616478	0.059737	OK
829	TANAH LUNAK	LinRespSpec	Max	5.311191	1.61645	0.205145	OK
835	TANAH LUNAK	LinRespSpec	Max	5.311191	1.61645	0.205145	OK
952	TANAH LUNAK	LinRespSpec	Max	5.311191	1.61645	0.205145	OK
958	TANAH LUNAK	LinRespSpec	Max	5.311191	1.61645	0.205145	OK

4. Hasil analisa Joint Reaction Pada Tower



Gambar 13 Titik Joint Reaction Pada Tower

Tabel 15 Nilai Joint Reaction Pada Jenis Tanah Batuan

TABLE: Joint Reactions							
Joint	OutputCase	F1	F2	F3	M1	M2	M3
Text	Text	N	N	N	N-mm	N-mm	N-mm
762	TANAH BATUAN	25537.18	38141.21	525264.61	23333974.22	101017001.2	2585403.7
765	TANAH BATUAN	25537.18	38141.21	525264.61	23333974.31	101017001.1	2585403.7
885	TANAH BATUAN	25537.18	38141.21	525264.61	23333974.24	101017001.2	2585403.7
888	TANAH BATUAN	25537.18	38141.21	525264.61	23333974.28	101017001.1	2585403.7

Tabel 16 Nilai Joint Reaction Pada Jenis Tanah Keras

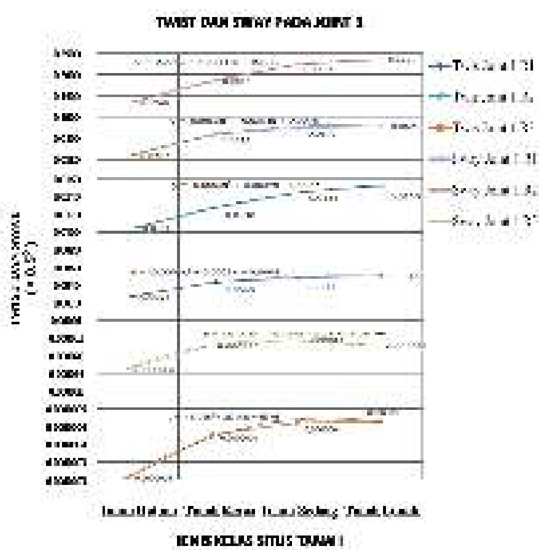
TABLE: Joint Reactions							
Joint	OutputCase	F1	F2	F3	M1	M2	M3
Text	Text	N	N	N	N-mm	N-mm	N-mm
762	TANAH KERAS	30754.63	45050.37	628425.3	37066191.18	117961974.6	3075998
765	TANAH KERAS	30754.63	45050.37	628425.3	37066191.26	117961974.6	3075998
885	TANAH KERAS	30754.63	45050.37	628425.3	37066191.2	117961974.7	3075998
888	TANAH KERAS	30754.63	45050.37	628425.3	37066191.23	117961974.6	3075998

Tabel 17 Nilai Joint Reaction Pada Jenis Tanah Sedang

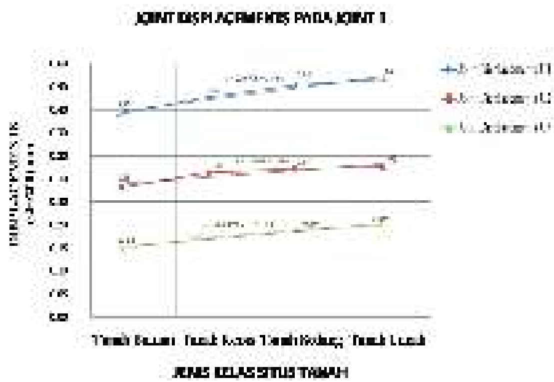
TABLE: Joint Reactions							
Joint	OutputCase	F1	F2	F3	M1	M2	M3
Text	Text	N	N	N	N-mm	N-mm	N-mm
762	TANAH SEDANG	33835.36	49740	693927.07	40907409.55	130180313.5	3393090.6
765	TANAH SEDANG	33835.36	49740.01	693927.07	40907409.64	130180313.4	3393090.6
885	TANAH SEDANG	33835.36	49740	693927.07	40907409.57	130180313.5	3393090.6
888	TANAH SEDANG	33835.36	49740.01	693927.07	40907409.61	130180313.4	3393090.6

Tabel 18 Nilai Joint Reaction Pada Jenis Tanah Lunak

TABLE: Joint Reactions							
Joint	OutputCase	F1	F2	F3	M1	M2	M3
Text	Text	N	N	N	N-mm	N-mm	N-mm
762	TANAH LUNAK	34823.87	51858.75	723798.83	42585646.27	135497841.3	3526036.7
765	TANAH LUNAK	34823.87	51858.75	723798.83	42585646.37	135497841.2	3526036.7
885	TANAH LUNAK	34823.87	51858.75	723798.83	42585646.3	135497841.3	3526036.7
888	TANAH LUNAK	34823.87	51858.75	723798.83	42585646.34	135497841.2	3526036.7



Gambar 14 Grafik Hubungan Jenis Tanah Dan Twist & Sway



Gambar 15 Grafik Hubungan Jenis Tanah Dan Displacement

4. KESIMPULAN

Dari hasil analisa di atas didapat kesimpulan sebagai berikut:

1. Pengaruh beban gempa terhadap nilai *Twist, Sway, dan Displacement* yang terjadi pada struktur tower BTS tidak melebihi syarat yang di tentukan dimana nilai *Twis dan* Sway tidak melebihi **0.5^0** dan untuk nilai *Displacement* tidak melebihi **H/200 (30000/200 = 150 mm)**.
2. Pengaruh beban gempa dengan beberapa situs kelas tanah yang berupa tanah batuan, tanah keras, tanah sedang dan tanah lunak didapat nilai twist & sway sebagai berikut :
   a. Semakin lunak kondisi tanah maka terjadi peningkatan nilai *Twist* pada struktur tower dimana nilai *Twis* tertinggi terjadi pada jenis tanah lunak pada arah Y sebesar 0.015^0.
   b. Semakin lunak kondisi tanah maka terjadi peningkatan nilai *Sway* pada struktur tower dimana nilai *Sway* tertinggi terjadi pada jenis tanah lunak pada arah Y sebesar 0.227^0.
3. Pengaruh *Displacement* yang terjadi akibat beban gempa dimana :
   a. Pada arah x terjadi peningkatan nilai *Displacement* dari jenis tanah batuan ke jenis tanah lunak dimana nilai *Displacement* tertinggi terjadi pada

jenis tanah lunak sebesar 5.31mm <H/200(30000/200=150 mm).

b. Pada arah y terjadi peningkatan nilai *Displacement* dari jenis tanah batuan ke jenis tanah lunak dimana nilai *Displacement* tertinggi terjadi pada jenis tanah lunak sebesar 1.62 mm <H/200(30000/200=150 mm).

c. Pada arah z terjadi peningkatan nilai *Displacement* dari jenis tanah batuan ke jenis tanah lunak dimana nilai *Displacement* tertinggi terjadi pada jenis tanah lunak sebesar 0.20 mm < H/200 (30000/200 = 150 mm).

4. Hasil dari perhitungan pengaruh beban gempa terhadap nilai twist, sway (point 2) maupun displacement (point 3) yang terjadi pada struktur tower BTS masih dibawah/tidak melebihi syarat nilai yang ditentukan. Nilai puntiran, goyangan maupun perpindahan yang diakibatkan beban gempa tersebut dengan kondisonal berbagai jenis tanah dikabupaten jember, masih **AMAN** *dimana* gaya - gaya yang ditimbulkan tidak berpengaruh pada struktur Tower BTS maupun antena yang terpasang.

5. REFERENSI

[1] ANSI/TIA/EIA. 1996, Structural Standards for Steel Antenna Tower and Antenna Supporting Structure. U.S.A.

[2] American Institute of Steel Construction (AISC). (2010), Specification for structural steel buildings, Chicago.

[3] ASTM. 2014. Annual Book of ASTM Standards. Vol. 05.06. American Society for Testing and Materials: West Conshohocken, PA.

[4] Badan Standarisasi Nasional. 2012. Tata Cara Perencanaan Ketahanan Gempa Untuk Bangunan Gedung (SNI 03-1726-2012). Jakarta.

[5] Gunawan, Rudi. 1987, Tabel Profil Konstruksi Baja, Kanisius, Jakarta. Pusat Penelitian dan Pengembangan Permukiman - Kementerian Pekerjaan Umum. Aplikasi Desain Spectra Indonesia, PPMB-ITB