SKRIPSI

STUDI PERENCANAAN DENGAN SISTEM RANGKA PEMIKUL MOMEN

PADA BANGUNAN GEDUNG HOTEL PATTIMURA MALANG

disusun oleh:

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JURUSAN TEKNIK SIPIL S-1

FAKULTAS TEKNIK SIPIL DAN PERENCANAAN

INSTITUT TEKNOLOGI NASIONAL

MALANG

2015

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SKRIPSI

" STUDI PERENCANAAN STRUKTUR RANGKA PEMIKUL MOMEN PADA BANGUNAN HOTEL PATTIMURA MALANG "

Disusun dan Diajukan Sebagai Salah Satu Syarat Memperoleh Gelar
Sarjana Teknik Sipil S-1
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" STUDI PERENCANAAN STRUKTUR RANGKA PEMIKUL MOMEN PADA BANGUNAN HOTEL PATTIMURA MALANG "

Dipertahankan Dihadapan Majelis Penguji Sidang Skripsi
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Pada Hari : Rabu
Tanggal : 12 Agustus 2015
Dan Diterima Untuk Memenuhi Salah Satu Persyaratan
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2015

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" STUDI PERENCANAAN STRUKTUR RANGKA PEMIKUL MOMEN PADA BANGUNAN HOTRL PATTIMURA MALANG "

Adalah hasil karya sendiri bukan duplikat serta tidak mengutip atau menyadur dari hasil karya orang lain kecuali disebutkan sumbernya.

Malang, September 2015

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ABSTRAKSI

Andrio Umbu Doli, 10.21.038, 2015. "STUDI PERENCANAAN STRUKTUR RANGKA PEMIKUL MOMEN PADA BANGUNAN GEDUNG HOTEL PATTIMURA MALANG".
Skripsi, Program Studi Teknik Sipil S-1, Institut Teknologi Nasional Malang. Pembimbing : (I) Ir. A. Agus Santosa, MT, (II) Ir. Ester Priskasari, MT.

Kata kunci : Struktur Tahan Gempa, SRPM, SRPMK

Indonesia yang semakin rawan akan terjadinya gempa merupakan salah satu pendorong para ilmuwan-ilmuwan sipil dalam mengeluarkan peraturan-peraturan baru dalam perencanaan struktur agar tahan terhadap gaya akibat gempa. Struktur diharapkan mampu memberikan kapasitas tertentu untuk tetap bertahan dan berprilaku daktail pada saat terjadi gempa kuat.

SNI 2847-2013 dan SNI 1726-2012 yang merupakan peraturan baru dalam bidang sipil memberikan sistem dan tata cara tersendiri dalam merencanakan struktur tahan gempa dengan menggunakan Sistem Rangka Pemikul Momen (SRPM). Sehingga peraturan ini sangat diperlukan sosialisasinya dalam masyarakat, baik dari kalangan akademisi, konsultan maupun pelaksana agar apa yang diharapkan dalam standarisasi dapat tercapai dengan baik.

Sehubungan dengan hal di atas, penulis mencoba merencanakan ulang Hotel Patimura Malang, yang meliputi : balok, kolom, hubungan balok kolom. Dengan menggunakan Sistem Rangka Pemikul Momen Khusus (SRPMK) seperti yang terdapat dalam SNI 2847-2013 dan SNI 1726-2012. Hal ini terkait karena selain bertempat di Malang yang merupakan daerah gempa sedang juga karena struktur itu sendiri tergolong gedung bertingkat tinggi sehingga dalam pelaksanaan harus direncanakan ketahanannya terhadap gaya gempa. Sedangkan untuk analisa pembebanannya menggunakan Peraturan Pembebanan Indonesia Untuk Gedung (PPIUG) 1987, untuk analisa statikanya menggunakan STAAD Pro.

Dengan sistem ini struktur diharapkan mempunyai ketahanan yang kuat terhadap momen khusus yang disebabkan oleh gaya gempa. Selain itu SRPMK juga mengharapkan agar struktur mempunyai pola keruntuhan yang aman saat struktur tersebut harus runtuh, yaitu diharapkan agar komponen baloknya hancur terlebih dahulu dari komponen lainnya seperti kolom ataupun hubungan balok kolom. Sehingga sebelum runtuh struktur mampu memberikan waktu plastisitas yang cukup untuk keamanan tersebut.

Untuk mencapai kondisi di atas diperlukan detail penulangan yang benar dan harus diselesaikan dengan sistem yang ada terutama pada bagian sendi plastis yang kemungkinan mengalami plastisitas terlebih dahulu apabila terjadi gempa kuat.

KATA PENGANTAR

Puji syukur kehadirat Tuhan Yang Maha Esa karena atas berkat dan rahmat-Nya saya dapat menyelesaikan skripsi yang berjudul **"STUDI PERENCANAAN DENGAN SISTEM RANGKA PEMIKUL MOMEN PADA BANGUNAN GEDUNG HOTEL PATTIMURA MALANG"**.

Selesainya skripsi ini berkat adanya dorongan, bimbingan dan motivasi dari semua pihak. Oleh karena itu tak lupa saya mengucapkan terimakasih yang sebesar-besarnya kepada :

1. Bapak Ir. H. Sudirman Indra, M.Sc selaku Dekan Fakultas Teknik Sipil dan Perencanaan Institut Teknologi Nasional Malang.
2. Bapak Ir. Agus Santosa, MT selaku Ketua Program Studi Teknik Sipil S-1 Institut Teknologi Nasional Malang dan Dosen Pembimbing I.
3. Ibu Lila Ayu Ratna Winanda, ST., MT selaku Sekretaris Program Studi Teknik Sipil S-1 Institut Teknologi Nasional Malang
4. Ibu Ir. Ester Priskasari, MT selaku Dosen Pembimbing II.
5. Kedua orang tua dan keluarga yang selalu memberikan motivasi dan nasehat.
6. Teman-teman yang terlibat baik langsung maupun tidak langsung dalam penyelesaian skrispi ini.

Dalam penulisan skripsi ini maupun dalam pengerjaannya masih jauh dari sempurna dan masih banyak terdapat kesalahan. Oleh karena itu saya sangat mengharapkan kritik dan saran demi penyempurnaan penyusunan skripsi ini selanjutnya.

Malang, ……..................... 2015

Penyusun

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BAB I

PENDAHULUAN

1.1 Latar Belakang

Bangunan gedung Hotel di malang sangat berperan penting dalam usaha pengembangan pariwisata di kota malang. Dilihat dari letak geografis ,Indonesia merupakan salah satu Negara rawan gempa di dunia .Hal ini di sebabkan karena posisi wilayah Indonesia yang berada pada pertemuan tiga lempeng tektonik besar di dunia,yaitu tapal batas lempeng Eurasia,lempeng Indo-Australia,dan lempeng pasifik.Oleh sebab itu dalam merencanakan gedung-gedung bertingkat hendaknya di rencanakan agar dapat menahan beban lateral gempa.

Dalam perencanaan bangunan bertingkat masalah yang timbul adalah kemampuan struktur tersebut sebagai kesatuan system bangunan untuk menahan beban lateral, disamping berat sendiri dari struktur tersebut. Oleh karena itu di perlukan pengetahuan dalam perencanaan struktur yang tahan terhadap beban gravitasi dan gempa.

Perencanaan struktur tidak hanya di perhitungkan keamanan dan ketahanan struktur tersebut untuk menahan beban – beban yang bekerja pada sruktur tersebut, tetapi juga harus memperhatikan rasa aman dan nyaman bagi orang yang berada pada bangunan tersebut,maka di sini perencana tidak hanya memperhitungkan keamanan dan kenyamanan struktur saja tetapi juga harus mengutamakan asas kemanusiaan, bila bangunan terkena gempa yang kuat melampaui batas rencana,bangunan tidan langsung runuh sehingga dapat meminimalisir korban jiwa. Disini , kita sebagai perencana di tuntut untuk merencanakan bangunan tahan gempa yang tidak hanya tahan terhadap gempa tapi juga memberikan keamanan bagi manusia,aset – asset penting dan lain sebagainya yang ada di dalam bangunan tersebut. Maka dari itu perlu di perhatikan dalam perencanaan gedung tahan gempa ialah perilaku hubungan balok kolom (HBK) sesuai dengan pembagian wilayah gempa.

Proyek yang di tinjau dalam sripsi ini adalah bangunan gedung Hotel Pattimura Malang yang terdiri dari 7 lantai.

Dari penjelasan diatas berdasarkan wilayah gempa dan ketinggian bangunan Hotel Pattimura malang,maka penulis akan mencoba merencanakan ulang struktur beton bertulang pada gedung tersebut yang berjudul :

“STUDI PERENCANAAN STRUKTUR DENGAN SISTEM RANGKA PEMIKUL MOMEN PADA BANGUNAN GEDUNG HOTEL PATTIMURA MALANG”

1.2 Idenifikasi Masalah

Mengingat Malang termasuk dalam salah satu wilayah rawan gempa di Indonesia gempa yang berarti bahwa dimana menurut tabel 2.6 SNI 1726-2012 salah satu sitem penahan gaya gempa menggunakan sistem rangka pemikul momen , maka pada pembangunan gedung Hotel Patimura malang struktur yang di rencanakan harus menjamin struktur tidak mengalami kerusakan pada waktu menahan gempa dengan kekuatan kecil atau sedang dan tidak mengalami kerusakan yang fatal akibat gempa kuat.

Dengan demikian dalam studi yang di bahas mengenai perencanaan gedung Hotel Pattimura malang dengan menggunakan Sistem Rangka Pemikul Momen , yang direncanakan sedemikian rupa sehingga mampu menahan struktur saat di landa gempa.

1.3.Rumusan Masalah

Permasalahan yang akan di bahas pada perencanaan Struktur Rangka Pemikul Momen:

- Berapakah dimensi balok dan kolom yang kuat untuk menahan beban gempa yang bekerja pada strukur rangka?
- Berapakah dimensi dan jumlah tulangan yang dibutuhkan?

1.4.Maksud Dan Tujuan

Maksud dan tujuan secara umum dari penulisan skripsi ini adalah menerapkan perencanaan struktur yang sebenarnya.serta mempelajari dan memahami lebih jauh mengenai cara merencanakan struktur dengan konsep desain kapasitas sehingga menghasilkan struktur gedung yang kuat,aman,serta memberikan kenyamanan.

Sedangkan tujuan yang ingin di capai dalam penulisan struktur ini adalah:

- Mengetahui dimensi balok dan kolom yang kuat untuk menahan beban gempa yang bekerja pada struktur rangka.
- Mengetahui dimensi dan jumlah tulangan yang dibutuhkan.

1.5.Batasan masalah

Adapun batasan masalah yang diambil dalam studi perencanaan Sistem Rangka Pemikul Momen pada bangunan gedung Hotel Patimura Malang meliputi beberapa hal sebagai berikut :

- Perencanaan dimensi pada balok dan kolom.
- Perencanaan dimensi dan jumlah tulangan pada balok dan kolom.
- Perilaku struktur yang di tinjau hanya strukur bagian atas saja,sehingga perencanaan gedung tidak diikuti dengan perencanaan pondasi
- Perencanaan hanya di lakukan untuk balok dan kolom pada portal line 4
- Pedoman Perencanaan Berdasarkan Referensi yang adad antara lain :
    - Tata cara parencanaan ketahanan gempa untuk stuktur bangunan gedung dan non gedung, SNI 03-1726-2012
    - Persyaratan beton struktural untuk bangunan gedung, SNI 03-2847-2013, dan
    - Pedoman Perencanaan Pembebanan untuk Rumah dan Gedung 1987

BAB II

TINJAUN PUSTAKA

2.1. Pendahuluan

Dalam perencanaan struktur bangunan tahan gempa, di perlukan standar dan peraturan perencanaan bangunan untuk menjamin keselamatan penghuni terhadap gempa besar yang mungkin terjadi serta menghindari dan meminimalisasi kerusakan struktur bangunan dan korban jiwa terhadap gempa bumi yang sering terjadi.

Oleh karena itu, struktur bangunan tahan gempa harus memiliki kekuatan,kekakuan dan stabilisasi yang cukup untuk mencegah terjadinya kerunuhan bangunan.Filosofi dan konsep dasar perencanaan bangunan tahan gempa adalah:

- Pada saat terjadi gempa ringan, struktur bangunan dan fungsi bangunan harus dapat tetap berjalan (*servicable*) sehingga struktur harus kuat dan tidak ada kerusakan baik pada elemen struktural dan elemen nonstruktural bangunan.
- Pada saat terjadi gempa moderat atau medium, struktur di perbolehkan mengalami kerusakan pada elemen non struktural,tetapi tidak di perbolehkan terjadi kerusakan pada elemen struktural.
- Pada saa terjadi gempa besar,di perbolehkan terjadi kerusakan pada elemen struktural dan non struktural, namun tidak sampai menyebabkan bangunan runtuh sehingga tidak menyebabkan koban jiwa atau meminimalisasi korban jiwa.

2.2. Perencanaan Struktur Tahan Gempa

Dalam perencanaan struktur gedung terhadap gempa rencana, semua unsur gedung, baik bagian dari subsistem struktur gedung maupun bagian dari sistem struktur gedung seperti rangka (portal), dinding geser,kolom,balok,lantai,lantai tanpa balok (lantai cendawan) dan kombinasinya, harus di perhitungkan memikul pengaruh gempa rencana, sehingga struktur yang di rencanakan tidak mengalami kerusakan pada waktu di beri beban gempa kecil atau sedang dan tidak mengalami keruntuhan yang fatal ketika terjadi gempa kuat. Struktur yang di rencanakan di harapkan mampu bertahan oleh beban bolak balik memasuki perilaku inelastik. Kemampuan ini di sebut kemampuan daktilitas struktur.

Daktilitas adalah kemampuan suatu struktur gedung untuk mengalami simpangan pasca elastik yang besar secara berulang kali di bolak balik akibat gempa yang menyebabkan terjadinya pelelehan pertama, sambil mempertahankan kekuatan dan kekakuan yang cukup, sehingga sruktur gedung tersebut tetap berdiri walaupun sudah berada dalam posisi ambang keruntuhan.

Berikut ini adalah macam-macam tingkat daktilias beserta kondisi yang di timbulkan:

- Daktilitas 1 : keadaan elastis, dengan konsep ini tulangan di desain besar-besar untuk membuat bangunan menjadi kaku (full elactic). Konsekuensinya, saat gempa melebihi rencana maka gedung akan langsung roboh tanpa memberi tanda (peringatan) terlebih dahulu.
- Dakilitas 2 : keadaan paltis tingkat menengah (intermediate)
- Daktilitas 3 : keadaan plastis dengan struktur yang dektail, perencanaan struktur dengan metode capacity desain. Ini yang di jadikan dasar

perencanaan bangunan tahan gempa di Indonesia, yaitu dengan pembentukan sendi plastis di balok, sehingga saat terjadi gempa bangunan akan memberikan tanda atau peringatan terlebih dahulu, seingga dapa memberikan waktu kepada orang di dalamnya untuk menyelamatkan diri.

Dalam struktur portal, kolom adalah komponen struktur yang menopang balok,lantai, seluruh beban di lantan dan lantai-lantai di atasnya. Sedangkan balok hanya komponen struktur yang menopang dan mendistribusikan beban-beban di lantai tersebut menuju kolom .

Kalau sampai kolom runtuh, maka runtuhlah seluruh system struktur di atasnya. Tetapi kalau balok yang runtuh maka kerusakan awal hanya terjadi di bagian balok itu saja kemudian merambat ke elemen balok yang lain dan sterusnya hingga struktur benar-benar runuh ketika tidak lagi kuat menahan beban (dalam hal ini beban geser akibat gempa)

Maka tak heran jika bangunan-bangunan tinggi di desain dengan konsep ‘’*strong column weak beam*’’. Jika pada suatu saat terjadi goncangan yang besar akibat gempa, kolom bangunan yang di desain akan tetap bertahan, sehingga orang-orang yang berada berada di dalam gedung masih mempunyai waktu untuk menyelamatkan diri sebelum bangunan roboh seketika.

Dalam perencanaan struktur bangunan tahan gempa, titik pertemuan (joint) rangka harus memenuhi beberapa ketentuan berdasarkan wilayah dan resiko gempa, dimana akan berpengaruh pada perencanaan HubunganBalok Kolom (HBK). Dan di desain dengan sistem rangka pemikul momen yang sudah di bagi berdasarkan wilayah dan resiko gempa.

2.3. Pengertian Sistem Rangka Pemikul Momen

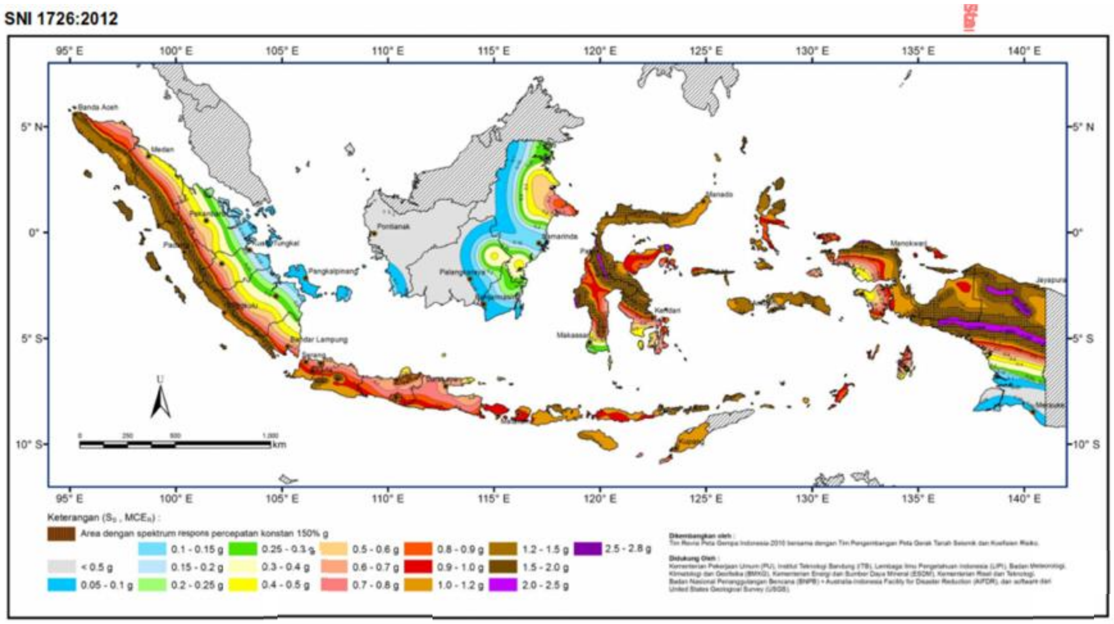
Menurut SNI -1726-2012 pasal 3.53 hal.7

Pengertian dari Sistem Rangka Pemikul Momen (SRPM) adalah sistem struktur yang pada dasarnya memiliki rangka ruang pemikul beban gravitasi secara lengkap,sedangkan beban lateral yang diakibatkan oleh gempa di pikul oleh rangka pemikul momen melalui mekanisme lentur.

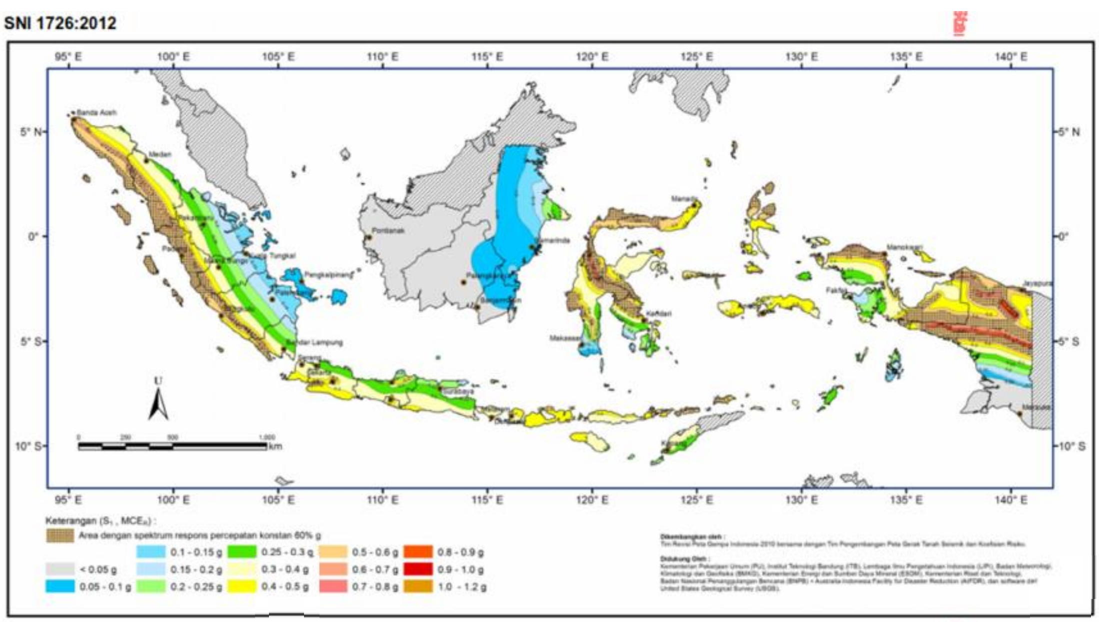
tercantum 3 jenis SRPM yaitu SRPMB (B = biasa),SRPMM (M = menengah),SRPMK (K = khusus).

1. Sistem Rangka Pemikul Momen Biasa (SRPMB)
2. Sistem Rangka Pemikul Momen Menengah (SRPMM)
3. Sistem Rangka Pemikul Momen Khusus (SRPMK)

Berdasarkan SNI 1726-2012 pasal 6.1.1, zonasi peta gempa menggunakan peta gempa untuk probabilitas 2% terlampaui dalam 50 tahun atau memiliki periode ulang 2500 tahun. Wilayah gempa berdasarkan SNI 1726-2012 pasal 14, ditetapkan berdasarkan parameter S_s (percepatan batuan dasar pada periode pendek 0,2 detik) dan S_1 (percepatan batuan dasar pada periode 1 detik). Hal ini dapat dilihat pada Gambar 2.1 dan 2.2



Gambar 2.1 - S_S, Gempa maksimum yang di pertimbangkan resiko-tertarget (MCE_R), kelas situs SB



Gambar 2.2 - S_1, Gempa maksimum yang di pertimbangkan resiko-tertarget (MCE_R), kelas situs SB

Karena gedung Hotel Pattimura Malang berada di kota Malang yang menurut SNI 1726-2012,kota malang berada pada wilayah rawan gempa dimana menurut tabel 2.6 SNI 1726-2012 sitem penahan gaya gempanya menggunakan sistem rangka pemikul momen , maka dalam penyusunan skripsi ini, perencanaan struktur Gedung Hotel Pattimura Malang menggunakan Sistem Rangka Pemikul Momen , yang sesuai dengan wilayah gempa kota malang.

2.4 Pembebanan Struktur

Beban-beban yang bekerja dan diperhitungkan adalah beban vertikal dan beban horisontal. Beban horisontal dapat berupa beban angin dan beban gempa. Struktur portal direncanakan terhadap beban horisontal akibat beban gempa saja karena dalam perencanaan struktur beton bertulang beban gempa lebih dominan dibanding beban angin. Beban vertikal meliputi beban mati dan beban hidup. Dari analisa pembebanan inilah akan direncanakan untuk dapat menahan beban, sehingga konstruksi dapat digunakan dengan aman.

Jenis pembebanan yang dipakai dalam perencanaan gedung ini adalah :

2.4.1 Beban Mati

Beban mati adalah beban yang berasal dari material yang digunakan pada struktur dan beban mati tambahan yang bekerja pada stuktur.

Berat material bangunan tergantung dari jenis bahan bangunan yang dipakai. Contoh berat sendiri bahan bangunan dan komponen gedung berdasarkan Peraturan Pembebanan Indonesia Untuk Gedung (PPIUG 1987) tabel 1 adalah :

1. Baja = 7850 kg/m^3
2. Batu alam = 2600 kg/m^3
3. Beton berulang = 2400 kg/m^3

4. Pasangan bata merah = 1700 kg/m^3

Beban mati tambahan adalah beban yang berasal dari finishing lantai (keramik, plester), beban dinding dan beban tambahan lainnya. Contoh berat jenis dari bahan tambahan berdasarkan Peraturan Pembebanan Indonesia Untuk Gedung (PPIUG 1987) adalah :

1. Beban finishing (keramik) = 24 kg/m^3
2. Spesi 2,5 cm (2,5 x 21 kg/m^2) = 53 kg/m^3
3. Beban plafond dan penggantung = 18 kg/m^3
4. Beban dinding = 250 kg/m^3

2.4.2 Beban Hidup

Beban hidup adalah semua beban yang terjadi akibat penghunian atau penggunaan fungsi suatu gedung dan kedalamnya termasuk beban-beban pada lantai yang berasal dari barang-barang yang dapat berpindah, mesin-mesin serta peralatan yang tak terpisahkan dari gedung selama masa hidup dari gedung itu, sehingga mengakibatkan perubahan dalam pembebanan lantai dan atap tersebut.

Contoh beban hidup berdasarkan fungsi ruangan menurut tabel 3.1 Peraturan Pembebanan Indonesia Untuk Gedung (PPIUG 1987) :

- Parkir = 400 kg/m^2
- Parkir lantai bawah = 800 kg/m^2
- Lantai Hotel = 250 kg/m^2
- Lantai rumah sakit = 250 kg/m^2
- Ruang pertemuan = 400 kg/m^2

- Ruang dansa = 500 kg/m^2
- Tangga dan bordes = 300 kg/m^2

Khusus pada atap ke dalam beban hidup dapat termasuk beban berasal dari air hujan, baik akibat genangan dan diambil beban orang minimum sebesar 100 kg/m.

2.4.3 Beban Gempa

Beban gempa adalah semua beban yang ditimbulkan dari gerakan lapisan bumi ke arah horisontal dan vertikal, dimana gerakan vertikalnya lebih kecil dari gerakan horisontalnya.

2.4.3.1 Arah Pembebanan Gempa

Untuk mensimulasikan arah pengaruh gempa rencana yang sembarangan terhadap struktur gedung, pengaruh pembebanan gempa dalam arah utama yang ditentukan harus dianggap efektif 100% dan harus dianggap terjadi bersamaan dengan pengaruh pembebanan gempa dalam arah tegak lurus pada arah utama pembebanan tadi, tetapi dengan efektivitas 30%.

2.4.3.2 Prosedur Analisis

Berdasarkan SNI 1726-2012 pasal 7.6, prosedur analisis yang digunakan seperti pada Tabel 2.5. Prosedur analisis yang digunakan terkait dengan berbagai parameter struktur bangunan tersebut, yaitu :

- Parameter keutamaan bangunan berdasarkan pasal 4.1.2 SNI 1726-2012 dan dapat dilihat pada Tabel 2.1.
- Parameter faktor keutamaan gempa berdasarkan pasal 4.1.2 SNI 1726-2012 dan dapat dilihat pada Tabel 2.2.

- Kategori desain seismik berdasarkan parameter percepatan respon spektra pada periode 1 detik *(S_1)* dan parameter percepatan respon spektra pada periode pendek *(Ss)* berdasarkan pasal 6.3 SNI 1726-2012 dapat dilihat pada Tabel 2.3 dan Tabel 2.4.

Tabel 2.1 kategori resiko bangunan gedung dan non gedung unuk beban gempa

Jenis pemanfaatan	Kategori resiko
Gedung dan non gedung yang memiliki resiko rendah terhadap jiwa manusia pada saat terjadi kegagalan, termasuk, tetapi tidak di batasi untuk, antara lain : • Fasilitas pertanian, perkebunan, peernakan, dan perikanan • Fasilitas sementara • Gudang penyimpanan • Rumah jaga dan struktur kecil lainnya	I
Semua gedung dan struktur lain, kecuali yang termasuk dalam kategori resiko I,III,IV, termasuk tetapi tidak di batasi untuk : • Perumahan • Rumah toko dan rumah kantor • Pasar • Gedung perkantoran • Gedung apartemen/rumah susun • Pusat perbelanjaan/mall • Bangunan industry • Fasilitas manufaktur	II

• pabrik	
Gedung dan non gedung yang memiliki resiko tinggi terhadap jiwa manusia pada saat terjadi kegagalan, termasuk, tetapi tidak di batasi untuk : • bioskop • gedung pertemuan • stadion • fasilitas kesehatan yang tidak memiliki uni bedah dan unit gawat darurat • fasilitas penitipan anak • penjara • bangunan untuk orang jompo gedung dan non gedung, tidak termasuk ke dalam kategori resiko IV, yang memiliki potensi untuk menyebabkan dampak ekonomi yang besar dan/atau gangguan massal erhadap kehidupan masyarakat sehari-hari bila terjadi kegagalan, termasuk , tapi tidak di batasi untuk : • pusat pembangkit listrik biasa • fasilitas penanganan air • fasilitas penanganan limbah • pusat telekomunikasi gedung dan non gedung yang tidak termasuk dalam kategori IV, (termasuk, tetapi tidak di batasi untuk fasilitas manufaktur, proses, penanganan, penyimpanan, penggunaan atau tempat pembuangan bahan bakr berbahaya, bahan kimia berbahaya, limbah berbahaya, atau bahan yang mudah meledak)	III

yang mengandung bahan beracun atau peledak di mana jumlah kandungan bahayanya melebihi nilai batas yang di syaratkan oleh instansi yang berwenan dan cukup menimbulkan bahaya bagi masyarakat jika terjadi kebocoran.	
Gedung dan non gedung yang di tunjuk sebagai fasilitas yang penting, termasuk, tetapi tidak di batasi untuk : • bangunan-bangunan monumental • gedung sekolah dan fasilitas pendidikan • rumah sakit dan fasilitas bedah dan unit gawa darurat • fasilitas pemadam kebakaran, ambulans, dan kantor polisi, serta garasi kendaraan darurat • tempat perlindungan terhadap gempa bumi, angina badai, dan empat perlindungan darurat lainnya • fasilitas kesiapan darurat, komunikasi, pusat operasi dan fasilitas lainnya untuk tanggap darurat • struktur tambahan (termasuk menara elekomunikasi, tangki penyimpanan bahan bakar, menara pendingin, struktur stasiun listrik, tangki air pemadam kebakaran atau struktur rumah atau stuktur pendukung air atau material atau peralatan pemadam kebakaran) yang di syaratkan beroperasi pada saat keadaan darurat gedug dan non gedung yang di butuhkan untuk mempertahankan fungsi struktur bangunan lain yang masuk ke dalam kategori resiko IV.	IV

Tabel 2.2 faktor keutamaan gempa

Kategori resiko	Faktor keutamaan gempa, I_e
I atau II	1,0
III	1,25
IV	1,50

Tabel 2.3 Kategori desain seismik berdasarkan parameter respons percepatan pada perioda pendek.

Nilai S_{DS}	Kategori resiko	
	I atau II atau III	IV
$S_{DS} < 0,167$	A	A
$0,167 \leq S_{DS} < 0,33$	B	C
$0,33 \leq S_{DS} < 0,50$	C	D
$0,50 \leq S_{DS}$	D	D

Tabel 2.4 Kategori desain seismik berdasarkan parameter respons percepatan pada perioda 1 detik.

Nilai S_{D1}	Kategori resiko	
	I atau II atau III	IV
$S_{D1} < 0,167$	A	A
$0,167 \leq S_{D1} < 0,133$	B	C
$0,133 \leq S_{D1} < 0,20$	C	D
$0,20 \leq S_{D1}$	D	D

Tabel 2.5 Prosedur analisis yang boleh digunakan.

Kategori desain seismik	Karakteristik struktur	Analisis gaya lateral ekivalen Pasal 7.8	Analisis spektrum respons ragam Pasal 7.9	Prosedur riwayat respons seismik Pasal 11
B, C	Bangunan dengan Kategori Risiko I atau II dari konstruksi rangka ringan dengan ketinggian tidak melebihi 3 tingkat	I	I	I
	Bangunan lainnya dengan Kategori Risiko I atau II, dengan ketinggian tidak melebihi 2 tingkat	I	I	I
	Semua struktur lainnya	I	I	I
D, E, F	Bangunan dengan Kategori Risiko I atau II dari konstruksi rangka ringan dengan ketinggian tidak melebihi 3 tingkat	I	I	I
	Bangunan lainnya dengan Kategori Risiko I atau II dengan ketinggian tidak melebihi 2 tingkat	I	I	I
	Struktur beraturan dengan $T< 3{,}5T_s$ dan semua struktur dari konstruksi rangka ringan	I	I	I
	Struktur tidak beraturan dengan $T< 3{,}5T_s$ dan mempunyai hanya ketidakteraturan horisontal Tipe 2, 3, 4, atau 5 dari **Tabel 10** atau ketidakteraturan vertikal Tipe 4, 5a, atau 5b dari **Tabel 11**	I	I	I
	Semua struktur lainnya	TI	I	I

CATATANI: Diijinkan, TI: Tidak Diijinkan

2.5 Struktur Penahan Gaya Seismik

Sistem penahan gaya seismik laterel dan vertikal dasar harus memenuhi salah satu tipe yang telah ditetapkan pada SNI 1726-2012 pasal 7.2. Setiap tipe dibagi-bagi berdasarkan tipe elemen vertikal yang digunakan untuk menahan gaya seismik lateral. Setiap sistem penahan gaya seismik yang dipilih harus dirancang dan didetailkan sesuai dengan persyaratan khusus bagi sistem tersebut yang telah ditetapkan. Berdasarkan SNI 1726-2012 pasal 7.2, sistem struktur penahan gaya seismik ditentukan oleh parameter berikut :

- Faktor koefisien modifikasi respons (R)
- Faktor kuat lebih sistem (C_d)
- Faktor pembesaran defleksi (Ω_0)
- Faktor batasan tinggi sistem struktur

Hal ini dapat dilihat pada Tabel 2.6

Tabel 2.6 Faktor *R*, C_d, Ω_0 untuk sistem penahan gaya gempa

Sistem panahan gaya seismik	Koefisien modifikasi respon R^a	Faktor kuat-lebih system, $\Omega_0{}^g$	Factor pembesaran defleksi $C_d{}^b$	Batasan system struktur dan batasan tinggi struktur, h_n (m)^c Kategori desain seismik				
				B	C	D^d	E^d	F^e
C. Sistem rangka pemikul momen								
1. Rangka baja pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
2. Rangka batang baja pemikul momen khusus	7	3	5½	TB	TB	48	30	TI
3. Rangka baja pemikul momen menengah	4½	3	4	TB	TB	$10^{h,i}$	TI^h	TI'
4. Rangka baja pemikul momen biasa	3½	3	3	TB	TB	TI^h	TI^h	TI'
5. Rangka beon bertulang pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
6. Rangka beon bertulang pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
7. Rangka beon bertulang pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
8. Rangka baja dan beton komposit pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
9. Rangka baja dan beton komposit pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
10. Rangka baja dan beton komposit terkekang parsial pemikul momen	6	3	5½	48	48	30	TI	TI
11.Rangka baja dan beton komposit pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
12.Rangka baja canai dingin pemikul momen khusus dengan pembautan	3½	3°	3½	10	10	10	10	10

2.6 Periode Alami Struktur

Periode adalah besarnya waktu yang dibutuhkan untuk mencapai satu getaran. Periode alami struktur perlu diketahui agar resonansi pada struktur dapat dihindari. Resonansi struktur adalah keadaan dimana frekuensi alami pada struktur sama dengan frekuensi beban luar yang bekerja sehingga dapat menyebabkan keruntuhan pada struktur. Berdasarkan SNI 1726-2012 pasal 7.8.2, terdapat dua nilai batas untuk periode bangunan, yaitu minimum periode bangunan *(*$T_{a\ minimum}$*)* dan nilai maksimum periode bangunan *(*$T_{a\ maksimum}$*)*.

Nilai minimum periode bangunan *(*$T_{a\ minimum}$*)* ditentukan oleh rumus :

$$T_{a\ minimum} = C_r h_n^x$$

Dimana :

$T_{a\ minimum}$ = nilai batas bawah periode bangunan.

h_n = ketinggian struktur dalam m di atas dasar sampai tingkat tertinggi struktur.

C_r = ditentukan dari Tabel 2.7.

x = ditentukan dari Tabel 2.7.

Tabel 2.7 Nilai parameter periode pendekatan *Ct* dan *x*

Tipe struktur	C_t	x
Sistem rangka pemikul momen di mana rangka memikul 100 persen gaya gempa yang disyaratkan dan tidak dilingkupi atau dihubungkan dengan komponen yang lebih kaku dan akan mencegah rangka dari defleksi jika dikenai gaya gempa:		
Rangka baja pemikul momen	0,0724 [a]	0,8
Rangka beton pemikul momen	0,0466 [a]	0,9
Rangka baja dengan bresing eksentris	0,0731 [a]	0,75
Rangka baja dengan bresing terkekang terhadap tekuk	0,0731 [a]	0,75
Semua sistem struktur lainnya	0,0488 [a]	0,75

Nilai maksimum periode bangunan *($T_{a\ maksimum}$)* ditentukan oleh rumus :

$$T_{a\ maksimum} = C_u T_{a\ minimum}$$

Dimana :

$T_{a\ maksimum}$ = nilai batas atas periode bangunan.

h_n = ketinggian struktur dalam m di atas dasar sampai tingkat tertinggi struktur.

C_u = ditentukan dari Tabel 2.8.

Parameter percepatan respons spektral desain pada 1 detik, S_{D1}	Koefisien C_u
≥ 0,4	1,4
0,3	1,4
0,2	1,5
0,15	1,6
≤ 0,1	1,7

Tabel 2.8 Koefisien untuk batas atas pada periode yang dihitung

2.7 Perhitungan Koefisien Respons Seismik

Berdasarkan SNI 1726-2012 pasal 7.8.1.1, perhitungan koefisien respons seismik (Cs) harus ditentukan sesuai dengan rumus :

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I}\right)}$$

Dimana :

S_{DS} = parameter percepatan spektrum respons desain dalam periode pendek.

R = faktor modifikasi respons berdasarkan Tabel 2.6.

I = faktor keutamaan gempa berdasarkan Tabel 2.2.

Nilai *Cs* yang dapat dihitung pada persamaan di atas tidak perlu melebihi nilai berikut ini.

$$C_s = \frac{S_{D1}}{T\left(\frac{R}{I}\right)}$$

Nilai *Cs* yang dihitung tidak kurang dari nilai berikut ini.

$$C_s = 0{,}044\ S_{DS} I \ \geq 0{,}01$$

Sebagai tambahan untuk struktur yang berlokasi di daerah di mana *S1* sama dengan atau lebih besar dari 0,6g maka *Cs* harus tidak kurang dari :

$$C_s = \frac{0{,}5 S_1}{\left(\frac{R}{I}\right)}$$

Dimana :

S_{D1} = parameter percepatan spektrum respons desain dalam periode 1 detik.

S_1 = parameter percepatan spektrum respons desain yang dipetakan.

T = periode struktur dasar (detik).

2.8 Parameter percepatan gempa

- Paremeter percepatan terpetakan

Parameter S_S (percepatan batuan dasar pada perioda pendek) dan S_1 (percepatan batuan dasar perioda 1 detik) harus di tetapkan masing-masing dari respon spectral percepatan 0,2 detik dan 1 detik dalam peta gerak tanah seismik pada pasal 14 dengan kemungkinan 2 persen atau terlampaui dalam 50 tahun (MCE_R, 2 persen dalam 50 tahun), dan dinyatakan dalam bilangan decimal terhadap percepatan gravitasi. Bila

$S_1 \leq$ 0,04 g dan $S_s \leq$ 0,15g, maka struktur bangunan boleh di masukkan ke dalam kategori desain seismic A, dan cukup memenuhi persyaratan dalam pasal 6.6.

- Kelas Situs

Berdasarkan sifat-sifat tanah pada situs, maka situs harus di klasifikasikan sebagai kelas situs SA, SB, SC, SD, SE, dan SFyang mengikuti 5.3. bila sifat-sifat tanah tidak teidentifikasi secara jenis sehingga tidak bias di tentukan kelas situsnya, maka kelas situs SE dapat di gunakan kecuali jika pemerintah atau dinas yang berwenang memiliki data geoeknik yang dapat menenukan kelas situs SF.

a) Koefisien-koefisien dan parameter-parameter respons spectral percepatan gampa maksimum yang di pertimbangkan resiko-tertarget (MCE_R)

Unuk penentuan respons spektral percepatan gempa MCE_R di permukaan tanah, di perlukan suatu faktor amplifikasi getaran terkait percepatan pada getaran periode pendek (F_a) dan factor amplifikasi terkait percepatan yang mewakili getaran perioda 1 detik (F_v). Parameter spectrum respon percepatan pada perioda pendek (S_{MS}) dan perioda 1 detik (S_{M1}) yang di sesuaikan dengan pengaruh klasifikasi situs, harus di tentukan dengan perumusan berikut ini:

$S_{MS} = F_a S_S$

$S_{M1} = F_v S_1$

Keterangan:

S_S = parameter respons spectral percepatan gempa MCE_R terpetakan untuk perioda pendek

S_1 = parameter respons spectral percepatan gempa MCE_R terpetakan untuk perioda 1,0 detik

Dan koofisien F_a dan F_v mengikuti tabel 5 dan tabel 6. Jika digunakan prosedur desain sesuai pasal 8, maka F_a harus di tentukan sesuai pasal 8.8.1 serta nilai F_v, S_{MS}, dan S_{M1} tidak perlu di tentukan.

tabel 2.9 koofisien situs, F_a

Kelas situs	paramete respons spektral percepatan gempa (MCE_R) terpetakan pada periода pendek, T= 0,2 detik, S_s				
	$S_s \leq 0{,}25$	$S_s = 0{,}5$	$S_s = 0{,}75$	$S_s = 1{,}0$	$S_s \geq 1{,}25$
SA	0,8	0,8	0,8	0,8	0,8
SB	1,0	1,0	1,0	1,0	1,0
SC	1,2	1,2	1,1	1,0	1,0
SD	1,6	1,4	1,2	1,1	1,0
SE	2,5	1,7	1,2	0,9	0,9
SF	SS^b				

Catatan :

a. Untuk nilai S_s dapat dilakukan interpolasi linier

b. SS = situs yang memerlukan investigasi geoteknik spesifik dan analisis respons situs-spesifik,lihat 6.10.1

tabel 2.10 koofisien situs, F_v

Kelas situs	paramete respons spektral percepatan gempa (MCE_R) terpetakan pada perioda 1 detik, S_1				
	$S_s \leq 0{,}1$	$S_s = 0{,}2$	$S_s = 0{,}3$	$S_s = 0{,}4$	$S_s \geq 0{,}5$
SA	0,8	0,8	0,8	0,8	0,8
SB	1,0	1,0	1,0	1,0	1,0
SC	1,7	1,6	1,5	1,4	1,3

SE	3,5	3,2	2,8	2,4	2,4
SF	2,[illegible] SS^b				

Catatan :

a. Untuk nilai S_1 dapat dilakukan interpolasi linier

b. SS = situs yang memerlukan investigasi geoteknik spesifik dan analisis respons situs-spesifik,lihat 6.10.1

- Paremeter Spektral desain

  Parameter percepatan spectral desain untuk periode pendek, S_{DS} dan pada perioda 1 detik, S_{D1} , harus di tentukan melalui perumusan berikut ini :

  $$S_{DS} = \frac{2}{3}\, S_{MS}$$

  $$S_{D1} = \frac{2}{3} S_{M1}$$

  Jika digunakan prosedur desain yang di sederhanakan sesuai pasal 8, maka nilai S_{DS} harus di tentukan sesuai pasal 8.8.1 dan nilai S_{D1} tidak perlu di tentukan.

- Spektrum Respons Desain

1. Untuk perioda yang lebih kecil T_0, Spektrum rspons percepatan desain, S_a ,harus diambil persamaan ;

$$S_a = S_{DS} + (0{,}4 + 0{,}6\ \frac{\mathrm{T}}{T_0}$$

2. untuk perioda lebih besar dari atau sama dengan T_0 dan lebih kecil atau sama dengan T_s spectrum respons percepatan desain, S_a , sama dengan S_{DS} ;
3. untuk perioda lebih besar dari T_s ,spectrum respons percepatan desain, S_a , diambil berdasarkan persamaan :

$$S_a = \frac{S_{D1}}{T}$$

Keterangan :

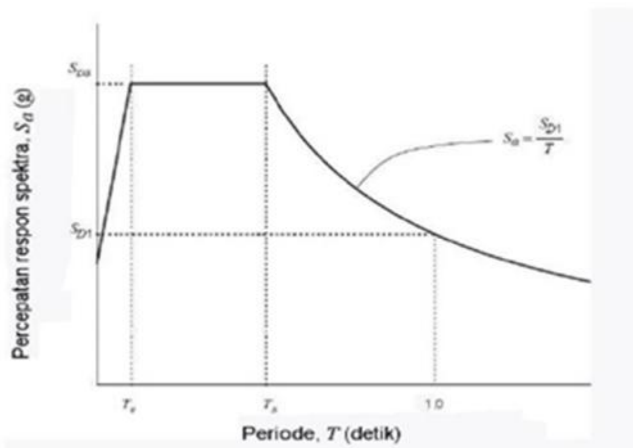
S_{DS} = Parameter respons spektral percepatan desain pada perioda pendek

S_{D1} = Parameter respons spectral percepatan desain pada perioda 1 detik

T = Perioda getar fundamental struktur

T_0 = $0{,}2\,\frac{S_{D1}}{S_{Ds}}$

T_s = $\frac{S_{D1}}{S_{Ds}}$



Gambar 2.3 spektrum respon desain

2.9 Gaya Dasar Seismik

Berdasarkan SNI 1726-2012, Geser dasar seismik (V) dalam arah yang ditetapkan harus ditentukan sesuai dengan persamaan berikut ini :

$$V = C_s W_t$$

Dimana :

C_s = koefisien respons seismik

W_t = berat total gedung

2.10 Perencanaan Balok Dengan Tulangan Tekan dan Tarik (Rangkap)

2.10.1 Balok T Tulangan Rangkap

Perencanaan balok T tulangan rangkap adalah proses menentukan dimensi tebal dan lebar flens. Lebar dan tinggi efektif balok, dan luas tulangan baja tarik. Balok T juga didefinisikan sebagai balok yang menyatu dengan plat, dimana plat tersebut mengalami tekanan.

Dengan nilai $M_{D\ b}$, $M_{L\ b}$, $M_{E\ b}$, (Statika / hasil STAAD Pro 2004), dimana kombinasi untuk Mu balok :

$= 1{,}4M_{D\,b}$

$= 1{,}2M_{D\,b} + 1{,}6M_{L\,b}$

$= 1{,}2M_{D\,b} + 1{,}0M_{L\,b} \pm 1{,}0M_{E\,b}$

$= 0{,}9M_{D\,b} \pm 1{,}0M_{E\,b}$

Dari keempat kombinasi di atas maka diambil nilai Mu yang paling besar. Balok persegi memiliki tulangan rangkap apabila momen yang harus ditahan cukup besar dan As perlu > As Maks.

Untuk tulangan maksimum ada persyaratan bahwa balok atau komponen struktur lain yang menerima beban lentur murni harus bertulang lemah (under reinforced) SNI 2847-2013 memberikan batasan tulangan tarik maksimum sebesar 75% dari yang diperlukan pada keadaan regang seimbang. *As maks = 0,75* ρ_b.

As maks = $0{,}75\left(\frac{0{,}85.fc.\beta 1}{fy} x \frac{600}{600+fy}\right)$

Untuk tulangan minimum agar menghindari terjadinya kahancuran getas pada balok, maka SNI 2847-2013 pada halaman 76 juga mengatur jumlah minimum tulangan yang harus terpasang pada balok, yaitu :

As min = $\frac{0,25\sqrt{fc'}}{4.fy}.bw.d$ dan tidak lebih kecil dari As min = $\frac{1,4}{fy}.bw.d$

Langkah-langkah perencanaan balok T tulangan rangkap

- Dapatkan nilai $M_{D\ b}$, $M_{L\ b}$, $M_{E\ b}$, (Statika / hasil STAAD Pro 2004), dimana kombinasi untuk Mu balok :

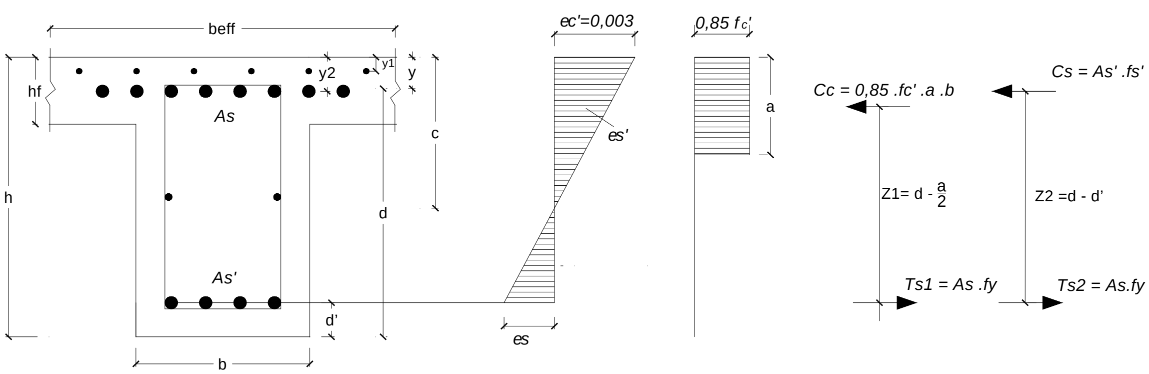
  = $1,4M_{D\ b}$

  = $1,2M_{D\ b} + 1,6M_{L\ b}$

  = $1,2M_{D\ b} + 1,0M_{L\ b} \pm 1,0M_{E\ b}$

  = $0,9M_{D\ b} \pm 1,0M_{E\ b}$

  1. Tentukan tulangan tarik dan tekan
  2. Hitung nilai d' = tebal selimut beton + diameter sengkang + ½ x diameter tulangan tarik. Setelah itu hitung d = h – d'.



Gambar 2.4 Gambar diagram tegangan balok T

Menurut SNI 2847-2013 pasal 8.12.2, lebar plat efektif yang diperhitungkan bekerja sama dengan rangka menahan momen lentur ditentukan sebagai berikut :

a. Jika balok mempunyai plat dua sisi.

Lebar efektif diambil nilai terkecil dari :

beff < ¼ dari bentang balok (panjang balok)

< bw + $8hf_{kiri}$ + $8hf_{kanan}$

< bw + ½ jarak bersih ke badan di sebalahnya.

b. Jika balok hanya mempunyai plat satu sisi.

Lebar efektif diambil nilai terkecil dari :

- b_{eff} < 1/12 dari bentang balok (panjang balok) L
- b_{eff} < bw + (6 x hf_{kir}) + (6 x hf_{kanan})
- beff < bw + ½ jarak bersih ke badan di sebalahnya.

3. Mencari letak garis netral

Analisa balok bertulang rangkap dimana tulangan tekan sudah leleh. Misalkan tulangan tarik dan tulangan leleh.

Cc = 0,85 . f'c . ab

Cs = As' . fs' = As' . fy

Ts = As . fy

∑H = 0 → Cc + Cs = Ts

0,85 . f'c . a . b + As' . fy = As . fy

0,85 . f'c . a . b = As . fy – As' . fy = fy (As – As')

Sehingga nilai a = $\frac{fy\ (As-As')}{0{,}85\ .f'c.a.b}\ .bw.d$

Dengan nilai tersebut kita kontrol tegangan yang terjadi apakah tulangan tekan leleh apa belum. Jika leleh, perhitungan dapat dilanjutkan dan jika belum leleh nilai a kita hitung kembali dengan persamaan lain.

Tinggi garis netral c = $\frac{a}{\beta 1} = \frac{fy\ (As-As')}{\beta 1\ .0{,}85\ .f'c.b}$

Dari diagram regangan $\frac{\varepsilon' s}{\varepsilon' c} = \frac{(c-d')}{c} \rightarrow \varepsilon' s = \frac{(c-d')}{c}\ \varepsilon' c$

Jika εs’ < εy = fy/εs → berarti tulangan tekan belum leleh maka perhitungan diulang.

Jika εs’ > εy = fy/εs → berarti tulangan tekan belum leleh maka perhitungan dilanjutkan.

Mn = Cc . z1 + Cs . z2 dimana : $z_1 = d - \frac{a}{2}$ dan $z_2 = z - z'$

Analisis balok bertulang rangkap dimana tulangan tekan belum leleh.

Ini terjadi jika nilai εs’ > εy = fy/εs

Untuk itu dicari nilai a dengan persamaan-persamaan sebagai berikut :

∑H = 0, maka Cc + Cs = Ts

0,85 . f’c . a . b + As’ . fy = As . fy

fs’ = εs’ . εs, dimana : $\varepsilon' s = \frac{(c-d')}{c}\ \varepsilon' c$

$$fs' = \frac{(c-d')}{c}\ \varepsilon' c \,.\, \varepsilon s = \frac{(c-d')}{c} . 0{,}003 \,.\, 200000$$

$$fs' = \frac{(c-d')}{c} . 600$$

Maka 0,85 . f’c . a . b + As’ . 600 = As . fy

(0,85 . f’c . a . b) . x + As’ . (c – d’) . 600 = As . fy . c

Dengan substitusi nilai a = β1 . c

(0,85 . f’c . β1 . c . b) . c + As’ . (c – d’) . 600 = As . fy . c

(0,85 . f’c . β1 . b) . c^2 + As’ . (c – d’) . 600 = As . fy . c

(0,85 . f’c . β1 . b) c^2 + 600.As’.c – As . fy . c – 600 . As’.d = 0

(0,85 . f’c . β1 . b) c^2 + (600.As’ – As . fy) . c – 600 . As’.d = 0

Dengan rumus ABC nilai x dapat dihitung :

$$c_{1.2} \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Selanjutnya dapat dihitung dengan nilai-nilai :

$$fs' = \frac{(c - d')}{c} . 600$$

Cc = 0,85 . f'c . a . b   dimana a = β1 . x

Cs = As' . fs'

$z_1 = d - \frac{a}{2}$ dan $z_2 = d - d'$

Mn = Cc . z_1 + Cs . z_2

2.10.2 Perencanaan Balok Terhadap Geser

Komponen struktur yang mengalami lentur akan mengalami juga kehancuran geser, selain kehancuran tarik/tekan. Sehingga dalam perencanaan struktur yang mengalami lentur selain direncanakan tulangan lentur, juga harus direncanakan tulangan geser.

Kuat geser pada struktur yang mengalami lentur SNI 2847-2013 adalah :

$\phi Vu \geq Vn$

Vn = Vc + Vs

Dimana :

Vu = gaya geser terfaktor pada penampang yang ditinjau.

Vc = kuat geser nominal yang disediakan oleh beton pada penampang yang ditinjau.

Vs = kuat geser nominal yang disediakan oleh tulangan geser pada penampang yang ditinjau.

Vn = kuat geser nominal pada penampang yang ditinjau.

Gaya geser terfaktor (Vu) ditinjau pada penampang sejarak (d) dari muka tumpuan dan untuk penampang yang jaraknya kurang dari d dapat direncanakan sama dengan pada penampang yang sejarak d.

Kuat geser yang disumbangkan oleh beton sesuai dengan SNI SNI 2847-2013 pasal 11.2.1.1 adalah :

$Vc = 0{,}17\ \lambda\sqrt{f'c}\ .\ bw\ .\ d$

Dimana :

bw = lebar badan balok

d = jarak dari serat terluar ke titik berat tulangan tarik longitudinal

Ada 2 keadaan :

Bila Vu > ½ ϕVc, maka harus dipasang tulangan geser minimum dengan luas tulangan :

$$Av = \frac{0{,}35\ b_w . s}{fy}$$

Dan bila Vu > ϕVc, maka harus dipasang tulangan geser, sedangkan besar gaya geser yang disumbangkan oleh tulangan adalah :

$$Vs = \frac{Av . fy . d}{s}$$

Dimana :

Av = luas tulangan geser dalam daerah sejarak s.

Av = 2 . ¼ π d^2

s = spasi tulangan geser dalam arah paralel dengan tulangan longitudinal.

Sedangkan untuk spasi sengkang adalah :

s ≤ ½ d

s ≤ 600 mm

Sedangkan bila Vs > $0{,}33\sqrt{f'_c}$ bw . d, maka spasi tulangan adalah :

s ≤ ¼ d

s ≤ 300 mm

Dalam hal ini Vs tidak boleh lebih besar dari 0,66$\sqrt{f'c}$ bw . d

2.10.3 Pemutusan Tulangan Balok

Dalam desain ini akan dicari jarak penghentian tulangan lentur dari muka kolom sejarak ld. Agar diperoleh panjang penghentian terbesar. Panjang penyaluran ld dalam kondisi tarik pada SNI 2847-2013 pasal 14.2.(2) dihitung dengan rumus tersebut di pasal 14.2.(3).

$$\left(\frac{fy.\psi_t.\psi_e}{1,1\lambda\sqrt{f'c}}\right)db$$

Dimana :

ψ_t, ψ_e, λ dimabil dari tabel SNI 2847-2013 halaman 113.

Penyaluran batang ulir yang berbeda dalam kondisi tekan.

1) Panjang penyaluran untuk batang tulangan ulir dan kawat ulir dalam kondisi tekan, *ld* harus ditentukan dari 12.3.2 dan faktor modifikasi yang sesuai dari 12.3.3, tetapi *ld* tidak boleh kurang dari 200 mm.
2) Untuk tulangan batang tulangan ulir dan kawat, *ld* harus diambil sebesar yang terbesar dari $\left(0,24f_y/\lambda\sqrt{f'c}\right)d_b$ dan (0,043f_y) d_b, dengan λ seperti diberikan dalam 12.2.4(d) dan konstanta 0,043 mempunyai satuan mm^2/N.
3) Panjang *ld* dalam 12.3.2 diizinkan untuk dikalikan dengan faktor yang sesuai untuk :
   a) Tulangan yang melebihi dari yang diperlukan oleh analisis............**(As perlu)/(As terpasang)**

b) Tulangan dilingkupi tulangan spiral tidak kurang dari berdiameter 6 mm dan tidak lebih dari spasi 100 mm atau dalam pengikat berdiameter 13 yang memenuhi 7.10.5 dan berspasi pusat ke pusat tidak lebih dari 100 mm..........................**0,75**

2.11 Perencanaan Struktur Dengan Sistem Rangka Pemikul Momen (SRPM)

2.11.1 Perencanaan Struktur Dengan Sistem Rangka pemikul Momen Biasa (SRPMB)

Persyratan Rangka Momen Biasa Menurut SNI 2847-2013

- Balok yang mempunyai paling sedikit dua batang tulangan longitudinal yang menerus sepanjang kedua muka atas dan bawah.tulangan ini harus di salurkan pada muka tumpuan
- Kolom yang mempunyai tinggi bersih kurang dari satu aau sama dengan lima kali dimensi c_1 harus di desain untuk geser sesuai pasal 21.3.3.2

2.11.2 Perencanaan Struktur Dengan Sistem Rangka pemikul Momen Menengah (SRPMM)

Persyaratan Rangka Pemikul Momen Menengah sesuai SNI 2847-2013 pasal 21.3

Detail tulangan pada komponrn struktur rangka harus memenuhi 21.3.4 bila gaya tekan aksial terfaktor, P_u, Untuk komponen struktur yang tidak melebihi $A_g f'_c$ / 10. Bila P_u lebih besar, detail tulangan rangka harus memenuhi 21.3.5. bila system slab dua arah tanpa balok membentuk sebagian dari system penahan gaya gempa, detail tulangan pada sembarang bentang yang menahan momen yang di akibatkan oleh E harus memenuhi 21.3.6

1. Kuat Geser

- ϕV_n balok yang menahan pengaruh gempa, ***E,*** tidak boleh kurang dari yang lebih kecil dari (a) dan (b) :
  a) Jumlah geser yang erkait dengan pengembangan M_n balok pada setiap ujung bentang bersih yang terkekang akibat lentur kurvatur balik dan geser yang di hitung oleh beban gravitasi terfaktor (gambar 2.6)
  b) Geser maksimum yang di peroleh dari kombinasi beban desain yang melibatkan ***E***, dengan ***E*** diasumsikan sebesar dua kali yang di tetapkan oleh tata cara bangunan umum yang di adopsi secara legal untuk desain tahan gempa.
- ϕV_n kolom yang menahan pengaruh gempa, ***E,*** tidak boleh kurang dari yang lebih kecil dari (a) dan (b) :
  a) Geser yang terkait dengan pengembangan kekuatan momen nominal kolom pada setiap ujung terkekang dari panjang yang tak tertumpu akibat lentur kurvatur balik.
     Kekuatan lentur kolom harus di hitung untuk gaya aksial terfaktor, konsisten dengan arah gaya lateral yang di tinjau,yang menghasilkan kekuatan lentur tertinggi. (gambar 2.6)
  b) Geser maksimum yang di peroleh dari kombinasi beban yang melibatkan ***E,*** dengan ***E*** ditingkatkan oleh Ω_0.

2. Balok
   a) Kekuatan moemen positif pada muka joint tidak boleh kurang dari sepertiga (1/3) kekuatan momen negaif yang di sediakan muka joint.

Baik kekuatan momen negative atau positif pada sembarang penampang sepanjang balok tidak boleh kurang dari seperlima (1/5) kekuatan momen maksimum yang di sediakan pada muka salah satu joint.

b) Pada kedua ujung balok, sengkang harus di sediakan sepanjang- panjang tidak kurang dari $2h$ diukur dari muka komponen stuktur penumpu kearah tengah bentang. Sengkang pertama harus ditempatkan tidak boleh lebih dari 50mm di muka komponen sruktur penumpu, spasi sengkang idak boleh melebihi yang terkecil dari :

- d/4
- delapan kali diameter batang tulangan longitudinal terkecil yang dilingkupi.
- 24 kali diameter batang tulangan sengkang
- 300mm

3. Kolom

a) Kolom harus ditulangi secara spiral sesuai pasal 7.10.4 atau harus memenuhi 21.3.5.4,sub pasal 21.3.5.5 berlaku untuk semua kolom, dan 21.3.5.6 berlaku untuk semua kolom yang menumpu komponen struktur kaku tak menerus.

b) Pada kedua ujung kolom, sengkang harus di sediakan dengan spasi S_0 sepanjang panjang ℓ_0 di ukur dari muka joint.

Spasi S_0 tidak boleh melebihi yang terkecil dari :

- Delapan kali diameter batang tulangan longitudinal terkecil yang di lingkupi;
- 24 kali dimeter tulangan begel ;
- Setengah dimensi penampang kolom terkecil ;

- 300 mm

Panjang ℓ_0 tidak boleh melebihi dari

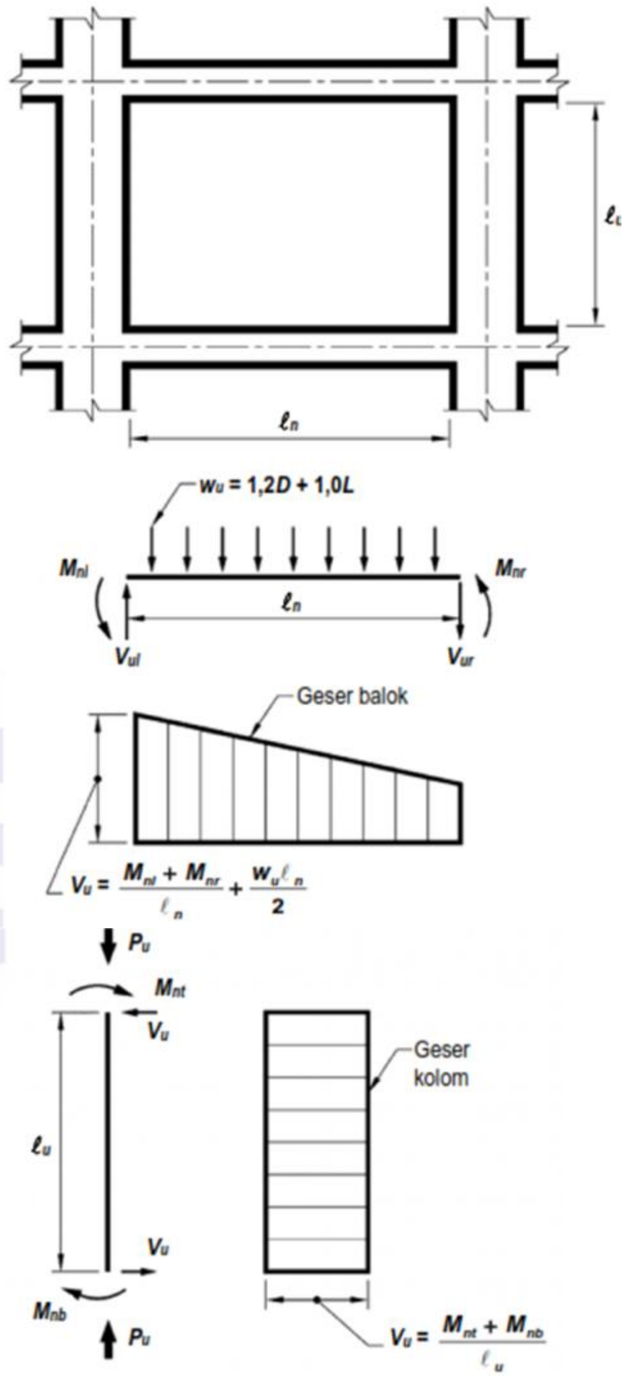
- Seperenam (1/6) batang bersih kolom
- Dimensi penampang maksimum kolom
- 450 mm

c) Sengkang tertutup pertama harus ditempatkan tidak lebih dari S_0 /2 dari muka joint.

d) Di luar panjang ℓ_0 ,spasi tulangan transversal harus memenuhi 7.10 dan 11.4.5.1

e) Tulangan transversal joint harus memenuhi 11.10.

f) Kolom yang menumpu reaksi dari komponen struktur kaku tak menerus, sepertí dinding, harus di sediakan dengan tulangan transversal dengan spasi, S_0, seperti di defenisikan dalam 21.3.5.2 sepanjang inggi penuh di bawah tingkat dimana diskontinuitas terjadi jika bagian gaya tekan aksial terfaktor pada komponen struktur ini terkait dengan pengaruh beban gempa yang melebihi $A_g f'_c$ / 10 . bila gaya desain harus di perbesar untuk memperhitungkan kekuatan lebih elemen vertikal sistem penahan gaya gempa, batas $A_g f'_c$ / 10 harus di tingkatkan menjadi $A_g f'_c$ / 4. Tulangan tranversal ini harus mmenerus diatas dan di bawah kolom seperti di syaratkan dalam 21.6.4.6 (b)



Gambar 2.5 Geser desain untuk stuktur rangka momen menengah

2.11.3 Perencanaan Komponen Lentur Pada Sistem Rangka Pemikul Momen Khusus (SRPMK)

Kuat lentur pada komponen lentur adalah Mu harus ditentukan dengan kombinasi sebagai berikut :

$Mu = 1,4\ M_D$

$Mu = 1,2\ M_D + 1,6\ M_L$

$Mu = 1,2\ M_D + 1,0\ M_L \pm 1,0\ M_E$

$M_{ub} = 0,9\ M_{Db} \pm M_{Eb}$

Dimana :

M_D = Momen lentur komponen portal akibat beban mati tak terfaktor

M_{Lb} = Momen lentur komponen portal akibat beban hidup tak terfaktor

M_{Eb} = Momen lentur komponen portal akibat beban gempa tak terfaktor

Selain penentuan kuat lentur, tiap komponen-komponen struktur yang menerima beban lentur dalam SRPMK sesuai dengan SNI 2847-2013 pasal 21.6.1.1 sampai dengan 21.6.1.2 harus memenuhi kondisi berikut :

1. Gaya tekan aksial terfaktor $Pu \leq Ag \cdot f'c / 10$
2. $bw/h \geq 0,4$
3. $bw \geq 300$ mm

dimana :

Ag = luas bruto penampang (mm^2)

d = tinggi efektif penampang (mm)

bw = lebar badan (mm)

h = tinggi total komponen struktur (mm)

Persyaratan penulangan untuk komponen lentur pada SRPMK menurut SNI 2847-2013 pasal 21.5.2.1 dan Pasal 21.5.2.2 adalah sebagai berikut :

a. Tulangan minimal baik atas maupun bawah harus sedikitnya :

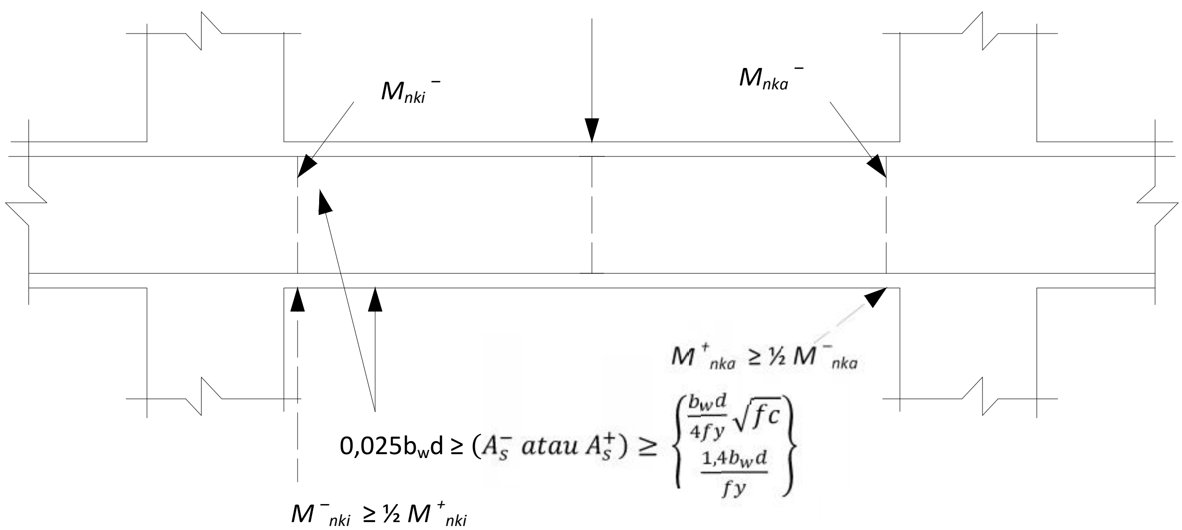
$$\frac{0{,}25\sqrt{f'c}}{f_y} b_w . d \text{ dan } \frac{1{,}4\, b_w\, .d}{f_y}$$

b. Rasio tulangan $\boldsymbol{\rho} \leq 0{,}025$

c. Kekuatan momen positif pada muka joint ≥ ½ kuat momen negatif yang disediakan pada muka joint tersebut.

d. Paling sedikit dua batang tulangan harus disediakan menerus pada kedua sisi atas dan bawah.

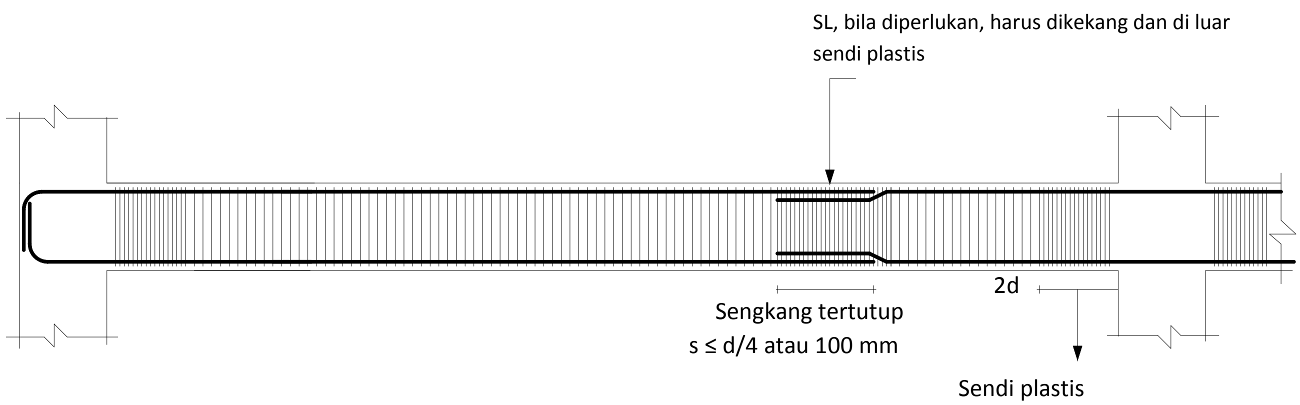
e. Baik kekuatan momen negatif atau positif pada sebarang penampang sepanjang panjang komponen struktur tidak boleh kurang dari ¼ kekuatan momen maksimum yang disediakan pada muka salah satu joint tersebut.



Gambar 2.7 Persyaratan Penulangan Komponen Lentur Pada SRPMK

Sementara untuk sambungan lewatan (SL) harus diletakkan di luar daerah sendi plastis. Bila dipakai SL, maka sambungan itu harus didesain sebagai SL tarik dan harus dikekang sebaik-baiknya. Menurut SNI 2847-2013 persyaratannya adalah :

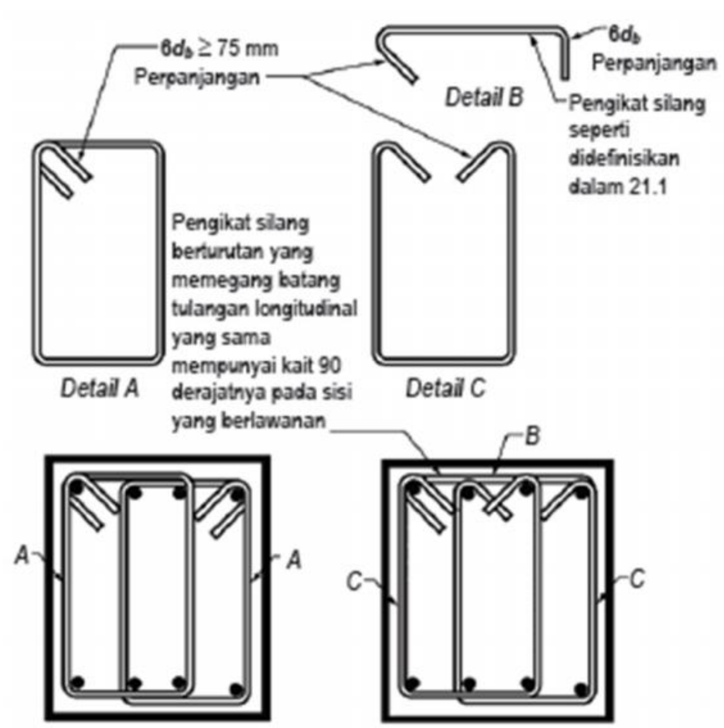
a. SL diizinkan hanya jika tulangan sengkang atau spiral disediakan sepanjang panjang sambungan.
b. Spasi tulangan transversal yang melingkupi batang tulangan yang disambung lewatkan tidak boleh melebihi d/4 dan 100 mm.
c. SL tidak boleh digunakan dalam Joint, dalam jarak 2d dari muka joint, di lokasi kemungkinan terjadi sendi plastis dan di daerah momen maksimum.



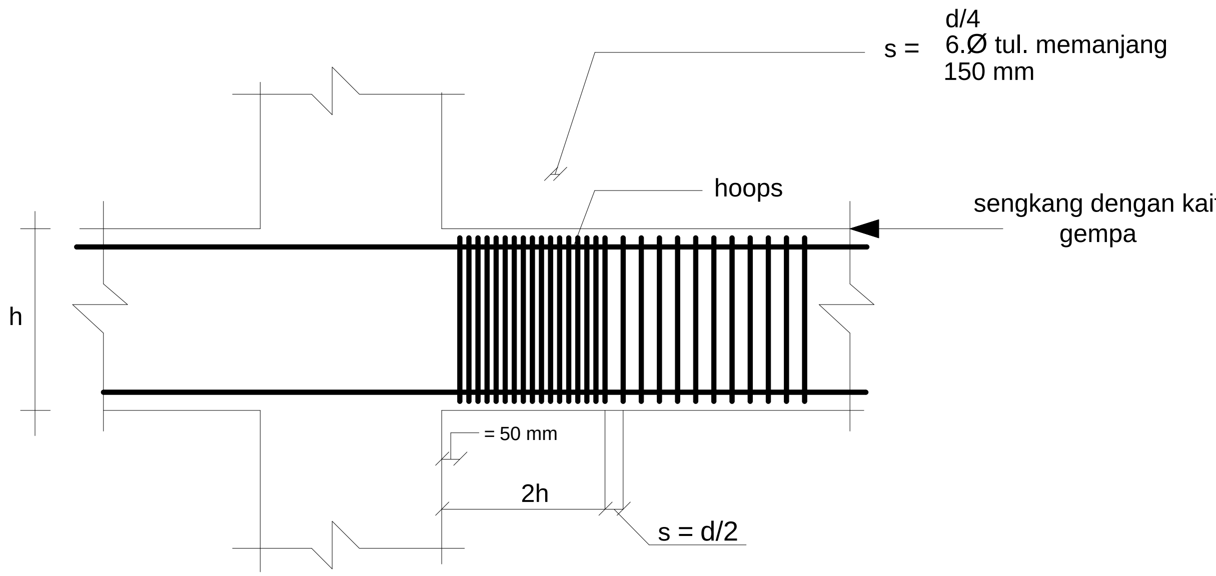
Gambar 2.8 Tipikal Sambungan Lewatan (SL)

Pengekangan yang cukup disyaratkan harus ada di ujung-ujung komponen kentur yang kemungkinan besar akan terjadi sendi plastis untuk menjamin kemampuan daktilitas struktur tersebut, bila terkena beban bolak-balik. Persyaratan tulangan pengekang disyaratkan di SNI 2847-2013 :

a. Hoops diperlukan sepanjang 2d dari muka kolom pada dua ujung komponen lentur, dengan meletakan hoops pertama sejarak 50 mm dari muka kolom.
b. Hoops juga diperlukan sepanjang 2 x d di dua sisi potongan yang momen leleh mungkin timbul berkenaan dengan lateral displacement inelastic dari rangka.
c. Hoops disyaratkan s harus tidak melebihi d/4, 6 x tulangan memanjang terkecil, dan 150 mm, spasi batang tulangan lentur tidak melebihi 350 mm.
d. Dimana hoops tidak disyaratkan, begel dengan hoops gempa di dua ujung harus dipasang dengan s ≤ d/2 sepanjang komponen.
e. Tulangan transversal harus pula dipasang untuk menahan gaya geser (Ve).



Gambar 2.8 Sambungan Lewatan dan Sengkang Tertutup pada SRPMK



Gambar 2.9 Penulangan Transversal Untuk Komponen Lentur pada SRPMK

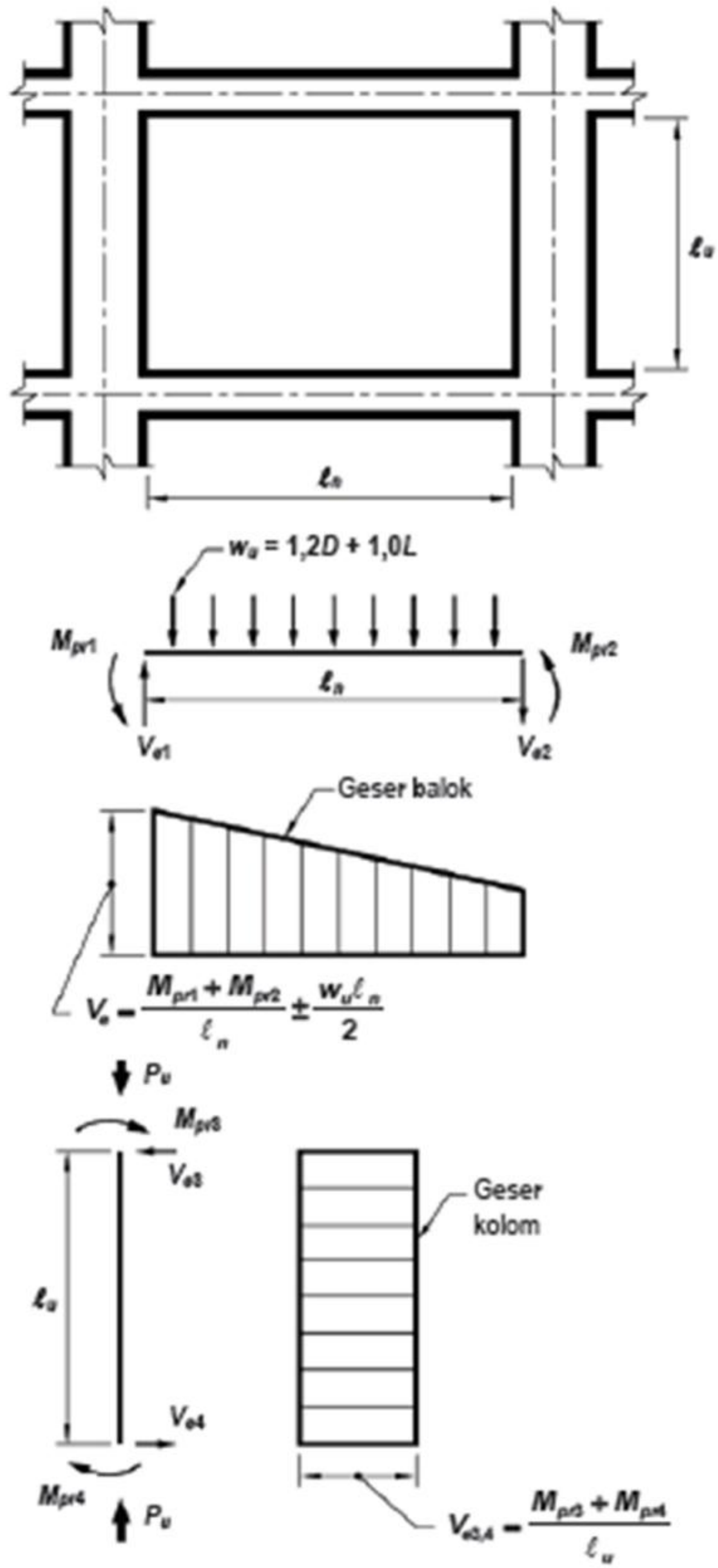
2.11.4 Persyaratan Kuat Geser Pada Sistem Rangka Pemikul Momen Khusus (SRPMK)

Tulangan geser pada Sistem Rangka Pemikul Momen Khusus (SRPMK) harus didesain sedemikian rupa sehingga tidak terjadi kegagalan getas oleh geser mendahului kegagalan oleh lentur. Kebutuhan tulangan geser harus dibandingkan dengan kebutuhan tulangan pengekangan untuk dipakai yang lebih banyak agar memenuhi kebutuhan keduanya.

Pada komponen struktur yang menerima beban lentur harus didesain dengan gaya geser dengan memakai momen maksimum yang mungkin terjadi (Mpr). Mpr merupakan momen kapasitas balok dengan tegangan tulang sebesar fs = 1,25 fy dan ϕ = 1, ditambah dengan beban gravitasi di balok.

Bila gaya geser akibat saja ≥ 0,5 maksimum kuat geser rencana, dan gaya aksial tekan terfaktor termasuk efek gempa kurang dari Ag f'c/20 maka kontribusi kuat geser beton Vc boleh diambil sama dengan nol.

Untuk komponen struktur yang kena beban aksial dan lentur pada SRPMK, gaya geser rencana Ve harus ditentukan dari gaya-gaya maksimum yang dapat terjadi di muka HBK di tiap ujung komponen kolom oleh Mpr maksimum terkait dengan beban-beban aksial terfaktor yang bekerja pada komponen struktur yang bersangkutan Ve yang didapat tak perlu lebih besar dari gaya melintang HBK yang diperoleh dari Mpr komponen transversal dan tak boleh lebih kecil dari hasil analisa struktur.



Gambar 2.10 Geser Desain Untuk Balok dan Kolom

2.11.5 Perencanaan Komponen Terkena Beban Lentur dan Aksial Pada Struktur Rangka Pemikul Momen Khusus (SRPMK)

Berdasarkan prinsip “Capacity Design” dimana kolom harus diberi cukup kekuatan, sehingga kolom-kolom tidak leleh lebih dahulu sebelum balok. Goyangan leteral memungkinkan terjadinya sendi plastis di ujung-ujung kolom akan menyebabkan kerusakan berat, karena itu harus dihindarkan. Oleh sebab itu kolom-kolom selalu didesain 20% lebih kuat dari balok-balok di suatu Hubungan Balok Kolom (HBK).

Komponen rangka yang termasuk dalam klasifikasi komponen struktur yang terkena beban lentur dan aksial dalam SRPMK harus memenuhi persyaratan sebagai berikut :

a. Beban aksial tekan terfaktor ≤ Ag . f’c/10.
b. Dimensi terkecil penampang ≥ 300 mm.
c. Ratio dimensi terkecil oenampang terhadap dimensi tegak lurusnya ≥ 0,4.

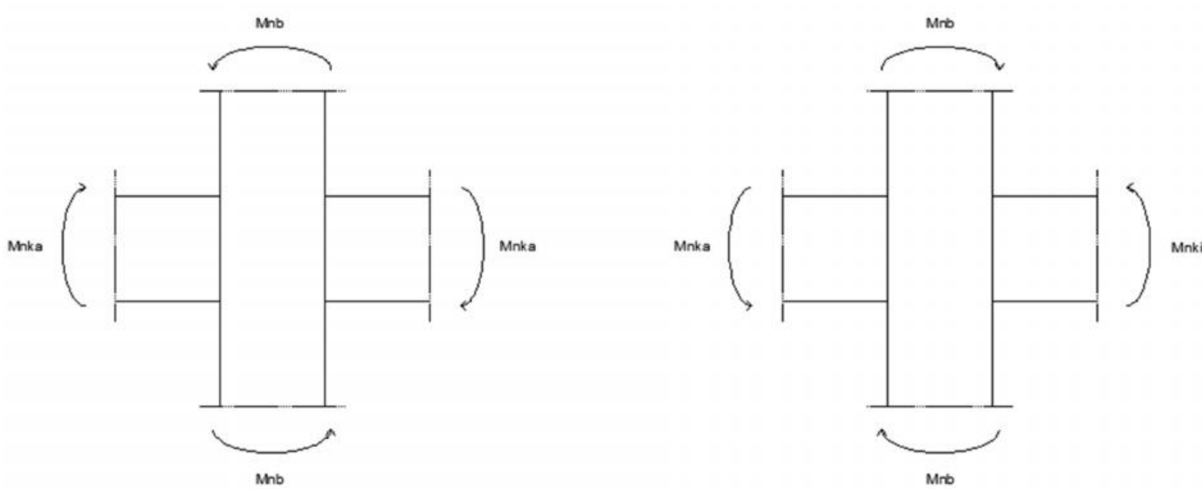
Kuat lentur komponen strukturnya dapat ditentukan dengan menggunakan rumus :

$$\sum M_{nc} \geq (1,2) \sum M_{nb}$$

Dimana :

∑Mnc = jumlah momen di muka HBK sesuai dengan desain kuat lentur.

∑Mnb = jumlah momen di muka HBK sesuai dengan desain kuat lentur nominal balok-balok.

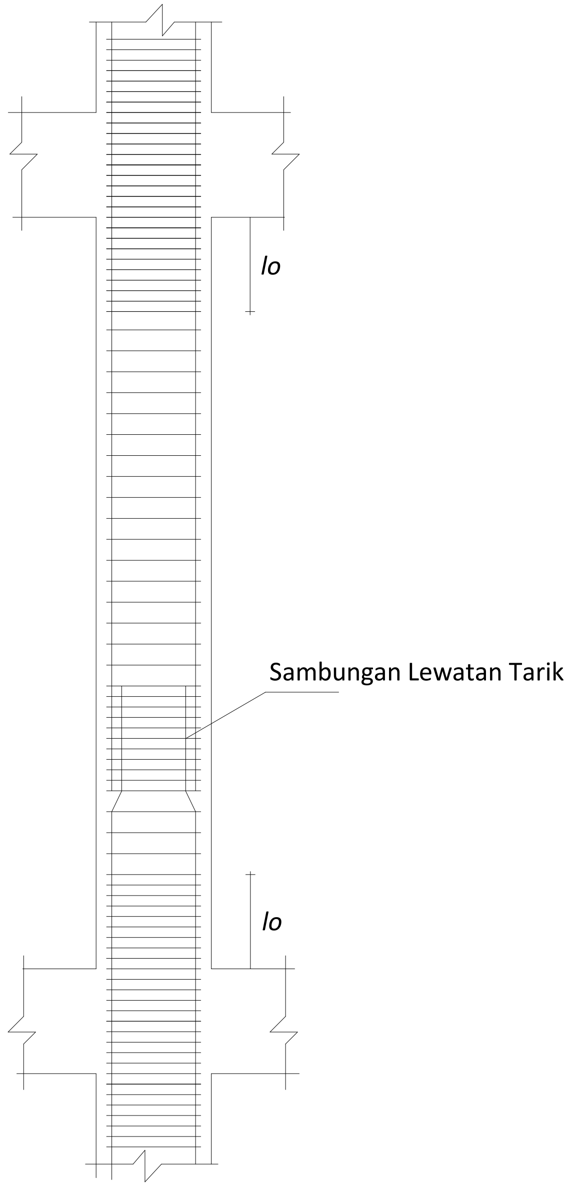


Keterangan : ka, ki, t dan b adalah kanan, kiri, top, dan bawah

Gambar 2.11 "Strong Column Weak Beam" Persyaratan Rangka pada SRPMK

d. Ratio tulangan (ρ_g) tidak boleh kurang dari 0,01 dan tidak boleh lebih dari 0,06

e. SL hanya diijinkan di sekitar tengah panjang komponen, harus sebagai sambungan tarik, yang harus dikenai tulangan transversal sepanjang penyalurannya.



Gambar 2.12 Tipikal Detail Sambungan Lewatan Kolom Pada SRPMK

Persyaratan Tulangan Transversal (TT) di SNI 2847-2013 adalah sebagai berikut :

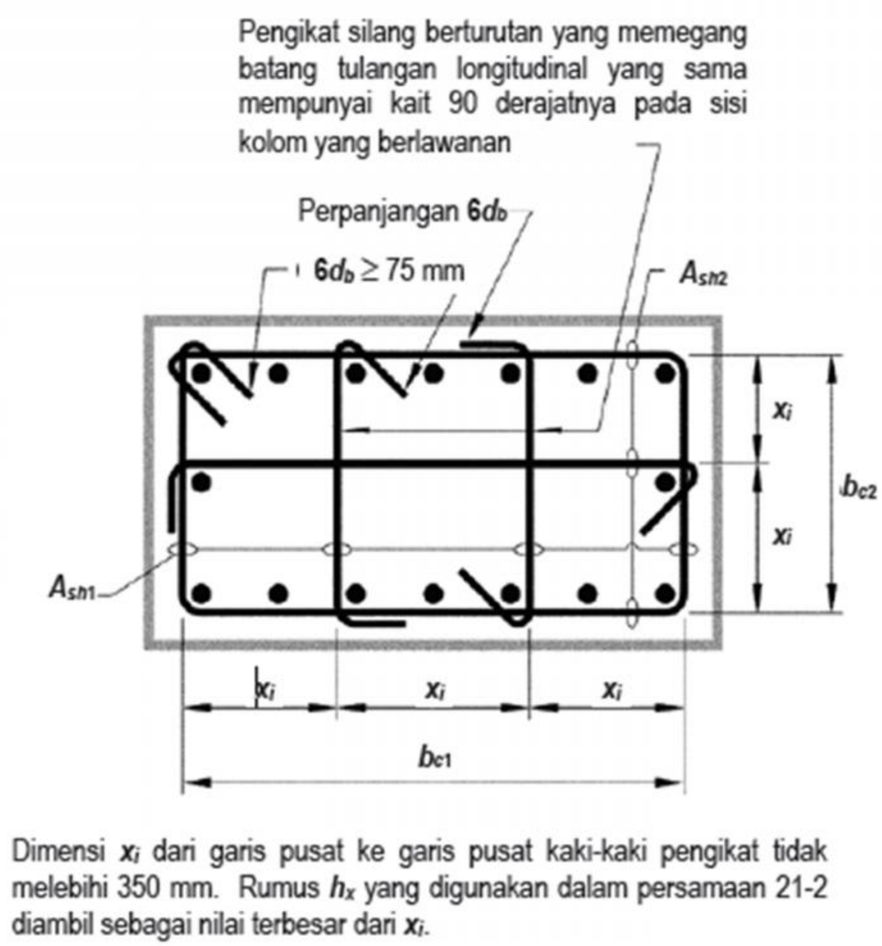
a. Ratio Volumerik tulangan spiral atau sengkang cincin tidak boleh kurang dari $\rho_s = 0{,}12\ f'c/f_{yh}$.

b. Total luas penampang tulangan hoops persegi panjang untuk pengekangan harus tidak boleh kurang dari nilai dua persamaan ini :

$$Ash = 0{,}3\ \frac{sb_c\,f'_c}{f_{yt}}\left[\left(\frac{A_g}{A_{ch}}\right) - 1\right]$$

$$Ash = 0{,}09\ \frac{sb_c\,f'_c}{f_{yt}}$$

c. Tulangan transversal harus berupa sengkang tunggal atau tumpuk.



Gambar 2.13 Tulangan Transversal pada Kolom

d. Perlu dipasang sepanjang lo dari muka HBK dikena ujung kolom dimana lentur leleh kemungkinan dapat terjadi lo harus tak boleh lebih kecil dari :

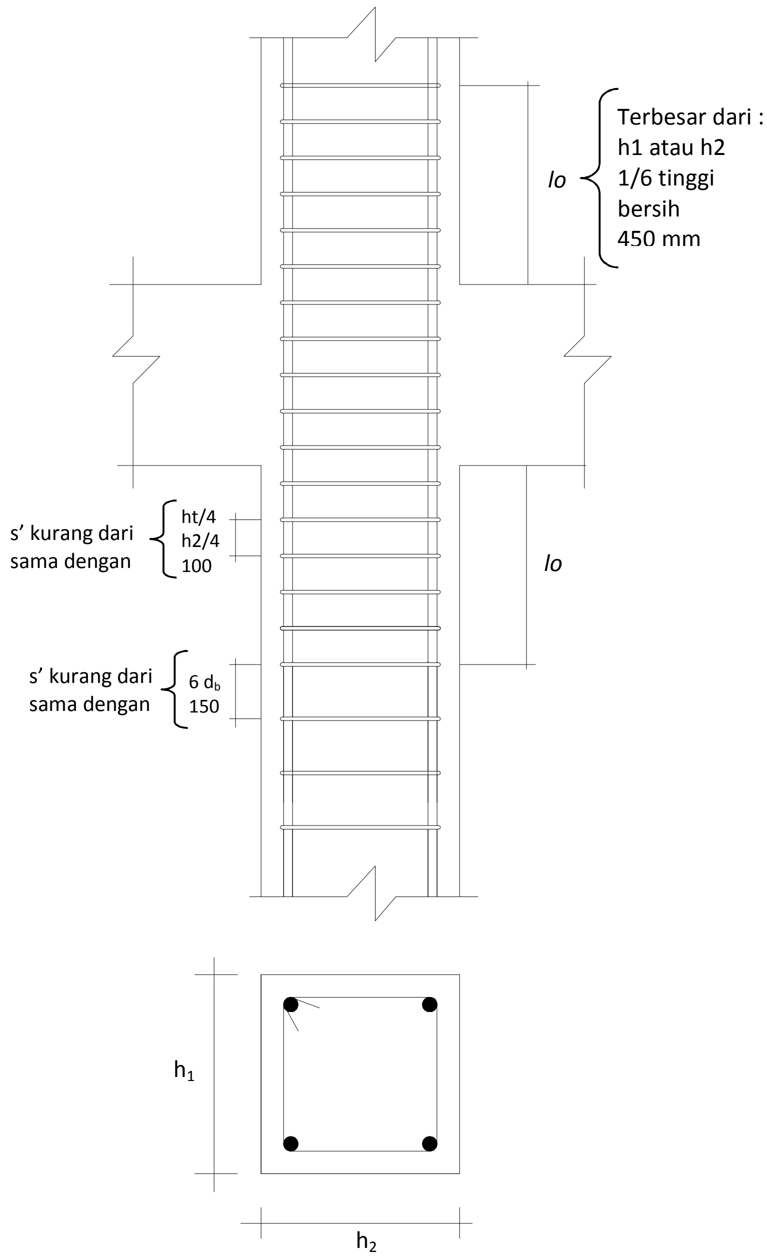
- Tinggi penampang komponen struktur pada HBK.

- 1/6 panjang bentah bersih.
- 450 mm

e. Spasi tulangan transversal sepanjang panjang *lo* tidak boleh melebihi ¼ dimensi komponen struktur minimum, 6 x Ø tulangan longitudinal, 100 mm ≤ so ≤ 150 mm.

f. Spasi pengikat sengkang atau kaki-kaki sengkang persegi, hx dalam penampang komponen struktur tidak boleh melebihi 350 mm pusat ke pusat.

g. Tulangan vertikal tidak boleh berjarak bersih lebih dari 150 mm dari tulangan yang didukung secara lateral. Bila TT untuk pengekangan tidak lagi disyaratkan maka sisa panjang kolom harus terpasang tulangan hoops dengan jarak s tak melebihi 6 x diameter tulangan memanjang atau 150 mm.



Gambar 2.14 Syarat Pengekangan Ujung-Ujung Kolom Penulangan Hoops (Sengkang Tertutup) Persegi

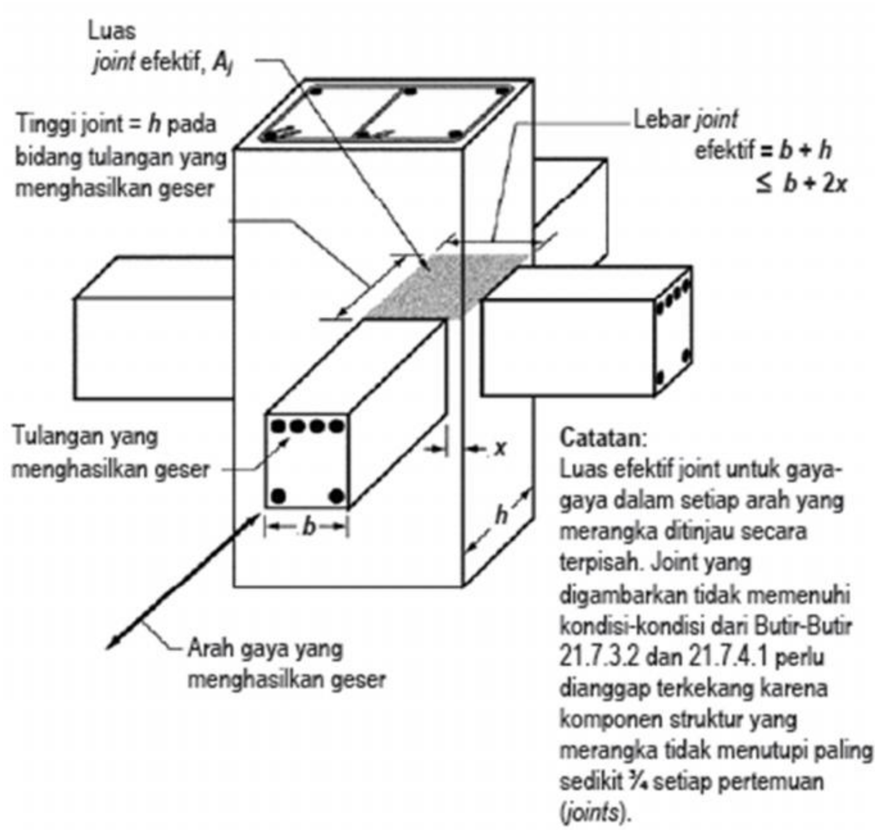
2.11.6 Hubungan Balok Kolom (HBK) Pada Sistem Rangka Pemikul Momen

Penulangan memanjang harus menerus menembus HBK dan dijangkar sebagai batang tarik atau tekan dengan panjang penyaluran yang benar dalam suatu inti kolom terkekang. Lekatan antara tulangan memanjang dan beton tidak boleh sampai lepas atau slip di dalam HBK yang berakibat menambah rotasi dalam HBK. Menurut SNI 2847-2013 Pasal 21.7 persyaratan ukuran minimum harus dipenuhi agar mengurangi kemungkinan kegagalan dan kehilangan lekatan pada waktu terjadi beban berbalik di atas tegangan leleh tulangan.

Bila tulangan memanjang balok menerus melewati HBK. Maka dimensi kolom yang sejajar tulangan balok harus tidak boleh lebih kecil dari 20 kali diameter terbesar tulangan memanjang.

Faktor paling penting dalam menentukan kuat geser nominal HBK adalah luas efektif (Aj) dari HBK. Untuk HBK yang dikekang oleh balok-balok di ke-empat mukanya, maka kapasitas atau kuat geser nominal HBK adalah sebesar 1,7 Aj $\sqrt{f'c}$. Untuk hubungan yang terkekang di tiga sisinya atau dua sisi yang berlawanan, maka kapasitasnya maka 1,25 Aj $\sqrt{f'c}$. Dan untuk kasus-kasus lainnya, kuat geser nominal = 1,0 Aj $\sqrt{f'c}$. Penting untuk dipahami bahwa kapasitas geser adalah hanya fungsi dari kekuatan beton dan luas Aj.

Dalam menghitung gaya geser di HBK gaya dalam tulangan memanjang balok di muka HBK, harus dianggap mempunyai tegangan tarik sebesar 1,25 fy.



Gambar 2.15 Luas Efektif dari HBK

BAB III

DATA PERENCANAAN

3.1. Data Bangunan

a) Spesifikasi dan parameter perencanaan

Data umum pembangunan Hotel Pattimura malang adalah sebagai berikut :

- Nama Gedung : Hotel Pattimura
- Lokasi Bangunan : Jl. Pattimura No.19
- Fungsi : Hunian
- Daerah gempa : Malang
- Panjang Bangunan : 38 m
- Lebar bangunan : 18,2 m
- Tinggi bangunan : 29,3 m
- Jumlah Lantai : 7
- Struktur Bangunan : Portal Rangka Beton

3.2. Mutu Bahan yang Digunakan

- Mutu Beton (*k*) `: K 300
- Mutu baja Ulir (f_y) : 400 Mpa = 4000 kg/cm²
- Mutu baja polos (f_y) : 240 Mpa = 2400 kg/m²

3.3 Peraturan perencanaan dasar

a. Tata Cara Perencanaan Ketahanan Gempa untuk Bangunan Gedung dan non gedung, SNI 03-1726-2012

b. Persyaratan beton structural untuk angunan gedung, SNI 03-2847-2013

c. Pedoman Perencanaan Pembebanan Rumah dan Gedung 1987

d. Grafik dan tabel perhitungan yang digunakan dalam perencanaan bangunan dengan struktur beton bertulang.

3.4 Metode Pengumpulan Data

3.4.1 Observasi (Pengamatan)

Observasi dilakukan untuk mengetahui situasi objek yang sedang dikaji yaitu dengan cara melakukan tinjauan langsung di lapangan

3.4.2 Pengambilan data yang sudah ada

Pengumpulan data-data primer yang sudah ada dari perusahaan yang berkaitan dengan bangunan gedung Hotel Pattimura Kota Malang, berupa Gambar-gambar pekerjaan proyek tahap pertama gedung Hotel Pattimura Kota malang diantaranya yaitu gambar Denah dan gambar potongan struktur sampai 7 Lantai.

3.4.3 Studi Literature

Kajian ini diambil dari publikasi hasil penilitian para pakar di dunia teknik sipil, peraturan-peraturan yang berlaku, dan buku-buku pelajaran terutama yang berhubungan dengan tema tugas akhir ini.

3.5 Analisa Data

Analisa data untuk beban gempa static ekivalen yaitu dengan meninjau beban-beban gempa static ekuivalen, sehubungan dengan sifat struktur gedung beraturan yang praktis berperilaku sebagai struktur 3 dimensi, sehingga renspons dinamiknya praktis hanya ditentukan oleh respon ragamnya yang pertama dan dapat ditampilkan sebagai akibat dari beban gempa static ekuivalen.

Dalam perencanaan, dilakukan beberapa tahap perhitungan yang dimulai dari:

3.5.1 Peninjauan gambar dan denah

Pada tahap ini, perencana melakukan peninjauan terhadap data-data yang sudah diperoleh untuk mengetahui bentuk portal, dimensi kolom, dimensi kolom, dan elemen-elemen struktur lainnya.

3.5.2 Input data perencanaan

Pada tahap ini, dari data yang sudah diperoleh dari peninjauan dimasukkan ke dalam program bantu teknik sipil yakni STAAD PRO mulai dari perencanaan dasar seperti bentuk portal yang meliputi jarak antar kolom, jarak antar balok, lebar gedung, tinggi gedung hingga dimensi kolom, dimensi balok dan jenis tumpuan. Setelah itu, dimasukkan lagi jenis beban pada batang maupun pada joint yang akan direncanakan seperti beban gravitasi yang terdiri dari beban mati (Dead Load) dan beban hidup (Live Load). Kemudian beban selanjutnya adalah beban angin (Wind Load) dan beban Gempa (Seismic Load). Untuk yang terakhir, beban-beban yang sudah dimasukkan tadi dikombinasikan (Combination Load) dengan ketentuan yang ada pada SNI 03-1726-2012 untuk mendapatkan serangkain beban (momen) terbesar yang nantinya akan mewakili untuk perhitungan analisa struktur dan pendimensian.

3.5.3 Analisa Pembebanan

Pembebanan yang diperhtungkan pada perencanaan Gedung Hotel Pattimura secara garis besar adalah sebagai berikut:

- Beban Mati (Dead Load)
- Beban Hidup (Live Load)
- Beban Gempa (Quake Load), untuk kota Malang berdasarkan SNI 1726-2012 memiliki percepatan percepatan batuan dasar, yaitu :

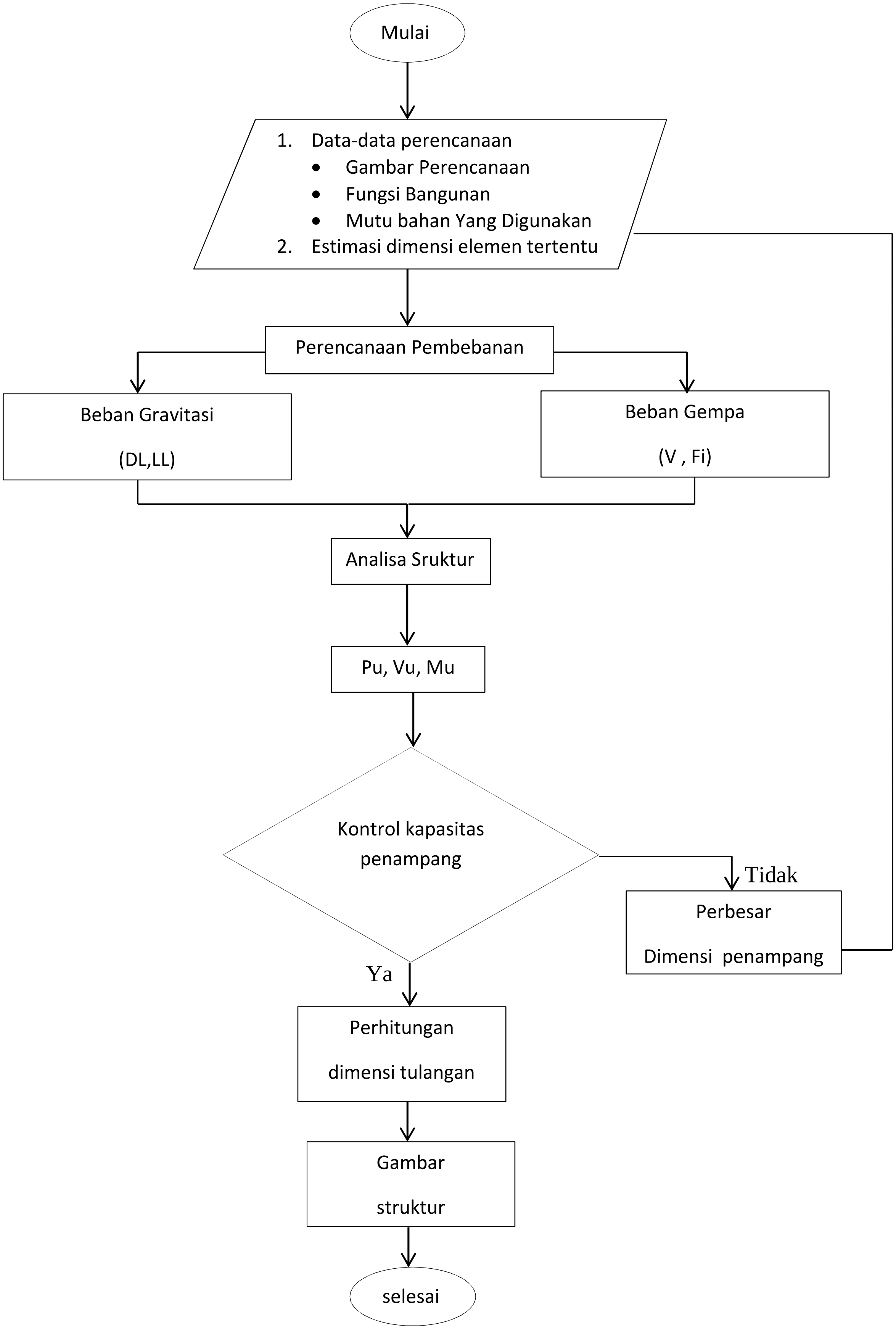
- S_s = 0,781
- S_1 = 0,330

Berdasarkan beban-beban tersebut maka struktur Gedung Hotel Pattimura malang harus mampu memikul semua kombinasi pembebanan berikut :

1. U = 1,4D
2. U = 1,2D + 1,6L + 0,5 (Lr atau R)
3. U = 1,2D + 1,6 (Lr atau R) + (1,0L atau W)
4. U = 1,2D + 1,0W + 1,0L + 0,5 (Lr atau R)
5. U = 1,2D + 1,0E + 1,0L
6. U = 0,9D + 1,0W
7. U = 0,9D + 1,0E

3.6 Diagram Alir Perencanaan

Alur metodelogi untuk perencanaan banginan hotel Pattimura sebagaimana di sebutkan secara urut di aas, jika di gambarkan dalam sebuah diagram metodelogi adalah sebagai berikut :


Mulai
1. Data-data perencanaan
• Gambar Perencanaan
• Fungsi Bangunan
• Mutu bahan Yang Digunakan
2. Estimasi dimensi elemen tertentu
Perencanaan Pembebanan
Beban Gravitasi
(DL,LL)
Beban Gempa
(V , Fi)
Analisa Sruktur
Pu, Vu, Mu
Kontrol kapasitas penampang
Tidak
Perbesar
Dimensi penampang
Ya
Perhitungan
dimensi tulangan
Gambar
struktur
selesai

3.7 Perencanaan Dimensi Balok dan Kolom

3.7.1 Dimensi Balok

Menurut SNI 2847-2013 pasal 21.5.1.3 bahwa lebar balok (b) tidak boleh kurang dari 250 mm dan perbandingan lebar (b) terhadap tinggi (h) tidak boleh kurang dari 0,3.

- Untuk panjang balok induk = 8,35 m = 835 cm

$$h = \frac{1}{12} L \approx \frac{1}{15} L = \frac{1}{12} 835 \approx \frac{1}{15} 835$$

$$= 69{,}583 \text{ cm s/d } 55{,}7 \text{ cm} \approx 60 \text{ cm}$$

$$b = \frac{1}{2} h \approx \frac{2}{3} h = \frac{1}{2} 60 \approx \frac{2}{3} 60$$

$$= 30 \text{ cm s/d } 40 \text{ cm} \approx 35 \text{ cm}$$

Dipakai balok induk berukuran 35/60

$$b/h = \frac{35}{60} = 0{,}6 > 0{,}3 \text{ (OK)}$$

- Untuk panjang balok induk = 7,75 m = 775 cm

$$h = \frac{1}{12} L \approx \frac{1}{15} L = \frac{1}{12} 775 \approx \frac{1}{15} 775$$

$$= 64{,}583 \text{ cm s/d } 51{,}7 \text{ cm} \approx 60 \text{ cm}$$

$$b = \frac{1}{2} h \approx \frac{2}{3} h = \frac{1}{2} 60 \approx \frac{2}{3} 60$$

$$= 30 \text{ cm s/d } 40 \text{ cm} \approx 30 \text{ cm}$$

Dipakai balok induk berukuran 30/60

$$b/h = \frac{30}{60} = 0{,}50 > 0{,}3 \text{ (OK)}$$

- Untuk panjang balok induk = 6,5 m = 650 cm

$$h = \frac{1}{12} L \approx \frac{1}{15} L = \frac{1}{12} 650 \quad \frac{1}{15} 650$$

$$= 54 \text{ cm s/d } 43{,}3333 \text{ cm} \approx 50 \text{ cm}$$

$$b = \frac{1}{2} h \approx \frac{2}{3} h = \frac{1}{2} 50 \approx \frac{2}{3} 50$$

$$= 25 \text{ cm s/d } 33{,}3333 \text{ cm} \approx 30 \text{ cm}$$

Dipakai balok induk berukuran 30/50

$$b/h = \frac{30}{50} = 0{,}60 > 0{,}3 \text{ (OK)}$$

Untuk panjang balok induk = 4 m = 400 cm

$$h = \frac{1}{12} L \approx \frac{1}{15} L = \frac{1}{12} 400 \approx \frac{1}{15} 400$$

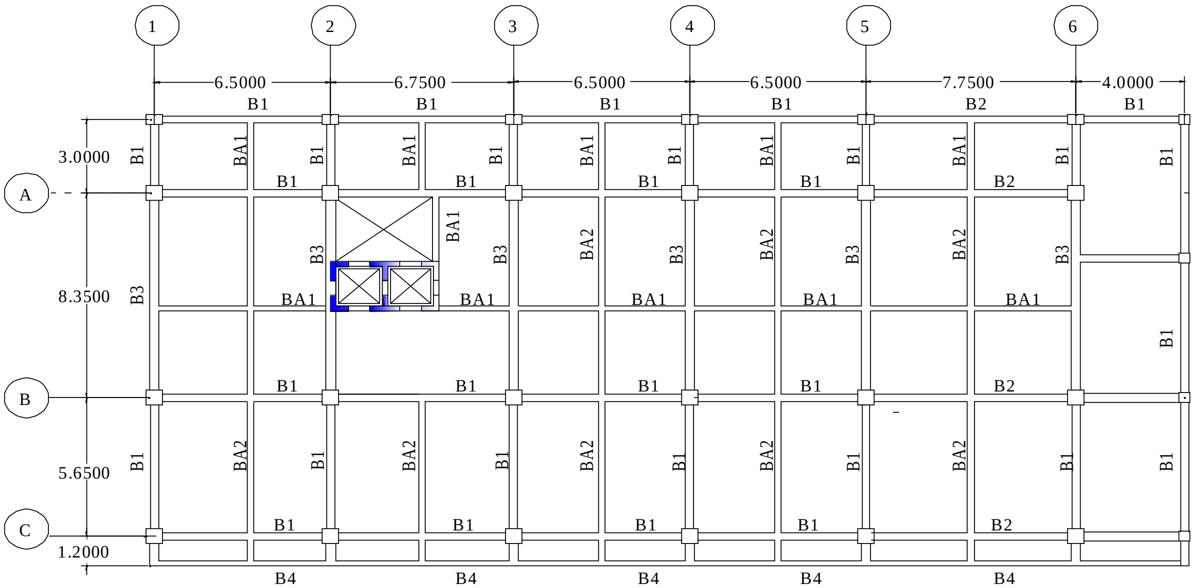
$$= 33 \text{ cm s/d } 26{,}6667 \text{ cm} \approx 30 \text{ cm}$$

$$b = \frac{1}{2} h \approx \frac{2}{3} h = \frac{1}{2} 30 \approx \frac{2}{3} 30$$

$$= 15 \text{ cm s/d } 20 \text{ cm} \approx 20 \text{ cm}$$

Dipakai balok induk berukuran 20/30

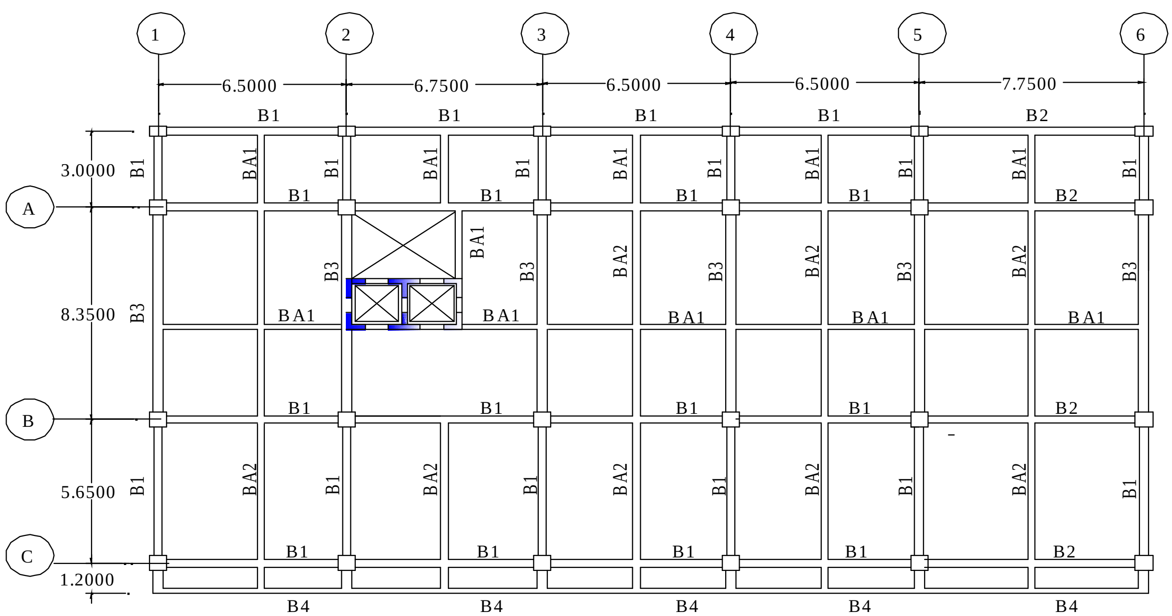
$$b/h = \frac{20}{30} = 0{,}67 > 0{,}3 \text{ (OK)}$$



KETERANGAN

B1 = 30/50
B2 = 30/60
B3 = 35/60
B4 = 20/30
BA1 = 20/30
BA2 = 25/30

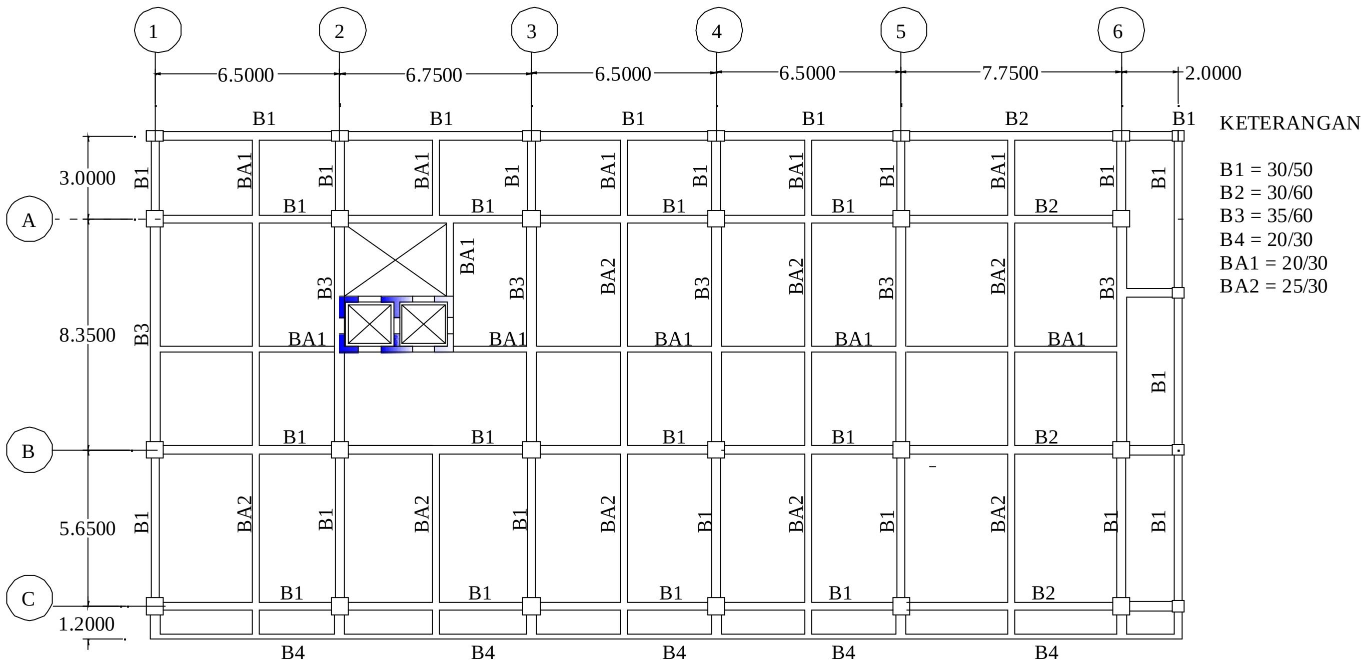
DENAH BALOK LANTAI 1
SKALA 1 : 100



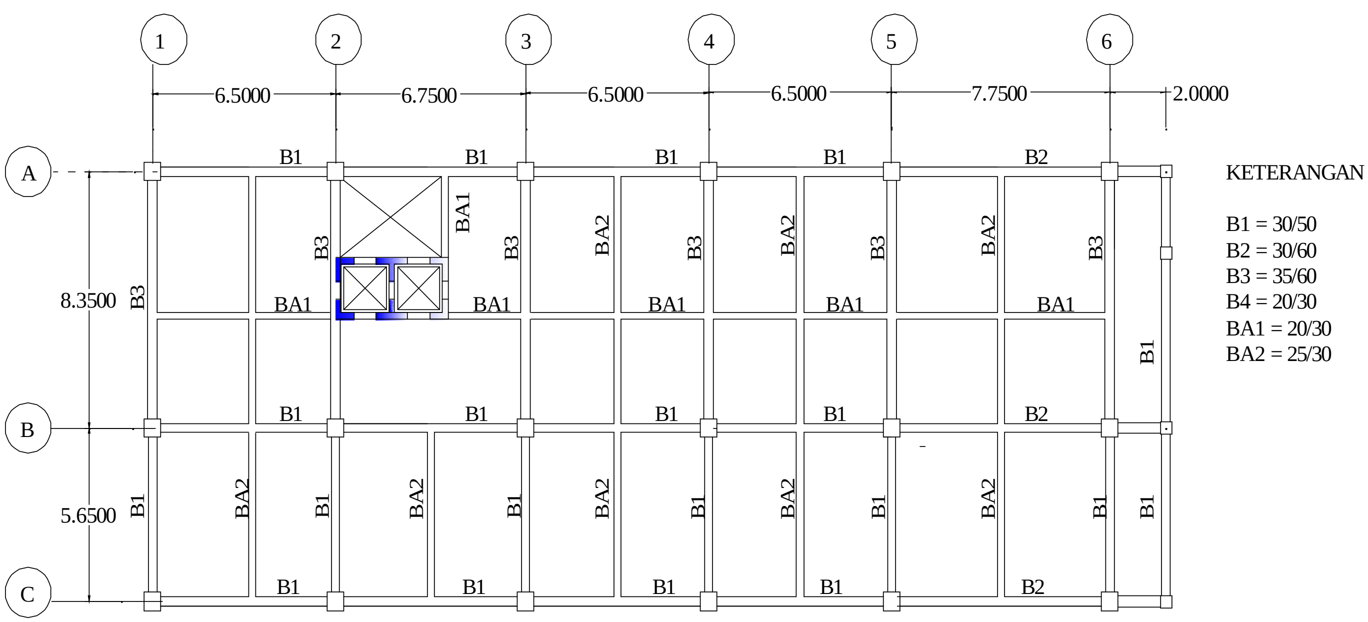
KETERANGAN

B1 = 30/50
B2 = 30/60
B3 = 35/60
B4 = 20/30
BA1 = 20/30
BA2 = 25/30

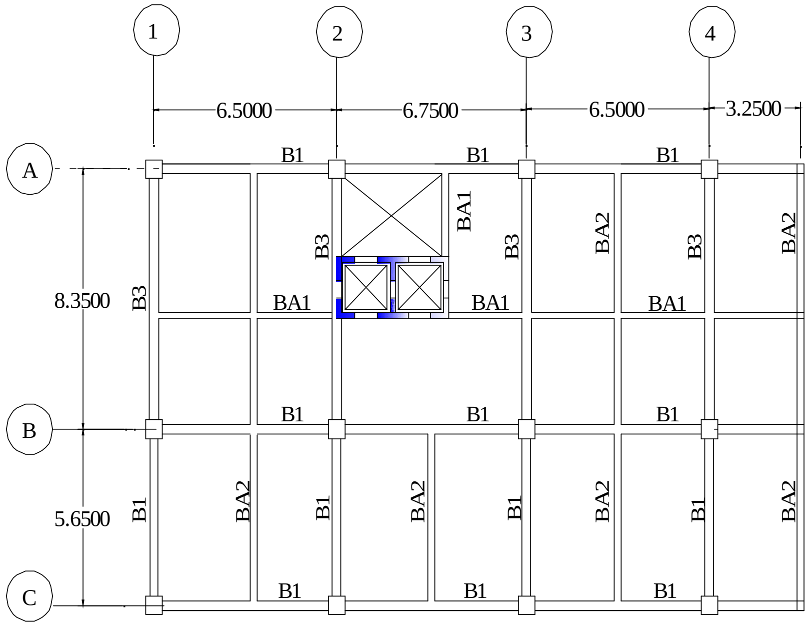
DENAH BALOK LANTAI 2



DENAH BALOK LANTAI 3
SKALA 1 : 100



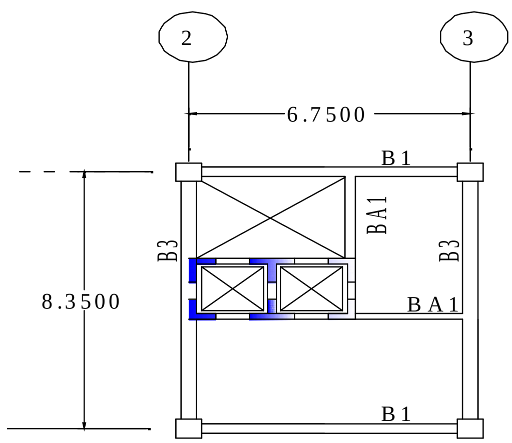
DENAH BALOK LANTAI 4,5,6
SKALA 1 : 100



KETERANGAN

B1 = 30/50
B2 = 30/60
B3 = 35/60
B4 = 20/30
BA1 = 20/30
BA2 = 25/30

DENAH BALOK LANTAI 7
SKALA 1 : 100



KETERANGAN

B1 = 30/50
B3 = 35/60
BA1 = 20/30

DENAH BALOK LANTAI ATAP
SKALA 1 : 100

3.7.2 Dimensi Kolom

Menurut SNI 2847-2013 pasal 21.6.1.1 dan 26.6.1.2 bahwa ukuran penampang

terkecil tidak boleh kurang dari 300 mm dan perbandingan antara ukuran terkecil penampang terhadap ukuran dalam arah tegak lurusnya tidak boleh kurang dari 0,4.

- Dipakai kolom berukuran 60 / 60

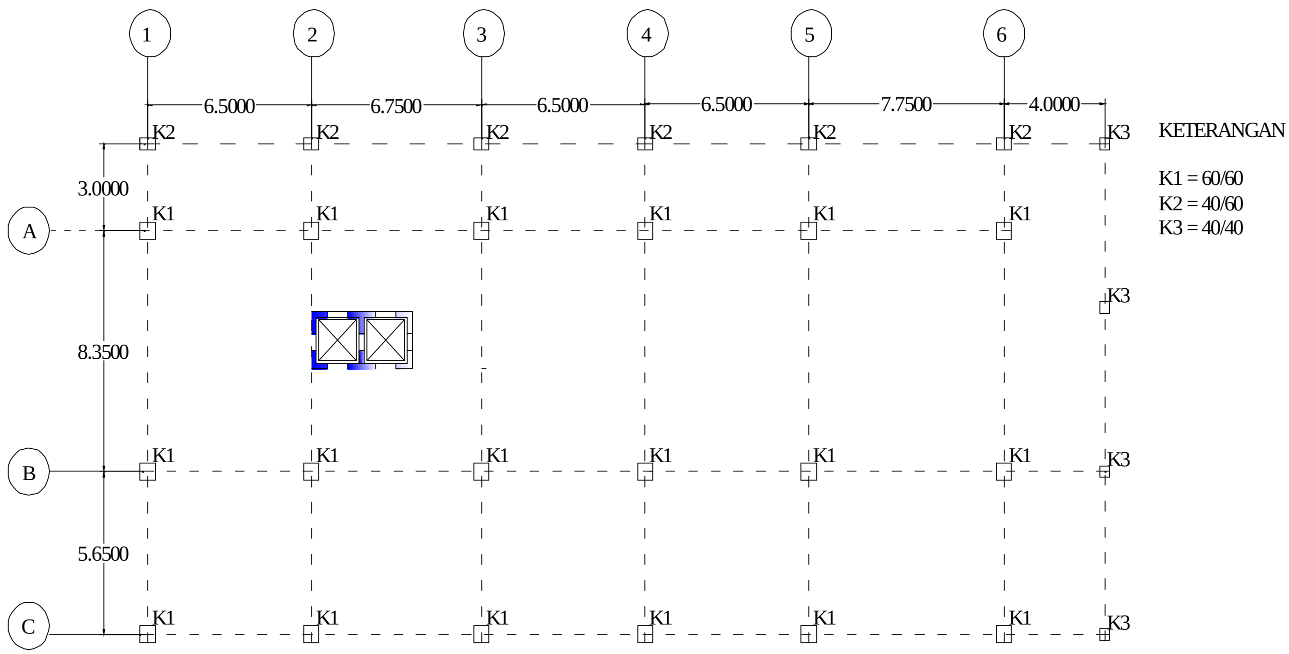
  60 / 60 = 1 > 0,4 (OK)

- Dipakai kolom berukuran 40 / 60

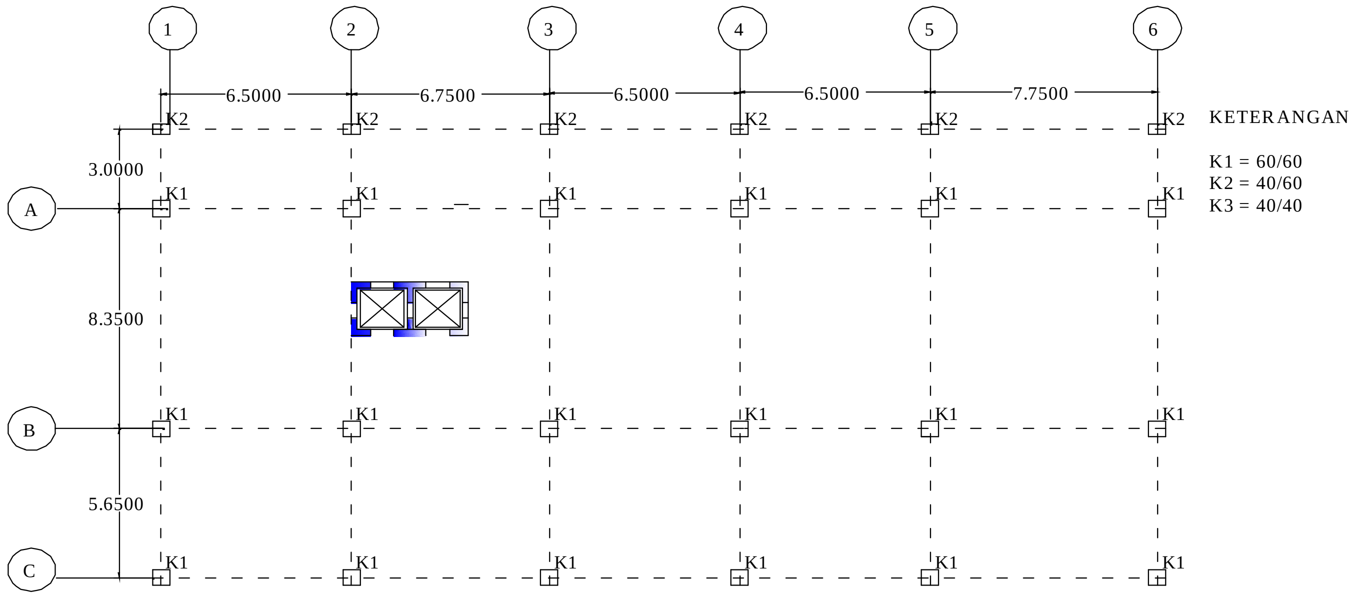
  40 / 60 = 0,66667 > 0,4 (OK)

- Dipakai kolom berukuran 40 / 40

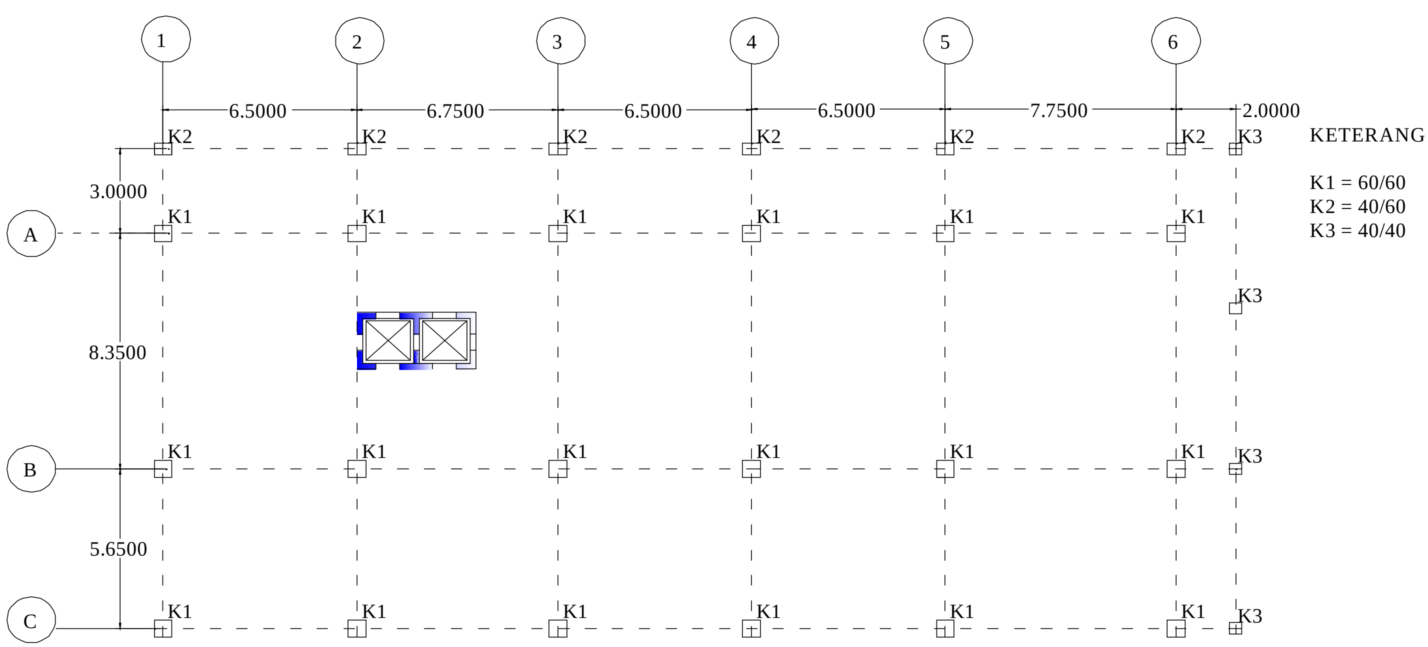
  40 / 40 = 1 > 0,4 (OK)



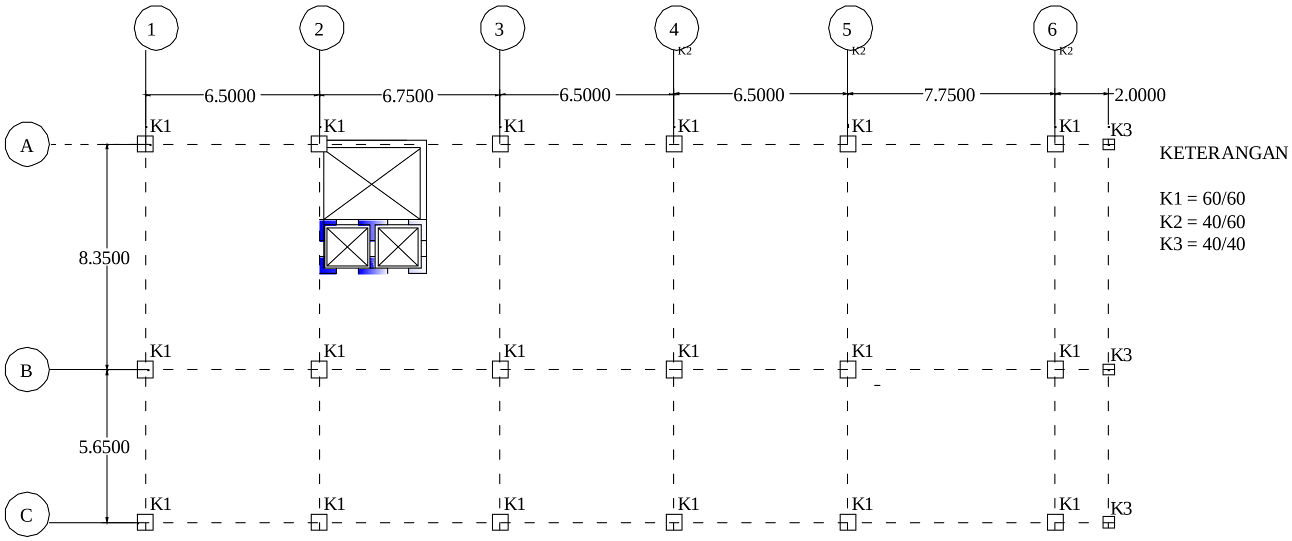
DENAH KOLOM LANTAI 1
SKALA 1 : 100



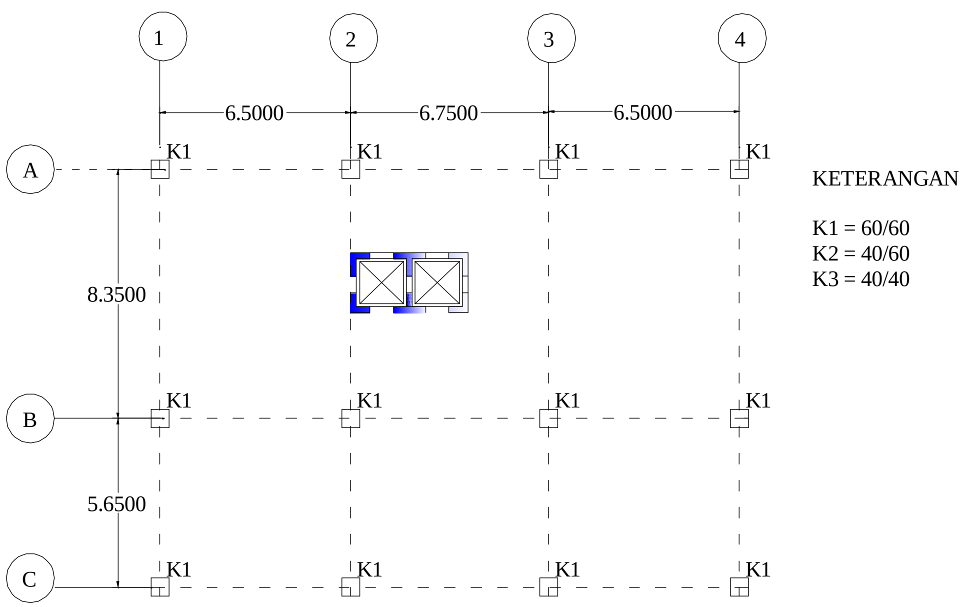
DENAH KOLOM LANTAI 2
SKALA 1 : 100



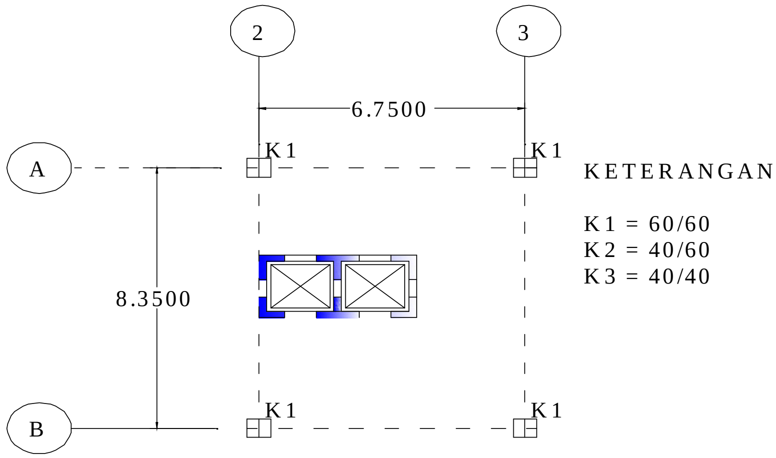
DENAH KOLOM LANTAI 3
SKALA 1 : 100



DENAH KOLOM LANTAI 4,5,6
SKALA 1 : 100



DENAH KOLOM LANTAI 7
SKALA 1 : 100



DENAH KOLOM LANTAI ATAP
SKALA 1 : 100

3.7.3 Dimensi Plat

Untuk plat lanai 1-7 digunakan tebal plat = 12cm, sedangkan untuk lantai atap digunakan tebal plat = 10cm.

3.8 Perhitungan Pembebanan

3.8.1 Beban Mati (Dead Load)

- **Beban Mati Bangunan**
  - Berat sendiri : untuk berat sendiri struktur menggunakan perintah selfweight pada program bantu STAAD Pro.
  - Beban tembok
    → Beban tembok lantai 1

      Tinggi tembok 5.5 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2

5.5 x 250 kg/m^2 1375 kg/m

→ Beban tembok lantai 2

Tinggi tembok 4,5 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2

4,5 x 250 kg/m^2 = 1125 kg/m

→ Beban tembok lantai 3-7

Tinggi tembok 3,4 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2

3,4 x 250 kg/m^2 = 850 kg/m

→ Beban tembok lantai atap

Tinggi tembok 2.5 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2

2.5 x 250 kg/m^2 = 625 kg/m

→ Beban tembok sebagian + kaca lantai 1

Tinggi tembok 5,5 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2 x 60%

5,5 x 250 kg/m^2 x 0,6 = 825 kg/m

→ Beban tembok sebagian + kaca lantai 2

Tinggi tembok 4,5 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2 x 60%

4,5 x 250 kg/m^2 x 0,6 = 675 kg/m

→ Beban tembok sebagian + kaca lantai 3-7

Tinggi tembok 3,4 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2 x 60%

3,4 x 250 kg/m^2 x 0,6 = 510 kg/m

→ Beban tembok sebagian + kaca lantai atap

Tinggi tembok 2,5 m dengan tebal setengah batu

Tinggi tembok x berat jenis per m^2

2,5 x 250 kg/m^2 x 0,6 = 375 kg/m

- Beban pasir urug tebal 5 cm

  Tebal urugan pasir x berat jenis

  0,05 m x 1600 kg/m^2 = 80 kg/m^2

- Beban keramik + adukan tebal 3 cm

  Tebal keramik + adukan x berat jenis

  0,03 m x 2100 kg/m^2 = 63 kg/m^2

- Beban plafond dan rangka plafond

  Berat plafond + penggantung

  11 kg/m^2 + 7 kg/m^2 = 18 kg/m^2

- **Beban Plat Lantai**

Berat plat lantai atap	= tebal plat x berat jenis beton bertulang
	= 0,10 x 2400 = 240 kg/m^2
Berat sendiri plat lantai 1-7	= tebal plat x berat jenis beton bertulang
	= 0,12 x 2400 = 288 kg/m^2
Berat pasir urug	= tebal urugan x berat jenis pasir
	= 0,05 x 1600 = 80 kg/m^2
Berat pasangan keramik	= (Tebal adukan x berat jenis adukan) + (Tebal keramik x berat jenis keramik)
	= (2x21) + (0,7 x 24) = 59 kg/m^2

Berat plafon + penggantumg = berat semen asbes + berat langit- langit

= 11 + 7 = 18 kg/m^2

qd lantai atap = 397 kg/m^2

qd lantai 1 -7 = 445 kg/m^2

3.8.2 Beban Hidup (Live Load)

Menurut Peraturan Pembebanan Indonesia Untuk Gedung 1987 (Tabel 3.1, halaman 17), beban hidup untuk lantai gedung yang berfungsi sebagai Hotel adalah 250 kg/m^2, sedangkan untuk lantai atap adalah 100 kg/m^2.

3.8.3 Beban Gempa (Earthquake load)

- Lantai Atap

Beban Mati

<u>Elemen Horizontal</u>

Berat lantai = luas lantai x qd lantai

= 8,35 x 6,75 x 397 = 22365 kg

Berat Balok = A x L x Bj x Σbalok

Berat balok memanjang

Balok (30/50) = 0,3 x (0,5 – 0,10) x (6,75 – 0,6) x 2400 x 2

= 0,12 x 6,15 x 2400 x 2 = 3542,4 kg

Balok Anak (20/30) = 0,2 x (0,3 – 0,10) x 2,58 x 2400 x 1

= 0,04 x 2,58 x 2400 x 1 = 247,68 kg

Berat balok melintang

Balok (35/60) = 0,35 x (0,6 – 0,10) x (8,35 – 0,6) x 2400 x 2

= 0,17 x 7,75 x 2400 x 2 = 6249,6 kg

Balok Anak (20/30) = 0,2 x (0,3– 0,10) x 2,65 x 2400 x 1

= 0,04 x 2,65 x 2400 x 1 = 254,4 kg

Elemen Vertical

Berat Kolom	= A x (h lantai atap + ½ h lantai 7) x Bj x Σ kolom		
Kolom (60/60)	= 0,36 x 4,2 x 2400 x 4	= 14515,2	kg

Berat Dinding	= b x h x L x Bj		
Memanjang	= 0,15 x 2,5 x 16,1 x 250	= 1506,5625	kg
Melintang	= 0,15 x 2,5 x 17,4 x 250	= 1626,5625	kg
	Wd Lantai Atap	= 50307,045	kg

Beban Hidup

Beban Hidup	= 250 kg/m²		
Factor reduksi gempa	= 0,3		
W1 lantai Atap	= 250 x 0,3 x 8,35 x 6,75	= 4227	kg

Beban Total Lantai Atap	= Wd + W1		
	= 50307,045 + 4227	= 54534,233	kg

- Lantai 7

Beban Mati

Elemen Horizontal

Berat lantai	= luas lantai x qd lantai		
	= 23 x 14 x 445	= 143226	kg
Berat Balok	= A x L x Bj x Σbalok		

Berat balok memanjang

Balok (30/50)	= 0,3 x (0,5-0,12) x (6,5-0,6) x 2400 x 6		
	= 0,11 x 5,9 x 2400 x 6	= 9685,44	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (6,75-0,6) x 2400 x 3		
	= 0,11 x 6,15 x 2400 x 3	= 5047,92	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (3,25-0,5) x 2400 x 3		
	= 0,11 x 2,83 x 2400 x 3	= 2318,76	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,297) x 2400 x 5		
	= 0,04 x 2,95 x 2400 x 5	= 1416	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,58 x 2400 x 1		
	= 0,04 x 2,58 x 2400 x 1	= 247,6	kg

Berat balok melintang

Balok (35/60)	= 0,35 x (0,6-0,12) x (8,35-0,6) x 2400 x 4		
	= 0,17 x 7,75 x 2400 x 4	= 12499,2	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,65-0,6) x 2400 x 4		
	= 0,11 x 5,05 x 2400 x 4	= 5526,72	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,65 x 2400 x 1		
	= 0,04 x 2,65 x 2400 x 1	= 254,4	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (5,65-0,3) x 2400 x 4		
	= 0,05 x 5,35 x 2400 x 4	= 2311,2	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (3,65-0,25) x 2400 x 3		
	= 0,05 x 3,4 x 2400 x 3	= 1101,6	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (4,7-0,25) x 2400 x 3		
	= 0,05 x 4,45 x 2400 x 3	= 1441,8	kg

<u>Elemen Vertical</u>

Berat Kolom = A x (h lantai atap + ½ h lantai bawah) x Bj x Σ kolom

Kolom (60/60) = 0,36 x 3,4 x 2400 x 12 = 35251,2 kg

Berat Dinding	= b x h x L x Bj		
Memanjang	= 0,15 x 3.4 x 58,55 x 250	= 7465,13	kg
Melintang	= 0,15 x 3,4 x 89 x 250	= 11348	kg

Wd Lantai 7	= 256765,745 kg

Beban Hidup

Beban Hidup	= 250 kg/m²	
Factor reduksi gempa	= 0,3	
W1 lantai 7	= 250 x 0,3 x 19,75 x 14	= 20738 kg

Beban Total Lantai 7	= Wd + W1	
	= 256765,745 + 20738	= 277503,245 kg

- Lantai 6

Beban Mati

<u>Elemen Horizontal</u>

Berat lantai	= luas lantai x qd lantai	
	= 36 x 14 x 445	= 224179 kg
Berat Balok	= A x L x Bj x Σbalok	

Berat balok memanjang

Balok (30/50)	= 0,3 x (0,5-0,12) x (6,5-0,6) x 2400 x 9		
	= 0,11 x 5,9 x 2400 x 9	= 14528,2	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (6,75-0,6) x 2400 x 3		
	= 0,11 x 6,15 x 2400 x 3	= 5047,92	kg
Balok (30/60)	= 0,3 x (0,6-0,12) x (7,75-0,6) x 2400 x 3		
	= 0,14 x 7,15 x 2400 x 3	= 7413,12	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (2-0,5) x 2400 x 3		
	= 0,11 x 1,5 x 2400 x 3	= 1231,2	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 3,95 x 2400 x 6	= 1699,2	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,58 x 2400 x 1		
	= 0,04 x 2,58 x 2400 x 1	= 247,68	kg

Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 687,36	kg

Berat balok melintang

Balok (35/60)	= 0,35x (0,6-0,12) x (8,35-0,6) x 2400 x 6		
	= 0,17 x 7,75 x 2400 x 6	= 18748,8	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,65-0,6) x 2400 x 7		
	= 0,11 x 5,05 x 2400 x 7	= 9671,76	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,69-0,4) x 2400 x 1		
	= 0,11 x 5,29 x 2400 x 1	= 1447,34	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (2,66-0,4) x 2400 x 1		
	= 0,11 x 2,26 x 2400 x 1	= 618,336	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (5,65-0,3) x 2400 x 5		
	= 0,05 x 5,35 x 2400 x 5	= 2889	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (3,65-0,25) x 2400 x 4		
	= 0,05 x 3,4 x 2400 x 4	= 1468,8	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (4,7-0,25) x 2400 x 4		
	= 0,05 x 4,45 x 2400 x 4	= 1922,4	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,65 x 2400 x 4		
	= 0,04 x 2,65 x 2400 x 1	= 254,4	kg

<u>Elemen Vertical</u>

Berat Kolom = A x (h lantai atap + ½ h lantai bawah) x Bj x Σ kolom

Kolom (60/60)	= 0,36 x 3,4 x 2400 x 18	= 52876,8 kg
Kolom (40/40)	= 0,16 x 3,4 x 2400 x 3	= 3916,8 kg

Berat Dinding = b x h x L x Bj

Memanjang	= 0,15 x 3.4 x 77 x 250	= 9766,5 kg
Melintang	= 0,15 x 3,4 x 127 x 250	= 16244 kg
	Wd Lantai 6	= 374858,28 kg

Beban Hidup

Beban Hidup = 250 kg/m²

Factor reduksi gempa	= 0,3
W1 lantai 6	= 250 x 0,3 x 36 x 14 = 37800 kg

Beban Total Lantai 6	= Wd + W1
	= 374858,28 + 37800 = 412658,280 kg

- Lantai 5

Beban Mati

<u>Elemen Horizontal</u>

Berat lantai	= luas lantai x qd lantai
	= 36 x 14 x 445 = 224179 kg
Berat Balok	= A x L x Bj x Σbalok

Berat balok memanjang

Balok (30/50)	= 0,3 x (0,5-0,12) x (6,5-0,6) x 2400 x 9		
	= 0,11 x 5,9 x 2400 x 9	= 14528,2	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (6,75-0,6) x 2400 x 3		
	= 0,11 x 6,15 x 2400 x 3	= 5047,92	kg
Balok (30/60)	= 0,3 x (0,6-0,12) x (7,75-0,6) x 2400 x 3		
	= 0,14 x 7,15 x 2400 x 3	= 7413,12	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (2-0,5) x 2400 x 3		
	= 0,11 x 1,5 x 2400 x 3	= 1231,2	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 3,95 x 2400 x 6	= 1699,2	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,58 x 2400 x 1		
	= 0,04 x 2,58 x 2400 x 1	= 247,68	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 687,36	kg

Berat balok melintang

Balok (35/60)	= 0,35x (0,6-0,12) x (8,35-0,6) x 2400 x 6		
	= 0,17 x 7,75 x 2400 x 6	= 18748,8	kg

Balok (30/50)	= 0,3 x (0,5-0,12) x (5,65-0,6) x 2400 x 7		
	= 0,11 x 5,05 x 2400 x 7	= 9671,76	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,69-0,4) x 2400 x 1		
	= 0,11 x 5,29 x 2400 x 1	= 1447,34	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (2,66-0,4) x 2400 x 1		
	= 0,11 x 2,26 x 2400 x 1	= 618,336	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (5,65-0,3) x 2400 x 5		
	= 0,05 x 5,35 x 2400 x 5	= 2889	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (3,65-0,25) x 2400 x 4		
	= 0,05 x 3,4 x 2400 x 4	= 1468,8	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (4,7-0,25) x 2400 x 4		
	= 0,05 x 4,45 x 2400 x 4	= 1922,4	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,65 x 2400 x 4		
	= 0,04 x 2,65 x 2400 x 1	= 254,4	kg

Elemen Vertical

Berat Kolom = A x (h lantai atap + ½ h lantai bawah) x Bj x Σ kolom

Kolom (60/60)	= 0,36 x 3,4 x 2400 x 18	= 52876,8 kg
Kolom (40/40)	= 0,16 x 3,4 x 2400 x 3	= 3916,8 kg

Berat Dinding = b x h x L x Bj

Memanjang	= 0,15 x 3.4 x 77 x 250	= 9766,5 kg
Melintang	= 0,15 x 3,4 x 127 x 250	= 16244 kg
	Wd Lantai 6	= 374858,28 kg

Beban Hidup

Beban Hidup = 250 kg/m²

Factor reduksi gempa = 0,3

W1 lantai 5 = 250 x 0,3 x 36 x 14 = 37800 kg

Beban Total Lantai 5 = Wd + W1

= 374858,28 + 37800 = 412658,280 kg

- Lantai 4

Beban Mati

<u>Elemen Horizontal</u>

Berat lantai	= luas lantai x qd lantai		
	= 36 x 14 x 445	= 224179 kg	
Berat Balok	= A x L x Bj x Σbalok		

Berat balok memanjang

Balok (30/50)	= 0,3 x (0,5-0,12) x (6,5-0,6) x 2400 x 9		
	= 0,11 x 5,9 x 2400 x 9	= 14528,2	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (6,75-0,6) x 2400 x 3		
	= 0,11 x 6,15 x 2400 x 3	= 5047,92	kg
Balok (30/60)	= 0,3 x (0,6-0,12) x (7,75-0,6) x 2400 x 3		
	= 0,14 x 7,15 x 2400 x 3	= 7413,12	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (2-0,5) x 2400 x 3		
	= 0,11 x 1,5 x 2400 x 3	= 1231,2	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 3,95 x 2400 x 6	= 1699,2	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,58 x 2400 x 1		
	= 0,04 x 2,58 x 2400 x 1	= 247,68	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 687,36	kg

Berat balok melintang

Balok (35/60)	= 0,35x (0,6-0,12) x (8,35-0,6) x 2400 x 6		
	= 0,17 x 7,75 x 2400 x 6	= 18748,8	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,65-0,6) x 2400 x 7		
	= 0,11 x 5,05 x 2400 x 7	= 9671,76	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,69-0,4) x 2400 x 1		
	= 0,11 x 5,29 x 2400 x 1	= 1447,34	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (2,66-0,4) x 2400 x 1		
	= 0,11 x 2,26 x 2400 x 1	= 618,336	kg

Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (5,65-0,3) x 2400 x 5		
	= 0,05 x 5,35 x 2400 x 5	= 2889	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (3,65-0,25) x 2400 x 4		
	= 0,05 x 3,4 x 2400 x 4	= 1468,8	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (4,7-0,25) x 2400 x 4		
	= 0,05 x 4,45 x 2400 x 4	= 1922,4	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,65 x 2400 x 4		
	= 0,04 x 2,65 x 2400 x 1	= 254,4	kg

<u>Elemen Vertical</u>

Berat Kolom = A x (h lantai atap + ½ h lantai bawah) x Bj x Σ kolom

Kolom (60/60)	= 0,36 x 3,4 x 2400 x 18	= 52876,8 kg
Kolom (40/40)	= 0,16 x 3,4 x 2400 x 3	= 3916,8 kg

Berat Dinding = b x h x L x Bj

Memanjang	= 0,15 x 3.4 x 77 x 250	= 9766,5 kg
Melintang	= 0,15 x 3,4 x 127 x 250	= 16244 kg
	Wd Lantai 6	= 374858,28 kg

Beban Hidup

Beban Hidup	= 250 kg/m²
Factor reduksi gempa	= 0,3
W1 lantai 4	= 250 x 0,3 x 36 x 14 = 37800 kg

Beban Total Lantai 4 = Wd + W1

= 374858,28 + 37800 = 412658,280 kg

- Lantai 3

Beban Mati

<u>Elemen Horizontal</u>

Berat lantai	= luas lantai x qd lantai		
	= 36 x 18,2 x 445	= 291433	kg
Berat Balok	= A x L x Bj x Σbalok		

Berat balok memanjang

Balok (30/50)	= 0,3 x (0,5-0,12) x (6,5-0,6) x 2400 x 12		
	= 0,11 x 5,9 x 2400 x 12	= 19370,9	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (6,75-0,6) x 2400 x 4		
	= 0,11 x 6,15 x 2400 x 4	= 6370,56	kg
Balok (30/60)	= 0,3 x (0,6-0,12) x (7,75-0,6) x 2400 x 4		
	= 0,14 x 7,15 x 2400 x 4	= 9884,16	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (2-0,5) x 2400 x 4		
	= 0,11 x 1,5 x 2400 x 4	= 1641,6	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 3,95 x 2400 x 6	= 1699,2	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,375-0,3) x 2400 x 2		
	= 0,04 x 3,08 x 2400 x 2	= 590,4	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 686,4	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (2-0,325) x 2400 x 1		
	= 0,04 x 1,68 x 2400 x 1	= 160,8	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x(3,25-0,3) x 2400 x 6		
	= 0,04 x 2,95 x 2400 x 6	= 1699,2	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,58 x 2400 x 1		
	= 0,04 x 2,58 x 2400 x 1	= 247,68	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 686,4	kg

Berat balok melintang

Balok (35/60)	= 0,35x (0,6-0,12) x (8,35-0,6) x 2400 x 6		
	= 0,17 x 7,75 x 2400 x 6	= 18748,8	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,65-0,6) x 2400 x 7		
	= 0,11 x 5,05 x 2400 x 7	= 9671,76	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (3-0,5) x 2400 x 6		
	= 0,11 x 2,5 x 2400 x 6	= 4104	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,68-0,4) x 2400 x 1		
	= 0,11 x 5,28 x 2400 x 1	= 1444,61	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,66-0,4) x 2400 x 1		
	= 0,11 x 5,26 x 2400 x 1	= 1439,14	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (1,2-0,5) x 2400 x 7		
	= 0,11 x 0,7 x 2400 x 7	= 1340,64	kg
Balok Anak (25/30)	= 0,2 x (0,3-0,12) x (5,65-0,3) x 2400 x 5		
	= 0,05 x 5,35 x 2400 x 5	= 2889	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (3,65-0,25) x 2400 x 4		
	= 0,05 x 3,4 x 2400 x 4	= 1468,8	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (1,2-0,4) x 2400 x 5		
	= 0,05 x 0,8 x 2400 x 5	= 432	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (4,7-0,25) x 2400 x 4		
	= 0,05 x 4,45 x 2400 x 4	= 1922,4	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3-0,3)x 2400 x 5		
	= 0,04 x 2,7 x 2400 x 5	= 1166,4	kg

<u>Elemen Vertical</u>

Berat Kolom = A x (h lantai atap + ½ h lantai bawah) x Bj x Σ kolom

Kolom (60/60)	= 0,36 x 3,95 x 2400 x 18	= 61430,4	kg
Kolom (40/60)	= 0,24 x 3,95 x 2400 x 6	= 13651,2	kg

Berat Dinding	= b x h x L x Bj		
Memanjang	= 0,15 x 3.4 x 77 x 250	= 9817,5	kg
Melintang	= 0,15 x 3,4 x 127 x 250	= 16192,5	kg
	Wd Lantai 3	= 480549,384	kg

Beban Hidup

Beban Hidup	= 250 kg/m²		
Factor reduksi gempa	= 0,3		
W1 lantai 3	= 250 x 0,3 x 36 x 18,2	= 49140	kg
Beban Total Lantai 3	= Wd + W1		
	= 480549,384 + 49140	= 529689,384	kg

- Lantai 2

Beban Mati

Elemen Horizontal

Berat lantai	= luas lantai x qd lantai	
	= 34 x 18,2 x 445	= 275242 kg
Berat Balok	= A x L x Bj x Σbalok	

Berat balok memanjang

Balok (30/50)	= 0,3 x (0,5-0,12) x (6,5-0,6) x 2400 x 12		
	= 0,11 x 5,9 x 2400 x 12	= 19370,9	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (6,75-0,6) x 2400 x 4		
	= 0,11 x 6,15 x 2400 x 4	= 6730,56	kg
Balok (30/60)	= 0,3 x (0,6-0,12) x (7,75-0,6) x 2400 x 4		
	= 0,14 x 7,15 x 2400 x 4	= 9884,16	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 2,95 x 2400 x 6	= 1529,28	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,75-0,3) x 2400 x 2		

	= 0,04 x 3,45 x 2400 x 2	= 596,16	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 4		
	= 0,04 x 3,58 x 2400 x 2	= 617,76	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 2,95 x 2400 x 6	= 1529,28	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,58 x 2400 x 1		
	= 0,04 x 2,58 x 2400 x 1	= 222,912	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 617,76	kg

Berat balok melintang

Balok (35/60)	= 0,35 x (0,6-0,12) x (8,35-0,6) x 2400 x 6		
	= 0,17 x 7,75 x 2400 x 6	= 18748,8	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,65-0,6) x 2400 x 6		
	= 0,11 x 5,05 x 2400 x 6	= 8290,08	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (3-0,5) x 2400 x 6		
	= 0,11 x 2,5 x 2400 x 6	= 4104	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (1,2-0,5) x 2400 x 6		
	= 0,11 x 0,7 x 2400 x 6	= 1149,12	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (5,65-0,3) x 2400 x 5		
	= 0,05 x 5,35 x 2400 x 5	= 2889	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (3,65-0,25) x 2400 x 4		
	= 0,05 x 3,4 x 2400 x 4	= 1468,8	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (1,2-0,4) x 2400 x 5		
	= 0,05 x 0,8 x 2400 x 5	= 432	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (4,7-0,25) x 2400 x 4		
	= 0,05 x 4,45 x 2400 x 4	= 1922,5	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3-0,3) x 2400 x 5		
	= 0,04 x 2,7 x 2400 x 5	= 1166,4	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,65 x 2400 x 1		
	= 0,04 x 2,65 x 2400 x 1	= 228,96	kg

Elemen Vertical

Berat Kolom	= A x (h lantai atap + ½ h lantai bawah) x Bj x Σ kolom	
Kolom (60/60)	= 0,36 x 5 x 2400 x 18	= 77760 kg
Kolom (40/60)	= 0,24 x 5 x 2400 x 6	= 17280 kg

Berat Dinding	= b x h x L x Bj	
Memanjang	= 0,15 x 4,5 x 94 x 250	= 15862,5 kg
Melintang	= 0,15 x 4,5 x 72 x 250	= 12150 kg
	Wd Lantai 2	= 479793,052 kg

Beban Hidup

Beban Hidup	= 250 kg/m²	
Factor reduksi gempa	= 0,3	
W1 lantai 2	= 250 x 0,3 x 34 x 18,2	= 46410 kg
Beban Total Lantai 2	= Wd + W1	
	= 479793,052 + 46410	= 526203,052 kg

- Lantai 1

Beban Mati

Elemen Horizontal

Berat lantai	= luas lantai x qd lantai	
	= 38 x 18,2 x 445	= 3076,24 kg
Berat Balok	= A x L x Bj x Σbalok	

Berat balok memanjang

Balok (30/50)	= 0,3 x (0,5-0,12) x (6,5-0,6) x 2400 x 12	
	= 0,11 x 5,9 x 2400 x 12	= 19371 kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (6,75-0,6) x 2400 x 4	

	= 0,11 x 6,15 x 2400 x 4	= 6731	kg
Balok (30/60)	= 0,3 x (0,6-0,12) x (6,5-0,6) x 2400 x 4		
	= 0,14 x 7,15 x 2400 x 4	= 9884	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (4-0,5) x 2400 x 4		
	= 0,11 x 3,5 x 2400 x 4	= 3830	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 2,95 x 2400 x 6	= 1529	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,375-0,3) x 2400 x 2		
	= 0,04 x 3,08 x 2400 x 2	= 531	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 618	kg
Balok (20/30)	= 0,2 x (0,3-0,12) x (4-0,5) x 2400 x 1		
	= 0,04 x 3,5 x 2400 x 1	= 346	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,25-0,3) x 2400 x 6		
	= 0,04 x 2,95 x 2400 x 6	= 1529	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,58 x 2400 x 1		
	= 0,04 x 2,58 x 2400 x 1	= 223	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3,875-0,3) x 2400 x 2		
	= 0,04 x 3,58 x 2400 x 2	= 618	kg

Berat balok melintang

Balok (35/60)	= 0,35 x (0,6-0,12) x (8,35-0,6) x 2400 x 6		
	= 0,17 x 7,75 x 2400 x 6	= 18749	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,65-0,6) x 2400 x 7		
	= 0,11 x 5,05 x 2400 x 7	= 9672	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (3-0,5) x 2400 x 6		
	= 0,11 x 2,5 x 2400 x 6	= 4104	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,68-0,4) x 2400 x 1		
	= 0,11 x 5,28 x 2400 x 1	= 1445	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (5,66-0,4) x 2400 x 1		
	= 0,11 x 5,26 x 2400 x 1	= 1439	kg
Balok (30/50)	= 0,3 x (0,5-0,12) x (1,2-0,5) x 2400 x 7		
	= 0,11 x 0,7 x 2400 x 7	= 1341	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (5,65-0,3) x 2400 x 5		

	= 0,05 x 5,35 x 2400 x 5	= 2889	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (3,65-0,25) x 2400 x 4		
	= 0,05 x 3,4 x 2400 x 4	= 1469	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (1,2-0,4) x 2400 x 5		
	= 0,05 x 0,8 x 2400 x 5	= 432	kg
Balok Anak (25/30)	= 0,25 x (0,3-0,12) x (4,7-0,25) x 2400 x 4		
	= 0,05 x 4,5 x 2400 x 4	= 1922	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x (3-0,3) x 2400 x 5		
	= 0,04 x 2,7 x 2400 x 5	= 1166	kg
Balok Anak (20/30)	= 0,2 x (0,3-0,12) x 2,65x 2400 x 1		
	= 0,04 x 2,65 x 2400 x 1	= 229	kg

<u>Elemen Vertical</u>

Berat Kolom = A x (h lantai atap + ½ h lantai bawah) x Bj x Σ kolom

Kolom (60/60)	= 0,36 x 5,95 x 2400 x 18	= 92534,4	kg
Kolom (40/60)	= 0,24 x 5,95 x 2400 x 6	= 20563,2	kg
Kolom (40/40)	= 0,16 x 5,95 x 2400 x 4	= 9139,2	kg

Berat Dinding = b x h x L x Bj

Memanjang	= 0,15 x 5,5 x 94 x 250	= 19387,5	kg
Melintang	= 0,15 x 5,5 x 47 x 250	= 9693,8	kg
	Wd Lantai 1	= 549008	kg

Beban Hidup

Beban Hidup	= 250 kg/m²	
Factor reduksi gempa	= 0,3	
W1 lantai 1	= 0,3 x 250 x 38 x 18,2	= 51870 kg

Beban Total Lantai 1 = Wd + Wl

= 549008 + 51870 = 600878,186 kg

Berat Total Bangunan

Berat Total Lantai 1	=	600878,186	kg
Berat Total Lantai 2	=	526203,052	kg
Berat Total Lantai 3	=	529689,384	kg
Berat Total Lantai 4	=	412658,280	kg
Berat Total Lantai 5	=	412658,280	kg
Berat Total Lantai 6	=	412658,280	kg
Berat Total Lantai 7	=	277503,245	kg
Berat Total Lantai Atap	=	54534,233	kg
Wt	=	3.226.782,940	kg

Tabel 3.1 Beban Gempa Dinamik Arah X,Z dan Y

Lantai	FX	FZ	FY (Kg)
	(Kg)	(Kg)	Wi x 10%
1	600878,186	600878,186	60087,818
2	526203,052	526203,052	52620,305
3	529689,384	529689,384	52968,938
4	412658,280	412658,280	41265,828
5	412658,280	412658,280	41265,828
6	412658,280	412658,280	41265,828
7	277503,245	277503,245	27750,324
Atap	54534,233	54534,233	5453,423

3.9. Spktrum Respons

Berdasarkan hitungan menggunakan aplikasi http://puskim.pu.go.id/Aplikasi/desain_spektra_indonesia_2011/ kota malang memiliki percepatan batuan dasar, yaitu :

- S_s = 0,781 g
- S_1 = 0,33 g

Jenis tanah untuk wilayah kota Malang di mana gedung tersebut berada adalah tanah keras.

- Penentuan koefisien situs F_a dan F_s

Koefisien situs F_a

Ditentukan berdasarkan beberapa parameter, yaitu nilai S_s yang Sesuai hasil hitungan http://puskim.pu.go.id/Aplikasi/desain_spektra_indonesia_2011/ dan kelas situs yang berdasarkan jenis tanah yang terdapat pada Tabel 4 SNI 726 2012.

S_s = 0,781

Kelas situs = SC (tanah keras)

Dari data di atas, didapat nilai :

F_a = 1,1

Koefisien situs F_v

Ditentukan berdasarkan beberapa parameter, yaitu nilai S_1 yang terdapat pada Tabel 2.11 dan kelas situs yang berdasarkan jenis tanah yang terdapat pada Tabel 5 SNI 1726 2012.

S_1 = 0,33

Kelas situs = SC (tanah keras)

Dari data di atas, didapat nilai :

F_v = 1,5

- Penentuan nilai S_{MS} dan S_{M1}

$$S_{MS} = F_a\, S_s$$

$$S_{MS} = 1{,}1 \quad X \quad 0{,}781 = 0{,}9$$

$$S_{M1} = F_v\, S_1$$

$$S_{M1} = 1{,}5 \quad X \quad 0{,}33 = 0{,}5$$

- Penentuan nilai S_{DS} dan S_{D1}

$$S_{DS} = \frac{2}{3}\, S_{MS}$$

$$S_{DS} = \frac{2}{3}\, 0{,}9 = 0{,}573$$

$$S_{D1} = \frac{2}{3}\, S_{M1}$$

$$S_{D1} = \frac{2}{3}\, 0{,}5 = 0{,}330$$

- Penentuan nilai T_0 dan T_s

$$T_0 = 0{,}2\, \frac{S_{D1}}{S_{DS}}$$

$$T_0 = 0{,}2\, \frac{0{,}330}{0{,}573} = 0{,}12$$

$$T_S = \frac{S_{D1}}{S_{DS}}$$

$$T_S = \frac{0{,}330}{0{,}573} = 0{,}576$$

- Penentuan nilai S_a

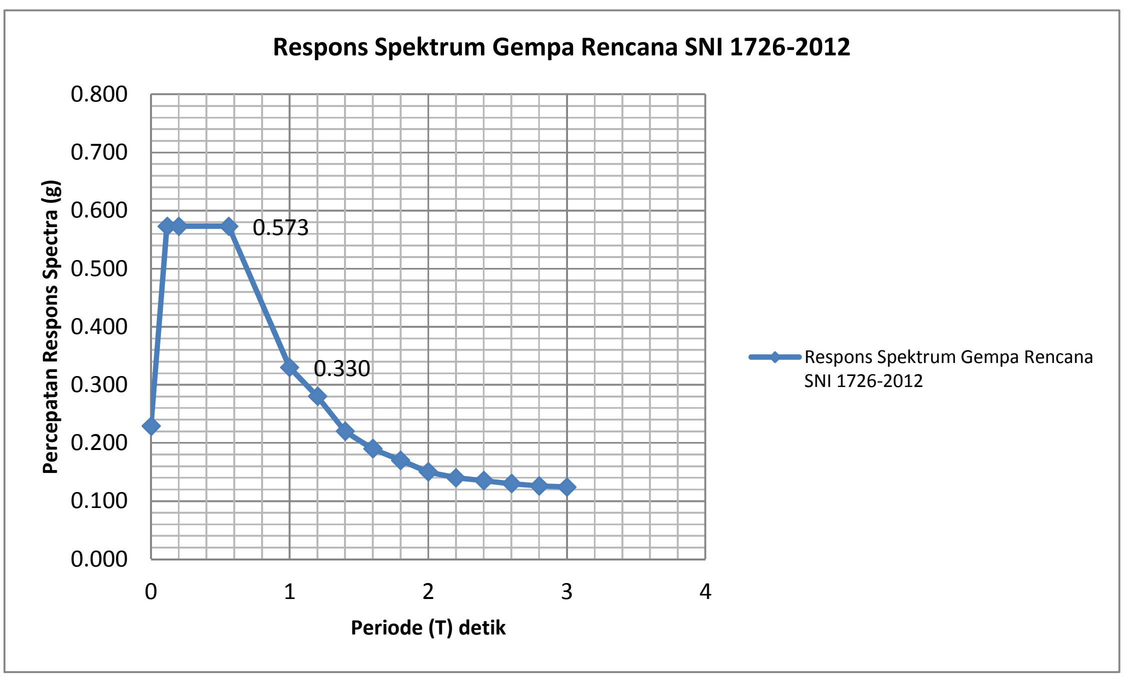
    1. Untuk periode yang lebih kecil dari T_0, spektrum respons percepatan desain, Sa harus diambil dari persamaan :

$$S_a = S_{DS}\left(0{,}4 + 0{,}6\frac{T}{T_0}\right)$$

    2. Untuk periode yang lebih besar dari atau sama dengan T_0 dan lebih kecil atau sama dengan T_s, spektrum respons desain, S_a, sama dengan S_{DS}.
    3. Untuk periode lebih besar dari $T_{s,}$ spektrum respons percepatan desain, S_a, diambil berdasarkan persamaan :

$$S_a = \frac{S_{D1}}{T}$$

Spektrum gempa rencana SNI 1726-2012 yang diplot ke dalam *Microsoft Excel* sebagai berikut.



Gambar 3.2 Respons Spketrum Gempa Rencana

T	g
0	0,267
0,115	0,573
0,2	0,573
0,576	0,573
1	0,330

3.10 Kategori Desain Seismik

Berdasarkan kategori resikonya yang ditetapkan dalam pasal 4.1.2 SNI 1726-2012 pada tabel 1 dan tabel 2, Bangunan hotel pattimura malang memiliki kategori resiko II resiko dengan faktor keutamaan gempa, I_e, 1,0.

Tabel 3.2 kategori resiko bangunan gedung dan non gedung unuk beban gempa

Jenis pemanfaatan	Kategori resiko
Gedung dan non gedung yang memiliki resiko rendah terhadap jiwa manusia pada saat terjadi kegagalan, termasuk, tetapi tidak di batasi untuk, antara lain : • Fasilitas pertanian, perkebunan, peernakan, dan perikanan • Fasilitas sementara • Gudang penyimpanan • Rumah jaga dan struktur kecil lainnya	I
Semua gedung dan struktur lain, kecuali yang termasuk dalam kategori resiko I,III,IV, termasuk tetapi tidak di batasi untuk : • Perumahan	

• Rumah toko dan rumah kantor • Pasar • Gedung perkantoran • Gedung apartemen/rumah susun • Pusat perbelanjaan/mall • Bangunan industri • Fasilitas manufaktur • pabrik	II
Gedung dan non gedung yang memiliki resiko tinggi terhadap jiwa manusia pada saat terjadi kegagalan, termasuk, tetapi tidak di batasi untuk : • bioskop • gedung pertemuan • stadion • fasilitas kesehatan yang tidak memiliki uni bedah dan unit gawat darurat • fasilitas penitipan anak • penjara • bangunan untuk orang jompo gedung dan non gedung, tidak termasuk ke dalam kategori resiko IV, yang memiliki potensi untuk menyebabkan dampak ekonomi yang besar dan/atau gangguan massal erhadap kehidupan masyarakat sehari-hari bila terjadi kegagalan, termasuk , tapi tidak di batasi untuk : • pusat pembangkit listrik biasa	III

• fasilitas penanganan air • fasilitas penanganan limbah • pusat telekomunikasi gedung dan non gedung yang tidak termasuk dalam kategori IV, (termasuk, tetapi tidak di batasi untuk fasilitas manufaktur, proses, penanganan, penyimpanan, penggunaan atau tempat pembuangan bahan bakr berbahaya, bahan kimia berbahaya, limbah berbahaya, atau bahan yang mudah meledak) yang mengandung bahan beracun atau peledak di mana jumlah kandungan bahayanya melebihi nilai batas yang di syaratkan oleh instansi yang berwenan dan cukup menimbulkan bahaya bagi masyarakat jika terjadi kebocoran.	
Gedung dan non gedung yang di tunjuk sebagai fasilitas yang penting, termasuk, tetapi tidak di batasi untuk : • bangunan-bangunan monumental • gedung sekolah dan fasilitas pendidikan • rumah sakit dan fasilitas bedah dan unit gawa darurat • fasilitas pemadam kebakaran, ambulans, dan kantor polisi, serta garasi kendaraan darurat • tempat perlindungan terhadap gempa bumi, angina badai, dan empat perlindungan darurat lainnya • fasilitas kesiapan darurat, komunikasi, pusat operasi dan fasilitas lainnya untuk tanggap darurat • struktur tambahan (termasuk menara elekomunikasi, tangki penyimpanan bahan bakar, menara pendingin, struktur stasiun listrik, tangki air pemadam kebakaran atau struktur rumah atau stuktur	IV

pendukung air atau material atau peralatan pemadam kebakaran) yang di syaratkan beroperasi pada saat keadaan darurat gedug dan non gedung yang di butuhkan untuk mempertahankan fungsi struktur bangunan lain yang masuk ke dalam kategori resiko IV.	

Tabel 3.3 faktor keutamaan gempa

Kategori resiko	Faktor keutamaan gempa, I_e
I atau II	1,0
III	1,25
IV	1,50

Kota malang di hitung menggunakan aplikasi http://puskim.pu.go.id/Aplikasi/desain_spektra_indonesia_2011/ memiliki percepatan batuan dasar,yaitu;

- S_S = 0,781 g
- S_1 = 0,33 g

Yang berarti bahwa sesuai SNI 1726-2012 pasal 6.5 bangunan yang berlokasi dimana parameter respon spektral percepatan terpetakan pada periode 1 detik, s_1, lebih kecil dari 0,75 maka ketegori desain seismiknya di tentukan sesuai dengan tabel 3.3

Tabel 3.4 kategori desain seismik berdasarkan parameter respon percepatan pada periode pendek

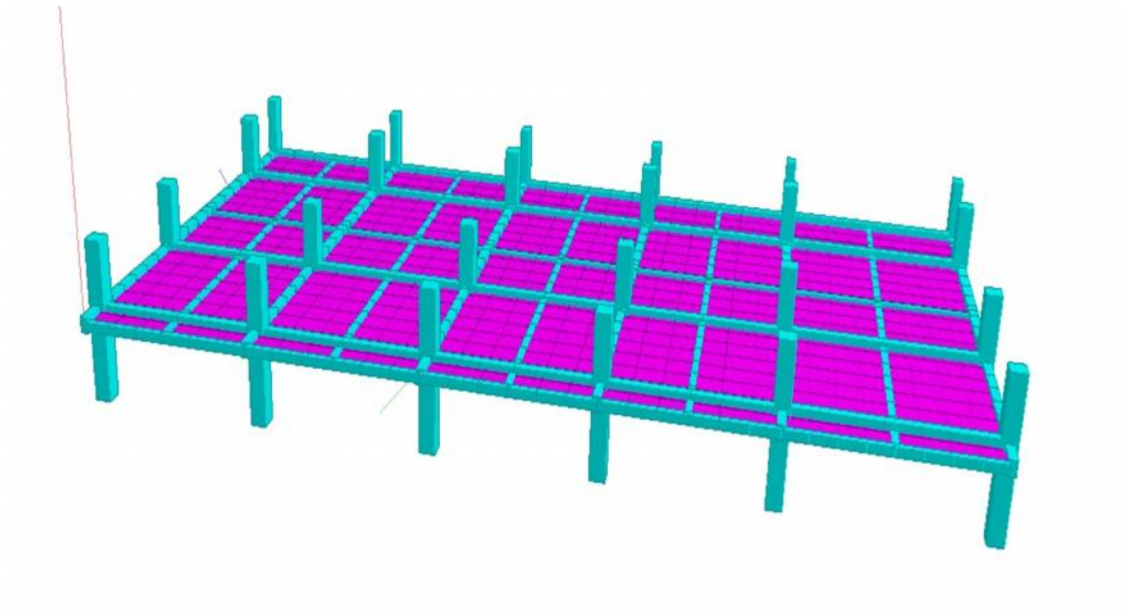
Nilai S_{DS}	Kategori resiko	
	I atau II atau III	IV
$S_{DS} < 0,167$	A	A
$0,167 \leq S_{DS} < 0,33$	B	C
$0,33 \leq S_{DS} < 0,50$	C	D
$0,50 \leq S_{DS}$	D	D

Dengan demikian sesuai hasil perhitungan S_{DS} diatas bangunan hotel pattimura di tetapkan memiliki kategori desain seismik D,maka sesuai pasal 7.2 SNI 1726-2012,ditetapkan bahwa bangunan hotel pattimura malang menggunakan ''Sistem Rangka Beton Pemikul Momen Khusus'' sebagai penahan gaya gempa.sesuai dengan tabel 3.4

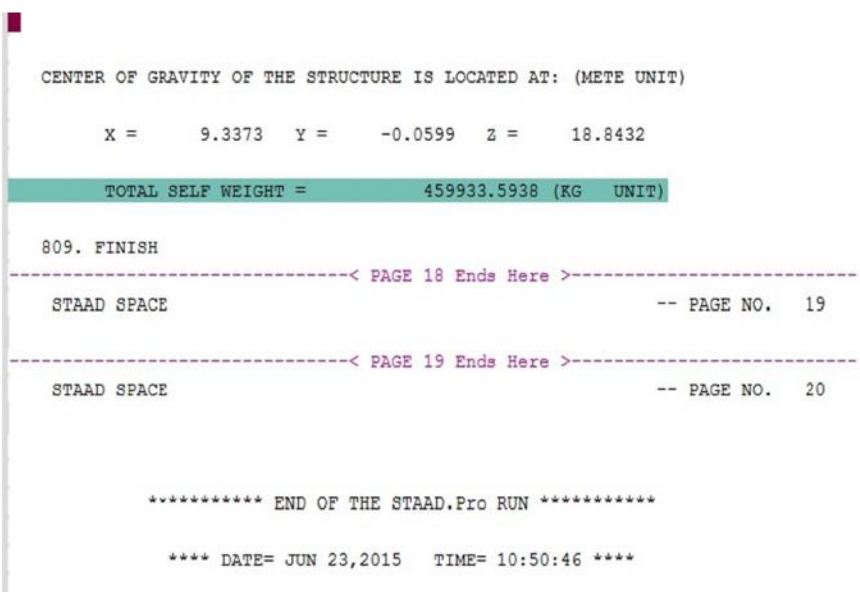
Tabel 3.5 Faktor *R*, C_d, Ω_0 untuk sistem penahan gaya gempa

Sistem panahan gaya seismik	Koefisien modifikasi respon R^a	Faktor kuat-lebih system, Ω_0 [g]	Factor pembesaran defleksi C_d [b]	Batasan system struktur dan batasan tinggi struktur, h_n (m)[c]				
				Kategori desain seismik				
				B	C	D^d	E^d	F^e
C. Sistem rangka pemikul momen								
13.Rangka baja pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
14.Rangka batang baja pemikul momen khusus	7	3	5½	TB	TB	48	30	TI
15.Rangka baja pemikul momen menengah	4½	3	4	TB	TB	10[h,i]	TI[h]	TI'
16.Rangka baja pemikul momen biasa	3½	3	3	TB	TB	TI[h]	TI[h]	TI'
17.Rangka beton bertulang pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
18.Rangka beton bertulang pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
19.Rangka beton bertulang pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
20.Rangka baja dan beton komposit pemikul momen khusus	8	3	5½	TB	TB	TB	TB	TB
21.Rangka baja dan beton komposit pemikul momen menengah	5	3	4½	TB	TB	TI	TI	TI
22. Rangka baja dan beton komposit terkekang parsial pemikul momen	6	3	5½	48	48	30	TI	TI
23.Rangka baja dan beton komposit pemikul momen biasa	3	3	2½	TB	TI	TI	TI	TI
24.Rangka baja canai dingin pemikul momen khusus dengan pembautan	3½	3°	3½	10	10	10	10	10

3.11 Pusat massa dan Pusat Kekakuan



Gambar 3.3 Pemodelan 3 dimensi pusat massa lantai 1



```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      9.3373   Y =     -0.0599   Z =     18.8432

     TOTAL SELF WEIGHT =           459933.5938 (KG   UNIT)

809. FINISH
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          *********** END OF THE STAAD.Pro RUN ***********

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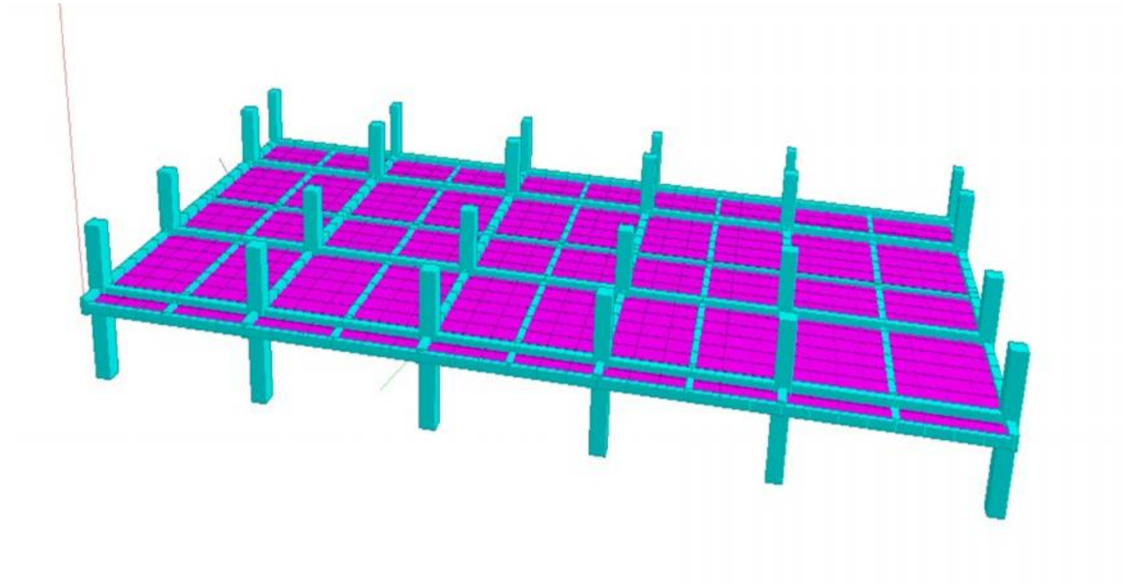
Gambar 3.4 Output pusat massa lantai 1



Gambar 3.5 Pemodelan 3 dimensi pusat massa lantai 2

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      9.3246   Y =     -0.0599   Z =     16.9224

     TOTAL SELF WEIGHT =           397044.4688 (KG   UNIT)

712. FINISH
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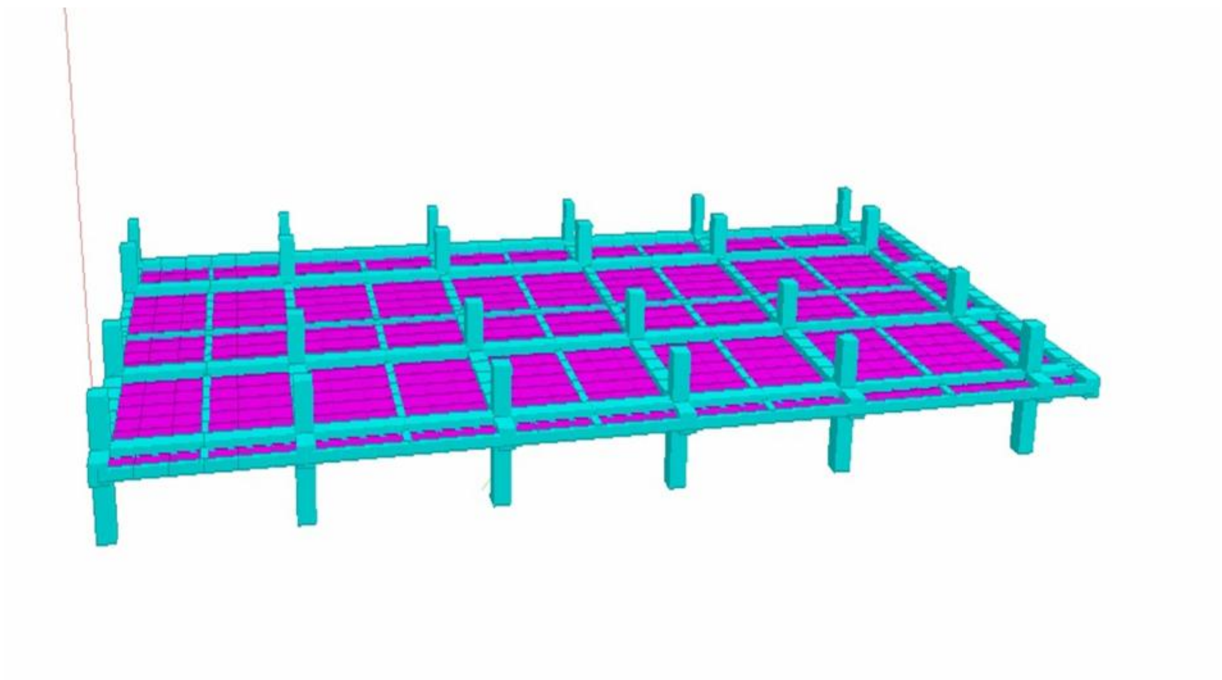
Gambar 3.6 Output pusat massa lantai 2



Gambar 3.7 Pemodelan 3 dimensi pusat massa lantai 3

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      9.2984   Y =     -0.0419   Z =     17.7661

     TOTAL SELF WEIGHT =          493294.5000 (KG   UNIT)

772. FINISH
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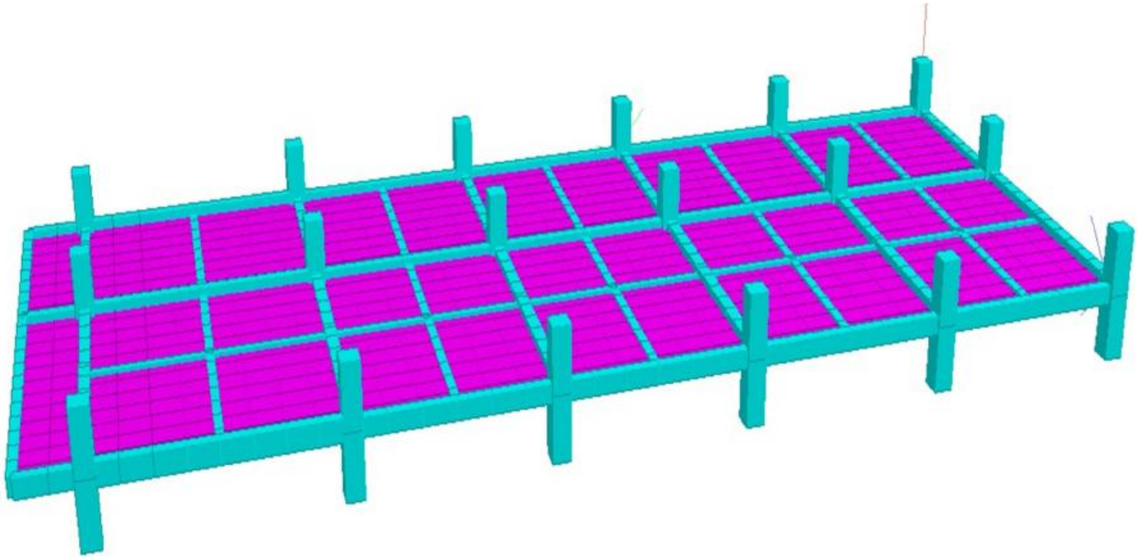
Gambar 3.8 Output pusat massa lantai 3



Gambar 3.9 Pemodelan 3 dimensi pusat massa lantai 4

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      7.5054   Y =      0.3340   Z =     10.9917

     TOTAL SELF WEIGHT =           210689.3594 (KG   UNIT)

443. FINISH
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           *********** END OF THE STAAD.Pro RUN ***********

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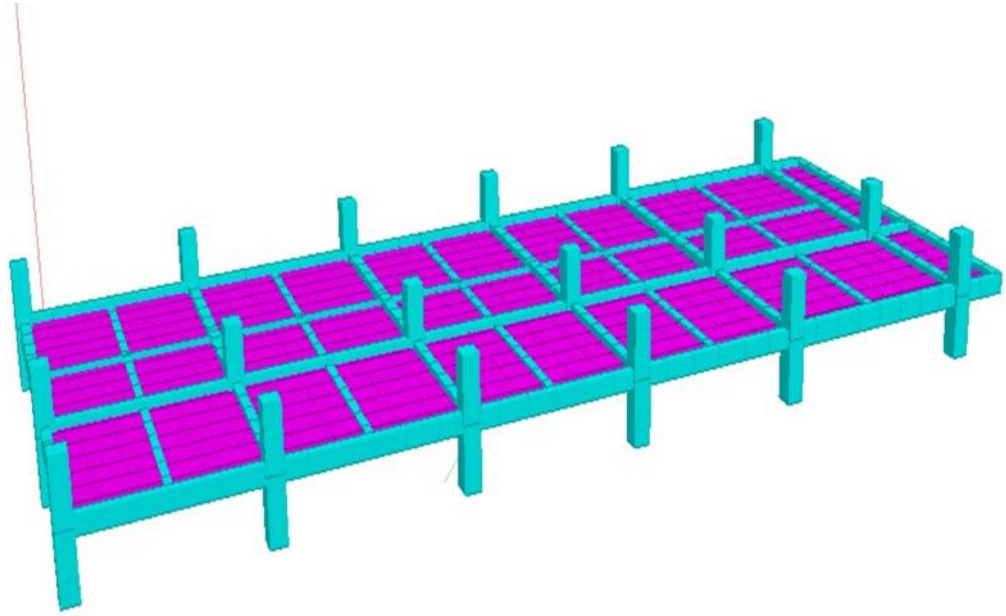
Gambar 3.10 Output pusat massa lantai 4



Gambar 3.11 Pemodelan 3 dimensi pusat massa lantai 5

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      6.9652   Y =      0.0000   Z =     17.8783

     TOTAL SELF WEIGHT =          298898.0625 (KG   UNIT)

651. FINISH
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          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUN 23,2015   TIME= 10:59:18 ****
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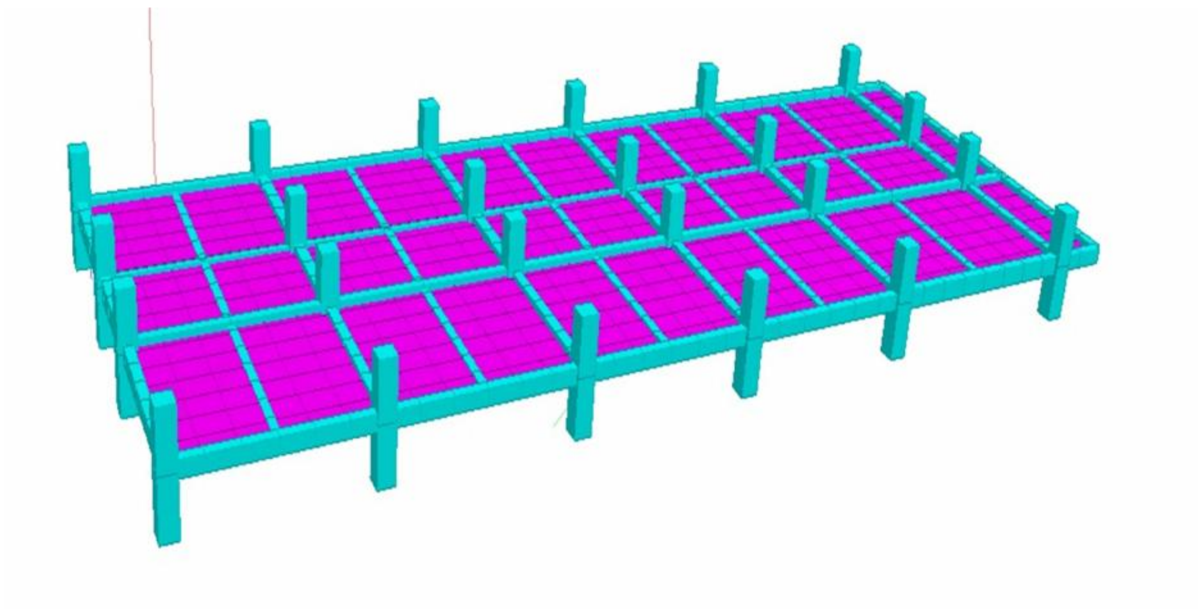
Gambar 3.12 Output pusat massa lantai 5



Gambar 3.13 Pemodelan 3 dimensi pusat massa lantai 6

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      7.0954   Y =      0.0000   Z =     17.8085

     TOTAL SELF WEIGHT =          316541.9375 (KG   UNIT)

665. FINISH
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           *********** END OF THE STAAD.Pro RUN ***********

             **** DATE= JUN 23,2015   TIME= 11: 0:53 ****
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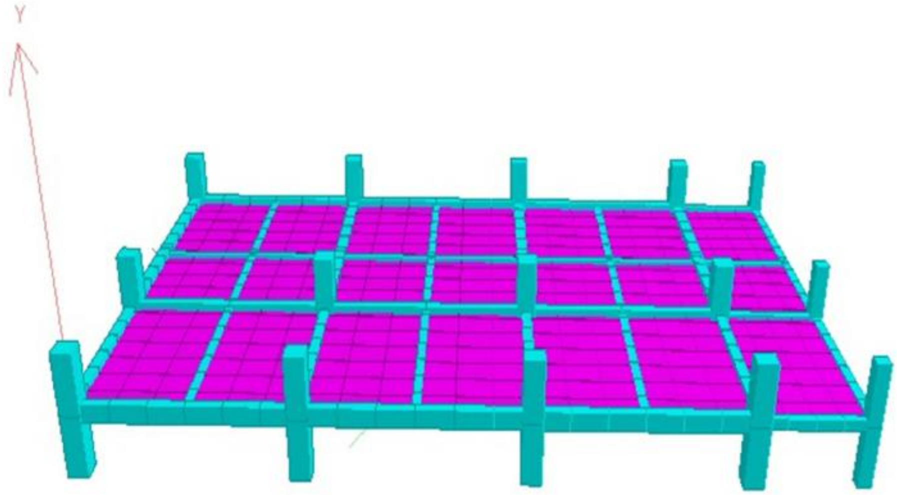
Gambar 3.14 Output pusat massa lantai 6



Gambar 3.15 Pemodelan 3 dimensi pusat massa lantai 7

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      6.9647   Y =      0.0000   Z =     11.2235

     TOTAL SELF WEIGHT =          193562.5469 (KG   UNIT)

419. FINISH
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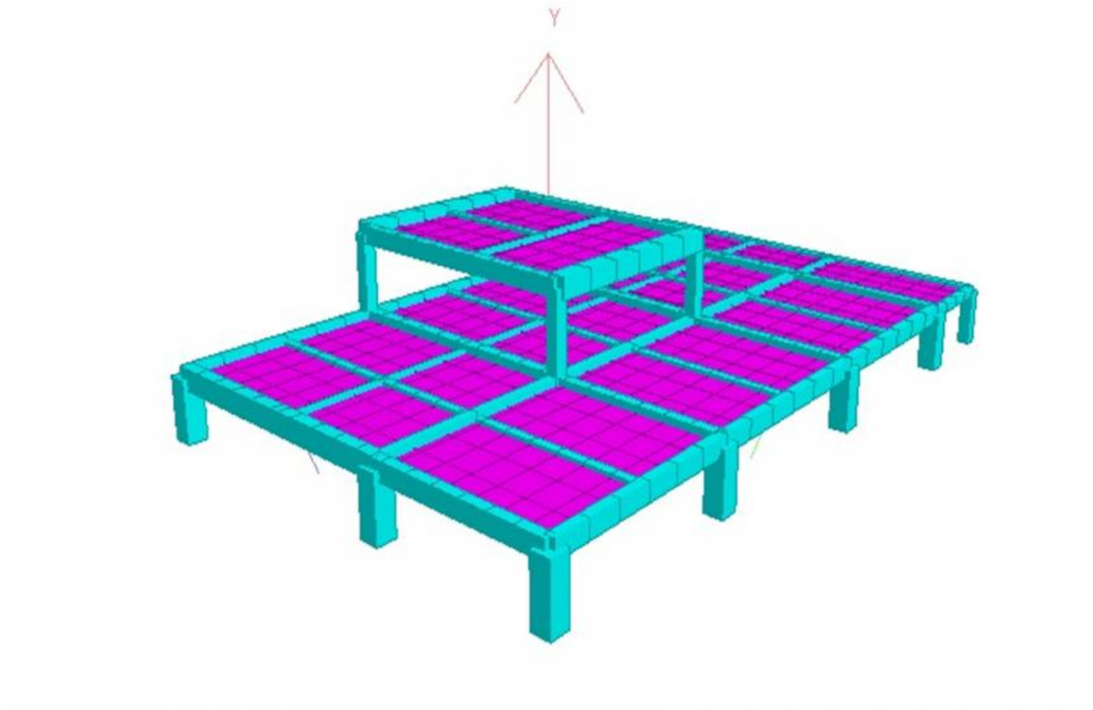
          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUN 23,2015   TIME= 11: 2: 6 ****
```

Gambar 3.16 Output pusat massa lantai 7



Gambar 3.17 Pemodelan 3 dimensi pusat massa lantai atap

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =      7.5054   Y =      0.3340   Z =      10.9917

     TOTAL SELF WEIGHT =            210689.3594 (KG   UNIT)

443. FINISH
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          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUN 23,2015   TIME= 11: 3:15 ****
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Gambar 3.18 Output pusat massa lantai atap

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

        X =        9.6491    Y =       -0.2250    Z =       18.2231

      TOTAL SELF WEIGHT =          122370.2188 (KG   UNIT)

  60. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

           **** DATE= JUL  8,2015   TIME= 20:48:46 ****

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      ************************************************************
      *  For technical assistance on STAAD.Pro, please visit     *
      *  http://selectservices.bentley.com/en-US/                *
      *                                                          *
      *  Details about additional assistance from                *
      *  Bentley and Partners can be found at program menu       *
      *  Help->Technical Support                                 *
      *                                                          *
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      *              http://www.bentley.com                      *
      ************************************************************
```

Gambar 3.19 Output pusat kekakuan lantai 1

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

        X =        9.6500    Y =       -0.2500    Z =       16.6250

      TOTAL SELF WEIGHT =           95143.7578 (KG   UNIT)

  56. FINISH
--------------------------------< PAGE 13 Ends Here >---------------------------
  STAAD SPACE                                             -- PAGE NO.   14


          *********** END OF THE STAAD.Pro RUN ***********

           **** DATE= JUL  8,2015   TIME= 20:51:41 ****

      ************************************************************
      *  For technical assistance on STAAD.Pro, please visit     *
      *  http://selectservices.bentley.com/en-US/                *
      *                                                          *
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      *  Help->Technical Support                                 *
      *                                                          *
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      *              http://www.bentley.com                      *
      ************************************************************
```

Gambar 3.20 Output pusat kekakuan lantai 2

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

       X =       9.6500   Y =     -0.2750   Z =      16.6250

       TOTAL SELF WEIGHT =           75163.5703 (KG   UNIT)

  55. FINISH
--------------------------------< PAGE 13 Ends Here >----------------------------
  STAAD SPACE                                            -- PAGE NO.   14


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUL  8,2015   TIME= 20:54:20 ****

      ************************************************************
      *    For technical assistance on STAAD.Pro, please visit    *
      *    http://selectservices.bentley.com/en-US/               *
      *                                                           *
      *    Details about additional assistance from               *
      *    Bentley and Partners can be found at program menu      *
      *    Help->Technical Support                                *
      *                                                           *
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      *                 http://www.bentley.com                    *
      ************************************************************
```

Gambar 3.21 Output pusat kekakuan lantai 3

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

       X =       6.5500   Y =      0.0000   Z =      16.6250

       TOTAL SELF WEIGHT =           52934.5156 (KG   UNIT)

  46. FINISH

          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUL  8,2015   TIME= 20:56:11 ****

--------------------------------< PAGE 11 Ends Here >----------------------------
  STAAD SPACE                                            -- PAGE NO.   12

      ************************************************************
      *    For technical assistance on STAAD.Pro, please visit    *
      *    http://selectservices.bentley.com/en-US/               *
      *                                                           *
      *    Details about additional assistance from               *
      *    Bentley and Partners can be found at program menu      *
      *    Help->Technical Support                                *
      *                                                           *
      *       Copyright (c) 1997-2014 Bentley Systems, Inc.
      *                 http://www.bentley.com                    *
      ************************************************************
```

Gambar 3.18 Output pusat kekakuan lantai 4

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

      X =       6.5500   Y =       0.0000   Z =      16.6250

      TOTAL SELF WEIGHT =            52934.5156 (KG   UNIT)

 46. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUL  8,2015   TIME= 20:58:47 ****

-----------------------------< PAGE 11 Ends Here >---------------------------
 STAAD SPACE                                              -- PAGE NO.   12

      ************************************************************
      *   For technical assistance on STAAD.Pro, please visit    *
      *   http://selectservices.bentley.com/en-US/               *
      *                                                          *
      *   Details about additional assistance from               *
      *   Bentley and Partners can be found at program menu      *
      *   Help->Technical Support                                *
      *                                                          *
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      *               http://www.bentley.com                     *
      ************************************************************
```

Gambar 3.22 Output pusat kekakuan lantai 5

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

      X =       7.2375   Y =       0.0000   Z =      16.6250

      TOTAL SELF WEIGHT =            70579.3594 (KG   UNIT)

 51. FINISH
-----------------------------< PAGE 13 Ends Here >---------------------------
 STAAD SPACE                                              -- PAGE NO.   14


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUL  8,2015   TIME= 21: 0:15 ****

      ************************************************************
      *   For technical assistance on STAAD.Pro, please visit    *
      *   http://selectservices.bentley.com/en-US/               *
      *                                                          *
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      *   Help->Technical Support                                *
      *                                                          *
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      ************************************************************
```

Gambar 3.23 Output pusat kekakuan lantai 6

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =       6.5500   Y =       0.0000   Z =     11.1875

     TOTAL SELF WEIGHT =            39210.7539 (KG   UNIT)

  44. FINISH
-------------------------------< PAGE 9 Ends Here >---------------------------
  STAAD SPACE                                             -- PAGE NO.   10


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUL  8,2015   TIME= 21: 1:45 ****

     ************************************************************
     *   For technical assistance on STAAD.Pro, please visit    *
     *   http://selectservices.bentley.com/en-US/               *
     *                                                          *
     *   Details about additional assistance from               *
     *   Bentley and Partners can be found at program menu      *
     *   Help->Technical Support                                *
     *                                                          *
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     ************************************************************
```

Gambar 3.24 Output pusat kekakuan lantai 7

```
CENTER OF GRAVITY OF THE STRUCTURE IS LOCATED AT: (METE UNIT)

     X =       7.0869   Y =      -0.5057   Z =     10.9723

     TOTAL SELF WEIGHT =            23449.5684 (KG   UNIT)

  40. FINISH
-------------------------------< PAGE 9 Ends Here >---------------------------
  STAAD SPACE                                             -- PAGE NO.   10


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= JUL  8,2015   TIME= 21: 3:25 ****

     ************************************************************
     *   For technical assistance on STAAD.Pro, please visit    *
     *   http://selectservices.bentley.com/en-US/               *
     *                                                          *
     *   Details about additional assistance from               *
     *   Bentley and Partners can be found at program menu      *
     *   Help->Technical Support                                *
     *                                                          *
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     ************************************************************
```

Gambar 3.25 Output pusat kekakuan lantai Atap

3.12 Eksentrisitas Struktur

Tabel 3.6 Selisis Pusat Massa Dan Pusat Kekakuan Pada Masing-masing Lantai

lantai	Koordinat Sumbu X		Koordinat Sumbu Z		Selisih	
	CR	CG	CR	CG	Sumbu X	Sumbu Z
1	9,6491	9,3373	18,2231	18,8432	0,3118	0,6201
2	9,6500	9,3246	16,6250	16,9224	0,3254	0,2974
3	9,6500	9,2984	16,6250	17,7661	0,3516	1,1411
4	6,5500	7,5054	16,6250	10,9917	0,9554	5,633
5	6,5500	6,9652	16,6250	17,8783	0,4152	1,2533
6	7,2375	7,0954	16,6250	17,8085	0,1421	1,1835
7	6,5500	6,9647	11,1875	11,2235	0,4147	0,036
Atap	7,0869	7,5054	10,9723	10,9917	0,4185	0,0194

- **Lantai 1**

e arah x = 0,3118

0,3b = 0.3 x 8,35

= 2,505

$0 < e \leq 0,3b$:

e_d = 1,5e + 0,05b

= 0,4677 + 0,4175

= 0,8852

e_d = e - 0,05b

= 0,3118 - 0,4175

= -0,1057

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 0,8852 m

e arah z = 0,6201

0,3b = 0.3 x 7,75

= 4,806

$0 < e \leq 0,3b$:

e_d = 1,5e + 0,05b

= 0,415 + 0,3875

$= 0{,}8025$

$e_d = e - 0{,}05b$

$= 0{,}3118 + 0{,}4175$

$= 0{,}7293$

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 0,7293 m

- **Lantai 2**

e arah x = 0,3254

0,3b = 0.3 x 8,35

= 2,505

$0 < e \leq 0{,}3b$:

$e_d = 1{,}5e + 0{,}05b$

$= 0{,}4881 + 0{,}4175$

$= 0{,}9056$

$e_d = e - 0{,}05b$

$= 0{,}3254 - 0{,}4175$

$= -0{,}0921$

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 0,9056 m

e arah z = 0,2974

0,3b = 0.3 x 7,75

= 4,806

$0 < e \leq 0{,}3b$:

$e_d = 1{,}5e + 0{,}05b$

$= 0{,}4461 + 0{,}3875$

$= 0{,}8336$

$e_d = e - 0{,}05b$

$= 0{,}2974 - 0{,}3875$

$= -0.09$

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 0,8336 m

- **Lantai 3**

e arah x = 0,3516

0,3b = 0.3 x 8,35

$= 2,505$

$0 < e \leq 0,3b$:

$e_d = 1,5e + 0,05b$

$= 0,4881 + 0,4175$

$= 0,9056$

$e_d = e - 0,05b$

$= 0,3254 - 0,4175$

$= -0,0921$

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 0,9056 m

e arah z $= 1,1411$

$0,3b = 0.3 \times 7,75$

$= 4,806$

$0 < e \leq 0,3b$:

$e_d = 1,5e + 0,05b$

$= 0,4461 + 0,3875$

$= 0,8336$

$e_d = e - 0,05b$

$= 0,2974 - 0,3875$

$= -0.09$

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 0,8336 m

- **Lantai 4**

e arah x $= 0,9554$

$0,3b = 0.3 \times 8,35$

$= 2,505$

$0 < e \leq 0,3b$:

$e_d = 1,5e + 0,05b$

$= 1,4331 + 0,4175$

$= 1,8506$

$e_d = e - 0,05b$

$= 0,9554 - 0,4175$

$= -0,5379$

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 1,8506 m

e arah z = 5,633

0,3b = 0.3 x 7,75

= 4,806

$0 < e \leq 0,3b$:

e_d = 1,5e + 0,05b

= 8,4495 + 0,3875

= 8,837

e_d = e - 0,05b

= 5,633 - 0,3875

= 5,2755

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 0,2755 m

- **Lantai 5**

e arah x = 0,4152

0,3b = 0.3 x 8,35

= 2,505

$0 < e \leq 0,3b$:

e_d = 1,5e + 0,05b

= 0,7128 + 0,4175

= 1,1303

e_d = e - 0,05b

= 0,4152 - 0,4175

= 0,0577

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 1,1303 m

e arah z = 1,2533

0,3b = 0.3 x 7,75

= 4,806

$0 < e \leq 0,3b$:

e_d = 1,5e + 0,05b

= 1,88 + 0,3875

= 2,2675

e_d = e - 0,05b

= 1,2533 - 0,3875

= 0,8658

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 2,2675 m

- **Lantai 6**

e arah x = 0,1421

0,3b = 0.3 x 8,35

= 2,505

$0 < e \leq 0{,}3b$:

e_d = 1,5e + 0,05b

= 0,2132 + 0,4175

= 0,631

e_d = e - 0,05b

= 0,1421 - 0,4175

= -0,2754

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 0,631 m

e arah z = 1,1835

0,3b = 0.3 x 7,75

= 4,806

$0 < e \leq 0{,}3b$:

e_d = 1,5e + 0,05b

= 1,775 + 0,3875

= 2,1628

e_d = e - 0,05b

= 1,1835 - 0,3875

= 0,796

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 2,1628 m

- **Lantai 7**

e arah x = 0,4147

0,3b = 0.3 x 8,35

= 2,505

$0 < e \leq 0{,}3b$:

e_d = 1,5e + 0,05b

= 0,622 + 0,4175

= 1,04

e_d = e - 0,05b

= 0,4147 - 0,4175

= -0,0028

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 1,04 m

e arah z = 0,036

0,3b = 0.3 x 7,75

= 4,806

$0 < e \leq 0{,}3b$:

e_d = 1,5e + 0,05b

= 0,054 + 0,3875

= 0,4415

e_d = e - 0,05b

= 0,036 - 0,3875

= -0,3515

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 0,4415 m

- **Lantai Atap**

e arah x = 0,4185

0,3b = 0.3 x 8,35

= 2,505

$0 < e \leq 0{,}3b$:

e_d = 1,5e + 0,05b

= 0,628 + 0,4175

= 1,0455

e_d = e - 0,05b

= 0,4185 - 0,4175

= 0,001

Dari hasil perhitungan dipakai nilai e_d arah x terbesar yaitu 1,0455 m e arah z = 0,0194

0,3b = 0.3 x 7,75

= 4,806

$0 < e \leq 0{,}3b$:

e_d = 1,5e + 0,05b

= 0,0291 + 0,3875

= 0,4166

e_d = e - 0,05b

= 0,0194 - 0,3875

= -0.3681

Dari hasil perhitungan dipakai nilai e_d arah z terbesar yaitu 0,4166 m

3.13 Simpangan Antarlantai (*Story Drift*) Δα

Berdasarkan SNI 1726-2012, simpangan antarlantai hanya ada kondisi kinerja batas ultimit saja.

Perhitungan simpangan antarlantai (*story drift*) kinerja batas ultimit pada lantai 7 :

- ✓ Nilai perpindahan elastis (*total drift*) dari STAAD Pro yang di hitung akibat gaya gempa pada lantai 7, yaitu 6.983 mm. jadi nilai δ_{e7} = 6.983 mm
- ✓ Nilai perpindahan elastis (*total drift*) dari STAAD Pro yang di hitung akibat gaya gempa pada lantai 6, yaitu 6.124 mm. jadi nilai δ_{e6} = 6.124 mm
- ✓ Hitung simpangan atau perpindahan antar lantai untuk lantai 7 yaitu dengan persamaan : (δ_{e7} - δ_{e6}) = 6.983 - 6.124 = 0.859 mm
- ✓ Hitung nilai perpindahan antar lantai (*story drift)* yang di perbesar, yaitu :

$$\frac{(\delta_{e7} - \delta_{e6})C_d}{I_e} = 4.7245$$

Story drift Δα antar lantai tidak boleh lebih besar dari :

Δα = 0,020 h_{sx} …………..SNI 1726-2012 pasal 7.12.1

Untuk lantai 1 dimana h = 5,5 m, maka :

Δα = 0.020 x 5,5 = 0,11 = 110 mm

Untuk lanai 2 dimana h = 4,5 m, maka :

$\Delta\alpha$ = 0.020 x 4,5 = 0,09 = 90 mm

Untuk lanai 3,4,5,6,7 dimana h = 3,4 m, maka :

$\Delta\alpha$ = 0.020 x 3,4 = 0,068 = 68 mm

- ✓ Cek nilai simpangan antarlantai (*story drift)* pada lantai 7, yaitu
  4.7245 mm < 68 OK

Tabel 3.7 Hasil perhitungan simpangan antarlantai (*story drift)*

lantai	Total drift	Perpindahan	Story drift	Story drift izin	Story drift < $\Delta\alpha$
	(mm)	(mm)	(mm)	$\Delta\alpha$	
Atap	7.257	0,274	1,507	68	OK
7	6.983	0.859	4.725	68	OK
6	6.124	0.575	3,163	68	OK
5	5.549	0.678	3,729	68	OK
4	4.871	0.763	4,197	68	OK
3	4.108	1.424	7,832	68	OK
2	2.684	2.17	11,935	90	OK
1	0.514	0.514	2,827	110	OK

STORY	HEIGHT	LOAD	DRIFT(CM)		ECCENTRICITY	RATIO
	(METE)		X	Z	(METE)	
BASE=	-3.20					
1	0.00	1	-0.0092	0.0004	0.0000	L / 34771
		2	-0.0021	0.0007	0.0000	L /152169
		3	0.0514	0.0129	0.0000	L / 6228
		4	-0.0129	0.0006	0.0000	L / 24836
		5	-0.0144	0.0016	0.0000	L / 22209
		6	0.0382	0.0141	0.0000	L / 8369
		7	0.0431	0.0133	0.0000	L / 7425
2	5.50	1	-0.0751	0.0101	0.0000	L / 11578
		2	-0.0157	0.0055	0.0000	L / 55541
		3	0.2684	0.0609	0.0000	L / 3241
		4	-0.1052	0.0141	0.0000	L / 8270
		5	-0.1152	0.0209	0.0000	L / 7550
		6	0.1626	0.0785	0.0000	L / 5352
		7	0.2008	0.0700	0.0000	L / 4333
3	10.00	1	-0.1689	0.0265	0.0000	L / 7816
		2	-0.0342	0.0128	0.0000	L / 38638
		3	0.4108	0.0828	0.0000	L / 3213

		4	-0.2364	0.0371	0.0000	L / 5583
		5	-0.2573	0.0524	0.0000	L / 5130
		6	0.1739	0.1275	0.0000	L / 7589
		7	0.2588	0.1067	0.0000	L / 5101
4	13.40	1	-0.1995	0.0484	0.0000	L / 8319
		2	-0.0381	0.0222	0.0000	L / 43620
		3	0.4871	0.0866	0.0000	L / 3408
		4	-0.2793	0.0677	0.0000	L / 5942
		5	-0.3003	0.0935	0.0000	L / 5527
		6	0.2096	0.1668	0.0000	L / 7921
		7	0.3075	0.1301	0.0000	L / 5398
5	16.80	1	-0.2020	0.0734	0.0000	L / 9902
		2	-0.0360	0.0326	0.0000	L / 55555
		3	0.5549	0.0976	0.0000	L / 3604
		4	-0.2828	0.1028	0.0000	L / 7073
		5	-0.3000	0.1403	0.0000	L / 6667
		6	0.2766	0.2183	0.0000	L / 7231
		7	0.3732	0.1637	0.0000	L / 5359
6	20.20	1	-0.1966	0.1032	0.0000	L / 11899
		2	-0.0322	0.0437	0.0000	L / 53544
		3	0.6124	0.1122	0.0000	L / 3821
		4	-0.2753	0.1445	0.0000	L / 8499
		5	-0.2875	0.1938	0.0000	L / 8138
		6	0.3442	0.2798	0.0000	L / 6798
		7	0.4354	0.2051	0.0000	L / 5374
7	23.60	1	-0.1810	0.2227	0.0000	L / 12033

		2	-0.0248	0.0690	0.0000	L / 38850
		3	0.6983	0.1232	0.0000	L / 3838

--------------------------------< PAGE 82 Ends Here >---------------------------

STAAD SPACE -- PAGE NO. 83

STORY	HEIGHT	LOAD	DRIFT(CM)		ECCENTRICITY	RATIO
	(METE)		X	Z	(METE)	
BASE=	-3.20					
		4	-0.2534	0.3118	0.0000	L / 8595
		5	-0.2569	0.3776	0.0000	L / 7097
		6	0.4562	0.4595	0.0000	L / 5833
		7	0.5353	0.3237	0.0000	L / 5006
8	26.10	1	-0.2194	0.2589	0.0000	L / 11318
		2	-0.0375	0.0784	0.0000	L / 37391
		3	0.7257	0.1219	0.0000	L / 4037
		4	-0.3072	0.3624	0.0000	L / 8085
		5	-0.3233	0.4360	0.0000	L / 6720
		6	0.4249	0.5109	0.0000	L / 5734
		7	0.5282	0.3549	0.0000	L / 5547

4321. FINISH

3.14 Kombinasi Pembebanan

Sesuai dengan ketentuan yang tertera dalam SNI 2847-2013 pasal 9 disebutkan agar struktur dan komponen struktur harus direncanakan hingga semua penampang mempunyai kuat rencana minimum sama dengan kuat perlu, yang dihitung bersadarkan kombinasi dan gaya terfaktor.

- U = 1,4 D
- U = 1,2D + 1,6L + 0,5 (Lr atau R)
- U = 1,2D + 1,6 (Lr atau R) + (1,0L atau W)
- U = 1,2D + 1,0W + 1,0L + 0,5 (Lr atau R)
- U = 1,2D + 1,0E + 1,0L
- U = 0,9D + 1,0W
- U = 0,9D + 1,0E

BAB IV

PERHITUNGAN PENULANGAN STRUKTUR

4.1 Perhitungan Penulangan Balok

4.1.1 Perhitungan Penulangan Lentur Balok

Penulangan yang direncanakan adalah pada balok melintang line 4 lantai 4 dengan balok no 301,3977,3985,3993,4001,4009

- Data Perencanaan

  b = 300 mm

  h = 500 mm

  f'c = 24.9 MPa

  fy_{ulir} = 400 MPa

  fy_{polos} = 240 MPa

  selimut beton 40 mm

  dipakai tulangan pokok D 19 mm

  dipakai tulangan sengkang Ø 10 mm

  bentang balok L = 5650 mm

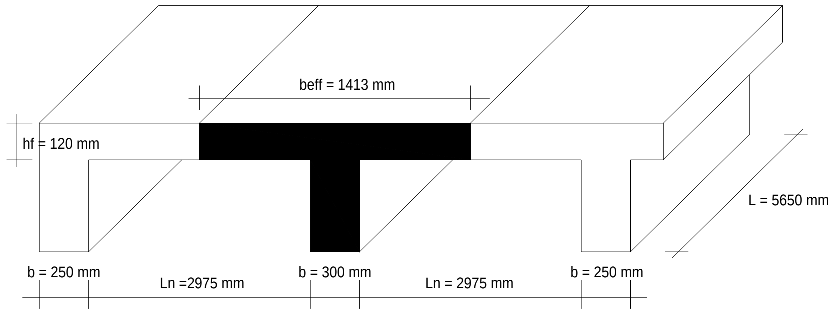
  bentang bersih balok (Ln) = 5050 mm

  d = h - selimut beton - diameter sengkang - ½ diameter tulangan rencana

  = 500 - 40 - 10 - ½ 19

  = 440.5 mm

- Perencanaan Penulangan



Gambar 4.1 Lebar efektif balok *(b $_{eff}$)*

Lebar flens efektif (beff)

- beff = ¼ L = ¼ x 5650 = 1413 mm
- beff = bw + 8 hf_{kr} + 8 hf_{kn} = 300+(8.120)+(8.120) = 2220 mm
- beff = bw + ½Ln_{kr} + ½Ln_{kn} = 300+(½.3225)+(½.3225) = 3275 mm

dipakai nilai beff terkecil yaitu = 1413 mm

Tulangan minimal sedikitnya harus dihitung menurut SNI 2847-2013

Pasal 10.5.1 :

$$A_{s\ min} = \frac{0.25}{fy}\sqrt{fc'}\ bw\ d = \frac{0.25 \quad x\sqrt{24,9}}{400}\ 300 \quad x \quad 441 \quad = \quad 412.1 \quad mm^2$$

dan

$$A_{s\ min} = \frac{1.4 \quad bw\ d}{fy} = \frac{1.4 \quad x \quad 300 \quad x \quad 441}{400} = \quad 462.53 \quad mm^2$$

Maka dipakai tulangan minima 2 D 19 (As = 566.77 mm^2 > 462.53 mm^2)

A. Perhitungan penulangan tumpuan kiri joint 138

Mu^{-} = 160.813 kNm

= 160813000 Nmm

Mu^{+} = 31.676 kNm

= 31676000 Nmm

Dicoba pemasangan tulangan sebagai berikut :

- Tulangan yang terpasang pada daerah tarik 4 D 19 (As = 1133.54 mm^2)
- Tulangan yang terpasang pada daerah tekan 3 D 19 (As' = 850.16 mm^2)
- Tulangan bagi plat terpasang di sepanjang beff 6 Ø 10 (As= 471.00 mm^2)

<u>Analisa Momen Negatif</u>

Tulangan tarik As_{plat} = 6 Ø 10 = 471.00 mm^2

As_{balok} = 4 D 19 = 1133.54 mm^2

Tulangan tekan As' = 3 D 19 = 850.16 mm^2

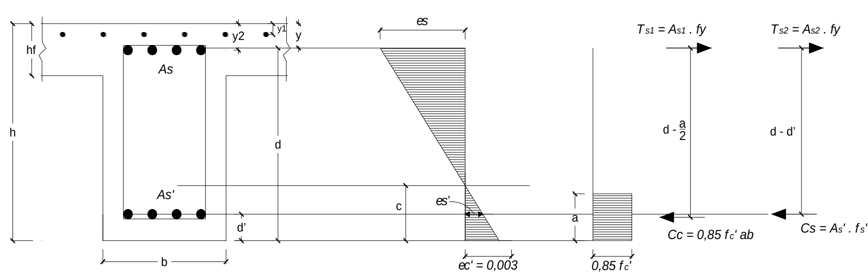
y1 = 20 + 1/2 10 = 25 mm

y2 = 40 + 10 + 1/2 19 = 59.5 mm

$$y = \frac{471 \times 25 + 1133.54 \times 59.5}{1604.54} = 49.373 \text{ mm}$$

d = 500 - 49.373 = 450.627 mm

d' = 40 + 10 + 1/2 19 = 59.5 mm



Gambar 4.2 Penampang balok dan diagram tegangan momen negatif tumpuan kiri

Dimisalkan garis netral > d' maka perhitungan garis netral harus dicari menggunakan persamaan :

0,85 . f'c . a . b + As' . fs' = As . fy

Substitusi nilai : fs' = $\frac{(c - d')}{c}$ x 600

$$(0{,}85 \cdot f'c \cdot a \cdot b) + As' \frac{(c - d')}{c} \times 600 = As_{plat} \cdot fy_{polos} + As_{balok} \cdot fy_{ulir}$$

(0,85.f'c'.a.b).c + As'(c-d').600 = $As_{plat}.fy_{polos}.c + As_{balok}.fy_{ulir}.c$

Substitusi nilai : a = β1.c

(0,85.f'c'.β1.c .b).c + As'(c-d').600 = $As_{plat}.fy_{polos}.c + As_{balok}.fy_{ulir}.c$

(0,85.f'c'.β1.b).c^2 + 600As'.c - 600As'.d' = $As_{plat}.fy_{polos}.c + As_{balok}.fy_{ulir}.c$

(0,85.f'c.β1.b)c^2 + 600As'.c - 600As'.d' - $As_{plat}.fy_{polos}.c - As_{balok}.fy_{ulir}.c = 0$

(0,85.f'c.β1.b)c^2 + (600As' - $As_{plat}.fy_{polos}$ - As_{balok}.fyulir).c - 600As'.d' = 0

(0,85.24,9.0,85.300)c^2+(600.850,16`-471.240-1133,54.400).c-600.850,16.59,5 = 0

5397.08 c^2 - 56363 c - 30350534 = 0

c = 80.393 mm

a = β. c

= 0.85 x 80.393 = 68.334 mm

$$\varepsilon s' = \frac{c - d'}{c} \times \varepsilon c = \frac{80.393 - 59.5}{80.393} \times 0.003 = 0.00078$$

$$\varepsilon s = \frac{d - c}{c} \times \varepsilon c = \frac{450.627 - 80.393}{80.393} \times 0.003 = 0.01382$$

$$\varepsilon y = \frac{fy}{Es} = \frac{400}{200000} = 0.0020$$

Karena εs > εy > εs' maka tulangan baja tarik telah leleh,baja tekan belum

Dihitung tegangan pada tulangan baja tekan

$f's = \varepsilon s' \times Es$

$= 0.00078 \times 200000$

$= 155.933 < 400$ MPa

Menghitung gaya tekan dan tarik

$Cc = 0,85 \cdot f'c \cdot a \cdot b$

$= 0.85 \times 24.9 \times 68.334 \times 300$

$= 433888.452$ N

$Cs = As' \times f's$

$= 850.16 \times 155.933$

$= 132567.153$ N

$Ts_1 = As_{plat} \times fy_{polos}$

$= 471 \times 240$

$= 113040$ N

$Ts_2 = As_{balok} \times fy_{ulir}$

$= 1133.54 \times 400$

$= 453416.0$ N

$Cc + Cs = Ts_1 + Ts_2$

$433888.452 + 132567.153 = 113040 + 453416.0$

$566456 = 566456$

$Z1 = d - (½ \cdot a)$

$= 450.627 - (1/2 \cdot 68.334)$

$= 416.460$ mm

$Z2 = d - d'$

$= 450.627 - 59.5$

$= 391.127$ mm

Mn = (ND1 . Z1) + (ND2 . Z2)

= 433888.452 x 416.460 + 132567.153 x 391.127

= 232547832.864 Nmm

Mr = ϕ Mn

= 0.9 . 232547832.864

= 209293049.578 Nmm > Mu = 160813000 Nmm Aman

Mpr = 1.25 . Mn

= 1.25 . 232547832.864

= 290684791.080 Nmm

Kontrol Momen Positif

Tulangan tekan As'_{plat} = 6 Ø 10 = 471.00 mm^2

As'_{balok} = 4 D 19 = 1133.54 mm^2

As' = 471.00 + 1133.54 = 1604.54 mm^2

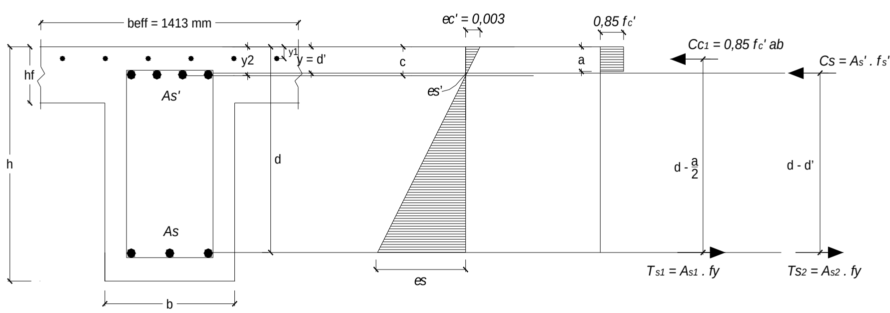
Tulangan tarik As = 3 D 19 = 850.16 mm^2

y1 = 20 + 1/2 10 = 25 mm

y2 = 40 + 10 + 1/2 19 = 59.5 mm

$$y = d' = \frac{471 \times 25 + 1133.54 \times 59.5}{1604.54} = 49.373 \text{ mm}$$

d = 500 - 59.5 = 440.5 mm



Gambar 4.3 Penampang balok dan diagram tegangan momen positif tumpuan kiri

Dimisalkan garis netral > y2 maka perhitungan garis netral harus dicari menggunakan persamaan :

$$0{,}85 \cdot f'c \cdot a \cdot b + As' \cdot fs' = As \cdot fy$$

Substitusi nilai : $fs' = \dfrac{(c - d')}{c} \times 600$

$$(0{,}85 \cdot f'c \cdot a \cdot b) + As' \, \frac{(c - d')}{c} \times 600 = As \cdot fy$$

$$(0{,}85 \cdot f'c \cdot a \cdot b) \cdot c + As' \, (c - d') \times 600 = As \cdot fy \cdot c$$

Substitusi nilai : $a = \beta 1.c$

$$(0{,}85 \cdot f'c \cdot \beta 1.c \cdot b) \cdot c + As' \, (c - d') \, 600 = As \cdot fy \cdot c$$

$$(0{,}85.f'c.\beta 1.b) \, c^2 + 600As'.c - 600As'.d' = As \cdot fy \cdot c$$

$$(0{,}85.f'c.\beta 1.b) \, c^2 + 600As'.c - 600As'.d' - As. \, fy \cdot c = 0$$

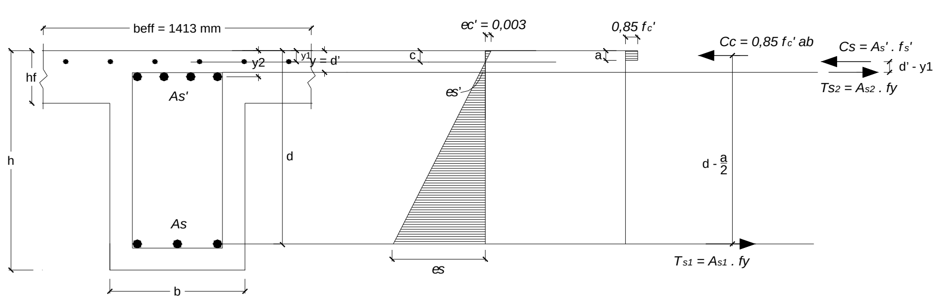
$$(0{,}85.f'c.\beta 1.b) \, c^2 + (600As' - As \cdot fy).c - 600As'.d' = 0$$

$$(0{,}85.24{,}9.0{,}85.300)c^2 + (600.1604{,}54-850{,}16.400).c - 600.1604{,}54.49{,}373 = 0$$

$$5397.08 \; c^2 + 622662.0 \; c - 47532378 = 0$$

$$c = 52.472 \text{ mm}$$

Karena c < y2, tulangan tekan sebagian mengalami gaya tarik maka nilai c harus dihitung ulang.



Gambar 4.4 Penampang balok dan diagram tegangan momen positif tumpuan kiri yang sudah dihitung ulang

Dimisalkan garis netral diantara y1 dan y2 maka perhitungan garis netral dica

dengan menggunakan persamaan :

$0{,}85 \cdot f'c \cdot a \cdot beff + As_{plat}' \cdot fs' = As1 \cdot fs + As2 \cdot fy_{ulir}$

Substitusi nilai : $fs' = \dfrac{(c - y_1)}{c} \times 600$ dan $fs = fy_{ulir}$

$$(0{,}85.f'c.a.beff) + As_{plat}' \frac{(c - y_1)}{c} \times 600 = As1 \cdot fy_{ulir} + As2 \cdot fy_{ulir}$$

$(0{,}85.f'c.a.beff).c + As_{plat}'.(c-y_1).600 = As1 \cdot fy_{ulir}.c + As2 \cdot fy_{ulir} \cdot c$

Substitusi nilai : $a = \beta 1.c$

$(0{,}85.f'c.\beta 1.c.beff).c + As_{plat}'.(c-y_1).600 = As1 \cdot fy_{ulir}.c + As2 \cdot fy_{ulir} \cdot c$

$(0{,}85.f'c.\beta 1.beff).c^2 + 600.As_{plat}'.c - 600.As_{plat}'.y_1 = As1 \cdot fy_{ulir}.c +$

$As2 \cdot fy_{ulir} \cdot c$

$(0{,}85.f'c.\beta 1.beff).c^2 + (600.As_{plat}' - As1.fy_{ulir} - As2.fy_{ulir}).c -$

$600.As_{plat}'.y1 = 0$

$(0{,}85.24{,}9.0{,}85.1413).c^2 + (600.471 - 1133{,}54.400 - 850{,}16.400).c -$

$600.471.25 = 0$

$25411.23 \ c^2 - 510878.000 - 7065000 = 0$

$c = 29.522$ mm

$a = \beta . c$

$= 0.85 \times 29.522 = 25.094$ mm

$fs' = \varepsilon s' . Es$

$= \dfrac{c - y_1}{c} . \varepsilon c . Es$

$= \dfrac{29.522 - 25}{29.522} \times 0.003 \times 200000 = 91.905$ MPa

$fs = fy_{ulir} = 400$ MPa

Menghitung gaya tekan dan tarik

$Cc = 0{,}85 \, . \, f'c \, . \, a \, . \, beff$

$= 0.85 \times 24.9 \times 25.094 \times 1413$

$= 750190.825$ N

$Cs = As' \times f's$

$= 471.00 \times 91.905$

$= 43287.120$ N

$Ts_1 = As1 \times fy$

$= 1133.54 \times 400$

$= 453416.000$ N

$Ts_2 = As1 \times fy$

$= 850.16 \times 400$

$= 340062.000$ N

$Cc + Cs = Ts_1 + Ts_2$

$750190.825 + 43287.120 = 453416.000 + 340062.000$

$793478 = 793478$

$Z1 = d - (1/2 \, . \, a)$

$= 440.5 - (1/2 \, . \, 25.094)$

$= 427.953$ mm

$Z2 = d' - y1$

$= 49.373 - 25$

$= 24.373$ mm

$Mn = (NT1 \, . \, Z1) + (NT2 \, . \, Z2)$

$= 453416.000 \times 427.953 + 340062.000 \times 24.373$

$= 202329063.887$ Nmm

$Mr = \phi \; Mn$

$= 0.9 \; . \; 202329063.887$

$= 182096157.498$ Nmm $>$ $Mu = 31676000$ Nmm Aman

$Mpr = 1.25 \; . \; Mn$

$= 1.25 \; . \; 202329063.887$

$= 252911329.859$ Nmm

Syarat kuat momen yang terpasag menurut SNI 2847-2013 pasal 21.5.2.2 :

$Mn^{+} \geq ½ \; Mn^{-}$

202329063.887 Nmm $\geq ½ \; . \; 232547832.864$ Nmm

202329063.887 Nmm ≥ 116273916.432 Nmm

B. Perhitungan penulangan lapangan

$Mu^{+} = 71.639$ kNm

$= 71639000$ Nmm

Dicoba pemasangan tulangan sebagai berikut :

- Tulangan yang terpasang pada daerah tarik 4 D 19 ($As = 1133.54 \; mm^2$)
- Tulangan yang terpasang pada daerah tekar 3 D 19 ($As' = 850.16 \; mm^2$)
- Tulangan bagi plat terpasang di sepanjang befl 6 Ø 10 ($As_{plat} = 471.00 \; mm^2$)

<u>Analisa Momen Positif</u>

Tulangan tekan As'_{plat} = 6 Ø 10 = $471.00 \; mm^2$

As'_{balok} = 3 D 19 = $850.16 \; mm^2$

$As' = 471.00 + 850.16 = 1321.16 \; mm^2$

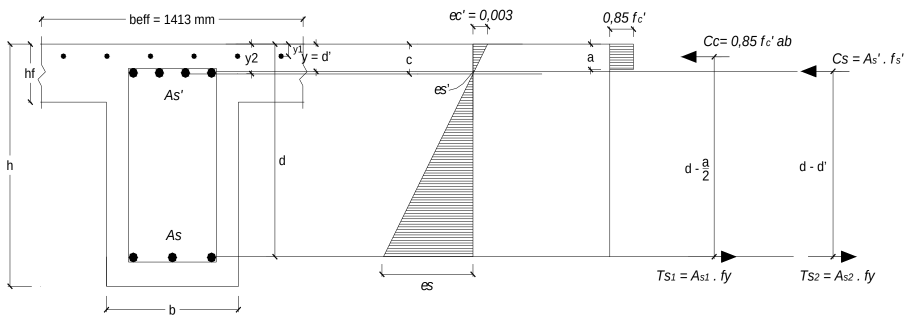
Tulangan tarik As = 4 D 19 = $1133.54 \; mm^2$

$y1 = 20 + 1/2 \; 10 = 25$ mm

$y2 = 40 + 10 + 1/2 \; 19 = 59.5$ mm

$$y = d' = \frac{471 \quad x \quad 25 \quad + \quad 850.16 \quad x \quad 59.5}{1321.16} = 47.201 \quad mm$$

$$d = 500 - 59.5 = 440.5 \quad mm$$



Gambar 4.6 Penampang balok dan diagram tegangan momen positif lapangan

Dimisalkan garis netral > y2 maka perhitungan garis netral harus dicari menggunakan persamaan :

0,85 . f'c . a . b + As' . fs' = As . fy

Substitusi nilai : $fs' = \frac{(c - d')}{c} \text{ x } 600$

$$(0{,}85 . f'c . a . b) + As' \frac{(c - d')}{c} \text{ x } 600 = As . fy$$

$$(0{,}85 . f'c . a . b) . c + As' \; (c - d') \text{ x } 600 = As . fy . c$$

Substitusi nilai : $a = \beta 1.c$

$$(0{,}85 . f'c . \beta 1.c . b) . c + As' \; (c - d')\, 600 = As . fy . c$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + 600As'.c - 600As'.d' = As . fy . c$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + 600As'.c - 600As'.d' - As. fy . c = 0$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + (600As' - As . fy).c - 600As'.d' = 0$$

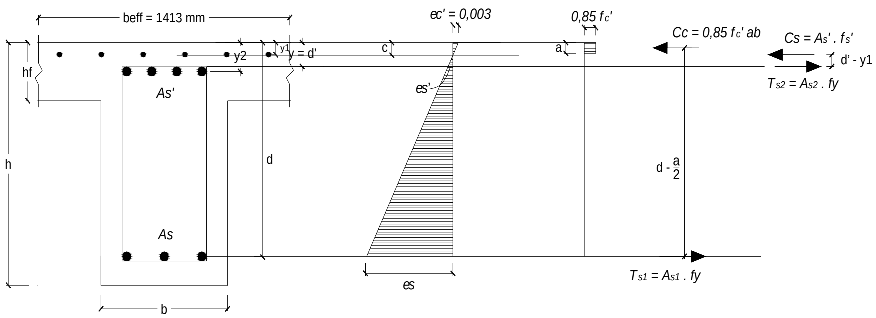
$$(0{,}85.30.0{,}85.300)c^2 + (600.1321{,}16-1133{,}54.400).c -$$

$600.1604,54.49,373 = 0$

$5397.08\ c^2 + 339277.0\ c - 37415533.50 = 0$

$c = 57.566$ mm

Karena c < y2, tulangan tekan sebagian mengalami gaya tarik maka nilai c harus dihitung ulang.



Gambar 4.7 Penampang balok dan diagram tegangan momen positif lapangan yang sudah dihitung ulang

Dimisalkan garis netral diantara y1 dan y2 maka perhitungan garis netral dica dengan menggunakan persamaan :

$0,85 . f'c . a . beff + As_{plat}' . fs' = As1 . fs + As2 . fy_{ulir}$

Substitusi nilai : $fs' = \frac{(c - y_1)}{c} \times 600$ dan $fs = fy_{ulir}$

$$(0,85.f'c.a.beff) + As_{plat}' \frac{(c - y_1)}{c} \times 600 = As1 . fy_{ulir} + As2 . fy_{ulir}$$

$(0,85.f'c.a.beff).c + As_{plat}'.(c-y_1).600 = As1 . fy_{ulir}.c + As2 . fy_{ulir} . c$

Substitusi nilai : $a = \beta 1.c$

$(0,85.f'c.\beta 1.c.beff).c + As_{plat}'.(c-y_1).600 = As1 . fy_{ulir}.c + As2 . fy_{ulir} . c$

$(0,85.f'c.\beta 1.beff).c^2 + 600.As_{plat}'.c - 600.As_{plat}'.y_1 = As1 . fy_{ulir}.c +$
$As2 . fy_{ulir} . c$

$(0{,}85.f'c.\beta 1.beff).c^2 + (600.As_{plat}' - As1.fy_{ulir} - As2.fy_{ulir}).c -$

$600.As_{plat}'.y1 = 0$

$(0{,}85.24{,}9.0{,}85.1413).c^2 + (600.471 - 850{,}16.400 - 1133{,}54.400).c -$

$600.471.25 = 0$

$25411.23 \quad c^2 \quad - \quad 510878.000 \quad - \quad 7065000 \quad = \quad 0$

$c \quad = \quad 29.522 \quad mm$

$a \quad = \beta . c$

$\quad = \quad 0.85 \quad x \quad 29.522 \quad = \quad 25.094 \quad mm$

$fs' \; = \; \varepsilon s' . Es$

$$= \frac{c - y_1}{c} . \varepsilon c . Es$$

$$= \frac{29.522 \quad - \quad 25}{29.522} \quad x \quad 0.003 \quad x \quad 200000 \quad = \quad 91.905 \quad MPa$$

$fs \quad = \; fy_{ulir} \quad = \quad 400 \quad MPa$

Menghitung gaya tekan dan tarik

$Cc \quad = \; 0{,}85 . f'c . a . beff$

$\quad = \quad 0.85 \quad x \quad 24.9 \quad x \quad 25.094 \quad x \quad 1413$

$\quad = \quad 750190.825 \quad N$

$Cs \quad = \quad As' \quad x \quad f's$

$\quad = \quad 471.00 \quad x \quad 91.905$

$\quad = \quad 43287.120 \quad N$

$Ts_1 \quad = \quad As1 \quad x \quad fy$

$\quad = \quad 850.16 \quad x \quad 400$

$\quad = \quad 340062.000 \quad N$

$Ts_2 \quad = \quad As2 \quad x \quad fy$

$\quad = \quad 1133.54 \quad x \quad 400$

$\quad = \quad 453416.000 \quad N$

$Cc + Cs = Ts_1 + Ts_2$

750190.825 + 43287.120 = 340062.000 + 453416.000

793478 = 793478

$Z1 = d - (1/2 . a)$

$= 440.500 - (1/2 . 25.094)$

$= 427.953$ mm

$Z2 = d' - y1$

$= 47.201 - 25$

$= 22.201$ mm

$Mn = (ND1 . Z1) + (ND2 . Z2)$

$= 340062.000 \times 427.953 + 453416.000 \times 22.201$

$= 155596678.648$ Nmm

$Mr = \phi \; Mn$

$= 0.9 . 155596678.648$

$= 140037010.783$ Nmm > Mu = 71639000 Nmm Aman

$Mpr = 1.25 . Mn$

$= 1.25 . 155596678.648$

$= 194495848.310$ Nmm

Syarat kuat momen yang terpasag menurut SNI 2847-2013 pasal 21.5.2.2 :

$Mn^+ \geq ½ \; Mn^-$

155596678.648 Nmm ≥ ½ . 155596678.648 Nmm

155596678.648 Nmm ≥ 77798339.324 Nmm

C. Perhitungan penulangan tumpuan kanan joint 143

Mu^{-} = 113.661 kNm

= 113661000 Nmm

Mu^{+} = 31.721 kNm

= 31721000 Nmm

Dicoba pemasangan tulangan sebagai berikut :

- Tulangan yang terpasang pada daerah tarik 4 D 19 (As = 1133.54 mm^2)
- Tulangan yang terpasang pada daerah tekar 3 D 19 (As' = 850.16 mm^2)
- Tulangan bagi plat terpasang di sepanjang befl 6 Ø 10 (As_{plat} = 471 mm^2)

Analisa Momen Negatif

Tulangan tarik As_{plat} = 6 Ø 10 = 471.00 mm^2

As_{balok} = 4 D 19 = 1133.54 mm^2

As = 471.00 + 1133.54 = 1604.54 mm^2

Tulangan tekan As' = 3 D 19 = 850.16 mm^2

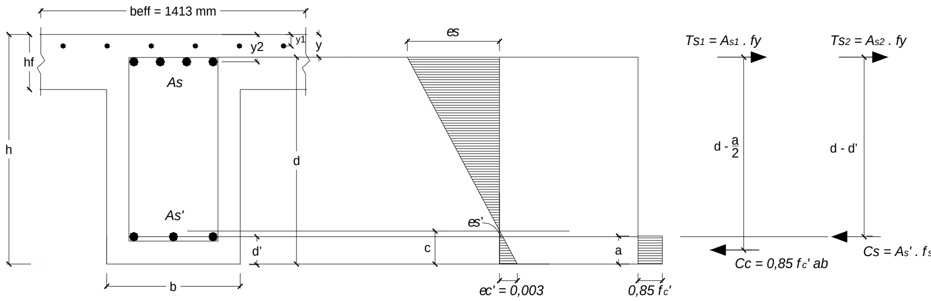
y1 = 20 + 1/2 10 = 25 mm

y2 = 40 + 10 + 1/2 19 = 59.5 mm

$$y = \frac{471 \times 25 + 1133.54 \times 59.5}{1604.54} = 49.373 \text{ mm}$$

d = 500 - 49.373 = 450.627 mm

d' = 40 + 10 + 1/2 19 = 59.5 mm



Gambar 4.8 Penampang balok dan diagram tegangan momen negatif tumpuan kanan

Dimisalkan garis netral > d' maka perhitungan garis netral harus dicari menggunakan persamaan :

0,85 . f'c . a . b + As' . fs' = As . fy

Substitusi nilai : $fs' = \frac{(c - d')}{c} \times 600$

$$(0,85 . f'c . a . b) + As' \frac{(c - d')}{c} \times 600 = As_{plat} . fy_{polos} + As_{balok} . fy_{ulir}$$

$(0,85.f'c'.a.b).c + As'(c-d').600 = As_{plat}.fy_{polos}.c + As_{balok}.fy_{ulir}.c$

Substitusi nilai : $a = \beta 1.c$

$(0,85.f'c'.\beta 1.c .b).c + As'(c-d').600 = As_{plat}.fy_{polos}.c + As_{balok}.fy_{ulir}.c$

$(0,85.f'c'.\beta 1.b).c^2 + 600As'.c - 600As'.d' = As_{plat}.fy_{polos}.c + As_{balok}.fy_{ulir}.c$

$(0,85.f'c.\beta 1.b)c^2 + 600As'.c - 600As'.d' - As_{plat}.fy_{polos}.c - As_{balok}.fy_{ulir}.c = 0$

$(0,85.f'c.\beta 1.b)c^2 + (600As' - As_{plat}.fy_{polos} - As_{balok}.fy_{ulir}).c - 600As'.d' = 0$

$(0,85.24,9.0,85.300)c^2$+(600.850,16`-471.240-1133,54.400).c-600.850,16.59,5 = 0

$5397.08\ c^2 - 56363\ c - 30350534 = 0$

c = 80.393 mm

a = β. c

$= 0.85 \times 80.393 = 68.334$ mm

$$\varepsilon s' = \frac{c - d'}{c} \times \varepsilon c = \frac{80.393 - 59.5}{80.393} \times 0.003 = 0.00078$$

$$\varepsilon s = \frac{d - c}{c} \times \varepsilon c = \frac{450.627 - 80.393}{80.393} \times 0.003 = 0.01382$$

$$\varepsilon y = \frac{fy}{Es} = \frac{400}{200000} = 0.0020$$

Karena $\varepsilon s > \varepsilon y > \varepsilon s'$ maka tulangan baja tarik telah leleh,baja tekan belum

Dihitung tegangan pada tulangan baja tekan

$f's = \varepsilon s' \times Es$

$= 0.00078 \times 200000$

$= 155.933 < 400$ MPa

Menghitung gaya tekan dan tarik

Cc $= 0{,}85 \cdot f'c \cdot a \cdot b$

$= 0.85 \times 24.9 \times 68.334 \times 300$

$= 433888.452$ N

Cs $= As' \times f's$

$= 850.16 \times 155.933$

$= 132567.152$ N

$TS_1 = As_{plat} \times fy_{polos}$

$= 471 \times 240$

$= 113040$ N

$TS_2 = As_{balok} \times fy_{ulir}$

$= 1133.54 \times 400$

$= 453416.0$ N

$Cc + Cs = TS_1 + TS_2$

$433888.452 + 132567.152 = 113040 + 453416.0$

566456 = 566456

Z1 = d - (1/2 . a)

= 450.627 - (1/2 . 68.334)

= 416.460 mm

Z2 = d - d'

= 450.627 - 59.5

= 391.127 mm

Mn = (ND1 . Z1) + (ND2 . Z2)

= 433888.452 x 416.460 + 132567.152 x 391.127

= 232547832.708 Nmm

Mr = ϕ Mn

= 0.9 . 232547832.708

= 209293049.437 Nmm > Mu = 113661000 Nmm Aman

Mpr = 1.25 . Mn

= 1.25 . 232547832.708

= 290684790.885 Nmm

Kontrol Momen Positif

Tulangan tekan As'_{plat} = 6 Ø 10 = 471.00 mm^2

As'_{balok} = 4 D 19 = 1133.54 mm^2

As' = 471.00 + 1133.54 = 1604.54 mm^2

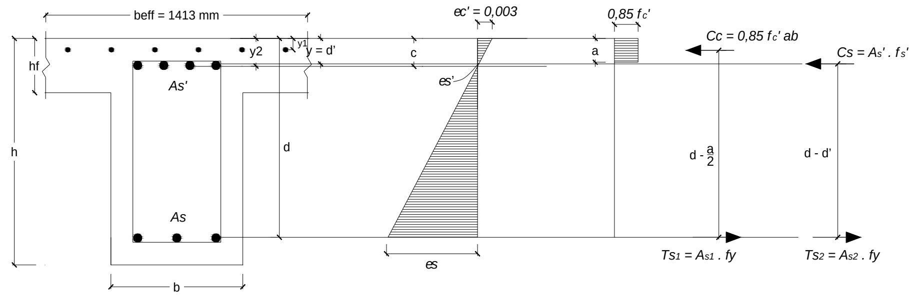
Tulangan tarik As = 3 D 19 = 850.16 mm^2

y1 = 20 + 1/2 10 = 25 mm

y2 = 40 + 10 + 1/2 19 = 59.5 mm

$$y = d' = \frac{471 \times 25 + 1133.54 \times 59.5}{1604.54} = 49.373 \text{ mm}$$

d = 500 - 59.5 = 440.5 mm



Gambar 4.9 Penampang balok dan diagram tegangan momen positif tumpuan kanan

Dimisalkan garis netral > y2 maka perhitungan garis netral harus dicari menggunakan persamaan :

$0{,}85 \cdot f'c \cdot a \cdot b + As' \cdot fs' = As \cdot fy$

Substitusi nilai : $fs' = \dfrac{(c - d')}{c} \times 600$

$$(0{,}85 \cdot f'c \cdot a \cdot b) + As' \frac{(c - d')}{c} \times 600 = As \cdot fy$$

$$(0{,}85 \cdot f'c \cdot a \cdot b) \cdot c + As' (c - d') \times 600 = As \cdot fy \cdot c$$

Substitusi nilai : $a = \beta 1.c$

$$(0{,}85 \cdot f'c \cdot \beta 1.c \cdot b) \cdot c + As' (c - d')\, 600 = As \cdot fy \cdot c$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + 600As'.c - 600As'.d' = As \cdot fy \cdot c$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + 600As'.c - 600As'.d' - As.\ fy \cdot c = 0$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + (600As' - As \cdot fy).c - 600As'.d' = 0$$

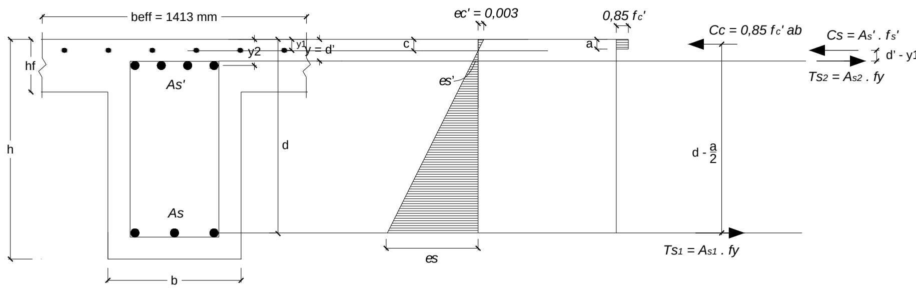
$(0{,}85.30.0{,}85.300)c^2 + (600.1604{,}54\text{-}850{,}16.400).c -$

$600.1604{,}54.49{,}373 = 0$

$$5397.08\ c^2 + 622662.0\ c - 47532378 = 0$$

$c = 52.472$ mm

Karena c < y2, tulangan tekan sebagian mengalami gaya tarik maka nilai c harus dihitung ulang.



Gambar 4.10 Penampang balok dan diagram tegangan momen positif tumpuan kanan yang sudah dihitung ulang

Dimisalkan garis netral diantara y1 dan y2 maka perhitungan garis netral dicari dengan menggunakan persamaan :

$0{,}85 . f'c . a . beff + As_{plat}' . fs' = As1 . fs + As2 . fy_{ulir}$

Substitusi nilai : $fs' = \frac{(c - y_1)}{c} \times 600$ dan $fs = fy_{ulir}$

$$(0{,}85.f'c.a.beff) + As_{plat}' \frac{(c - y_1)}{c} \times 600 = As1 . fy_{ulir} + As2 . fy_{ulir}$$

$(0{,}85.f'c.a.beff).c + As_{plat}'.(c\text{-}y_1).600 = As1 . fy_{ulir}.c + As2 . fy_{ulir} . c$

Substitusi nilai : $a = \beta 1.c$

$(0{,}85.f'c.\beta 1.c.beff).c + As_{plat}'.(c\text{-}y_1).600 = As1 . fy_{ulir}.c + As2 . fy_{ulir} . c$

$(0{,}85.f'c.\beta 1.beff).c^2 + 600.As_{plat}'.c - 600.As_{plat}'.y_1 = As1 . fy_{ulir}.c +$

$As2 . fy_{ulir} . c$

$(0{,}85.f'c.\beta 1.beff).c^2 + (600.As_{plat}' - As1.fy_{ulir} - As2.fy_{ulir}).c -$

$600.As_{plat}'.y1 = 0$

$(0{,}85.30.0{,}85.1413).c^2 + (600.471 - 1133{,}54.400 - 850{,}16.400).c -$

$600.471.25 = 0$

$25411.23 \; c^2 - 510878.000 - 7065000 = 0$

$c = 29.522 \text{ mm}$

$a = \beta . c$

$= 0.85 \times 29.522 = 25.094 \text{ mm}$

$f's = \varepsilon s' \times Es$

$$= \frac{c - y_1}{c} . \varepsilon c . Es$$

$$= \frac{29.522 - 25}{29.522} \times 0.003 \times 200000 = 91.905 \text{ MPa}$$

$fs = fy_{ulir} = 400 \text{ MPa}$

Menghitung gaya tekan dan tarik

$Cc = 0{,}85 . f'c . a . beff$

$= 0.85 \times 24.9 \times 25.094 \times 1413$

$= 750190.825 \text{ N}$

$Cs = As' \times f's$

$= 471.00 \times 91.905$

$= 43287.120 \text{ N}$

$Ts_1 = As1 \times fy$

$= 1133.54 \times 400$

$= 453416.000 \text{ N}$

$Ts_2 = As1 \times fy$

$= 850.16 \times 400$

$= 340062.000 \text{ N}$

$Cc + Cs = Ts_1 + Ts_2$

$750190.825 + 43287.120 = 453416.000 + 340062.000$

$793478 = 793478$

$Z1 \;=\; d \;-\; (1/2 \,.\, a)$

$\;\;\;\;\;= \; 440.500 \;-\; (1/2 \,.\, 25.094)$

$\;\;\;\;\;= \; 427.953$ mm

$Z2 \;=\; d' \;-\; y1$

$\;\;\;\;\;= \; 49.373 \;-\; 25$

$\;\;\;\;\;= \; 24.373$ mm

$Mn \;=\; (NT1 \,.\, Z1) + (NT2 \,.\, Z2)$

$\;\;\;\;\;= \; 453416.000 \;\text{x}\; 427.953 \;+\; 340062.000 \;\text{x}\; 24.373$

$\;\;\;\;\;= \; 202329063.887$ Nmm

$Mr \;=\; \phi \;\; Mn$

$\;\;\;\;\;= \; 0.9 \;\;.\;\; 202329063.887$

$\;\;\;\;\;= \; 182096157.498$ Nmm $>$ Mu = 31721000 Nmm Aman

$Mpr \;=\; 1.25 \;\;.\;\; Mn$

$\;\;\;\;\;= \; 1.25 \;\;.\;\; 202329063.887$

$\;\;\;\;\;= \; 252911329.859$ Nmm

Syarat kuat momen yang terpasag menurut SNI 2847-2013 pasal 21.5.2.2 :

$Mn^{+} \;\geq\; ½ \;\; Mn^{-}$

202329063.887 Nmm $\geq$ ½ . 232547832.708 Nmm

202329063.887 Nmm $\geq$ 116273916.354 Nmm

4.1.2 Penulangan Geser Balok

Diketahui :

b = 300 mm

h = 500 mm

d = 440.5 mm

L = 5650 mm

Ln = 5650 - (½ . 600 + ½ . 600)

$= 5050$ mm

$f'c = 24.9$ MPa

$fy_{ulir} = 400$ MPa

$fy_{polos} = 240$ MPa

kapsaitas momen ujung-ujung balok bila struktur bergoyang ke kanan

Momen Negatif :

$$a = \frac{(As\ balok \times 1{,}25\ fy_{ulir}) + (Asplat \times 1{,}25 \times fy_{polos})}{0{,}85 \times f'c \times b}$$

$$a = \frac{1133.54 \times 1.25 \times 400 + 471 \times 1.25 \times 240}{0.85 \times 24.9 \times 300}$$

$a = 111.516$ mm

Mpr1 $=$ *(As balok + Asplat) x (1,25 x fy) x (d - a/2)*

$= (1133{,}54 \times 1{,}25 \times 400) + (471 \times 1{,}25 \times 240) \times (441 - (90{,}706/2))$

$= 272424314.888$ Nmm

$= 272.424$ kNm

Momen Positif

$$a = \frac{(As'\ balok) \times (1{,}25 \times fy)}{0{,}85 \times f'c \times b}$$

$$a = \frac{850.16 \times 1.25 \times 400}{0.85 \times 24.9 \times 300}$$

$a = 66.947$ mm

Mpr2 $=$ *(As' balok) x (1,25 x fy) x (d - a/2)*

$= (850{,}16 \times 1{,}25 \times 390) \times (441 - (54{,}177/2))$

$= 173017889.950$ Nmm

$= 173.018$ kNm

kapsaitas momen ujung-ujung balok bila struktur bergoyang ke kiri

Momen Negatif :

$$a = \frac{(As\ balok\ x\ 1{,}25\ fy_{\ ulir}) + (Asplat\ x\ 1{,}25\ x\ fy_{\ polos})}{0{,}85\ x\ f'c\ x\ b}$$

$$a = \frac{1133.54 \times 1.25 \times 400 + 471 \times 1.25 \times 240}{0.85 \times 24.9 \times 300}$$

$a = 111.516$ mm

Mpr3 $=$ *(As balok + Asplat) x (1,25 x fy) x (d - a/2)*

$= (1133{,}54 \times 1{,}25 \times 400) + (471 \times 1{,}25 \times 240) \times (441 - (90{,}706/2))$

$= 272424314.888$ Nmm

$= 272.424$ kNm

Momen Positif

$$a = \frac{(As'\ balok)\ x\ (1{,}25\ x\ fy)}{0{,}85\ x\ f'c\ x\ b}$$

$$a = \frac{1133.54 \times 1.25 \times 400}{0.85 \times 24.9 \times 300}$$

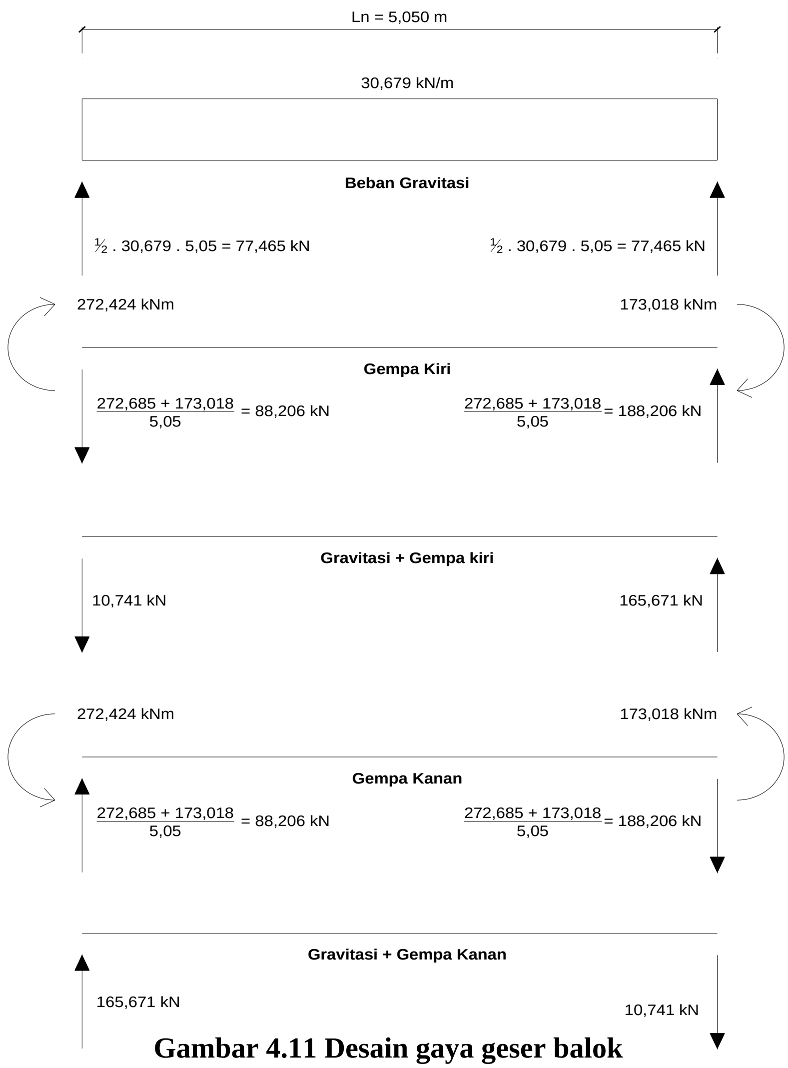
$a = 66.947$ mm

Mpr4 $=$ *(As' balok) x (1,25 x fy) x (d - a/2)*

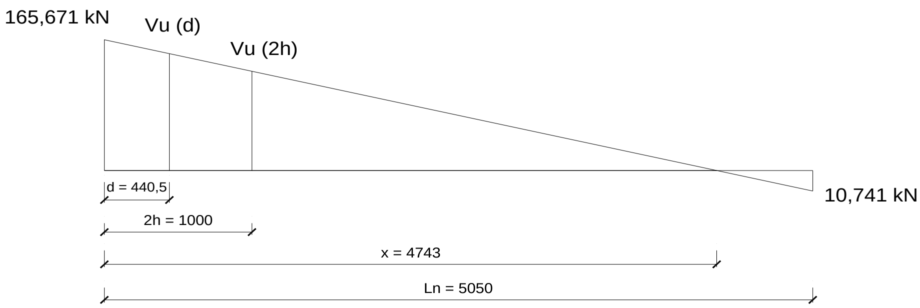
$= (850{,}16 \times 1{,}25 \times 390) \times (441 - (54{,}177/2))$

$= 173017889.950$ Nmm

$= 173.018$ kNm



Gambar 4.11 Desain gaya geser balok



Perhitungan Vu akibat beban gravitasi + gempa :

$$\frac{165.671}{x} = \frac{10.741}{5.05 - x}$$

$$10.741 \ x = 836.639 - 165.671 \ x$$

$$x = \frac{836.639}{176.412} = 4.743 \ \text{m} = 4743 \ \text{mm}$$

- **Tulangan geser pada daerah sendi plastis (joint 138)**

$$Vu\ (d) = 165.671 \ \frac{4743 - 440.5}{4743} = 150.283 \ \text{kN}$$

Vc = 0 apabila memenuhi ketentuan pada SNI 2847-2013 Pasal 21.5.4.2 berikut :

- Gaya geser akibat gempa > 0,5 total geser (akibat Mpr + beban gravitasi)

$$82.506 < 0.5 \ \text{x} \ 165.671 = 82.836$$

Pada daerah sendi plastis, Vc = 0

$$Vs = \frac{Vu\ (d)}{\phi} - 0 = \frac{150.283}{0.75} - 0 = 200.377 \ \text{kN}$$

Direncanakan tulangan sengkang ϕ 10 (2 kaki)

$$S = \frac{Av \cdot fy \cdot d}{Vs}$$

$$= \frac{(2.¼.\pi.10^2) \ . \ 240 \ . \ 440.5 \ . \ 10^{-3}}{200.377} = 82.834 \ \text{mm}$$

Persyaratan spasi maksimum pada daerah gempa SNI 2847-2013 pasal 21.5.3.2, S_{maks} sepanjang sendi plastis diujung balok 2h = 2 . 500 = 1000 mm, spasi maksimum tidak boleh melebihi :

- $\frac{d}{4} = \frac{440.5}{4} = 110.13$
- 6 x diameter tulangan utama = 6 . 19 = 114 mm
- 150 mm

Jadi dipakai sengkang Ø 10 - 70 mm

Vs terpasang = $\frac{Av \cdot fy \cdot d}{S}$

$$\frac{(2.\tfrac{1}{4}.\pi.10^2) \cdot 240 \cdot 440.5 \cdot 10^{-3}}{70} = 237.115 \text{ kN}$$

Vn = Vc + Vs terpasang

= 0 + 237.115

= 237.115 kN

ϕ Vn = 0.75 . Vn

= 0.75 . 237.115

= 177.836 kN > Vu (d) = 150.283 kN .... (Aman)

Kontrol kuat geser nominal menurut SNI 2847-2013 pasal 11.4.5.3

Vs maks ≤ 0.66 *bw . d*

Vs maks ≤ 0.66 $\sqrt{24{,}9}$ x 300 x 440.5 x 10^{-3}

237.115 kN < 435.222 kN .... OK

- **Tulangan geser I $\sqrt{fc'}$ laerah luar sendi plastis (joint 138)**

$$Vu\ (2h) = 165.671\ \frac{4743 \quad - \quad 1000}{4743} = 130.738\ \text{kN}$$

$$\begin{aligned}
Vc &= 0.17 \qquad bw\ .\ d \\
&= 0.17\sqrt{24{,}9}\ \ 300 \ .\ 440.5\ .\ 10^{-3} \\
&= 112.103\ \text{kN}
\end{aligned}$$

$$Vs = \frac{Vu\ (2h)}{\phi} - Vc = \frac{130.738}{0.75} - 112.103 = 62.215\ \text{kN}$$

Direncanakan tulangan sengkang ϕ 10 (2 kaki)

$$S = \frac{Av\ .\ \sqrt{fc'}\ -}{Vs}$$

$$= \frac{(2.¼.\pi.10^{2})\ .\ 240\ .\ 440.5\ .\ 10^{-3}}{62.215} = 266.787\ \text{mm}$$

Syarat jarak spasi sengkang maksimum pada daerah luar sendi plastis

menurut SNI 2847-2013 pasal 21.5.3.4 :

- $\frac{d}{2} = \frac{440.5}{2} = 220.250$ mm

- 350 mm

Jadi dipakai sengkang Ø 10 - 200 mm

$$Vs\ terpasang = \frac{Av\ .\ fy\ .d}{S}$$

$$\frac{(2.¼.\pi.10^{2})\ .\ 240\ .\ 440.5\ .\ 10^{-3}}{200} = 82.990\ \text{kN}$$

$$\begin{aligned}
Vn &= Vc + Vs\ terpasang \\
&= 112.103 + 82.990 \\
&= 195.093\ \text{kN}
\end{aligned}$$

ϕ Vn = 0.75 . Vn

= 0.75 . 195.093

= 146.320 kN > Vu (2h) = 130.738 kN .... (Aman)

Kontrol kuat geser nominal menurut SNI 2847-2013 pasal 11.4.5.3

$Vs\ maks \leq 0.66 \sqrt{fc'}\ bw \cdot d$

$Vs\ maks \leq 0.66\sqrt{24{,}9} \times 300 \times 440.5 \times 10^{-3}$

82.990 kN < 435.222 kN .... OK

- **Tulangan geser pada daerah sendi plastis (joint 143)**

$$Vu\ (d) = 165.671 \frac{4743 - 440.5}{4743} = 150.283\ kN$$

Vc = 0 apabila memenuhi ketentuan pada SNI 2847-2013 Pasal 21.5.4.2 berikut :

Gaya aksial tekan terfaktor < Ag.fc'/20

Pada daerah sendi plastis, Vc = 0

$$Vs = \frac{Vu\ (d)}{\phi} - 0 = \frac{150.283}{0.75} - 0 = 200.377\ kN$$

Direncanakan tulangan sengkang ϕ 10 (2 kaki)

$$S = \frac{Av \cdot fy \cdot d}{Vs}$$

$$= \frac{(2.¼.\pi.10^2) \cdot 240 \cdot 440.5 \cdot 10^{-3}}{200.377} = 82.834\ mm$$

Persyaratan spasi maksimum pada daerah gempa SNI 2847-2013 pasal 21.5.3.2, S_{maks} sepanjang sendi plastis diujung balok 2h = 2 . 500 = 1000 mm, spasi maksimum tidak boleh melebihi :

$$- \frac{d}{4} = \frac{440.5}{4} = 110.13$$

- 6 x diameter tulangan utama = 6 . 19 = 114 mm
- 150 mm

Jadi dipakai sengkang Ø 10 - 70 mm

Vs terpasang = $\dfrac{Av \cdot fy \cdot d}{S}$

$$\frac{(2.\tfrac{1}{4}.\pi.10^2) \;.\; 240 \;.\; 440.5 \;.\; 10^{-3}}{70} = 237.115 \text{ kN}$$

Vn = Vc + Vs terpasang

= 0.000 + 237.115

= 237.115 kN

ϕ Vn = 0.75 . Vn

= 0.75 . 237.115

= 177.836 kN > 150.283 kN .... (Aman)

Kontrol kuat geser nominal menurut SNI 2847-2013 pasal 11.4.5.3

Vs maks ≤ 0.66 $\sqrt{fc'}$ *bw . d*

Vs maks ≤ 0.66 $\sqrt{24,9}$ x 300 x 440.5 x 10^{-3}

237.115 kN < 435.222 kN .... OK

- **Tulangan geser pada daerah luar sendi plastis (joint 143)**

Vu (2h) = 165.671 $\dfrac{4743 - 1000}{4743}$ = 130.738 kN

Vc = 0.17 $\sqrt{fc'}$ bw . d

= 0.17 $\sqrt{24,9}$. 300 . 440.5 . 10^{-3}

= 112.103 kN

Vs = $\dfrac{Vu\ (2h)}{\phi}$ - Vc = $\dfrac{130.738}{0.75}$ - 112.103 = 62.215 kN

$$S = \frac{Av \cdot fy \cdot d}{Vs}$$

$$= \frac{(2.\tfrac{1}{4}.\pi.10^2) \;.\; 240 \;.\; 440.5 \;.\; 10^{-3}}{62.215} = 266.787 \text{ mm}$$

$\sqrt{fc'}$

Syarat jarak spasi sengkang maksimum pada daerah luar sendi plastis menurut SNI 2847-2013 pasal 21.5.3.4 :

- $\frac{d}{2} = \frac{440.5}{2} = 220.250$ mm

- 350 mm

Jadi dipakai sengkang Ø 10 - 200 mm

$$Vs \text{ terpasang} = \frac{Av \cdot fy \cdot d}{S}$$

$$\frac{(2.\tfrac{1}{4}.\pi.10^2) \;.\; 240 \;.\; 440.5 \;.\; 10^{-3}}{200} = 82.990 \text{ kN}$$

Vn = Vc + Vs terpasang

= 112.103 + 82.990

= 195.093 kN

ϕ Vn = 0.75 . Vn

= 0.75 . 195.093

= 146.320 kN > Vu (2h) = 130.738 kN .... (Aman)

Kontrol kuat geser nominal menurut SNI 2847-2013 pasal 11.4.5.3

Vs maks ≤ 0.66 *bw . d*

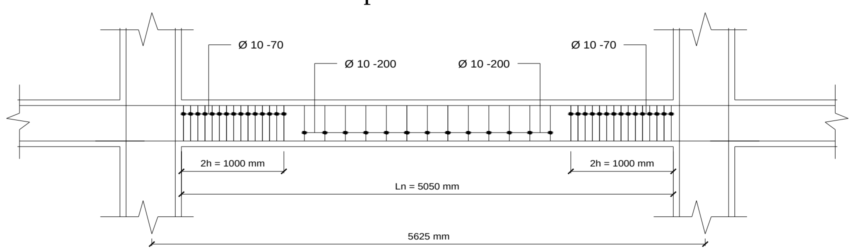
Vs maks ≤ $0.66\sqrt{24{,}9}$ x 300 x 440.5 x 10^{-3}

82.990 kN < 435.222 kN .... OK

Dari hasil perhitungan dan ketentuan-ketentuan di atas maka dipasang tulangan

Dari hasil perhitungan dan ketentuan-ketentuan di atas maka dipasang tulangan sengkang sebagai berikut :

- Joint 138 $\sqrt{fc'}$
  - Daerah sendi plastis = 2 kaki Ø 10 - 70
  - Daerah luar sendi plastis = 2 kaki Ø 10 - 200
- Joint 143
  - Daerah sendi plastis = 2 kaki Ø 10 - 70
  - Daerah luar sendi plastis = 2 kaki Ø 10 - 200



Gambar 4.12 Penulangan geser pada balok

Perhitungan Panjang Penyaluran

Berdasarkan SNI 2847-2013 pasal 21.7.5 untuk batang Ø10 sampai D-36 panjang penyaluran, ℓ_{dh} untuk batang tulangan dengan kait 90 derajat standar pada beton normal (normalweight) tidak boleh kurang dari yang terbesar dari $8d_b$,150 mm dan panjang yg di syaratkan oleh pers 21-6

$$\ell_{dh} = \frac{f_y \, d_b}{5.4 \sqrt{f'c}}$$

$$\ell_{dh} = \frac{400 \times 19}{5.4 \sqrt{24,9}}$$

$$= 282.05 \text{ mm}$$

Dengan syarat minimum panjang ℓ_{dh} = 282,05 mm maka pada perencanaan digunakan panjang ℓ_{dh} sebesar = 350 mm

Penulangan Torsi

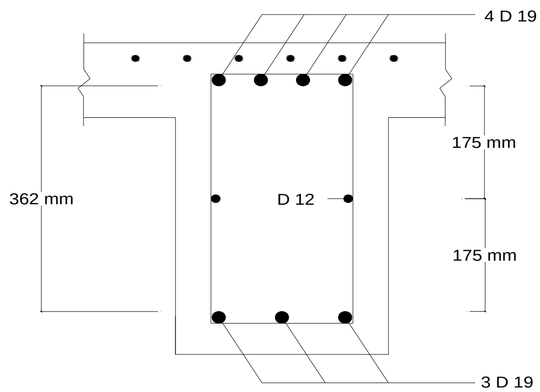
Pada balok inggi,pemasangan tulangan torsi perlu di lakukan untuk menghinda ri puntir yang terjadi akibat besarnya beban gempa yang terjadi.

Berdasarkan SNI 2847-2013 pasal 11.5.6, penulangan torsi harus memenuhi syarat-syarat berikut:

- pada tiap sudut sengkang harus terdapat minimal 1 tulangan longitudinal
- Spasi maksimum antara tulangan longitudinal untuk torsi di sekitar parime ter tulangan sengkang adalah sekitar 300 mm.
- diameter tulangan harus di ambil yang erbesar dari 0,042 x spasi terbesar sengkang dan 10 mm.

Pada analisa penulangan lentur,di ketahui bentang terdekat antara tulanan tarik dan tekan adalah 362 mm. maka dari itu, untuk memenuhi persyaratan spasi maksimum sebesar 300 mm, maka hanya di perlukan 1 tulangan longitudinal sebagai tulangan torsi. Sehingga jarak maksimum antara tulangan longitudinal balok yang terjadi adalah : 175 mm

sedangkan untuk diameter tulangan, dengan spasi terbesar yang di rencanakan yaitu 200 mm, maka 0,042 x 200 mm = 8,4 mm, digunakan D 12.



gambar 4.13 Penulangan torsi pada balok

4.2 Perhitungan Penulangan Kolom

4.2.1 Perhitungan Penulangan Lentur Kolom

Penulangan kolom yang dihitung adalah pada kolom yang berada pada struktur portal memanjang line B, kolom no 267.

Diketahui :

b = 600 mm

h = 600 mm

Tulangan sengkang Ø 10

Tulangan utama dipakai D 19

Tebal selimut beton 40 mm

Tinggi kolom = h kolom - h balok

= 3400 - 500 = 2900 mm

f'c = 24.9 MPa

fy = 400 MPa

Dicoba tulangan D 19 mm

d = h - selimut beton - Ø sengkang - ½ Ø tulangan pokok

= 600 - 40 - 10 - ½ 19

= 540.5 mm

d' = 600 - 540.5 = 59.5 mm

- Luas Penampang kolom (Ag)

Ag = b . h

= 600 . 600

= 360000 mm^2

Jumlah tulangan pada kolom 1% - 6% dicoba dengan jumlah tulangan 1.15 % ,ρ = 0.0115

As_{perlu} = ρ . Ag

= 0.0115 . 360000

= 4140 mm^2

Maka dipakai tulangan 16 D 19 ,As ada = 4534.16 mm^2

- Beban Sentris

Po = 0,85 . f'c (Ag - Ast) + fy . Ast

= (0,85 . 24,9 (360000 - 4534,16) + 400 . 4534,16) . 10^{-3}

= 9337.099 kN

Pn = 0,80 . Po

= 0.80 . 9337.099

= 7469.679 kN

ϕ Pn = 0.65 . 7469.679

= 4855.291 kN

- Kondisi Seimbang

$$cb = \frac{600.\ d}{600 + fy} = \frac{600 \times 540.5}{600 + 400} = 324.300 \text{ mm}$$

ab = cb . β

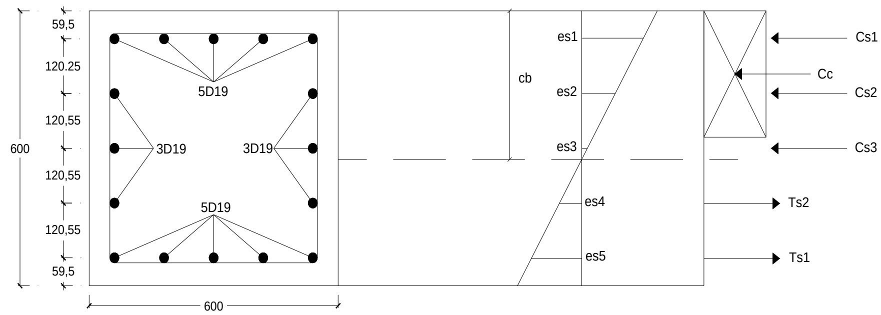
= 324.300 . 0.85

= 275.655 mm

Cc = 0,85 . f'c . ab . b

= 0.85 . 24.9 . 275.655 . 600 . 10^{-3}

= 3500.5428 kN



Gambar 4.13 Diagram tegangan dan regangan kolom kondisi seimbang

$$\varepsilon y = \frac{fy}{Es} = \frac{400}{200000} = 0.00200$$

$$\varepsilon s_1 = \frac{324.300 - 59.5}{324.300} \text{ x } 0.003$$

$= 0.00245 > \varepsilon y$; maka fs = fy = 400 MPa

$Cs_1 = 1133.540 \ . \ 400 \ . \ 10^{-3} = 453.416$ kN

$$\varepsilon s_2 = \frac{324.300 - 155.70}{324.300} \text{ x } 0.003$$

$= 0.00156 < \varepsilon y$;

maka fs = 0.00156 . 200000 = 311.933 MPa

$Cs_2 = 566.770 \ . \ 311.933 \ . \ 10^{-3} = 176.794$ kN

$$\varepsilon s_3 = \frac{324.300 - 276.25}{324.300} \text{ x } 0.003$$

$= 0.00044 < \varepsilon y$;

maka fs = 0.00044 . 200000 = 88.899 MPa

$Cs_3 = 566.770 \ . \ 88.899 \ . \ 10^{-3} = 50.385$ kN

$$\varepsilon s_4 = \frac{396.800 \;-\; 324}{324} \times 0.003$$

$= 0.0007 < \varepsilon y$;

maka fs $= 0.0007 \;.\; 200000 = 134.135$ MPa

$Ts_2 = 566.770 \;.\; 134.14 \;.\; 10^{-3} = 76.024$ kN

$$\varepsilon s_6 = \frac{517 \;-\; 324.300}{324.300} \times 0.003$$

$= 0.00179 < \varepsilon y$;

maka fs $= 0.00179 \;.\; 200000 = 357.169$ MPa

$Ts_1 = 1133.540 \;.\; 357.169 \;.\; 10^{-3} = 404.866$ kN

$Pnb = Cc + Cs_1 + Cs_2 + Cs_3 - Ts_1 - Ts_2$

$= 3500.5428 + 453.416 + 176.794 + 50.385 - 404.866 -$

76.024

$= 3700.249$ kN

$\phi\ Pnb = 0.65 \;.\; 3700.249$

$= 2405.1621$ kN

$Mnb = Cc(h/2 - ab/2)+\{(Cs_1+Ts_1).(h/2 - 59,5)\}+\{(Cs_2+Ts_2).$

$h/2 - 179,75\}$

$= [3500,543.(600/2-275,655/2)+\{(453,416+251,665).$

$(600/2-59,5)\}+\{(176,794+24,957).(600/2-179,75)\}$

$= 804.50992$ kNm

$\phi\ Mnb = 0.65 \;.\; 804.51$

$= 522.93$ kNm

$$eb = \frac{Mnb}{Pnb} = \frac{804.50992}{3700.249} = 0.2174 \text{ m} = 217.420 \text{ mm}$$

- Kondisi Seimbang dengan 1,25 fy

fy = 1.25 x 400 = 500.00 MPa

$$cb = \frac{600.\ d}{600 + fy} = \frac{600 \quad x \quad 540.5}{600 \quad + \quad 500.00} = 294.818 \text{ mm}$$

ab = cb . β

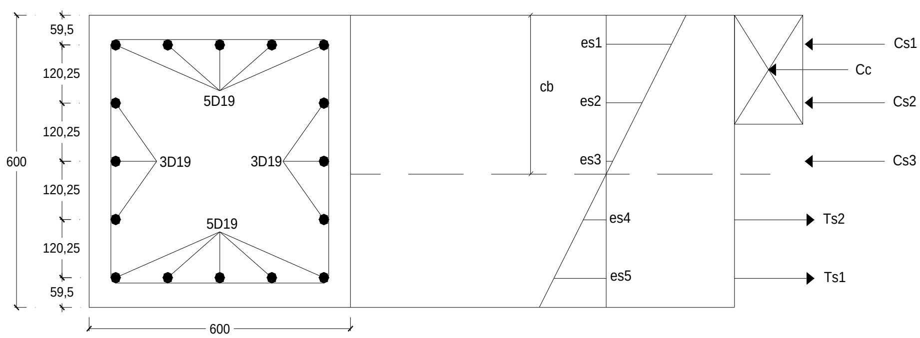
= 294.818 . 0.85

= 250.595 mm

Cc = 0,85 . f'c . ab . b

= 0.85 . 24.9 . 250.595 . 600 . 10^{-3}

= 3182.3117 kN



Gambar 4.14 Diagram tegangan dan regangan kolom kondisi seimbang *1,25 fy*

$$\varepsilon y = \frac{fy}{Es} = \frac{500.00}{200000} = 0.00250$$

$$\varepsilon s_1 = \frac{294.818 \ - \ 59.5}{294.818} \ x \quad 0.003$$

= 0.00239 < εy ;

maka fs = 0.00239 . 200000 = 478.91 MPa

$Cs_1 = 1133.540 \;.\; 478.91 \;.\; 10^{-3} = 542.862$ kN

$$\varepsilon s_2 = \frac{294.818 - 155.70}{294.818} \times 0.003$$

$= 0.00142 < \varepsilon y$;

maka fs $= 0.00142 \;.\; 200000 = 283.127$ MPa

$Cs_2 = 566.770 \;.\; 283.127 \;.\; 10^{-3} = 160.468$ kN

$$\varepsilon s_3 = \frac{294.818 - 251.90}{294.818} \times 0.003$$

$= 0.0004 < \varepsilon y$;

maka fs $= 0.0004 \;.\; 200000 = 87.35$ MPa

$Cs_3 = 566.770 \;.\; 87.35 \;.\; 10^{-3} = 49.505$ kN

$$\varepsilon s_4 = \frac{372.150 - 294.818}{294.818} \times 0.003$$

$= 0.00079 < \varepsilon y$;

maka fs $= 0.0008 \;.\; 200000 = 157.38$ MPa

$Ts_2 = 566.770 \;.\; 157.38 \;.\; 10^{-3} = 89.199$ kN

$$\varepsilon s_6 = \frac{492.70 - 294.818}{294.818} \times 0.003$$

$= 0.0020 < \varepsilon y$;

maka fs $= 0.0020 \;.\; 200000 = 402.72$ MPa

$Ts_1 = 1133.540 \;.\; 402.72 \;.\; 10^{-3} = 456.499$ kN

$Pnb = Cc + Cs_1 + Cs_2 + Cs_3 - Ts_1 - Ts_2 - Ts_3$

$= 3182.3117 + 542.862 + 160.468 + 49.505 - 456.499 -$

89.199

$= 3389.447$ kN

ϕ Pnb = 0.6 . 3389.447

= 2033.668 kN

Mnb = $ND_D(h/2 - ab/2)+\{(ND_1+NT_1).(h/2 - 59,5)\}+\{(ND_2+NT_2).$

$h/2 - 179,75\}$

= [3182,312.(600/2-250,595/2)+{(542,862+456,499).

(600/2-59,5)}+{(160,468+89,199).(600/2-179,75)} . 10^{-3}

= 826.32582 kNm

ϕ Mnb = 0.6 . 826.326

= 495.795 kNm

$$eb = \frac{Mnb}{Pnb} = \frac{826.32582}{3389.447} = 0.2438 \text{ m} = 243.794 \text{ mm}$$

- Kondisi Patah Desak (c > cb)

Dipakai nilai c = 450 mm

a = c . β

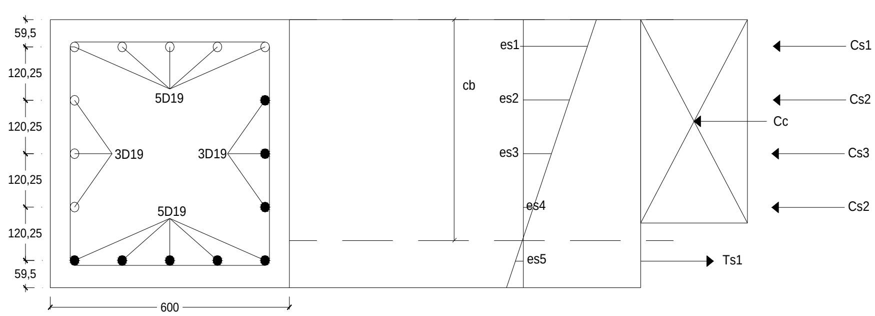
= 450 . 0.85

= 383 mm

Cc = 0,85 . f'c . a . b

= 0.85 . 24.9 . 383 . 600 . 10^{-3}

= 4857.368 kN



Gambar 4.15 Diagram tegangan dan regangan kolom kondisi patah desak

$$\varepsilon y = \frac{fy}{Es} = \frac{400}{200000} = 0.00200$$

$$\varepsilon s_1 = \frac{450 - 59.5}{450} \times 0.003$$

$= 0.00260 > \varepsilon y$; maka fs = fy = 400 MPa

$Cs_1 = 1133.540 \cdot 400 \cdot 10^{-3} = 453.416$ kN

$$\varepsilon s_2 = \frac{450 - 155.70}{450} \times 0.003$$

$= 0.00196 > \varepsilon y$; maka fs = fy = 400 MPa

$Cs_2 = 566.770 \cdot 400 \cdot 10^{-3} = 226.708$ kN

$$\varepsilon s_3 = \frac{450 - 275.95}{450} \times 0.003$$

$= 0.00116 < \varepsilon y$;

maka fs $= 0.00116 \cdot 200000 = 232.07$ MPa

$Cs_3 = 566.770 \cdot 232.07 \cdot 10^{-3} = 131.528$ kN

$$\varepsilon s_4 = \frac{450 - 396}{450} \times 0.003$$

$= 0.00036 < \varepsilon y$;

maka fs $= 0.00036 \cdot 200000 = 72$ MPa

$Ts_2 = 566.770 \cdot 72 \cdot 10^{-3} = 40.656$ kN

$$\varepsilon s_6 = \frac{516 - 450}{450} \times 0.003$$

$= 0.0004 < \varepsilon y$;

maka fs $= 0.0004 \cdot 200000 = 88.60$ MPa

$Ts_1 = 1133.540 \cdot 88.600 \cdot 10^{-3} = 100.432$ kN

$Pn = Cc + Cs_1 + Cs_2 + Cs_3 - Ts_1 - Ts_2$

$= 4857.368 + 453.416 + 226.708 + 131.528 - 100.432 -$

40.656

$= \quad 5527.932 \quad kN$

$\phi \; Pn \quad = \; 0.65 \; . \; 5527.932$

$= \; 3593.1558 \; kN$

$Mn \quad = \; Cc(h/2 - ab/2)+\{(Cs_1+Ts_1).(h/2 - 59,5)\}+\{(Cs_2+Ts_2).$

$h/2 - 179,75)\}$

$= \; [417,660.(600/2-340/2)+\{(453,416+198,001).(600/2-59,5)\}+$

$\{(226,708+(3,213)).(600/2-179,75)\} \quad . \; 10^{-3}$

$= \quad 693.590 \quad kNm$

$\phi \; Mn \quad = \; 0.65 \; . \; 693.590$

$= \; 450.833 \; kNm$

$$eb = \frac{Mn}{Pn} = \frac{693.58963}{5527.932} = 0.1255 \; m = 125.470 \; mm$$

- Kondisi Patah Tarik (c < cb)

Dipakai nilai c = 150 mm

$a \; = \; c \; . \; \beta$

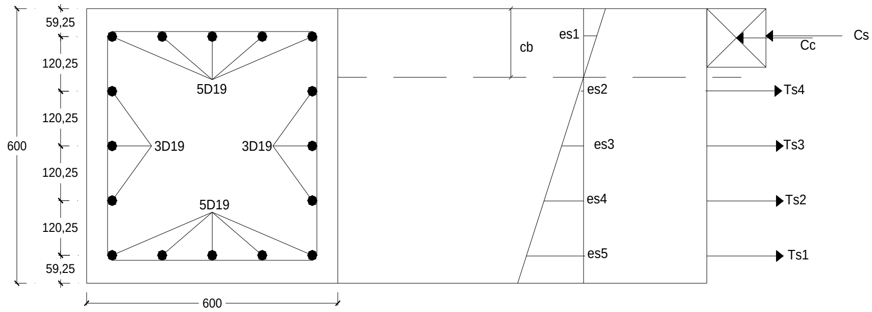
$= \quad 150 \quad . \quad 0.85$

$= \quad 128 \quad mm$

$Cc \quad = \; 0,85 \; . \; f'c \; . \; a \; . \; b$

$= \; 0.85 \; . \; 24.9 \; . \; 128 \; . \; 600 \; . \; 10^{-3}$

$= \quad 1619.123 \quad kN$



Gambar 4.16 Diagram tegangan dan regangan kolom kondisi patah tarik

$$\varepsilon y = \frac{fy}{Es} = \frac{400}{200000} = 0.00200$$

$$\varepsilon s_1 = \frac{150 - 59.5}{150} \times 0.003$$

$= 0.00181 > \varepsilon y$; maka fs = fy = 400 MPa

Cs = 1133.540 . 400 . 10^{-3} = 453.416 kN

$$\varepsilon s_2 = \frac{155.70 - 150}{150} \times 0.003$$

$= 0.0001 < \varepsilon y$;

maka fs = 0.00011 . 200000 = 22.800 MPa

Ts_4 = 566.770 . 22.800 . 10^{-3} = 12.922 kN

$$\varepsilon s_3 = \frac{276 - 150}{150} \times 0.003$$

$= 0.00252 > \varepsilon y$; maka fs = 400 MPa

Ts_3 = 566.770 . 400.000 . 10^{-3} = 226.708 kN

$$\varepsilon s_4 = \frac{396 - 150}{150} \times 0.003$$

$= 0.00492 > \varepsilon y$; maka fs = fy = 400 MPa

Ts_2 = 566.770 . 400 . 10^{-3} = 226.708 kN

$$\varepsilon s_5 = \frac{516.45 \quad - \quad 150}{150} \text{ x } 0.003$$

$= 0.00733 > \varepsilon y$; maka fs = fy = 400 MPa

$Ts_1 = 1133.540 \;.\; 400 \;.\; 10^{-3} = 453.416$ kN

$Pn = Cc + Cs - Ts_1 - Ts_2 - Ts_3 - Ts_4$

$= 1619.123 + 453.416 - 453.416 - 226.708 - 226.708 -$
12.922

$= 1152.784$ kN

ϕ Pn = 0.65 . 1152.784

= 749.30969 kN

$Mn = Cc(h/2 - ab/2)+\{(Cs+Ts_1).(h/2 - 59,5)\}+\{(Ts_4+Ts_2).$
$h/2 - 179,75)\}$

$= [1619,123.(600/2\text{-}170/2)+\{(453,416+453,416).(600/2\text{-}59,5)\}+$
$\{(12,992+226,708).(600/2\text{-}179,25)\}] \;.\; 10^{-3}$

= 629.546 kNm

ϕ Mn = 0.65 . 629.546

= 409.205 kNm

$$eb = \frac{Mn}{Pn} = \frac{629.54615}{1152.784} = 0.5461 \text{ m} = 546.109 \text{ mm}$$

- Kondisi Lentur Murni

Dicoba dipasang tulangan sebagai berikut :

Tulangan tarik As = 7 D 19 = 1983.695 mm^2

Tulangan tekan As' = 9 D 19 = 2550.465 mm^2

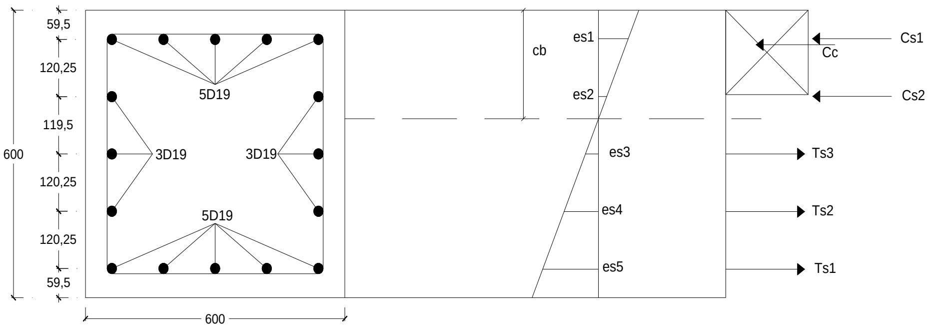
As' 1 = 4 D 19 = 1133.540 mm^2

As' 2 = 5 D 19 = 1416.925 mm^2

y1 = 40 + 10 + 1/2 19 = 59.5 mm

$$y2 = 59.5 + 96.2 = 156 \text{ mm}$$

$$y = d' = \frac{1133.54 \times 59.5 + 1416.93 \times 156}{2550.465} = 112.933 \text{ mm}$$



Gambar 4.17 Diagram tegangan dan regangan kolom kondisi 1 lentur murni

Dimisalkan garis netral (c) > y2 maka perhitungan garis netral harus dicari menggunakan persamaan :

$$0{,}85 \cdot f'c \cdot a \cdot b + As' \cdot fs' = As \cdot fy$$

Substitusi nilai : $fs' = \dfrac{(c - d')}{c} \times 600$

$$(0{,}85 \cdot f'c \cdot a \cdot b) + As' \frac{(c - d')}{c} \times 600 = As \cdot fy$$

$$(0{,}85 \cdot f'c \cdot a \cdot b) \cdot c + As' \, (c - d') \times 600 = As \cdot fy \cdot c$$

Substitusi nilai : $a = \beta 1.c$

$$(0{,}85 \cdot f'c \cdot \beta 1.c \cdot b) \cdot c + As' \, (c - d')\, 600 = As \cdot fy \cdot c$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + 600As'.c - 600As'.d' = As \cdot fy \cdot c$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + 600As'.c - 600As'.d' - As.\ fy \cdot c = 0$$

$$(0{,}85.f'c.\beta 1.b)\, c^2 + (600As' - As \cdot fy).c - 600As'.d' = 0$$

$$(0{,}85.24{,}9.0{,}85.600)c^2 + (600.2550{,}465\text{-}1983{,}695.400).c - 600.2550{,}465.112{,}933 = 0$$

$10794 \quad c^2 \quad + \quad 736801.000 \quad c \quad - \quad 172819508.4 \quad = \quad 0$

$c \quad = \quad 96.925 \quad mm$

Karena nilai c < y2 maka dihitung nilai c sebenarnya berdasarkan persamaan yang kedua.

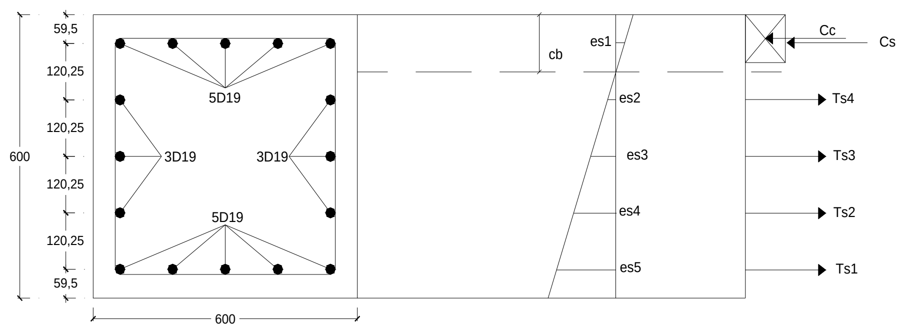
Dicoba dipasang tulangan sebagai berikut :

Tulangan tarik As = 11 D 19 = 3117.235 mm^2

Tulangan tekan As' = 5 D 19 = 1416.925 mm^2

$d' \quad = \quad 40 \quad + \quad 10 \quad + \quad 1/2 \quad 19 \quad = \quad 59.5 \quad mm$

$d \quad = \quad 600 \quad - \quad 59.5 \quad = \quad 541 \quad mm$



Gambar 4.18 Diagram tegangan dan regangan kolom kondisi 2 lentur murni

0,85 . f'c . a . b + As' . fs' = As . fy

Substitusi nilai : $fs' = \dfrac{(c - d')}{c} \times 600$

$$(0{,}85 \cdot f'c \cdot a \cdot b) + As' \, \frac{(c - d')}{c} \times 600 = As \cdot fy$$

$$(0{,}85 \cdot f'c \cdot a \cdot b) \cdot c + As' \, (c - d') \times 600 = As \cdot fy \cdot c$$

Substitusi nilai : $a = \beta 1.c$

$$(0{,}85 \cdot f'c \cdot \beta 1.c \cdot b) \cdot c + As' \, (c - d') \, 600 = As \cdot fy \cdot c$$

$$(0{,}85.f'c.\beta 1.b) \, c^2 + 600As'.c - 600As'.d' = As \cdot fy \cdot c$$

$(0{,}85.f'c.\beta 1.b)\ c^2 + 600As'.c - 600As'.d' - As.\ fy\ .\ c = 0$

$(0{,}85.f'c.\beta 1.b)\ c^2 + (600As' - As\ .\ fy).c - 600As'.d' = 0$

$(0{,}85.24{,}9.0{,}85.600)c^2 + (600.1416{,}925\text{-}3117{,}275.400).c -$

$600.1416{,}925.59{,}5 = 0$

$10794\ c^2 - 396739.000\ c - 50584222.500 = 0$

$c = 89.258$ mm

$a = \beta.\ c$

$= 0.85 \times 89.258 = 75.870$ mm

$Cc = 0{,}85\ .\ fc'\ .\ a\ .\ b$

$= 0.85 \times 24.9 \times 75.870 \times 600$

$= 963.469$ kN

$Cs = fs'\ .\ As'$

$= \frac{(c - d')}{c} \times 600\ .\ As'$

$= \frac{89.258 - 59.5}{89.258} \times 600 \times 1416.925 \times 10^{-3}$

$= 283.439$ MPa

$Ts_1 = As1 \times fy$

$= 1416.925 \times 400 \times 10^{-3}$

$= 566.770$ kN

$Ts_2 = As1 \times fy$

$= 566.770 \times 400 \times 10^{-3}$

$= 226.708$ kN

$Ts_3 = As1 \times fy$

$= 566.770 \times 400 \times 10^{-3}$

$= 226.708$ kN

$Ts_4 = As1 \times fy$

$= 566.770 \times 400 \times 10^{-3}$

$= 226.708$ kN

Cc + Cs = Ts1 + Ts2 + Ts3 + Ts4

963.469 + 283.439 = 566.770 + 226.708 + 226.708 + 226.708

1247 kN = 1247 kN

$ZD_D = c - a/2$

$= 89.258 - \dfrac{75.870}{2}$

$= 51.324$ mm

$ZD_1 = c - y1$

$= 89.258 - 59.5$

$= 29.758$ mm

$ZT_4 = y3 - c$

$= 276.3 - 89.258$

$= 186.992$ mm

$ZT_3 = y4 - c$

$= 324 - 89.258$

$= 235.042$ mm

$ZT_2 = y5 - c$

$= 420.50 - 89.258$

$= 331.242$ mm

$ZT_1 = y6 - c$

$= 517 - 89.258$

$= 428.092$ mm

$Mn = (Cc.ZD_D) + (Cs_1.ZD_1) + (Ts_1.ZT_1) + (Ts_2.ZT_2) +$

$(Ts_3.ZT_3) + (Ts_4.ZT_4)$

= {(963,469.51,324) + (283,439.29,758) + (566,770.428,092)+

(226,708.331,242) + (226,708.235,042) + (226,708.186,992)

= 375.608 kNm

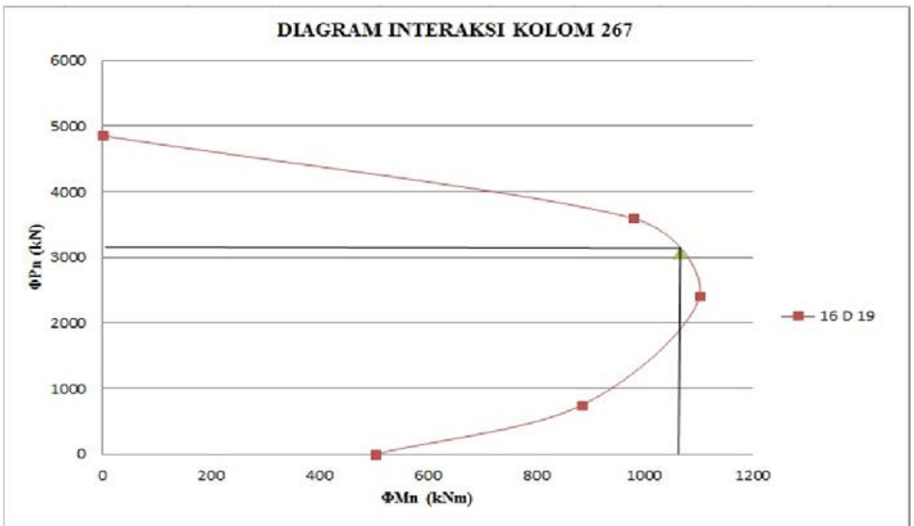
ϕ Mn = 0.65 . 375.608

= 244.145 kNm

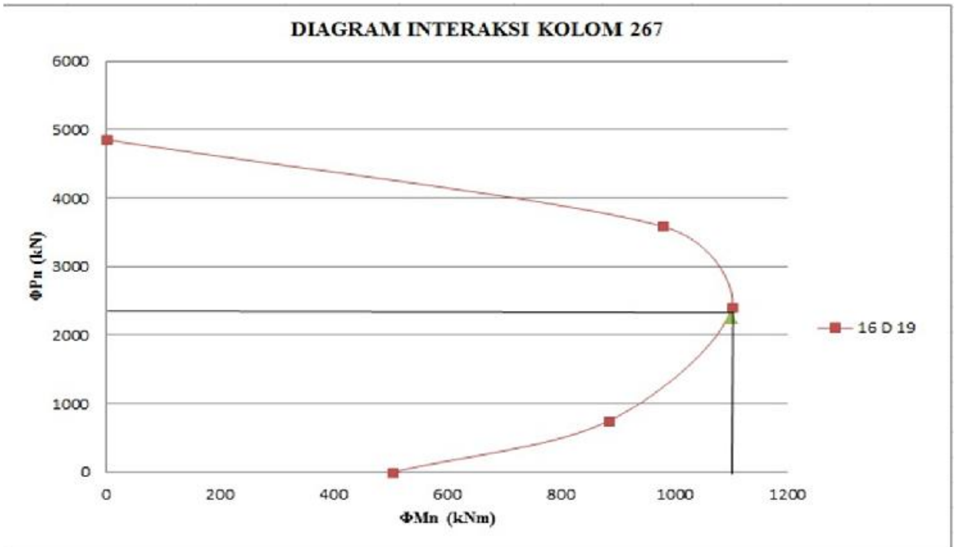
KOLOM 267

Kondisi	16 D 19	
	ϕ Pn (kN)	ϕ Mn (kNm)
Sentris	4855.291	0
Patah Desak	3593.156	450.833
Balance	2405.162	522.931
Patah Tarik	749.310	409.205
Lentur	0	244.145

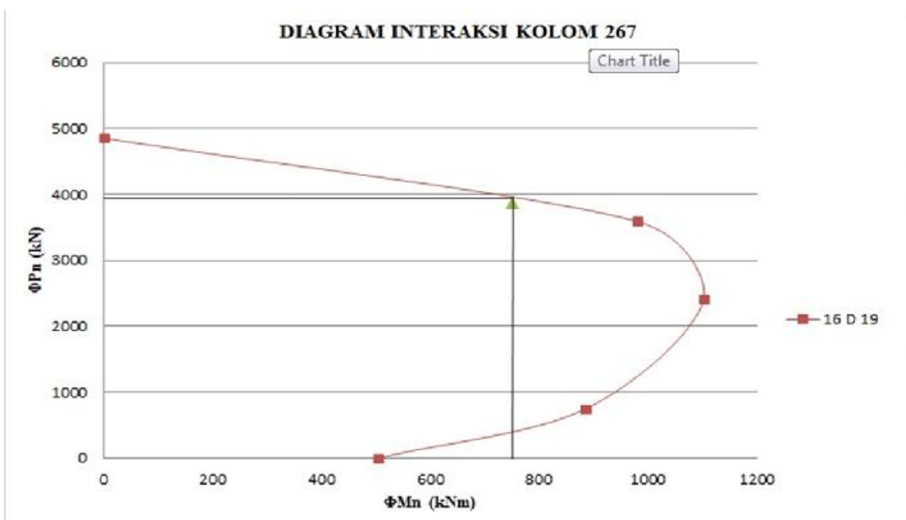
ϕPn (kN) kolom desain	=	3068.829	kN
ϕPn (kN) kolom Atas	=	2257.036	kN
ϕPn (kN) kolom Bawah	=	3877.449	kN
ϕMn (kN) kolom Desain	=	1065	kN
ϕMn (kN) kolom Atas	=	1100	kN
ϕMn (kN) kolom Bawah	=	750	kN



Gambar 4.19 Diagram Interaksi Kolom Desain (267)



Gambar 4.20 Diagram Interaksi Kolom Atas (326)



Gambar 4.21 Diagram Interaksi Kolom Bawah (186)

4.2.2 Perhitungan Penulangan Geser Kolom

Penulangan geser kolom no. 267 pada portal memanjang line B.

Diketahui : h = 600 mm   f'c = 24.9 MPa

b = 600 mm fy_{ulir} = 400 MPa

d = 540.5 mm fy_{polos} = 240 MPa

Tinggi bersih ln = 2900 mm

Tulangan sengkang = Ø 12 mm

a. Pengekangan Kolom

Daerah yang berpotensi sendi plastis terletak sepanjang lo (SNI 2847-2013 Pasal 21.6.4.1) dari muka yang ditinjau, dimana panjang lo tidak boleh kurang dari :

- h = 600 mm
- ⅙ ln = ⅙ . 2900 = 483.333 mm
- 450 mm

Jadi daerah yang berpotensi terjadi sendi plastis sejauh 600 mm dari muka hubungan balok - kolom.

Persyaratan spasi maksimum pada daerah gempa (SNI 2847-2013 Pasal 21.6.4.3), spasi maksimum tidak boleh melebihi :

- ¼ x dimensi terkecil komponen struktur = ¼ x 600 = 150 mm
- 6 x diameter terkecil komponen struktur = 6 x 19 = 114 mm
- 100 mm

Dipasang tulangan geser 4 Ø 12 mm

A_s = 4 x ¼ x 3,14 x 12^2

= 452.16 mm^2

Jadi As = 452.16 mm^2 ≥ A_{sh}

$h_c \quad = \quad 600 \quad - \quad 40 \quad - \quad 40 \quad - \quad 12 \quad = \quad 508 \quad mm$

$A_{ch} \quad = \left(600 \quad - \quad 2 \quad x \quad 40 \right)^2 \quad = \quad 270400 \quad mm^2$

A_{sh} minimum harus memenuhi persyaratan sesuai SNI 2847-2013 Pasal 21.6.4.4.(b) dan diambil nilai yang terbesar dari hasil rumus berikut ini :

$$A_{sh} \quad = \quad 0.3 \left(\frac{s.h_c.f'_c}{f_{yh}} \right) \left(\left(\frac{Ag}{A_{ch}} \right) - \quad 1 \right)$$

$$452.16 \quad = \quad 0.3 \left(\frac{s \quad x \quad 508 \quad x \quad 24.9}{240} \right) \left(\left(\frac{360000}{270400} \right) - \quad 1 \right)$$

$$452.16 \quad = \quad 0.3 \quad x \quad 52.7 \; s \quad x \quad 0.331$$

$$452.16 \quad = \quad 5.2393 \quad s$$

$$s \quad = \quad 86.301 \quad mm$$

atau

$$A_{sh} \quad = \quad 0.09 \left(\frac{s.h_c.f'_c}{f_{yh}} \right)$$

$$452.16 \quad = \quad 0.09 \left(\frac{s \quad x \quad 508 \quad x \quad 24.9}{240} \right)$$

$$452.16 \quad = \quad 0.09 \quad x \quad 52.7 \; s$$

$$452.16 \quad = \quad 4.7435 \quad s$$

$$s \quad = \quad 95.323 \quad mm$$

Dipakai s = 90 mm

Jadi dipasang tulangan geser 4 Ø 12 - 90 mm.

a. Perhitungan Tulangan Transversal Kolom Akibat Ve

Diketahui : h = 600 mm f'c = 24.9 MPa

b = 600 mm fy_{ulir} = 400 MPa

d = 540.5 mm fy_{polos} = 240 MPa

Tinggi bersih hn = 2900 mm

Tulangan sengkang = Ø 12 mm

Nu, k = 1782971 N

Perhitungan Momen Probabilitas (Mpr)

Mpr = Mnb = 826325817.581 Nmm

Karena tulangan longitudinal sepanjang kolom sama, maka Mpr_3 dan Mpr_4

= 826325817.581 Nmm, sehingga :

$$Ve_{kolom} = \frac{M pr_3 + M pr_4}{hn}$$

$$= \frac{826325817.581 + 826325817.581}{2900}$$

$$= 569879.874 \text{ N}$$

$$Ve_{balok} = \frac{M Pr_1 + M Pr_2}{hn}$$

$$= \frac{272424314.888 + 173017889.950}{5050}$$

$$= 88206.377 \text{ N} < Ve_{kolom} = 569879.874 \text{ N}$$

Vc = apabila memenuhi ketentuan pada SNI 2847-2013 Pasal 21.5.4.2

sebagai berikut :

Gaya aksial terfaktor < Ag.f'c/20

$$1782971 \text{ N} < \frac{600 \times 600 \times 24.9}{20}$$

$$1782971 \text{ N} > 448200 \text{ N}$$

Maka dipakai Vc sesuai dengan SNI 2847-2013 Pasal 11.2.1.2 :

$$Vc = 0.17 \left(1 + \frac{Nu}{14.Ag}\right) \lambda \ x \ \sqrt{fc'} \ x \ bw \ x \ d$$

$$= 0.17 \left(1 + \frac{1782971}{14 \quad x \quad 360000}\right) x \quad 1 \quad x \quad \sqrt{24{,}9} \ x \quad 600 \quad x \quad 540.5$$

$$= 372424.748 \quad N$$

- Tulangan geser di dalam daerah sendi plastis

Daerah yang berpotensi sendi plastis terletak sepanjang lo (SNI 2847-2013 Pasal 21.6.4.1) dari muka yang ditinjau, dimana panjang lo tidak boleh kurang dari :

- h = 600 mm
- ⅙ ln = ⅙ . 2900 = 483.333 mm
- 450 mm

Jadi daerah yang berpotensi terjadi sendi plastis sejauh 600 mm dari muka hubungan balok - kolom.

Persyaratan spasi maksimum pada daerah gempa (SNI 2847-2013 Pasal 21.6.4.3), spasi maksimum tidak boleh melebihi :

- ¼ x dimensi terkecil komponen struktur = ¼ x 600 = 150 mm
- 6 x diameter terkecil komponen struktur = 6 x 19 = 114 mm
- $S_o = 100 + \dfrac{350 - h_x}{3}$, dimana $h_x = \dfrac{2}{3} h_c = \dfrac{2}{3} \ x \ 508 = 339$

$$= 100 + \frac{350 - 339}{3} = 104 \quad mm$$

Dipasang tulangan geser 4 Ø 12 mm

A_s = 4 x ¼ x 3,14 x 12^2

= 452.16 mm^2

Jadi As = 452.16 mm^2 ≥ A_{sh}

h_c = 600 - 40 - 40 - 12 = 508 mm

A_{ch} = $(600 - 2 \times 40)^2$ = 270400 mm^2

A_{sh} minimum harus memenuhi persyaratan sesuai SNI 2847-2013 Pasal 21.6.4.4.(b) dan diambil nilai yang terbesar dari hasil rumus berikut ini :

$$A_{sh} = 0.3\left(\frac{s.h_c.f'_c}{f_{yh}}\right)\left(\left(\frac{Ag}{A_{ch}}\right) - 1\right)$$

$$452.16 = 0.3\left(\frac{s \times 508 \times 24.9}{240}\right)\left(\left(\frac{360000}{270400}\right) - 1\right)$$

$$452.16 = 0.3 \times 52.7\ s \times 0.331$$

$$452.16 = 5.2393\ s$$

$$s = 86.301 \text{ mm}$$

atau

$$A_{sh} = 0.09\left(\frac{s.h_c.f'_c}{f_{yh}}\right)$$

$$452.16 = 0.09\left(\frac{s \times 508 \times 24.9}{240}\right)$$

$$452.16 = 0.09 \times 52.7\ s$$

$$452.16 = 4.7435\ s$$

$$s = 95.323 \text{ mm}$$

Dipakai s = 80 mm

$$Vs = \frac{As \cdot fy \cdot d}{s} = \frac{452.16 \times 240 \times 540.5}{80}$$

$= 733177.440$ N

Jadi dipasang tulangan geser 4 Ø 12 - 80 mm

Kontrol kuat geser nominal menurut SNI 2847-2013 Pasal 11.4.7.9

$Vs \leq 0.66 \quad bw \cdot d$

$Vs \leq 0.66 \sqrt{24{,}9} \times 600 \times 540.5$

733177.440 N $<$ 1068047.475 N .... OK

Maka :

$\phi\,(V_s + V_c) = 0.75 \left(733177.440 + 372424.748 \right)$

$= 829201.641$ N $>$ Vu = 88206.377 N .... OK

Jadi untuk penulangan geser di daerah yang berpotensi terjadi sendi plastis sejauh lo = 600 mm dipasang tulangan geser 4 kaki Ø 12-80.

- Tulangan geser di luar daerah sendi plastis

Persyaratan spasi maksimum untuk daerah luar sendi plastis menurut SNI 2847-2013 Pasal 21.6.4.5, spasi maksimum tidak boleh melebihi :

- 6 x diameter tulangan utama = 6 x 19 = 114 mm
- 150 mm

Dipakai sengk $\sqrt{fc'}$ Ø 12 dengan spasi 100 mm

$$Vs = \frac{As \cdot fy \cdot d}{s} = \frac{452.16 \times 240 \times 540.5}{100}$$

$= 586541.952$ N

Kontrol kuat geser nominal menurut SNI 2847-2013 Pasal 11.4.7.9

Vs $\leq$ 0.66 $bw \, . \, d$

Vs $\leq$ 0.66 $\sqrt{24{,}9}$ x 600 x 540.5

586541.952 N < 1068047.475 N .... OK

Maka :

$\phi \, (V_s + V_c)$ = 0.75 (586541.952 + 372424.748)

= 719225.025 N > Vu = 88206.377 N .... OK

Jadi untuk penulangan geser di luar sendi plastis dipasang tulangan geser 4 kaki Ø 12-100.

4.3 Sambungan Lewatan Tulangan Vertikal Kolom

Sesuai SNI 2847-2013 Pasal 12.2.3 panjang sambungan lewatan harus dihitung sesuai dengan rumus sebagai berikut :

$$l_d = \left(\frac{f_y}{1{,}1\lambda} \cdot \frac{\Psi_t \; \Psi_o \; \Psi_s}{\left(\frac{c_b + K_{tr}}{d_b} \right)} \right) d_b$$

dimana : Ψt = 1 Ψo = 1 Ψs = 0.8 λ = 1

c = $\sqrt{fc'}$ ut beton + Ø sengkang + ½ D kolom

= 40 + 12 + (½ . 19)

= 61.5 mm

$$c = \frac{600 - 2 \left(40 + 12 \right) - 19}{2 \times 4}$$

= 59.625 mm

diambil c = 59.625 mm yang menentukan

K_{tr} = 0

$$\left(\frac{c_b + K_{tr}}{d_b} \right) = \frac{59.625 + 0}{19} = 3.138$$

Sehingga : $l_d = \dfrac{400}{1.1 \;\; x \;\; 1 \quad \sqrt{24,9}} . \dfrac{1 \;\; x \;\; 1 \;\; x \;\; 0.8}{3.138} . \quad 19$

$\sqrt{fc'}$

$= \; 352.969 \;\; mm$

Sesuai Pasal 21.6.3.3, sambungan lewatan harus diletakan ditengah panjang kolom dan harus dihitung sebagai sambungan tarik.

Mengingat sambungan lewatan ini termasuk kelas B, maka panjangnya harus = 1,3 l_d = 1.3 x 352.969 = 458.860 mm ≈ 500 mm.

- menurut SNI 2847-2013 pasal 21.5.2.3 spasi tulangan transversal yang melingkupi batang tulangan yang di sambung lewatkan tidak boleh melebihi yang terkecil dari :
  - ***d/4*** = 135 mm
  - 100 mm

jadi,dipakai spasi tulangan sambungan lewatan = 80 mm

4.4 Kontrol Desain Kapasitas

Kontrol desain kapasitas untuk joint 143

a. Momen pada kolom

$\sum Mnc = \phi M_{n\ bawah} + \phi M_{n\ desain}$

$= 1815000000$ Nmm

$\sum Mnc = \phi M_{n\ Atas} + \phi M_{n\ desain}$

$= 2165000000$ Nmm

b. Momen pada balok

$Mpr^{-} = 272424314.888$ Nmm

$Mpr^{+} = 173017889.950$ Nmm

$\sum Mnc \geq 1.2 \sum Mnb$

$$\sum Mnc = \frac{1815000000.000 + 2165000000.000}{0.65}$$

$= 6123076923.077$ Nmm

$$1.2 \sum Mnb = \frac{1.2 \times 272424314.888 + 173017889.950}{0.9}$$

$= 593922939.785$ Nmm

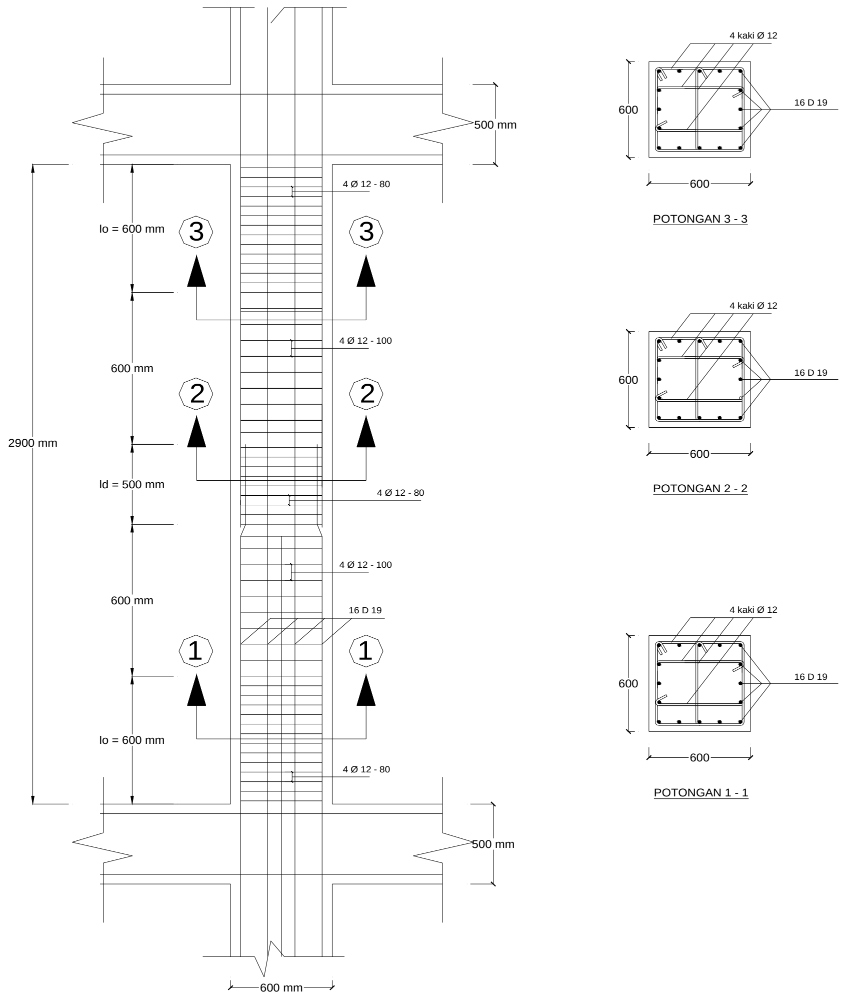
Maka :

$\sum Mnc \geq 1.2 \sum Mnb$

6123076923.077 Nmm > 593922939.785 Nmm .... OK

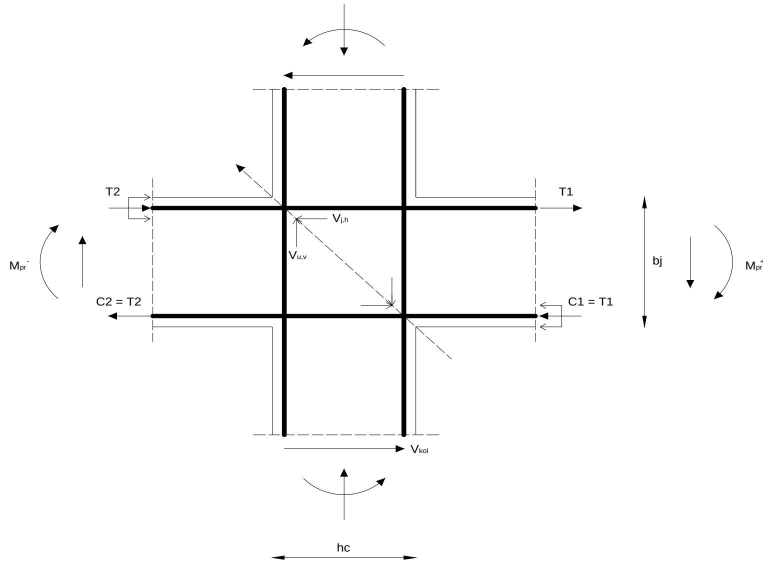
Dari hasil perencanaan balok dan kolom dapat disimpulkan bahwa :

Persyaratan "Strong Column Weak Beam" telah terpenuhi ....OK



Gambar 4.20 Detail Penulangan Longitudinal dan Transversal Kolom 267

4.5 Perhitungan Pertemuan Balok-Kolom



Gambar 4.21 Analisa geser dari hubungan balok kolom *(Joint 143)*

Data perencanaan :

f'c = 24.9 MPa

fy = 400 MPa

Mpr^-, b = 272424314.888 Nmm

Mpr^+, b = 173017889.950 Nmm

hn, a = 2900 mm

hn, b = 2900 mm

Tulangan yang terpasang pada balok :

balok kiri = 4 D 19

balok kanan = 3 D 19

Pemeriksaan kuat geser nominal pada joint :

Gaya geser yang terjadi

As_1 = 4 . ¼ . 3.14 . 19^2 = 1133.54 mm^2

As_2 = 3 . ¼ . 3.14 . 19^2 = 850.16 mm^2

$T = As \cdot 1{,}25 \cdot fy$

$T_1 = 1133.54 \cdot 1.25 \cdot 400 = 566770.000 \text{ N}$

$T_2 = 850.16 \cdot 1.25 \cdot 400 = 425077.500 \text{ N}$

$$Mu = \frac{\text{Mpr, b kanan} + \text{Mpr, b kiri}}{2}$$

$$= \frac{272424314.888 + 173017889.950}{2}$$

$$= 222721102.419 \text{ Nmm}$$

$$Vh = \frac{2 \times Mu}{h_n / 2}$$

$$= \frac{2 \times 222721102.419}{2900 / 2}$$

$$= 307201.521 \text{ N}$$

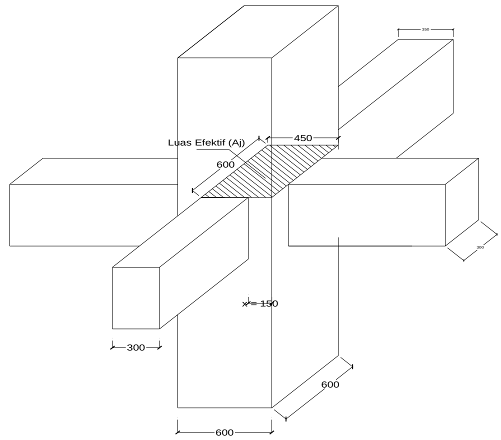
$Vjh = T_1 + T_2 - Vh$

$= 566770.000 + 425077.500 - 307201.521$

$= 684645.979 \text{ N}$

Kuat geser nominal untuk HBK yang terkekang keempat sisinya maka berlaku :

$V_{jh} < \phi \times 1.7 \times \quad \times Aj$



Gambar 4.22 Luas efektif *(Aj)* untuk HBK

Maka :

V_{jh} < ϕ x 1.7 x $\sqrt{fc'}$ x Aj

684645.979 < 0.75 x 1.7 x $\sqrt{24{,}9}$ x 450 x 600

684645.979 N < 1717804.051 N .... OK

- Penulangan geser horisontal

Nu = 1782971 N

$$\frac{Nu}{Ag} = \frac{1782971}{600 \times 600}$$

= 6.191 N/mm^2 > 0,1 . f'c = 0.1 x 24.9 = 2.5 N/mm^2

Jadi $V_{c,h}$ dihitung menurut persamaan

$$V_{c,h} = \frac{2}{3}\sqrt{\left(\frac{Nu,k}{360000} - 0{,}1 \times 24{,}9\right)} \times 600 \times 600$$

$$= \frac{2}{3}\sqrt{\left(\frac{Nu,k}{Ag} - 0{,}1 \times f'c\right)} \times bj \times hc$$

= 461703.585 N

$V_{s,h} + V_{c,h} = V_{j,h}$

$V_{s,h} = V_{j,h} \; \sqrt{fc'}_{,h}$

$= 684645.979 - 461703.585$

$= 222942.395$ N

$$A_{j,h} = \frac{V_{s,h}}{fy}$$

$$= \frac{222942.395}{400}$$

$= 557.35599 \text{ mm}^2$

Coba dipasang 4 lapis tulangan sengkang :

Maka As ada $= 4 \; . \; 452.16$

$= 1808.640 \text{ mm}^2 > A_{j,h} = 557.35599 \text{ mm}^2$ ... Aman

- Penulangan geser vertikal

$$V_{j,v} = \frac{hc}{bj} V_{j,h}$$

$$= \frac{600}{600} \times 684645.979$$

$= 684645.979$ N

$$V_{c,v} = \frac{As' \, . \, V_{j,h}}{As} \times \left(0.6 + \frac{Nu, k}{Ag \, . \, f'c} \right)$$

$$= \frac{850.16 \times 684645.979}{1133.54} \times \left(0.6 + \frac{1782971}{360000 \times 24.9} \right)$$

$= 410224.553$ N

$V_{s,v} \;=\; V_{j,v} - V_{c,v}$

$= \; 684645.979 \; - \; 410224.553$

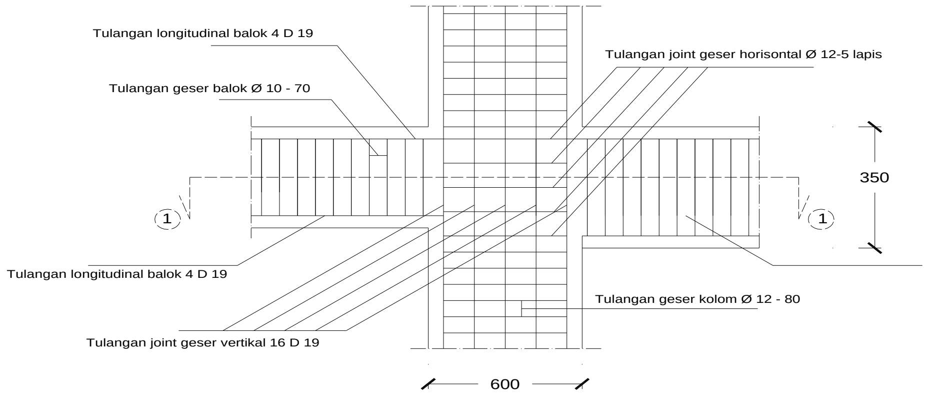
$= \; 274421.426 \;\; N$

$A_{j,v} = \dfrac{V_{s,v}}{fy}$

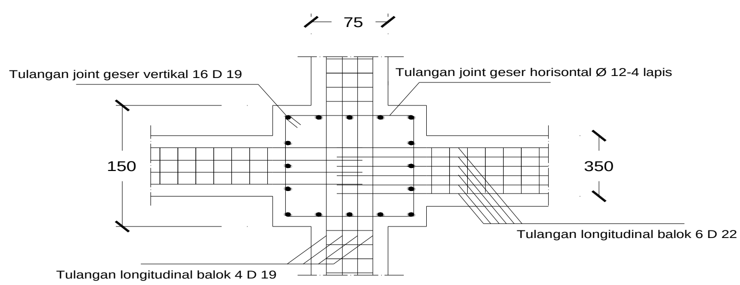
$= \dfrac{274421.426}{400}$

$= \; 686.054 \;\; mm^2$

Tulangan kolom yang terpasang 16 D 19, dimana luas tulangan (As ada = 4534.16 mm^2) > 686.054 mm^2. Maka tidak diperlukan lagi tulangan geser vertikal karena sudah ditahan oleh tulangan kolom yang terpasang.



DETAIL TULANGAN JOINT 2
Skala 1 : 100

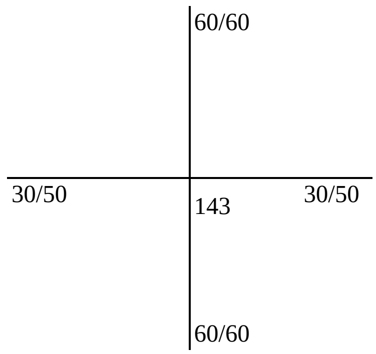


POTONGAN 1 - 1
Skala 1 : 100

Gambar 4.23 Penulangan Hubungan Balok Kolom ***(Joint 143)***

4.6 Perhitungan Pendetailan Tulangan

Perhitungan pendetailan joint 143



- Pendetailan Tulangan Tumpuan Tarik (atas)
  - Untuk pemberhentian tulangan tumpu tarik ke dalam balok adalah sejauh

    ¼ Ln = ¼ . 5050 = 1263 mm dari muka kolom.

    Ditambah dengan penjangkaran yang diperlukan untuk penjangkaran sejauh

    12 db = 12 x 19 = 228 mm

    $$\frac{1}{16} \text{ ln} = \frac{1}{16} \times 5050 = 315.625 \text{ mm}$$

    d = 440.50 mm

    Dipakai perpanjangan 440,50 mm

    Total panjang yang diperlukan = 1263 + 440.50 = 1703.00 mm

    Modifikasi yang digunakan :

    † Batang tulangan baja paling atas dengan elevasi antara tulangan tersebut dengan lapisan beton terbawah tidak kurang dari 300 mm.

    500 - 40 - 10 - (0,5 x 19) = 440.50 mm > 300 mm

† Ld yang dibutuhkan adalah :

$$Ldb = \frac{0,02.As.fy}{\sqrt{fc'}} = \frac{0,02.(¼.\pi.19^2).390}{\sqrt{30}} = 454.326 \text{ mm}$$

Ldb = 0.06 . 19 . 400 = 456.000 mm

Dipakai Ldb = 456.000 mm

Dipakai faktor 1.4

Maka Ld = 456.000 x 1.4

= 638.400 mm ditambah perpanjangan 440,50 mm.

Ld = 638.400 + 440.50

= 1078.900 mm < 1703.00 mm

Jadi dipakai panjang penyaluran Ld = 1703.00 mm ≈ 1800 mm

- Penjangkaran masuk ke dalam kolom

- Pendetailan tulangan tumpuan tekan balok (SNI 2847-2013 Pasal 12.3.2)

Untuk tulangan tumpuan tekan, panjang penyaluran yang masuk ke dalam kolom adalah :

$$Ldb = \frac{db.fy}{4\sqrt{fc'}} = \frac{19 \times 400}{4\sqrt{24,9}} = 380.762 \text{ mm}$$

Panjang Ldb tidak boleh kurang dari :

Ldb = 0.04 . 19 . 400 = 304.000 mm

Ldb = 200 mm

Dipakai Ldb = 380.762 mm ≈ 390 mm

- Pendetailan tulangan tumpuan tarik balok (SNI 2847-2013 Pasal 12.5.2)

$$Lhb = \frac{100.db}{\sqrt{fc'}} = \frac{100 \times 19}{\sqrt{24,9}} = 380.762 \text{ mm}$$

Tidak kurang dari :

8 db = 8 x 19 = 152 mm

Ldh = 380.762 mm > 8 db = 152 mm

Dipakai Ldh = 380.762 mm ≈ 390 mm

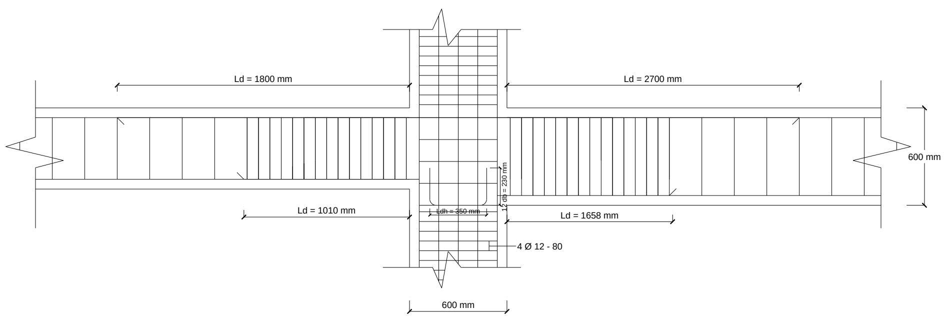
Dipilih pembengkokan 90^{o} dengan panjang pembengkokan 12 db

= 12 x 19 = 228 mm ≈ 230 mm

- Pemutusan tulangan tumpuan tekan

  Untuk pemberhentian tulangan tumpuan tekan adalah sejauh

  ln = x 5050 = 1010 mm dari muka kolom.



Gambar 4.24 Pendetailan Tulangan Joint 143

BAB V

PENUTUP

5.1 Kesimpulan

Pada perencanaan Gedung Hotel Patimura Malang menggunakan struktur portal tahan gempa dengan konsep Sistem Rangka Pemikul Momen Khusus (SRPMK). Mutu beton yang digunakan fc’ = 24,9 MPa, mutu baja ulir fy = 400 MPa, mutu baja polos fy = 240 MPa dan untuk perhitungan analisa struktur menggunakan program bantu STAAD Pro. Portal yang dianalisa adalah portal melintang line 4. Dari perencanaan pada laporan skripsi ini diperoleh hasil diantaranya adalah sebagai berikut :

➢ **<u>Balok</u>**

- Dimensi Balok : 30/50
- Tulangan Tumpuan Kiri : atas 4 D 19, bawah 3 D 19
- Tulangan Lapangan : atas 3 D 19, bawah 4 D 19
- Tulangan Tumpuan Kanan : atas 4 D 19, bawah 3 D 19
- Tulangan Geser

  Joint Kiri

  Daerah Sendi Plastis : Ø 10 – 70 (2 kaki)

  Daerah Luar Sendi Plastis : Ø 10 – 200 (2 kaki)

Joint Kanan

Daerah Sendi Plastis : Ø 10 – 70 (2 kaki)

Daerah Luar Sendi Plastis : Ø 10 – 200 (2 kaki)

- <u>**Kolom**</u>

  Kolom pada portal ini direncanakan menggunakan dimensi 60/60 dengan jumlah tulangan 16 D 19, dengan spesifikasi tulangan geser :

  Daerah Sendi Plastis : Ø 12 – 80 (4 kaki)

  Daerah Luar Sendi Plastis : Ø 12 – 100 (4 kaki)

- Pada perencanaan kolom pada portal ini telah memenuhi konsep “Capacity Design” yaitu Strong Column Weak Beam. Misalkan pada joint 267 :

  2900000000 Nmm > 593922939,785 Nmm …………….. OK

- Pada hubungan balok kolom dipasang pengekang horisontal 4 Ø 12 (4 kaki) dan untuk pengekang vertikal menggunakan tulangan longitudinal kolom.

- Dari hasil perhitungan di atas dapat disimpulkan struktur yang didesain diharapkan mampu menahan gaya gempa dan tidak mengalami kerusakan pada waktu menahan gaya gempa dengan kekuatan kecil, sedang dan tidak mengalami kerusakan fatal akibat gempa kuat.

5.2 Saran

Dengan kemajuan teknologi saat ini, perencanaan struktur gedung portal 3D, kita dapat menggunakan fasilitas program STAAD Pro yang mampu menghasilkan penulangan dan hasil output secara langsung, tetapi tetap memperhatikan peraturan-peraturan yang ada akan lebih efisien dan dapat menghemat biaya pelaksanaan pekerjaan.

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LAMPIRAN

“LEMBAR PERSEMBAHAN”

Puji syukur kepada Bapa di surga atas segala berkat,rahmat dan penjagaannya selama saya berada di kota Malang,terlebih khusus karena saya telah menyelesaikan masa studi di Institut Teknologi Nasional Malang.

AMIN

SKRIPSI INI SAYA PERSEMBAHAN KHUSUS UNTUK :

- Bapa Drs.BORA GHELLO dan Ibu ROSALIN BAWA LOMI,kedua pria dan wanita terhebat dalam hidup saya,orang yang sangat saya sayangi dan sangat berarti untuk saya,terima kasih telah merawat saya selama 22 tahun,segala usaha agar saya bisa menyelesaikan studi saya,tidak ada yang bisa saya lakukan untuk membalas segala kasih saying Bapa dan Mama hanyalah ucapan trima kasih dan doa semoga TUHAN YESUS memberikan Bapa dan Mama umur panjang.AMIN
- Nenek sera di sumba dengan Opa Bernabas n Oma Elizabeth di sabu yang sangat-sangat saya sayangi,semoga Tuhan Yesus kasih umur yang lebih panjang lagi,AMIN
- Untuk adik-adik tercinta NATALIA BORA,MELANITA BORA,MARVINO JUANDRIS TANGGU,ELIEZER JUNIARTON BORA,terima kasi telah dukung kaka slama ini,sekolah yang rajin supaya bisa buat bapa dengan mama bangga.khusus untuk AMA dgn JUN jangan terlalu katillak nanti kaka pulang sumba itu katillak hilang.hahaha
- Untuk kedua sepupu tercinta PAULINA MILLA dan NIMAN SANJAIB sekolah baik-baik biar om dengan tante bangga.
- Untuk keponakan yang paling om sayang AERIL cepat besar sayang ee,,biar bisa sekolah sama dengan om.
- Untuk kekasih tercinta YUNINGSI BEATRIX ANGLENI BOIMAU,terima kasih ina sudah temani saya selama susun skripsi,sudah bela-bela jadi bahan pelampiasan kena marah kalau sudah stress dengan skripsi,tempat curhat,dll, saya hanya bisa bilang "I LOVE U"..
- Untuk teman- teman seperjuangan, KOMANG,RINA,NOI,JOHAN,DENDI, akhirnyan kita slesasi juga kawan kita sekarang sudah Sarjana Teknik,ingat kalo kerja jangan lupa kita,hahaha
- Untuk teman-teman 2010 EKA,NIUS,NORIS,ROBIN,DENI buru skripsinya biar cepat slessai,pokoknya tetap semangat,,caaaayooo,,

- Untuk anak-anak kontrakan ANGKI,DEDI,SANDI,NORIS,ROBIN,LIUS,HERY,NIOR terima kasih untuk semua waktu selama dimalang banyak suka duka yang kita lewati sama-sama,banyak sekali kenangan yang kita lalui,ketawa,main catur,tidak makan,cepat-cepat selesai sudah supaya kita bisa sama-sama lagi di sumba.
- Untuk NORIS n ROBIN : Trima kasih banyak sudah sama-sama dengan saya dari SMA sampai sekarang aw,,banyak skali kita 2 punya kenangan dari tidak makan sampai mabok,biar kalau mabok kita sering batengkar tetap sudah kamu 2 saya punya aw terbaik,,hhhh.satu pesannya saya cepat sudah urus itu skripsi biar cepat selesai dan bisa kerja,satu lagi pesan paling penting ingat kalo mabok jangan rese-rese lagi aw,nanti kalo kamu 2 minum sama-sama jangan bakalai lagi saya sudah tidak da di malang nanti tidak ada yang kasih pisah kamu 2 lagi,,hhhh
- Untuk ANGKI (master catur sekaligus Bandar) lebih semangat lagi kaka biar cepat slesai jangan cepat putus asa,nanti suatu saat kalau kita main catur lagi saya pasti menang dengan semoga cepat dapat maitua supaya akhiri itu puasa pacaran,hahaha
- Untuk DEDI : belajar banyak main catur aw nanti kalau sdh pulang sumba supaya bisa kasih kalah saya jangan hanya remis tok,,hahaha
- Untuk HERY : Buru itu skripsi aw biar maret bisa wisuda,,tetap semangat,nanti baru kita ketemu lagi di sumba.
- Untuk SANDY : kalau main Hp jangan terlalu serius orang ajak omong juga tidak peduli,rajin sedikit ke kampus diks,hhh
- Untuk NIOR n LIUS : Tetap rajin kuliah diks,semoga cepat slesai ee

Tuhan YESUS tolong jaga saya punya sodara-sodara di malang eee,semoga apa yang mereka perjuangkan selama ini bisa tercapai.

AMIN

ANDRIO UMBU DOLI

10.21.038

LAMPIRAN

“STAAD PRO”

Job Information

	Engineer	Checked	Approved
Name:			
Date:	23-Jun-15		

Structure Type	SPACE FRAME

Number of Nodes	4517	Highest Node	4541
Number of Elements	2453	Highest Beam	6364
Number of Plates	3836	Highest Plate	6285

Number of Basic Load Cases	4
Number of Combination Load Cases	18

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	BEBAN MATI
Primary	2	BEBAN HIDUP
Primary	3	BEBAN GEMPA DINAMIK X
Primary	4	BEBAN GEMPA DINAMIK Z
Combination	5	1,4 DL
Combination	6	1,2 DL +1,6 LL
Combination	7	1,2 DL + 1 LL + 0,3 EX + 1 EY
Combination	8	1,2 DL + 1 LL - 0,3 EX - 1 EY
Combination	9	1,2 DL + 1 LL + 0,3 EX - 1 EY
Combination	10	1,2 DL + 1 LL - 0,3 EX + 1EY
Combination	11	1,2 DL + 1 LL + 1 EX +0,3 EY
Combination	12	1,2 DL + 1 LL - 1 EX -0.3 EY
Combination	13	1,2 DL + 1 LL + 1 EX - 0,3 EY
Combination	14	1,2 DL + 1 LL - 1 EX + 0,3 EY
Combination	15	0,9 DL + 0,3 EX + 1 EY
Combination	16	0,9 DL - 0,3 EX - 1 EY
Combination	17	0,9 DL + 0,3 EX - 1 EY
Combination	18	0,9 DL - 0,3 EX + 1 EY
Combination	19	0,9 DL + 1 EX + 0,3 EY
Combination	20	0,9 DL - 1 EX - 0,3 EY
Combination	21	0,9 DL + 1 EX - 0,3 EY
Combination	22	0,9 DL - 1 EX + 0,3 EY

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
5	1,4 DL	1	BEBAN MATI	1.40
6	1,2 DL +1,6 LL	1	BEBAN MATI	1.20
		2	BEBAN HIDUP	1.60
7	1,2 DL + 1 LL + 0,3 EX + 1 EY	1	BEBAN MATI	1.20
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	0.30
		4	BEBAN GEMPA DINAMIK Z	1.00
8	1,2 DL + 1 LL - 0,3 EX - 1 EY	1	BEBAN MATI	1.20
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	-0.30
		4	BEBAN GEMPA DINAMIK Z	-1.00
9	1,2 DL + 1 LL + 0,3 EX - 1 EY	1	BEBAN MATI	1.00
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	0.30
		4	BEBAN GEMPA DINAMIK Z	-1.00
10	1,2 DL + 1 LL - 0,3 EX + 1EY	1	BEBAN MATI	1.20
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	-0.30
		4	BEBAN GEMPA DINAMIK Z	1.00
11	1,2 DL + 1 LL + 1 EX +0,3 EY	1	BEBAN MATI	1.20
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	1.00
		4	BEBAN GEMPA DINAMIK Z	0.30
12	1,2 DL + 1 LL - 1 EX -0.3 EY	1	BEBAN MATI	1.20
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	1.00
		4	BEBAN GEMPA DINAMIK Z	-0.30
13	1,2 DL + 1 LL + 1 EX - 0,3 EY	1	BEBAN MATI	1.20
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	1.00
		4	BEBAN GEMPA DINAMIK Z	-0.30
14	1,2 DL + 1 LL - 1 EX + 0,3 EY	1	BEBAN MATI	1.10
		2	BEBAN HIDUP	1.00
		3	BEBAN GEMPA DINAMIK X	-1.00
		4	BEBAN GEMPA DINAMIK Z	0.30
15	0,9 DL + 0,3 EX + 1 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	0.30
		4	BEBAN GEMPA DINAMIK Z	1.00
16	0,9 DL - 0,3 EX - 1 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	-0.30
		4	BEBAN GEMPA DINAMIK Z	-1.00
17	0,9 DL + 0,3 EX - 1 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	0.30
		4	BEBAN GEMPA DINAMIK Z	-1.00
18	0,9 DL - 0,3 EX + 1 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	-0.30
		4	BEBAN GEMPA DINAMIK Z	1.00
19	0,9 DL + 1 EX + 0,3 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	1.00

Combination Load Cases Cont...

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
		4	BEBAN GEMPA DINAMIK Z	0.30
20	0,9 DL - 1 EX - 0,3 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	-1.00
		4	BEBAN GEMPA DINAMIK Z	-0.30
21	0,9 DL + 1 EX - 0,3 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	1.00
		4	BEBAN GEMPA DINAMIK Z	-0.30
22	0,9 DL - 1 EX + 0,3 EY	1	BEBAN MATI	0.90
		3	BEBAN GEMPA DINAMIK X	-1.00
		4	BEBAN GEMPA DINAMIK Z	0.30

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN˙m/deg)	rY (kN˙m/deg)	rZ (kN˙m/deg)
36	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
37	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
38	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
39	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
40	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
41	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
42	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
43	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
44	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
45	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
46	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
47	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
48	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
49	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
50	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
51	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
52	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
53	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
54	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
55	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
56	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
57	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
58	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
59	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
60	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
61	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
62	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
63	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed

Materials

Mat	Name	E (kN/mm²)	¬	Density (kg/m³)	~ (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Section Properties

Prop	Section	Area (cm²)	I_{yy} (cm⁴)	I_{zz} (cm⁴)	J (cm⁴)	Material
12	Rect 0.60x0.60	3.6E+3	1.08E+6	1.08E+6	1.82E+6	CONCRETE
13	Rect 0.60x0.40	2.4E+3	320E+3	720E+3	751E+3	CONCRETE
14	Rect 0.40x0.40	1.6E+3	213E+3	213E+3	360E+3	CONCRETE
15	Rect 0.50x0.30	1.5E+3	113E+3	313E+3	282E+3	CONCRETE
16	Rect 0.50x0.30	1.5E+3	113E+3	313E+3	282E+3	CONCRETE
17	Rect 0.50x0.30	1.5E+3	113E+3	313E+3	282E+3	CONCRETE
18	Rect 0.50x0.30	1.5E+3	113E+3	313E+3	282E+3	CONCRETE
19	Rect 0.50x0.30	1.5E+3	113E+3	313E+3	282E+3	CONCRETE
20	Rect 0.60x0.30	1.8E+3	135E+3	540E+3	371E+3	CONCRETE
21	Rect 0.60x0.35	2.1E+3	214E+3	630E+3	545E+3	CONCRETE
22	Rect 0.60x0.35	2.1E+3	214E+3	630E+3	545E+3	CONCRETE
23	Rect 0.60x0.35	2.1E+3	214E+3	630E+3	545E+3	CONCRETE
24	Rect 0.30x0.20	600.000	20E+3	45E+3	47E+3	CONCRETE
25	Rect 0.30x0.25	750.000	39.1E+3	56.3E+3	77.5E+3	CONCRETE
26	Rect 0.30x0.25	750.000	39.1E+3	56.3E+3	77.5E+3	CONCRETE
27	Rect 0.30x0.25	750.000	39.1E+3	56.3E+3	77.5E+3	CONCRETE
28	Rect 0.30x0.25	750.000	39.1E+3	56.3E+3	77.5E+3	CONCRETE
29	Rect 0.30x0.25	750.000	39.1E+3	56.3E+3	77.5E+3	CONCRETE

Plate Thickness

Prop	Node A (cm)	Node B (cm)	Node C (cm)	Node D (cm)	Material
1	12.000	12.000	12.000	12.000	CONCRETE
2	12.000	12.000	12.000	12.000	CONCRETE
3	12.000	12.000	12.000	12.000	CONCRETE
4	12.000	12.000	12.000	12.000	CONCRETE
5	12.000	12.000	12.000	12.000	CONCRETE
6	12.000	12.000	12.000	12.000	CONCRETE
7	12.000	12.000	12.000	12.000	CONCRETE
8	12.000	12.000	12.000	12.000	CONCRETE
9	12.000	12.000	12.000	12.000	CONCRETE
10	12.000	12.000	12.000	12.000	CONCRETE
11	10.000	10.000	10.000	10.000	CONCRETE

Primary Load Cases

Number	Name	Type
1	BEBAN MATI	Dead
2	BEBAN HIDUP	Live
3	BEBAN GEMPA DINAMIK X	None
4	BEBAN GEMPA DINAMIK Z	None

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STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 23-Jun-15
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KG
JOINT COORDINATES
1 0 0 0; 2 0 0 6.5; 3 0 0 13.25; 4 0 0 19.75; 5 0 0 26.25; 6 0 0 34; 7 0 0 38;
8 1.2 0 38; 9 6.85 0 38; 10 12.55 0 38; 11 18.2 0 38; 12 18.2 0 34;
13 18.2 0 26.25; 14 18.2 0 19.75; 15 18.2 0 13.25; 16 18.2 0 6.5; 17 18.2 0 0;
18 15.2 0 0; 19 6.85 0 0; 20 1.2 0 0; 21 1.2 0 6.5; 22 1.2 0 13.25;
23 1.2 0 19.75; 24 1.2 0 26.25; 25 1.2 0 34; 26 6.85 0 6.5; 27 6.85 0 13.25;
28 6.85 0 19.75; 29 6.85 0 26.25; 30 6.85 0 34; 31 15.2 0 6.5; 32 15.2 0 13.25;
33 15.2 0 19.75; 34 15.2 0 26.25; 35 15.2 0 34; 36 1.2 -3.2 38;
37 6.85 -3.2 38; 38 12.55 -3.2 38; 39 18.2 -3.2 38; 40 18.2 -3.2 34;
41 18.2 -3.2 26.25; 42 18.2 -3.2 19.75; 43 18.2 -3.2 13.25; 44 18.2 -3.2 6.5;
45 18.2 -3.2 0; 46 15.2 -3.2 0; 47 6.85 -3.2 0; 48 1.2 -3.2 0; 49 1.2 -3.2 6.5;
50 1.2 -3.2 13.25; 51 1.2 -3.2 19.75; 52 1.2 -3.2 26.25; 53 1.2 -3.2 34;
54 6.85 -3.2 6.5; 55 6.85 -3.2 13.25; 56 6.85 -3.2 19.75; 57 6.85 -3.2 26.25;
58 6.85 -3.2 34; 59 15.2 -3.2 6.5; 60 15.2 -3.2 13.25; 61 15.2 -3.2 19.75;
62 15.2 -3.2 26.25; 63 15.2 -3.2 34; 64 12.55 0 34; 65 0 5.5 0; 66 0 5.5 6.5;
67 0 5.5 13.25; 68 0 5.5 19.75; 69 0 5.5 26.25; 70 0 5.5 34; 71 18.2 5.5 34;
72 18.2 5.5 26.25; 73 18.2 5.5 19.75; 74 18.2 5.5 13.25; 75 18.2 5.5 6.5;
76 18.2 5.5 0; 77 15.2 5.5 0; 78 6.85 5.5 0; 79 1.2 5.5 0; 80 1.2 5.5 6.5;
81 1.2 5.5 13.25; 82 1.2 5.5 19.75; 83 1.2 5.5 26.25; 84 1.2 5.5 34;
85 6.85 5.5 6.5; 86 6.85 5.5 13.25; 87 6.85 5.5 19.75; 88 6.85 5.5 26.25;
89 6.85 5.5 34; 90 15.2 5.5 6.5; 91 15.2 5.5 13.25; 92 15.2 5.5 19.75;
93 15.2 5.5 26.25; 94 15.2 5.5 34; 95 12.55 5.5 34; 96 18.2 10 34;
97 18.2 10 26.25; 98 18.2 10 19.75; 99 18.2 10 13.25; 100 18.2 10 6.5;
101 18.2 10 0; 102 15.2 10 0; 103 6.85 10 0; 104 1.2 10 0; 105 1.2 10 6.5;
106 1.2 10 13.25; 107 1.2 10 19.75; 108 1.2 10 26.25; 109 1.2 10 34;
110 6.85 10 6.5; 111 6.85 10 13.25; 112 6.85 10 19.75; 113 6.85 10 26.25;
114 6.85 10 34; 115 15.2 10 6.5; 116 15.2 10 13.25; 117 15.2 10 19.75;
118 15.2 10 26.25; 119 15.2 10 34; 120 12.55 10 34; 121 0 10 0; 122 0 10 6.5;
123 0 10 13.25; 124 0 10 19.75; 125 0 10 26.25; 126 0 10 34; 128 1.2 10 36;
129 6.85 10 36; 131 12.55 10 36; 132 0 10 36; 133 15.2 13.4 0; 134 6.85 13.4 0;
135 1.2 13.4 0; 136 1.2 13.4 6.5; 137 1.2 13.4 13.25; 138 1.2 13.4 19.75;
139 1.2 13.4 26.25; 140 1.2 13.4 34; 141 6.85 13.4 6.5; 142 6.85 13.4 13.25;
143 6.85 13.4 19.75; 144 6.85 13.4 26.25; 145 6.85 13.4 34; 146 15.2 13.4 6.5;
147 15.2 13.4 13.25; 148 15.2 13.4 19.75; 149 15.2 13.4 26.25;
150 15.2 13.4 34; 151 12.55 13.4 34; 152 15.2 13.4 36; 153 1.2 13.4 36;
154 6.85 13.4 36; 155 12.55 13.4 36; 157 15.2 16.8 0; 158 6.85 16.8 0;
159 1.2 16.8 0; 160 1.2 16.8 6.5; 161 1.2 16.8 13.25; 162 1.2 16.8 19.75;
163 1.2 16.8 26.25; 164 1.2 16.8 34; 165 6.85 16.8 6.5; 166 6.85 16.8 13.25;
167 6.85 16.8 19.75; 168 6.85 16.8 26.25; 169 6.85 16.8 34; 170 15.2 16.8 6.5;
171 15.2 16.8 13.25; 172 15.2 16.8 19.75; 173 15.2 16.8 26.25;
174 15.2 16.8 34; 175 12.55 16.8 34; 176 15.2 20.2 0; 177 6.85 20.2 0;
178 1.2 20.2 0; 179 1.2 20.2 6.5; 180 1.2 20.2 13.25; 181 1.2 20.2 19.75;
182 1.2 20.2 26.25; 183 1.2 20.2 34; 184 6.85 20.2 6.5; 185 6.85 20.2 13.25;
186 6.85 20.2 19.75; 187 6.85 20.2 26.25; 188 6.85 20.2 34; 189 15.2 20.2 6.5;
190 15.2 20.2 13.25; 191 15.2 20.2 19.75; 192 15.2 20.2 26.25;
193 15.2 20.2 34; 194 12.55 20.2 34; 195 15.2 16.8 36; 196 1.2 16.8 36;
197 6.85 16.8 36; 198 12.55 16.8 36; 199 15.2 20.2 36; 200 1.2 20.2 36;
201 6.85 20.2 36; 202 12.55 20.2 36; 203 1.2 20.2 23; 204 6.85 20.2 23;
205 15.2 20.2 23; 206 15.2 23.6 0; 207 6.85 23.6 0; 208 1.2 23.6 0;
209 1.2 23.6 6.5; 210 1.2 23.6 13.25; 211 1.2 23.6 19.75; 212 6.85 23.6 6.5;
213 6.85 23.6 13.25; 214 6.85 23.6 19.75; 215 15.2 23.6 6.5;
216 15.2 23.6 13.25; 217 15.2 23.6 19.75; 218 1.2 23.6 23; 219 6.85 23.6 23;
220 15.2 23.6 23; 221 6.85 26.1 6.5; 222 6.85 26.1 13.25; 223 15.2 26.1 6.5;
224 15.2 26.1 13.25; 225 10.5 0 0; 226 10.5 0 6.5; 227 10.5 0 13.25;
228 10.5 0 19.75; 229 10.5 0 26.25; 230 10.5 0 34; 231 0 0 3.25;
232 18.2 0 3.25; 233 15.2 0 3.25; 234 6.85 0 3.25; 235 1.2 0 3.25;
236 10.5 0 3.25; 237 0 0 9.875; 238 18.2 0 9.875; 239 1.2 0 9.875;
240 6.85 0 9.875; 241 15.2 0 9.875; 242 10.5 0 9.875; 243 0 0 16.5;
244 18.2 0 16.5; 245 1.2 0 16.5; 246 6.85 0 16.5; 247 15.2 0 16.5;
248 10.5 0 16.5; 249 0 0 23; 250 18.2 0 23; 251 1.2 0 23; 252 6.85 0 23;
253 15.2 0 23; 254 10.5 0 23; 255 0 0 30.125; 256 18.2 0 30.125;
257 1.2 0 30.125; 258 6.85 0 30.125; 259 15.2 0 30.125; 260 10.5 0 30.125;
261 10.5 5.5 0; 262 10.5 5.5 6.5; 263 10.5 5.5 13.25; 264 10.5 5.5 19.75;
265 10.5 5.5 26.25; 266 10.5 5.5 34; 267 0 5.5 3.25; 268 18.2 5.5 3.25;
269 15.2 5.5 3.25; 270 6.85 5.5 3.25; 271 1.2 5.5 3.25; 272 10.5 5.5 3.25;
273 0 5.5 9.875; 274 18.2 5.5 9.875; 275 1.2 5.5 9.875; 276 6.85 5.5 9.875;
277 15.2 5.5 9.875; 278 10.5 5.5 9.875; 279 0 5.5 16.5; 280 18.2 5.5 16.5;
281 1.2 5.5 16.5; 282 6.85 5.5 16.5; 283 15.2 5.5 16.5; 284 10.5 5.5 16.5;
285 0 5.5 23; 286 18.2 5.5 23; 287 1.2 5.5 23; 288 6.85 5.5 23;
289 15.2 5.5 23; 290 10.5 5.5 23; 291 0 5.5 30.125; 292 18.2 5.5 30.125;
293 1.2 5.5 30.125; 294 6.85 5.5 30.125; 295 15.2 5.5 30.125;
296 10.5 5.5 30.125; 297 10.5 10 0; 298 10.5 10 6.5; 299 10.5 10 13.25;
300 10.5 10 19.75; 301 10.5 10 26.25; 302 10.5 10 34; 303 0 10 3.25;
304 18.2 10 3.25; 305 15.2 10 3.25; 306 6.85 10 3.25; 307 1.2 10 3.25;
308 10.5 10 3.25; 309 0 10 9.875; 310 18.2 10 9.875; 311 1.2 10 9.875;
312 6.85 10 9.875; 313 15.2 10 9.875; 314 10.5 10 9.875; 315 0 10 16.5;
316 18.2 10 16.5; 317 1.2 10 16.5; 318 6.85 10 16.5; 319 15.2 10 16.5;
320 10.5 10 16.5; 321 0 10 23; 322 18.2 10 23; 323 1.2 10 23; 324 6.85 10 23;
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325 15.2 10 23; 326 10.5 10 23; 327 0 10 30.125; 328 18.2 10 30.125;
329 1.2 10 30.125; 330 6.85 10 30.125; 331 15.2 10 30.125; 332 10.5 10 30.125;
333 10.5 13.4 0; 334 10.5 13.4 6.5; 335 10.5 13.4 13.25; 336 10.5 13.4 19.75;
337 10.5 13.4 26.25; 338 10.5 13.4 34; 339 15.2 13.4 3.25; 340 6.85 13.4 3.25;
341 1.2 13.4 3.25; 342 10.5 13.4 3.25; 343 1.2 13.4 9.875; 344 6.85 13.4 9.875;
345 15.2 13.4 9.875; 346 10.5 13.4 9.875; 347 1.2 13.4 16.5;
348 6.85 13.4 16.5; 349 15.2 13.4 16.5; 350 10.5 13.4 16.5; 352 1.2 13.4 23;
353 6.85 13.4 23; 354 15.2 13.4 23; 355 10.5 13.4 23; 356 1.2 13.4 30.125;
357 6.85 13.4 30.125; 358 15.2 13.4 30.125; 359 10.5 13.4 30.125;
360 10.5 16.8 0; 361 10.5 16.8 6.5; 362 10.5 16.8 13.25; 363 10.5 16.8 19.75;
364 10.5 16.8 26.25; 365 10.5 16.8 34; 366 15.2 16.8 3.25; 367 6.85 16.8 3.25;
368 1.2 16.8 3.25; 369 10.5 16.8 3.25; 370 1.2 16.8 9.875; 371 6.85 16.8 9.875;
372 15.2 16.8 9.875; 373 10.5 16.8 9.875; 374 1.2 16.8 16.5;
375 6.85 16.8 16.5; 376 15.2 16.8 16.5; 377 10.5 16.8 16.5; 379 1.2 16.8 23;
380 6.85 16.8 23; 381 15.2 16.8 23; 382 10.5 16.8 23; 383 1.2 16.8 30.125;
384 6.85 16.8 30.125; 385 15.2 16.8 30.125; 386 10.5 16.8 30.125;
387 10.5 20.2 0; 388 10.5 20.2 6.5; 389 10.5 20.2 13.25; 390 10.5 20.2 19.75;
391 10.5 20.2 26.25; 392 10.5 20.2 34; 393 15.2 20.2 3.25; 394 6.85 20.2 3.25;
395 1.2 20.2 3.25; 396 10.5 20.2 3.25; 397 1.2 20.2 9.875; 398 6.85 20.2 9.875;
399 15.2 20.2 9.875; 400 10.5 20.2 9.875; 401 1.2 20.2 16.5;
402 6.85 20.2 16.5; 403 15.2 20.2 16.5; 404 10.5 20.2 16.5; 406 10.5 20.2 23;
407 1.2 20.2 30.125; 408 6.85 20.2 30.125; 409 15.2 20.2 30.125;
410 10.5 20.2 30.125; 411 10.5 23.6 0; 412 10.5 23.6 6.5; 413 10.5 23.6 13.25;
414 10.5 23.6 19.75; 415 15.2 23.6 3.25; 416 6.85 23.6 3.25; 417 1.2 23.6 3.25;
418 10.5 23.6 3.25; 419 1.2 23.6 9.875; 420 6.85 23.6 9.875;
421 15.2 23.6 9.875; 422 10.5 23.6 9.875; 423 1.2 23.6 16.5;
424 6.85 23.6 16.5; 425 15.2 23.6 16.5; 426 10.5 23.6 16.5; 427 10.5 23.6 23;
428 10.5 26.1 6.5; 429 10.5 26.1 13.25; 430 15.2 26.1 9.875;
431 10.5 26.1 9.875; 432 18.2 10 36; 433 0.91 0 0; 434 0.91 0 1.08333;
435 0 0 1.08333; 436 1.82 0 0; 437 1.82 0 1.08333; 438 2.73 0 0;
439 2.73 0 1.08333; 440 3.64 0 0; 441 3.64 0 1.08333; 442 4.55 0 0;
443 4.55 0 1.08333; 444 5.46 0 0; 445 5.46 0 1.08333; 446 6.37 0 0;
447 6.37 0 1.08333; 448 7.28 0 0; 449 7.28 0 1.08333; 450 8.19 0 0;
451 8.19 0 1.08333; 452 9.1 0 0; 453 9.1 0 1.08333; 454 10.01 0 0;
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ELEMENT PROPERTY
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6224 TO 6228 6230 6232 6233 6235 TO 6237 6239 6241 6242 6244 TO 6246 6248 -
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6271 TO 6273 6275 6277 6279 6280 6282 6284 6285 THICKNESS 0.1
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POISSON 0.17
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ALPHA 1e-005
DAMP 0.05
TYPE CONCRETE
STRENGTH FCU 2.81228e+006
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MEMBER PROPERTY AMERICAN
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560 TO 563 611 TO 614 616 TO 619 621 TO 624 626 TO 629 676 TO 687 -
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4193 4195 4198 4200 4217 4227 4237 4247 4257 4396 TO 4398 4400 TO 4403 4405 -
4406 4408 4409 4411 4412 4414 4439 TO 4444 4446 TO 4448 4450 4452 4454 4456 -
4473 TO 4478 4480 TO 4482 4484 4486 4488 4490 4507 TO 4512 4514 TO 4516 4518 -
4520 4522 4524 4541 TO 4544 4552 4554 4556 4558 4560 5074 TO 5076 -
5078 TO 5081 5083 5084 5086 5087 PRIS YD 0.5 ZD 0.3
5089 5090 5092 5117 TO 5122 5124 TO 5126 5128 5130 5132 5134 5151 TO 5156 -
5158 TO 5160 5162 5164 5166 5168 5185 TO 5190 5192 TO 5194 5196 5198 5200 -
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5891 5893 5901 5909 5917 5925 5991 5993 5996 5998 6001 6003 6007 6009 6011 -
6019 6027 6035 6043 6109 6111 6114 6116 6119 6121 6123 6187 6189 6191 6194 -
6197 6199 6201 6203 6276 6278 6281 6283 6364 PRIS YD 0.5 ZD 0.3
12 25 31 37 120 133 138 143 195 207 212 217 286 291 296 341 346 351 388 393 -
398 528 TO 531 565 TO 568 631 TO 634 688 TO 690 735 TO 737 780 TO 782 1752 -
1754 1756 1759 1761 1763 2750 2752 2754 2757 2759 2761 3643 3645 3647 3650 -
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4546 TO 4547 4549 TO 4551 4577 TO 4582 5223 TO 5225 5227 TO 5229 5255 TO 5259 -
5260 PRIS YD 0.6 ZD 0.3
18 41 45 49 53 57 87 126 146 150 154 158 162 164 201 219 222 225 228 231 233 -
280 298 300 302 304 306 307 335 353 355 357 359 361 362 382 400 402 404 406 -
408 409 439 451 453 455 470 TO 477 538 TO 543 604 TO 609 670 TO 675 -
717 TO 722 764 TO 769 806 TO 809 836 837 888 890 892 894 896 898 900 902 -
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2001 2008 2010 2017 2122 2130 2138 2146 2154 2162 2170 2178 2186 2288 2296 -
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4277 4287 4297 4307 4317 4327 4337 4415 PRIS YD 0.6 ZD 0.35
6286 6292 TO 6295 6300 6308 TO 6311 6314 6317 TO 6320 6323 6326 TO 6328 -
6334 PRIS YD 0.6 ZD 0.35
4417 4418 4420 4421 4423 4424 4426 4427 4429 4430 4432 4433 4435 4436 4438 -
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4506 4526 4528 4530 4532 4534 4536 4538 4540 4562 4564 4566 4568 4570 4572 -
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6231 6238 6240 6247 6249 6256 6258 6265 6267 6274 6331 6335 6338 6342 6343 -
6345 6349 6350 6353 6359 PRIS YD 0.6 ZD 0.35
1 TO 6 165 TO 169 240 TO 244 246 247 249 250 308 309 313 410 411 414 416 417 -
420 478 TO 483 488 489 494 499 503 505 510 514 516 521 525 527 532 536 544 -
549 554 559 564 569 TO 575 580 584 586 590 592 596 598 602 610 615 620 625 -
630 635 TO 640 646 652 658 664 691 TO 696 700 704 708 713 738 TO 743 747 -
751 755 760 783 TO 788 792 796 800 802 820 TO 824 828 832 839 TO 841 871 -
874 914 968 970 972 975 997 1058 1060 1064 1066 1192 1200 1208 1224 1226 -
1230 1232 1358 1366 1374 1390 1392 1396 1398 1524 1532 1540 1556 1558 1560 -
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2743 2764 2767 2771 2773 2949 2951 2955 2957 3115 3117 3121 3123 3281 3283 -
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6313 PRIS YD 0.3 ZD 0.2
251 252 255 311 312 315 412 413 415 418 419 421 425 426 462 463 490 TO 493 -
500 TO 502 504 511 TO 513 515 522 TO 524 526 533 TO 535 537 576 TO 579 581 -
582 TO 583 585 587 TO 589 591 593 TO 595 597 599 TO 601 603 641 TO 645 647 -
648 TO 651 653 TO 657 659 TO 663 665 TO 669 697 TO 699 701 TO 703 705 TO 707 -
710 TO 712 714 TO 716 744 TO 746 748 TO 750 752 TO 754 757 TO 759 -
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829 TO 831 833 TO 835 872 936 938 940 942 944 946 948 950 952 954 956 958 -
960 962 964 966 1062 1072 1080 1088 1096 1104 1112 1120 1128 1136 1144 1152 -
1160 1168 1176 1184 1228 1238 1246 1254 1262 1270 1278 1286 1294 1302 1310 -
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2603 2613 2623 2633 2643 2653 2663 2673 2683 PRIS YD 0.3 ZD 0.25
6296 6312 PRIS YD 0.3 ZD 0.25
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3153 3161 3169 3177 3185 3193 3201 3209 3217 3225 3233 3241 3249 3257 3265 -
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4029 4037 4045 4053 4061 4069 4089 4099 4107 4115 4123 4131 4139 4147 4155 -
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5100 5103 5106 5109 5112 5115 5123 5127 5129 5131 PRIS YD 0.3 ZD 0.25
6321 6329 6336 PRIS YD 0.3 ZD 0.25
5133 5135 5137 5139 5141 5143 5145 5147 5149 5157 5161 5163 5165 5167 5169 -
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5249 5251 5253 5262 TO 5274 5757 5768 5777 5786 5795 5804 5813 5822 5831 -
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5977 5985 6005 6015 6023 6031 6039 6047 6055 6063 6071 6079 6087 6095 6103 -
6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6351 -
6362 PRIS YD 0.3 ZD 0.25
CONSTANTS
MATERIAL CONCRETE ALL
SUPPORTS
36 TO 63 FIXED
LOAD 1 LOADTYPE Dead  TITLE BEBAN MATI
SELFWEIGHT Y -1
MEMBER LOAD
12 TO 19 21 TO 25 29 30 40 TO 42 44 56 TO 58 87 472 473 477 484 487 495 496 -
506 TO 508 517 518 523 528 529 876 878 880 882 884 886 888 890 892 894 896 -
898 900 902 904 906 908 910 912 934 995 1017 1021 1023 1025 1027 1029 1031 -
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1100 1108 1116 1214 1216 1219 1221 1380 1382 1385 1387 1404 1412 1420 1428 -
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1670 1680 1690 1700 1710 1720 1730 1740 1750 1752 1754 1756 1759 1761 1763 -
6286 6291 UNI GY -1375
120 TO 127 129 TO 133 145 TO 147 153 TO 155 161 TO 164 538 539 541 543 545 -
548 550 551 555 556 560 561 565 566 1884 1891 1893 1900 1902 1909 1911 1918 -
1920 1927 1929 1936 1938 1945 1947 1954 1956 1963 1965 1972 1974 1981 1983 -
1990 1992 1999 2001 2008 2010 2017 2019 2026 2028 2035 2037 2044 2046 2048 -
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2312 2320 2328 2336 2344 2352 2360 2368 2376 2378 2380 2383 2385 2544 2546 -
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2708 2718 2728 2738 2748 2750 2752 2754 2757 2759 2761 6300 -
6304 UNI GY -1125
201 TO 218 221 224 227 230 231 233 280 TO 297 299 301 303 305 TO 307 -
335 TO 352 354 356 358 360 TO 362 382 TO 399 401 403 405 407 TO 409 -
422 TO 425 439 TO 450 452 454 459 TO 463 604 TO 609 612 TO 614 617 TO 619 -
622 TO 624 627 TO 629 632 TO 640 642 643 646 648 651 652 654 657 658 660 -
663 664 666 669 TO 698 700 701 703 TO 705 707 708 710 712 TO 714 716 TO 745 -
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800 802 803 805 TO 826 828 829 831 TO 833 835 2777 2780 2784 2786 2789 2793 -
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3157 3161 3165 3169 3173 3209 3213 3217 3221 3225 3229 3233 3237 3241 3245 -
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3387 3391 3395 3399 3403 3407 3411 3466 3471 3476 3481 3486 3491 3496 3501 -
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3747 3749 3752 3756 3758 3761 3765 3767 3776 3785 3794 3803 UNI GY -850
6356 UNI GY -850
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6005 6007 6009 6011 6015 6019 6023 6027 6031 6035 6039 6043 6079 6083 6087 -
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6140 6145 6150 6155 6160 6165 6170 6175 UNI GY -850
6353 6359 UNI GY -850
6180 6185 6187 6189 6191 6314 6316 6323 6325 6331 6333 6338 6341 6345 -
6348 UNI GY -850
468 TO 471 836 TO 838 6194 6195 6197 6199 6201 6203 6205 6207 6213 6215 6221 -
6223 6229 6231 6238 6240 6247 6249 6256 6258 6265 6267 6274 6276 6278 6281 -
6283 6364 UNI GY -625
12 TO 19 21 TO 25 56 TO 58 87 472 477 484 487 495 496 506 507 517 518 528 -
529 876 878 880 882 884 886 888 890 892 894 896 898 900 902 904 906 908 910 -
912 934 995 1017 1214 1216 1219 1221 1380 1382 1385 1387 1546 1548 1551 1553 -
1580 1590 1600 1610 1620 1630 1640 1650 1660 1670 1680 1690 1700 1710 1720 -
1730 1740 1750 1752 1754 1756 1759 1761 1763 6286 UNI GY -825
120 TO 127 129 TO 133 161 TO 164 538 543 545 548 550 551 555 556 560 561 565 -
566 1884 1893 1902 1911 1920 1929 1938 1947 1956 1965 1974 1983 1992 2001 -
2010 2019 2028 2037 2046 2048 2051 2053 2212 2214 2217 2219 2378 2380 2383 -
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6304 UNI GY -675
201 TO 217 230 231 233 280 TO 296 305 TO 307 335 TO 351 360 TO 362 -
382 TO 398 407 TO 409 422 TO 424 439 TO 443 447 TO 449 459 461 TO 463 604 -
609 612 TO 614 617 TO 619 622 TO 624 627 TO 629 632 TO 640 646 652 658 664 -
670 675 TO 696 700 704 708 713 717 722 TO 743 747 751 755 760 764 -
769 TO 778 780 TO 788 792 796 800 802 806 810 812 813 815 816 818 819 2777 -
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5219 TO 5225 UNI GY -510
5227 TO 5230 5232 5234 5236 5238 5240 5242 5244 5246 5248 5250 5252 -
5254 TO 5260 5752 5753 5755 5759 5761 5765 5774 5783 5792 5801 5810 5819 -
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6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6187 6189 6191 6314 -
6316 6323 6325 6331 6333 6338 6341 6345 6353 6359 UNI GY -510
ELEMENT LOAD
875 877 879 881 883 885 887 889 891 893 895 897 899 901 903 905 907 909 911 -
913 915 TO 933 935 937 939 941 943 945 947 949 951 953 955 957 959 961 963 -
965 967 969 971 973 974 976 TO 994 996 998 TO 1016 1018 1020 1022 1024 1026 -
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1082 TO 1083 1085 TO 1087 1089 TO 1091 1093 TO 1095 1097 TO 1099 1101 TO 1103 -
1105 TO 1107 1109 TO 1111 1113 TO 1115 1117 TO 1119 1121 TO 1123 -
1125 TO 1127 1129 TO 1131 1133 TO 1135 1137 TO 1139 1141 TO 1143 -
1145 TO 1147 1149 TO 1151 1153 TO 1155 1157 TO 1159 1161 TO 1163 -
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1255 TO 1257 1259 TO 1261 1263 TO 1265 1267 TO 1269 1271 TO 1273 -
1275 TO 1277 1279 TO 1281 1283 TO 1285 1287 TO 1289 1291 TO 1293 -
1295 TO 1297 1299 TO 1301 1303 TO 1305 1307 TO 1309 1311 TO 1313 -
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1437 TO 1439 1441 TO 1443 1445 TO 1447 1449 TO 1451 1453 TO 1455 -
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1721 TO 1724 1726 TO 1729 1731 TO 1734 1736 TO 1739 1741 TO 1744 -
1746 TO 1749 1751 1753 1755 1757 1758 1760 1762 1764 1765 1767 -
1769 PR GY -80
1771 1773 TO 1776 1778 TO 1781 1783 TO 1786 1788 TO 1791 1793 TO 1796 1798 -
1799 TO 1801 1803 TO 1806 1808 TO 1811 1813 TO 1816 1818 TO 1821 1823 TO 1826 -
1828 TO 1831 1833 TO 1836 1838 TO 1841 1843 TO 1846 1848 TO 1851 -
1853 TO 1856 1858 TO 1861 1863 1865 1867 1869 1870 1873 1875 1877 1879 1881 -
1883 1885 1886 1888 TO 1890 1892 1894 1895 1897 TO 1899 1901 1903 1904 1906 -
1907 TO 1908 1910 1912 1913 1915 TO 1917 1919 1921 1922 1924 TO 1926 1928 -
1930 1931 1933 TO 1935 1937 1939 1940 1942 TO 1944 1946 1948 1949 -
1951 TO 1953 1955 1957 1958 1960 TO 1962 1964 1966 1967 1969 TO 1971 1973 -
1975 1976 1978 TO 1980 1982 1984 1985 1987 TO 1989 1991 1993 1994 -
1996 TO 1998 2000 2002 2003 2005 TO 2007 2009 2011 2012 2014 TO 2016 2018 -
2020 2021 2023 TO 2025 2027 2029 2030 2032 TO 2034 2036 2038 2039 -
2041 TO 2043 2045 2047 2049 2050 2052 2054 2055 2057 2059 2061 2063 2065 -
2067 TO 2069 2071 TO 2073 2075 TO 2077 2079 TO 2081 2083 TO 2085 -
2087 TO 2089 2091 TO 2093 2095 TO 2097 2099 TO 2101 2103 TO 2105 -
2107 TO 2109 2111 TO 2113 2115 TO 2117 2119 TO 2121 2123 TO 2125 -
2127 TO 2129 2131 TO 2133 2135 TO 2137 2139 TO 2141 2143 TO 2145 -
2147 TO 2149 2151 TO 2153 2155 TO 2157 2159 TO 2161 2163 TO 2165 -
2167 TO 2169 2171 TO 2173 2175 TO 2177 2179 TO 2181 2183 TO 2185 -
2187 TO 2189 2191 PR GY -80
2192 2193 2195 TO 2197 2199 TO 2201 2203 TO 2205 2207 TO 2209 2211 2213 2215 -
2216 2218 2220 2221 2223 2225 2227 2229 2231 2233 TO 2235 2237 TO 2239 2241 -
2242 TO 2243 2245 TO 2247 2249 TO 2251 2253 TO 2255 2257 TO 2259 2261 TO 2263 -
2265 TO 2267 2269 TO 2271 2273 TO 2275 2277 TO 2279 2281 TO 2283 -
2285 TO 2287 2289 TO 2291 2293 TO 2295 2297 TO 2299 2301 TO 2303 -
2305 TO 2307 2309 TO 2311 2313 TO 2315 2317 TO 2319 2321 TO 2323 -
2325 TO 2327 2329 TO 2331 2333 TO 2335 2337 TO 2339 2341 TO 2343 -
2345 TO 2347 2349 TO 2351 2353 TO 2355 2357 TO 2359 2361 TO 2363 -
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3304 TO 3306 3308 TO 3310 3312 TO 3314 3316 TO 3318 3320 TO 3322 -
3324 TO 3326 3328 TO 3330 3332 TO 3334 3336 TO 3338 3340 TO 3342 -
3344 TO 3346 3348 TO 3350 3352 TO 3354 3356 TO 3358 3360 TO 3362 -
3364 TO 3366 3368 TO 3370 3372 TO 3374 3376 TO 3378 3380 TO 3382 -
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3405 3406 3408 TO 3410 3412 TO 3414 3416 TO 3418 3420 TO 3422 3424 TO 3426 -
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3852 3854 3856 3858 3860 TO 3862 3864 TO 3866 3868 TO 3870 3872 TO 3874 3876 -
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5868 TO 5870 5872 5874 5876 5877 5879 5881 5882 5884 5886 5888 5890 5892 -
5894 TO 5896 5898 TO 5900 5902 TO 5904 5906 TO 5908 5910 TO 5912 -
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6024 TO 6026 6028 PR GY -250
6029 6030 6032 TO 6034 6036 TO 6038 6040 TO 6042 6044 TO 6046 6048 TO 6050 -
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6072 TO 6074 6076 TO 6078 6080 TO 6082 6084 TO 6086 6088 TO 6090 -
6092 TO 6094 6096 TO 6098 6100 TO 6102 6104 TO 6106 6108 6110 6112 6113 6115 -
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6171 TO 6174 6176 TO 6179 6181 TO 6184 6186 6188 6190 6192 6193 PR GY -250
6196 6198 6200 6202 6204 6206 6208 TO 6212 6214 6216 TO 6220 6222 -
6224 TO 6228 6230 6232 6233 6235 TO 6237 6239 6241 6242 6244 TO 6246 6248 -
6250 6251 6253 TO 6255 6257 6259 6260 6262 TO 6264 6266 6268 6269 -
6271 TO 6273 6275 6277 6279 6280 6282 6284 6285 PR GY -100
LOAD 3 LOADTYPE None  TITLE BEBAN GEMPA DINAMIK X
JOINT LOAD
4482 FX 600878
4496 FX 526203
4504 FX 529689
4511 FX 412658
4517 FX 412658
4524 FX 412658
4530 FX 261707
SPECTRUM SRSS X 1 Y 1 Z 1 ACC SCALE 1.2 DAMP 0.05 LIN
0 0.267; 0.115 0.667; 0.2 0.667; 0.567 0.667; 1 0.373;
LOAD 4 LOADTYPE None  TITLE BEBAN GEMPA DINAMIK Z
JOINT LOAD
4482 FZ 600878
4496 FZ 526203
4504 FZ 529689
4511 FZ 412658
4517 FZ 412658
4524 FZ 412658
4530 FZ 261707
SPECTRUM SRSS X 1 Y 1 Z 1 ACC SCALE 1.2 DAMP 0.05 LIN
0 0.267; 0.115 0.573; 0.2 0.573; 0.576 0.573; 1 0.33;
LOAD COMB 5 1,4 DL
1 1.4
LOAD COMB 6 1,2 DL +1,6 LL
1 1.2 2 1.6
LOAD COMB 7 1,2 DL + 1 LL + 0,3 EX + 1 EY
1 1.2 2 1.0 3 0.3 4 1.0
LOAD COMB 8 1,2 DL + 1 LL - 0,3 EX - 1 EY
1 1.2 2 1.0 3 -0.3 4 -1.0
LOAD COMB 9 1,2 DL + 1 LL + 0,3 EX - 1 EY
1 1.0 2 1.0 3 0.3 4 -1.0
LOAD COMB 10 1,2 DL + 1 LL - 0,3 EX + 1EY
1 1.2 2 1.0 3 -0.3 4 1.0
LOAD COMB 11 1,2 DL + 1 LL + 1 EX +0,3 EY
1 1.2 2 1.0 3 1.0 4 0.3
LOAD COMB 12 1,2 DL + 1 LL - 1 EX -0.3 EY
1 1.2 2 1.0 3 1.0 4 -0.3
LOAD COMB 13 1,2 DL + 1 LL + 1 EX - 0,3 EY
1 1.2 2 1.0 3 1.0 4 -0.3
LOAD COMB 14 1,2 DL + 1 LL - 1 EX + 0,3 EY
1 1.1 2 1.0 3 -1.0 4 0.3
LOAD COMB 15 0,9 DL + 0,3 EX + 1 EY
1 0.9 3 0.3 4 1.0
LOAD COMB 16 0,9 DL - 0,3 EX - 1 EY
1 0.9 3 -0.3 4 -1.0
LOAD COMB 17 0,9 DL + 0,3 EX - 1 EY
1 0.9 3 0.3 4 -1.0
LOAD COMB 18 0,9 DL - 0,3 EX + 1 EY
1 0.9 3 -0.3 4 1.0
LOAD COMB 19 0,9 DL + 1 EX + 0,3 EY
1 0.9 3 1.0 4 0.3
LOAD COMB 20 0,9 DL - 1 EX - 0,3 EY
1 0.9 3 -1.0 4 -0.3
LOAD COMB 21 0,9 DL + 1 EX - 0,3 EY
1 0.9 3 1.0 4 -0.3
LOAD COMB 22 0,9 DL - 1 EX + 0,3 EY
1 0.9 3 -1.0 4 0.3
PERFORM ANALYSIS
PRINT STORY DRIFT
FINISH
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*           STAAD.Pro V8i SELECTseries5            *
*           Version  20.07.10.64                   *
*           Proprietary Program of                 *
*           Bentley Systems, Inc.                  *
*           Date=    JUL  9, 2015                  *
*           Time=    15:29:35                      *
*                                                  *
*      USER ID: yamaha                             *
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INPUT FILE: hotel pattimura malang.STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 23-JUN-15
     4. END JOB INFORMATION
     5. INPUT WIDTH 79
     6. UNIT METER KG
     7. JOINT COORDINATES
     8. 1 0 0 0; 2 0 0 6.5; 3 0 0 13.25; 4 0 0 19.75; 5 0 0 26.25; 6 0 0 34; 7 0 0 38
     9. 8 1.2 0 38; 9 6.85 0 38; 10 12.55 0 38; 11 18.2 0 38; 12 18.2 0 34
    10. 13 18.2 0 26.25; 14 18.2 0 19.75; 15 18.2 0 13.25; 16 18.2 0 6.5; 17 18.2 0 0
    11. 18 15.2 0 0; 19 6.85 0 0; 20 1.2 0 0; 21 1.2 0 6.5; 22 1.2 0 13.25
    12. 23 1.2 0 19.75; 24 1.2 0 26.25; 25 1.2 0 34; 26 6.85 0 6.5; 27 6.85 0 13.25
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    14. 33 15.2 0 19.75; 34 15.2 0 26.25; 35 15.2 0 34; 36 1.2 -3.2 38
    15. 37 6.85 -3.2 38; 38 12.55 -3.2 38; 39 18.2 -3.2 38; 40 18.2 -3.2 34
    16. 41 18.2 -3.2 26.25; 42 18.2 -3.2 19.75; 43 18.2 -3.2 13.25; 44 18.2 -3.2 6.5
    17. 45 18.2 -3.2 0; 46 15.2 -3.2 0; 47 6.85 -3.2 0; 48 1.2 -3.2 0; 49 1.2 -3.2 6.5
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    20. 58 6.85 -3.2 34; 59 15.2 -3.2 6.5; 60 15.2 -3.2 13.25; 61 15.2 -3.2 19.75
    21. 62 15.2 -3.2 26.25; 63 15.2 -3.2 34; 64 12.55 0 34; 65 0 5.5 0; 66 0 5.5 6.5
    22. 67 0 5.5 13.25; 68 0 5.5 19.75; 69 0 5.5 26.25; 70 0 5.5 34; 71 18.2 5.5 34
    23. 72 18.2 5.5 26.25; 73 18.2 5.5 19.75; 74 18.2 5.5 13.25; 75 18.2 5.5 6.5
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    26. 85 6.85 5.5 6.5; 86 6.85 5.5 13.25; 87 6.85 5.5 19.75; 88 6.85 5.5 26.25
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    28. 93 15.2 5.5 26.25; 94 15.2 5.5 34; 95 12.55 5.5 34; 96 18.2 10 34
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    38. 139 1.2 13.4 26.25; 140 1.2 13.4 34; 141 6.85 13.4 6.5; 142 6.85 13.4 13.25
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3191. 1769 THICKNESS 0.12
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3194. 1828 TO 1831 1833 TO 1836 1838 TO 1841 1843 TO 1846 1848 TO 1851 -
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3230. 2585 TO 2587 2589 TO 2592 2594 TO 2597 2599 TO 2602 2604 TO 2607 2609 TO 2612 -
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3266. 3384 TO 3386 3388 TO 3390 3392 TO 3394 3396 TO 3398 3400 TO 3402 -
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3278. 3663 3664 3666 3667 3669 3670 3672 3673 3675 3676 3678 3679 3681 3682 3684 -
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3284. 3804 3805 3807 TO 3809 3811 3813 3814 3816 TO 3818 3820 3822 3823 -
3285. 3825 TO 3827 3829 3831 3832 3834 TO 3836 3838 3840 3842 3843 3845 3847 3848 -
3286. 3850 THICKNESS 0.12
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3306. 4254 TO 4256 4258 TO 4261 4263 TO 4266 4268 TO 4271 4273 TO 4276 4278 TO 4281 -
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3322. 5974 TO 5976 5978 TO 5980 5982 TO 5984 5986 TO 5988 5990 5992 5994 5995 5997 -
3323. 5999 6000 6002 6004 6006 6008 6010 6012 TO 6014 6016 TO 6018 6020 TO 6022 -
3324. 6024 TO 6026 6028 THICKNESS 0.12
3325. 6029 6030 6032 TO 6034 6036 TO 6038 6040 TO 6042 6044 TO 6046 6048 TO 6050 -
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3327. 6072 TO 6074 6076 TO 6078 6080 TO 6082 6084 TO 6086 6088 TO 6090 -
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3331. 6171 TO 6174 6176 TO 6179 6181 TO 6184 6186 6188 6190 6192 -
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3333. 6196 6198 6200 6202 6204 6206 6208 TO 6212 6214 6216 TO 6220 6222 -
3334. 6224 TO 6228 6230 6232 6233 6235 TO 6237 6239 6241 6242 6244 TO 6246 6248 -
3335. 6250 6251 6253 TO 6255 6257 6259 6260 6262 TO 6264 6266 6268 6269 -
3336. 6271 TO 6273 6275 6277 6279 6280 6282 6284 6285 THICKNESS 0.1
3337. DEFINE MATERIAL START
3338. ISOTROPIC CONCRETE
3339. E 2.21467E+009
3340. POISSON 0.17
3341. DENSITY 2402.62
3342. ALPHA 1E-005
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3343. DAMP 0.05
3344. TYPE CONCRETE
3345. STRENGTH FCU 2.81228E+006
3346. END DEFINE MATERIAL
3347. MEMBER PROPERTY AMERICAN
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3350. 63 TO 68 95 TO 100 170 TO 175 464 TO 467 PRIS YD 0.6 ZD 0.4
3351. 59 TO 62 456 TO 458 PRIS YD 0.4 ZD 0.4
3352. 7 TO 11 13 TO 17 19 TO 24 26 TO 30 32 TO 36 39 40 42 TO 44 46 TO 48 -
3353. 50 TO 52 54 TO 56 58 88 121 TO 125 127 TO 132 134 TO 137 139 TO 142 144 145 -
3354. 147 TO 149 151 TO 153 155 TO 157 159 TO 161 163 196 TO 200 202 TO 206 208 -
3355. 209 TO 211 213 TO 216 218 220 221 223 224 226 227 229 230 232 234 TO 239 281 -
3356. 282 TO 285 287 TO 290 292 TO 295 297 299 301 303 305 336 TO 340 342 TO 345 -
3357. 347 TO 350 352 354 356 358 360 383 TO 387 389 TO 392 394 TO 397 399 401 403 -
3358. 405 407 422 TO 424 440 TO 450 452 454 459 TO 461 468 469 484 TO 487 -
3359. 495 TO 498 506 TO 509 517 TO 520 545 TO 548 550 TO 553 555 TO 558 -
3360. 560 TO 563 611 TO 614 616 TO 619 621 TO 624 626 TO 629 676 TO 687 -
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3366. 1610 1620 1630 1730 1740 1750 1772 1777 1782 1787 1792 1797 1802 1807 1812 -
3367. 1817 1822 1827 1832 1837 1842 1847 1852 PRIS YD 0.5 ZD 0.3
3368. 6356 PRIS YD 0.5 ZD 0.3
3369. 6291 6304 6307 6316 6322 6325 6330 6333 6337 6341 6344 6348 6352 -
3370. 6357 PRIS YD 0.5 ZD 0.3
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3396. 6197 6199 6201 6203 6276 6278 6281 6283 6364 PRIS YD 0.5 ZD 0.3
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3405. 408 409 439 451 453 455 470 TO 477 538 TO 543 604 TO 609 670 TO 675 -
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3422. 6334 PRIS YD 0.6 ZD 0.35
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3433. 6345 6349 6350 6353 6359 PRIS YD 0.6 ZD 0.35
3434. 1 TO 6 165 TO 169 240 TO 244 246 247 249 250 308 309 313 410 411 414 416 417 -
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3446. 5275 6234 6243 6252 6261 6270 6289 6297 TO 6299 6303 -
3447. 6313 PRIS YD 0.3 ZD 0.2
3448. 251 252 255 311 312 315 412 413 415 418 419 421 425 426 462 463 490 TO 493 -
3449. 500 TO 502 504 511 TO 513 515 522 TO 524 526 533 TO 535 537 576 TO 579 581 -
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3454. 829 TO 831 833 TO 835 872 936 938 940 942 944 946 948 950 952 954 956 958 -
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3465. 6296 6312 PRIS YD 0.3 ZD 0.25
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3493. 6362 PRIS YD 0.3 ZD 0.25
3494. CONSTANTS
3495. MATERIAL CONCRETE ALL
3496. SUPPORTS
3497. 36 TO 63 FIXED
3498. LOAD 1 LOADTYPE DEAD  TITLE BEBAN MATI
3499. SELFWEIGHT Y -1
3500. MEMBER LOAD
3501. 12 TO 19 21 TO 25 29 30 40 TO 42 44 56 TO 58 87 472 473 477 484 487 495 496 -
3502. 506 TO 508 517 518 523 528 529 876 878 880 882 884 886 888 890 892 894 896 -
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3509. 120 TO 127 129 TO 133 145 TO 147 153 TO 155 161 TO 164 538 539 541 543 545 -
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3519. 335 TO 352 354 356 358 360 TO 362 382 TO 399 401 403 405 407 TO 409 -
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3958. 1315 TO 1317 1319 TO 1321 1323 TO 1325 1327 TO 1329 1331 TO 1333 -
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4014. 2535 TO 2537 2539 TO 2541 2543 2545 2547 2548 2550 2552 2553 2555 2557 2559 -
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4116. 6146 TO 6149 6151 TO 6154 6156 TO 6159 6161 TO 6164 6166 TO 6169 -
4117. 6171 TO 6174 6176 TO 6179 6181 TO 6184 6186 6188 6190 6192 6193 PR GY -18
4118. LOAD 2 LOADTYPE LIVE  TITLE BEBAN HIDUP
4119. ELEMENT LOAD
4120. 875 877 879 881 883 885 887 889 891 893 895 897 899 901 903 905 907 909 911 -
4121. 913 915 TO 933 935 937 939 941 943 945 947 949 951 953 955 957 959 961 963 -
4122. 965 967 969 971 973 974 976 TO 994 996 998 TO 1016 1018 1020 1022 1024 1026 -
4123. 1028 1030 1032 1034 1036 1038 1040 1042 1044 1046 1048 1050 1052 1054 1056 -
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4126. 1105 TO 1107 1109 TO 1111 1113 TO 1115 1117 TO 1119 1121 TO 1123 -
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4138. 1344 1345 1347 TO 1349 1351 TO 1353 1355 TO 1357 1359 TO 1361 1363 TO 1365 -
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4202. 2794 2796 2797 2799 TO 2801 2803 2805 2806 2808 TO 2810 2812 2814 2815 2817 -
4203. 2818 TO 2819 2821 2823 2824 2826 TO 2828 2830 2832 2833 2835 TO 2837 2839 -
4204. 2841 2842 2844 TO 2846 2848 2850 2851 2853 TO 2855 2857 2859 2860 -
4205. 2862 TO 2864 2866 2868 2869 2871 TO 2873 2875 2877 2878 2880 TO 2882 2884 -
4206. 2886 2887 2889 TO 2891 2893 2895 2896 2898 TO 2900 2902 2904 2905 -
4207. 2907 TO 2909 2911 2913 2914 2916 TO 2918 2920 2922 2923 2925 TO 2927 2929 -
4208. 2931 2932 2934 TO 2936 2938 2940 2942 2943 2945 2947 2948 2950 2952 2954 -
4209. 2956 2958 2960 TO 2962 2964 TO 2966 2968 TO 2970 2972 TO 2974 2976 TO 2978 -
4210. 2980 TO 2982 2984 TO 2986 2988 TO 2990 2992 TO 2994 2996 TO 2998 -
4211. 3000 TO 3002 3004 TO 3006 3008 TO 3010 3012 TO 3014 3016 TO 3018 -
4212. 3020 PR GY -250
4213. 3021 3022 3024 TO 3026 3028 TO 3030 3032 TO 3034 3036 TO 3038 3040 TO 3042 -
4214. 3044 TO 3046 3048 TO 3050 3052 TO 3054 3056 TO 3058 3060 TO 3062 -
4215. 3064 TO 3066 3068 TO 3070 3072 TO 3074 3076 TO 3078 3080 TO 3082 -
4216. 3084 TO 3086 3088 TO 3090 3092 TO 3094 3096 TO 3098 3100 TO 3102 3104 3106 -
4217. 3108 3109 3111 3113 3114 3116 3118 3120 3122 3124 3126 TO 3128 3130 TO 3132 -
4218. 3134 TO 3136 3138 TO 3140 3142 TO 3144 3146 TO 3148 3150 TO 3152 -
4219. 3154 TO 3156 3158 TO 3160 3162 TO 3164 3166 TO 3168 3170 TO 3172 -
4220. 3174 TO 3176 3178 TO 3180 3182 TO 3184 3186 TO 3188 3190 TO 3192 -
4221. 3194 TO 3196 3198 TO 3200 3202 TO 3204 3206 TO 3208 3210 TO 3212 -
4222. 3214 TO 3216 3218 TO 3220 3222 TO 3224 3226 TO 3228 3230 TO 3232 -
4223. 3234 TO 3236 3238 TO 3240 3242 TO 3244 3246 TO 3248 3250 TO 3252 -
4224. 3254 TO 3256 3258 TO 3260 3262 TO 3264 3266 TO 3268 3270 3272 3274 3275 3277 -
4225. 3279 3280 3282 3284 3286 3288 3290 3292 TO 3294 3296 TO 3298 3300 TO 3302 -
4226. 3304 TO 3306 3308 TO 3310 3312 TO 3314 3316 TO 3318 3320 TO 3322 -
4227. 3324 TO 3326 3328 TO 3330 3332 TO 3334 3336 TO 3338 3340 TO 3342 -
4228. 3344 TO 3346 3348 TO 3350 3352 TO 3354 3356 TO 3358 3360 TO 3362 -
4229. 3364 TO 3366 3368 TO 3370 3372 TO 3374 3376 TO 3378 3380 TO 3382 -
4230. 3384 TO 3386 3388 TO 3390 3392 TO 3394 3396 TO 3398 3400 TO 3402 -
4231. 3404 PR GY -250
4232. 3405 3406 3408 TO 3410 3412 TO 3414 3416 TO 3418 3420 TO 3422 3424 TO 3426 -
4233. 3428 TO 3430 3432 TO 3434 3436 3438 3440 3441 3443 3445 3446 3448 3450 3452 -
4234. 3454 3456 3458 3460 3462 TO 3465 3467 TO 3470 3472 TO 3475 3477 TO 3480 3482 -
4235. 3483 TO 3485 3487 TO 3490 3492 TO 3495 3497 TO 3500 3502 TO 3505 3507 TO 3510 -
4236. 3512 TO 3515 3517 TO 3520 3522 TO 3525 3527 TO 3530 3532 TO 3535 -
4237. 3537 TO 3540 3542 TO 3545 3547 TO 3550 3552 TO 3555 3557 TO 3560 -
4238. 3562 TO 3565 3567 TO 3570 3572 TO 3575 3577 TO 3580 3582 TO 3585 -
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3587 TO 3590 3592 TO 3595 3597 TO 3600 3602 TO 3605 3607 TO 3610 -
3612 TO 3615 3617 TO 3620 3622 TO 3625 3627 TO 3630 3632 TO 3635 -
3637 TO 3640 3642 3644 3646 3648 3649 3651 3653 3655 3656 3658 3660 3661 -
3663 3664 3666 3667 3669 3670 3672 3673 3675 3676 3678 3679 3681 3682 3684 -
3685 3687 3688 3690 3691 3693 3694 3696 3697 3699 3700 3702 3703 3705 3706 -
3708 3709 3711 3712 3714 3716 3717 3720 3722 3724 3726 3728 3730 3732 3733 -
3735 TO 3737 3739 3741 3742 3744 TO 3746 3748 3750 3751 3753 TO 3755 3757 -
3759 3760 3762 TO 3764 3766 3768 3769 3771 TO 3773 3775 3777 3778 -
3780 TO 3782 3784 3786 3787 3789 TO 3791 3793 3795 3796 3798 TO 3800 3802 -
3804 3805 3807 TO 3809 3811 3813 3814 3816 TO 3818 3820 3822 3823 -
3825 TO 3827 3829 3831 3832 3834 TO 3836 3838 3840 3842 3843 3845 3847 3848 -
3850 PR GY -250
3852 3854 3856 3858 3860 TO 3862 3864 TO 3866 3868 TO 3870 3872 TO 3874 3876 -
3877 TO 3878 3880 TO 3882 3884 TO 3886 3888 TO 3890 3892 TO 3894 3896 TO 3898 -
3900 TO 3902 3904 TO 3906 3908 TO 3910 3912 TO 3914 3916 TO 3918 -
3920 TO 3922 3924 TO 3926 3928 TO 3930 3932 TO 3934 3936 TO 3938 -
3940 TO 3942 3944 TO 3946 3948 TO 3950 3952 TO 3954 3956 3958 3960 3961 3963 -
3965 3966 3968 3970 3972 3974 3976 3978 TO 3980 3982 TO 3984 3986 TO 3988 -
3990 TO 3992 3994 TO 3996 3998 TO 4000 4002 TO 4004 4006 TO 4008 -
4010 TO 4012 4014 TO 4016 4018 TO 4020 4022 TO 4024 4026 TO 4028 -
4030 TO 4032 4034 TO 4036 4038 TO 4040 4042 TO 4044 4046 TO 4048 -
4050 TO 4052 4054 TO 4056 4058 TO 4060 4062 TO 4064 4066 TO 4068 -
4070 TO 4072 4074 4076 4078 4079 4081 4083 4084 4086 4088 4090 4092 4094 -
4096 TO 4098 4100 TO 4102 4104 TO 4106 4108 TO 4110 4112 TO 4114 -
4116 TO 4118 4120 TO 4122 4124 TO 4126 4128 TO 4130 4132 TO 4134 -
4136 TO 4138 4140 TO 4142 4144 TO 4146 4148 TO 4150 4152 TO 4154 -
4156 TO 4158 4160 TO 4162 4164 TO 4166 4168 TO 4170 4172 TO 4174 -
4176 TO 4178 4180 TO 4182 4184 TO 4186 4188 TO 4190 4192 4194 4196 4197 4199 -
4201 4202 4204 4206 4208 4210 4212 4214 4216 4218 TO 4221 4223 TO 4226 4228 -
4229 TO 4231 4233 TO 4236 4238 TO 4241 4243 TO 4246 4248 TO 4251 -
4253  PR GY -250
4254 TO 4256 4258 TO 4261 4263 TO 4266 4268 TO 4271 4273 TO 4276 4278 TO 4281 -
4283 TO 4286 4288 TO 4291 4293 TO 4296 4298 TO 4301 4303 TO 4306 -
4308 TO 4311 4313 TO 4316 4318 TO 4321 4323 TO 4326 4328 TO 4331 -
4333 TO 4336 4338 4340 4342 4344 4345 4347 4349 4351 4352 4354 4356 4357 -
4359 4360 4362 4363 4365 4366 4368 4369 4371 4372 4374 4375 4377 4378 4380 -
4381 4383 4384 4386 4387 4389 4390 4392 4394 4395 4598 TO 5073 5276 TO 5751 -
5754 5756 5758 5760 5762 5764 5766 5767 5769 TO 5771 5773 5775 5776 5778 -
5779 TO 5780 5782 5784 5785 5787 TO 5789 5791 5793 5794 5796 TO 5798 5800 -
5802 5803 5805 TO 5807 5809 5811 5812 5814 TO 5816 5818 5820 5821 -
5823 TO 5825 5827 5829 5830 5832 TO 5834 5836 5838 5839 5841 TO 5843 5845 -
5847 5848 5850 TO 5852 5854 5856 5857 5859 TO 5861 5863 5865 5866 -
5868 TO 5870 5872 5874 5876 5877 5879 5881 5882 5884 5886 5888 5890 5892 -
5894 TO 5896 5898 TO 5900 5902 TO 5904 5906 TO 5908 5910 TO 5912 -
5914 TO 5916 5918 TO 5920 5922 TO 5924 5926 TO 5928 5930 TO 5932 -
5934 TO 5936 5938 TO 5940 5942 TO 5944 5946 TO 5948 5950 TO 5952 -
5954 TO 5956 5958 TO 5960 5962 TO 5964 5966 TO 5968 5970 TO 5972 -
5974 TO 5976 5978 TO 5980 5982 TO 5984 5986 TO 5988 5990 5992 5994 5995 5997 -
5999 6000 6002 6004 6006 6008 6010 6012 TO 6014 6016 TO 6018 6020 TO 6022 -
6024 TO 6026 6028 PR GY -250
6029 6030 6032 TO 6034 6036 TO 6038 6040 TO 6042 6044 TO 6046 6048 TO 6050 -
6052 TO 6054 6056 TO 6058 6060 TO 6062 6064 TO 6066 6068 TO 6070 -
6072 TO 6074 6076 TO 6078 6080 TO 6082 6084 TO 6086 6088 TO 6090 -
6092 TO 6094 6096 TO 6098 6100 TO 6102 6104 TO 6106 6108 6110 6112 6113 6115 -
6117 6118 6120 6122 6124 6126 TO 6129 6131 TO 6134 6136 TO 6139 6141 TO 6144 -
6146 TO 6149 6151 TO 6154 6156 TO 6159 6161 TO 6164 6166 TO 6169 -
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6171 TO 6174 6176 TO 6179 6181 TO 6184 6186 6188 6190 6192 6193 PR GY -250
6196 6198 6200 6202 6204 6206 6208 TO 6212 6214 6216 TO 6220 6222 -
6224 TO 6228 6230 6232 6233 6235 TO 6237 6239 6241 6242 6244 TO 6246 6248 -
6250 6251 6253 TO 6255 6257 6259 6260 6262 TO 6264 6266 6268 6269 -
6271 TO 6273 6275 6277 6279 6280 6282 6284 6285 PR GY -100
LOAD 3 LOADTYPE NONE  TITLE BEBAN GEMPA DINAMIK X
JOINT LOAD
4482 FX 600878
4496 FX 526203
4504 FX 529689
4511 FX 412658
4517 FX 412658
4524 FX 412658
4530 FX 261707
SPECTRUM SRSS X 1 Y 1 Z 1 ACC SCALE 1.2 DAMP 0.05 LIN
0 0.267; 0.115 0.667; 0.2 0.667; 0.567 0.667; 1 0.373
LOAD 4 LOADTYPE NONE  TITLE BEBAN GEMPA DINAMIK Z
JOINT LOAD
4482 FZ 600878
4496 FZ 526203
4504 FZ 529689
4511 FZ 412658
4517 FZ 412658
4524 FZ 412658
4530 FZ 261707
SPECTRUM SRSS X 1 Y 1 Z 1 ACC SCALE 1.2 DAMP 0.05 LIN
0 0.267; 0.115 0.573; 0.2 0.573; 0.576 0.573; 1 0.33
LOAD COMB 5 1,4 DL
1 1.4
LOAD COMB 6 1,2 DL +1,6 LL
1 1.2 2 1.6
LOAD COMB 7 1,2 DL + 1 LL + 0,3 EX + 1 EY
1 1.2 2 1.0 3 0.3 4 1.0
LOAD COMB 8 1,2 DL + 1 LL - 0,3 EX - 1 EY
1 1.2 2 1.0 3 -0.3 4 -1.0
LOAD COMB 9 1,2 DL + 1 LL + 0,3 EX - 1 EY
1 1.0 2 1.0 3 0.3 4 -1.0
LOAD COMB 10 1,2 DL + 1 LL - 0,3 EX + 1EY
1 1.2 2 1.0 3 -0.3 4 1.0
LOAD COMB 11 1,2 DL + 1 LL + 1 EX +0,3 EY
1 1.2 2 1.0 3 1.0 4 0.3
LOAD COMB 12 1,2 DL + 1 LL - 1 EX -0.3 EY
1 1.2 2 1.0 3 1.0 4 -0.3
LOAD COMB 13 1,2 DL + 1 LL + 1 EX - 0,3 EY
1 1.2 2 1.0 3 1.0 4 -0.3
LOAD COMB 14 1,2 DL + 1 LL - 1 EX + 0,3 EY
1 1.1 2 1.0 3 -1.0 4 0.3
LOAD COMB 15 0,9 DL + 0,3 EX + 1 EY
1 0.9 3 0.3 4 1.0
LOAD COMB 16 0,9 DL - 0,3 EX - 1 EY
1 0.9 3 -0.3 4 -1.0
LOAD COMB 17 0,9 DL + 0,3 EX - 1 EY
1 0.9 3 0.3 4 -1.0
LOAD COMB 18 0,9 DL - 0,3 EX + 1 EY
1 0.9 3 -0.3 4 1.0
LOAD COMB 19 0,9 DL + 1 EX + 0,3 EY
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4351. 1 0.9 3 1.0 4 0.3
4352. LOAD COMB 20 0,9 DL - 1 EX - 0,3 EY
4353. 1 0.9 3 -1.0 4 -0.3
4354. LOAD COMB 21 0,9 DL + 1 EX - 0,3 EY
4355. 1 0.9 3 1.0 4 -0.3
4356. LOAD COMB 22 0,9 DL - 1 EX + 0,3 EY
4357. 1 0.9 3 -1.0 4 0.3
4358. PERFORM ANALYSIS
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P R O B L E M   S T A T I S T I C S

NUMBER OF JOINTS	**4517**	**NUMBER OF MEMBERS**	**2453**
NUMBER OF PLATES	**3836**	**NUMBER OF SOLIDS**	**0**
NUMBER OF SURFACES	**0**	**NUMBER OF SUPPORTS**	**28**

SOLVER USED IS THE IN-CORE ADVANCED SOLVER

TOTAL PRIMARY LOAD CASES = 4, TOTAL DEGREES OF FREEDOM = 26934
TOTAL LOAD COMBINATION CASES = 18 SO FAR.

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NUMBER OF MODES REQUESTED              =     6
NUMBER OF EXISTING MASSES IN THE MODEL =     7
NUMBER OF MODES THAT WILL BE USED      =     6
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CALCULATED FREQUENCIES FOR LOAD CASE 3

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	0.667	1.49820
2	2.130	0.46939
3	3.381	0.29577
4	3.876	0.25797
5	4.893	0.20438
6	5.572	0.17946

RESPONSE LOAD CASE 3

MODE	MODAL WEIGHT (MODAL MASS TIMES g) IN KG X	Y	Z	GENERALIZED WEIGHT
1	0.000000E+00	0.000000E+00	2.471787E+06	1.500637E+06
2	0.000000E+00	0.000000E+00	2.521433E+05	1.089243E+06
3	0.000000E+00	0.000000E+00	3.855171E+05	9.384984E+05
4	0.000000E+00	0.000000E+00	4.674592E+04	1.484551E+06
5	0.000000E+00	0.000000E+00	2.177897E+02	8.735930E+05
6	0.000000E+00	0.000000E+00	4.021777E+01	9.046029E+05

SRSS MODAL COMBINATION METHOD USED.

DYNAMIC WEIGHT X Y Z 0.000000E+00 0.000000E+00 3.156451E+06 KG

MISSING WEIGHT X Y Z 0.000000E+00 0.000000E+00 -3.667769E-02 KG

MODAL WEIGHT X Y Z 0.000000E+00 0.000000E+00 3.156451E+06 KG

MODE	ACCELERATION-G	DAMPING
1	0.00425	0.05000
2	0.08162	0.05000
3	0.08162	0.05000
4	0.08162	0.05000
5	0.08162	0.05000
6	0.08162	0.05000

MODAL BASE ACTIONS FORCES IN KG LENGTH IN METE

MOMENTS ARE ABOUT THE ORIGIN

MODE	PERIOD	FX	FY	FZ	MX	MY	MZ
1	1.498	0.00	0.00	10504.36	158033.70	-90474.07	0.00
2	0.469	0.00	0.00	20579.45	-147768.93	-213086.75	0.00
3	0.296	0.00	0.00	31465.17	-607.78	-295316.04	0.00
4	0.258	0.00	0.00	3815.31	-16283.06	-33225.69	0.00
5	0.204	0.00	0.00	17.78	-508.85	78.68	0.00
6	0.179	0.00	0.00	3.28	155.37	-26.41	0.00

	MASS PARTICIPATION FACTORS IN PERCENT						BASE SHEAR IN KG		
MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	0.00	0.00	78.31	0.000	0.000	78.309	0.00	0.00	10504.36
2	0.00	0.00	7.99	0.000	0.000	86.297	0.00	0.00	20579.45
3	0.00	0.00	12.21	0.000	0.000	98.511	0.00	0.00	31465.17
4	0.00	0.00	1.48	0.000	0.000	99.992	0.00	0.00	3815.31
5	0.00	0.00	0.01	0.000	0.000	99.999	0.00	0.00	17.78
6	0.00	0.00	0.00	0.000	0.000	100.000	0.00	0.00	3.28
				TOTAL SRSS		SHEAR	0.00	0.00	39223.33
				TOTAL 10PCT		SHEAR	0.00	0.00	39223.33
				TOTAL ABS		SHEAR	0.00	0.00	66385.35

RESPONSE LOAD CASE 4

	MODAL WEIGHT (MODAL MASS TIMES g) IN KG			GENERALIZED
MODE	X	Y	Z	WEIGHT
1	0.000000E+00	0.000000E+00	2.471787E+06	1.500637E+06
2	0.000000E+00	0.000000E+00	2.521433E+05	1.089243E+06
3	0.000000E+00	0.000000E+00	3.855171E+05	9.384984E+05
4	0.000000E+00	0.000000E+00	4.674592E+04	1.484551E+06
5	0.000000E+00	0.000000E+00	2.177897E+02	8.735930E+05
6	0.000000E+00	0.000000E+00	4.021777E+01	9.046029E+05

SRSS MODAL COMBINATION METHOD USED.
DYNAMIC WEIGHT X Y Z 0.000000E+00 0.000000E+00 3.156451E+06 KG
MISSING WEIGHT X Y Z 0.000000E+00 0.000000E+00 -3.667769E-02 KG
MODAL WEIGHT X Y Z 0.000000E+00 0.000000E+00 3.156451E+06 KG

MODE	ACCELERATION-G	DAMPING
1	0.00544	0.05000
2	0.07012	0.05000
3	0.07012	0.05000
4	0.07012	0.05000
5	0.07012	0.05000
6	0.07012	0.05000

MODAL BASE ACTIONS FORCES IN KG LENGTH IN METE

MOMENTS ARE ABOUT THE ORIGIN

MODE	PERIOD	FX	FY	FZ	MX	MY	MZ
1	1.498	0.00	0.00	13451.81	202376.98	-115860.53	0.00
2	0.469	0.00	0.00	17679.20	-126943.93	-183056.54	0.00
3	0.296	0.00	0.00	27030.80	-522.13	-253697.30	0.00
4	0.258	0.00	0.00	3277.62	-13988.29	-28543.21	0.00
5	0.204	0.00	0.00	15.27	-437.14	67.59	0.00
6	0.179	0.00	0.00	2.82	133.48	-22.69	0.00

MASS PARTICIPATION FACTORS IN PERCENT / BASE SHEAR IN KG

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	0.00	0.00	78.31	0.000	0.000	78.309	0.00	0.00	13451.81
2	0.00	0.00	7.99	0.000	0.000	86.297	0.00	0.00	17679.20
3	0.00	0.00	12.21	0.000	0.000	98.511	0.00	0.00	27030.80
4	0.00	0.00	1.48	0.000	0.000	99.992	0.00	0.00	3277.62
5	0.00	0.00	0.01	0.000	0.000	99.999	0.00	0.00	15.27
6	0.00	0.00	0.00	0.000	0.000	100.000	0.00	0.00	2.82
					TOTAL SRSS	SHEAR	0.00	0.00	35141.32
					TOTAL 10PCT	SHEAR	0.00	0.00	35141.32
					TOTAL ABS	SHEAR	0.00	0.00	61457.53

4359. PRINT STORY DRIFT

STORY	HEIGHT (METE)	LOAD	DRIFT(CM) X	DRIFT(CM) Z	ECCENTRICITY (METE)	RATIO
BASE=	-3.20					
1	0.00	1	-0.0092	0.0004	0.0000	L / 34771
		2	-0.0021	0.0007	0.0000	L /152169
		3	0.0026	0.0522	0.0000	L / 6131
		4	0.0023	0.0494	0.0000	L / 6482
		5	-0.0129	0.0006	0.0000	L / 24836
		6	-0.0144	0.0016	0.0000	L / 22209
		7	-0.0100	0.0662	0.0000	L / 4831
		8	-0.0163	-0.0638	0.0000	L / 5014
		9	-0.0129	-0.0326	0.0000	L / 9819
		10	-0.0116	0.0349	0.0000	L / 9164
		11	-0.0098	0.0682	0.0000	L / 4691
		12	-0.0112	0.0386	0.0000	L / 8293
		13	-0.0112	0.0386	0.0000	L / 8293
		14	-0.0142	-0.0362	0.0000	L / 8836
		15	-0.0051	0.0654	0.0000	L / 4893
		16	-0.0114	-0.0646	0.0000	L / 4950
		17	-0.0098	-0.0333	0.0000	L / 9600

		18	-0.0067	0.0341	0.0000	L / 9387
		19	-0.0050	0.0674	0.0000	L / 4749
		20	-0.0116	-0.0666	0.0000	L / 4803
		21	-0.0064	0.0378	0.0000	L / 8475
		22	-0.0102	-0.0370	0.0000	L / 8648
2	5.50	1	-0.0751	0.0101	0.0000	L / 11578
		2	-0.0157	0.0055	0.0000	L / 55541
		3	0.0127	0.1912	0.0000	L / 4549
		4	0.0114	0.1994	0.0000	L / 4362
		5	-0.1052	0.0141	0.0000	L / 8270
		6	-0.1152	0.0209	0.0000	L / 7550
		7	-0.0907	0.2744	0.0000	L / 3170
		8	-0.1210	-0.2392	0.0000	L / 3637
		9	-0.0984	-0.1265	0.0000	L / 6878
		10	-0.0983	0.1597	0.0000	L / 5449
		11	-0.0898	0.2686	0.0000	L / 3238
		12	-0.0966	0.1490	0.0000	L / 5839
		13	-0.0966	0.1490	0.0000	L / 5839
		14	-0.1076	-0.1148	0.0000	L / 7578
		15	-0.0525	0.2659	0.0000	L / 3272
		16	-0.0828	-0.2477	0.0000	L / 3512
		17	-0.0752	-0.1330	0.0000	L / 6541
		18	-0.0601	0.1511	0.0000	L / 5757
		19	-0.0516	0.2601	0.0000	L / 3345
		20	-0.0837	-0.2420	0.0000	L / 3595
		21	-0.0584	0.1405	0.0000	L / 6194
		22	-0.0769	-0.1223	0.0000	L / 7111
3	10.00	1	-0.1689	0.0265	0.0000	L / 7816

STORY	HEIGHT (METE)	LOAD	DRIFT(CM) X	Z	ECCENTRICITY (METE)	RATIO
BASE=	-3.20					
		2	-0.0342	0.0128	0.0000	L / 38638
		3	0.0208	0.2396	0.0000	L / 5508
		4	0.0188	0.2748	0.0000	L / 4804
		5	-0.2364	0.0371	0.0000	L / 5583
		6	-0.2573	0.0524	0.0000	L / 5130
		7	-0.2117	0.3913	0.0000	L / 3373
		8	-0.2619	-0.3020	0.0000	L / 4371
		9	-0.2156	-0.1635	0.0000	L / 6121
		10	-0.2242	0.2476	0.0000	L / 5332
		11	-0.2103	0.3667	0.0000	L / 3599
		12	-0.2216	0.2019	0.0000	L / 5955
		13	-0.2216	0.2019	0.0000	L / 5955
		14	-0.2351	-0.1152	0.0000	L / 5614
		15	-0.1269	0.3705	0.0000	L / 3562
		16	-0.1771	-0.3228	0.0000	L / 4089
		17	-0.1646	-0.1790	0.0000	L / 7373
		18	-0.1394	0.2268	0.0000	L / 5821
		19	-0.1255	0.3459	0.0000	L / 3815

		20	-0.1785	-0.2982	0.0000	L / 4426
		21	-0.1368	0.1811	0.0000	L / 7290
		22	-0.1672	-0.1333	0.0000	L / 7896
4	13.40	1	-0.1995	0.0484	0.0000	L / 8319
		2	-0.0381	0.0222	0.0000	L / 43620
		3	0.0215	0.2482	0.0000	L / 6688
		4	0.0194	0.3081	0.0000	L / 5388
		5	-0.2793	0.0677	0.0000	L / 5942
		6	-0.3003	0.0935	0.0000	L / 5527
		7	-0.2516	0.4628	0.0000	L / 3587
		8	-0.3034	-0.3023	0.0000	L / 5471
		9	-0.2506	-0.1631	0.0000	L / 6625
		10	-0.2645	0.3139	0.0000	L / 5289
		11	-0.2501	0.4208	0.0000	L / 3944
		12	-0.2618	0.2360	0.0000	L / 6341
		13	-0.2618	0.2360	0.0000	L / 6341
		14	-0.2732	-0.0804	0.0000	L / 6075
		15	-0.1537	0.4261	0.0000	L / 3896
		16	-0.2055	-0.3390	0.0000	L / 4896
		17	-0.1926	-0.1901	0.0000	L / 8620
		18	-0.1666	0.2772	0.0000	L / 5989
		19	-0.1522	0.3842	0.0000	L / 4321
		20	-0.2069	-0.2971	0.0000	L / 5587
		21	-0.1639	0.1993	0.0000	L / 8329
		22	-0.1953	-0.1122	0.0000	L / 8500
5	16.80	1	-0.2020	0.0734	0.0000	L / 9902
		2	-0.0360	0.0326	0.0000	L / 55555
		3	0.0199	0.2694	0.0000	L / 7423

STORY	HEIGHT	LOAD	DRIFT(CM)		ECCENTRICITY	RATIO
	(METE)		X	Z	(METE)	
BASE=	-3.20					
		4	0.0180	0.3428	0.0000	L / 5834
		5	-0.2828	0.1028	0.0000	L / 7073
		6	-0.3000	0.1403	0.0000	L / 6667
		7	-0.2544	0.5443	0.0000	L / 3674
		8	-0.3023	-0.3029	0.0000	L / 6603
		9	-0.2500	-0.1559	0.0000	L / 8001
		10	-0.2664	0.3827	0.0000	L / 5226
		11	-0.2531	0.4930	0.0000	L / 4057
		12	-0.2639	0.2873	0.0000	L / 6961
		13	-0.2639	0.2873	0.0000	L / 6961
		14	-0.2727	-0.0532	0.0000	L / 7334
		15	-0.1578	0.4897	0.0000	L / 4084
		16	-0.2057	-0.3575	0.0000	L / 5594
		17	-0.1938	-0.1959	0.0000	L / 10211
		18	-0.1698	0.3280	0.0000	L / 6097
		19	-0.1565	0.4383	0.0000	L / 4562
		20	-0.2071	-0.3062	0.0000	L / 6532
		21	-0.1673	0.2327	0.0000	L / 8596

		22	-0.1963	-0.1005	0.0000	L / 10189
6	20.20	1	-0.1966	0.1032	0.0000	L / 11899
		2	-0.0322	0.0437	0.0000	L / 53544
		3	0.0181	0.3143	0.0000	L / 7444
		4	0.0164	0.3841	0.0000	L / 6091
		5	-0.2753	0.1445	0.0000	L / 8499
		6	-0.2875	0.1938	0.0000	L / 8138
		7	-0.2463	0.6460	0.0000	L / 3622
		8	-0.2900	-0.3109	0.0000	L / 7527
		9	-0.2398	-0.1429	0.0000	L / 9756
		10	-0.2572	0.4574	0.0000	L / 5116
		11	-0.2451	0.5971	0.0000	L / 3919
		12	-0.2550	0.3666	0.0000	L / 6382
		13	-0.2550	0.3666	0.0000	L / 6382
		14	-0.2617	-0.0419	0.0000	L / 8941
		15	-0.1551	0.5713	0.0000	L / 4096
		16	-0.1988	-0.3855	0.0000	L / 6069
		17	-0.1880	-0.1970	0.0000	L / 11881
		18	-0.1660	0.3827	0.0000	L / 6114
		19	-0.1539	0.5224	0.0000	L / 4479
		20	-0.2000	-0.3367	0.0000	L / 6950
		21	-0.1638	0.2920	0.0000	L / 8014
		22	-0.1902	-0.1062	0.0000	L / 12304
7	23.60	1	-0.1810	0.2227	0.0000	L / 12033
		2	-0.0248	0.0690	0.0000	L / 38850
		3	0.0129	0.3615	0.0000	L / 7413
		4	0.0117	0.4215	0.0000	L / 6358
		5	-0.2534	0.3118	0.0000	L / 8595

STORY	HEIGHT	LOAD	DRIFT(CM) X	Z	ECCENTRICITY	RATIO
	(METE)				(METE)	
BASE=	-3.20					
		6	-0.2569	0.3776	0.0000	L / 7097
		7	-0.2264	0.8662	0.0000	L / 3094
		8	-0.2577	-0.1937	0.0000	L / 10401
		9	-0.2137	-0.0213	0.0000	L / 12542
		10	-0.2342	0.6493	0.0000	L / 4128
		11	-0.2256	0.8242	0.0000	L / 3251
		12	-0.2326	0.5713	0.0000	L / 4691
		13	-0.2326	0.5713	0.0000	L / 4691
		14	-0.2334	0.0789	0.0000	L / 11484
		15	-0.1473	0.7304	0.0000	L / 3669
		16	-0.1785	-0.3295	0.0000	L / 8133
		17	-0.1708	-0.1126	0.0000	L / 15693
		18	-0.1551	0.5135	0.0000	L / 5219
		19	-0.1465	0.6884	0.0000	L / 3893
		20	-0.1794	-0.2875	0.0000	L / 9321
		21	-0.1535	0.4355	0.0000	L / 6154
		22	-0.1723	-0.0346	0.0000	L / 15550
8	26.10	1	-0.2194	0.2589	0.0000	L / 11318

2	-0.0375	0.0784	0.0000	L / 37391
3	0.0128	0.3733	0.0000	L / 7848
4	0.0116	0.4302	0.0000	L / 6811
5	-0.3072	0.3624	0.0000	L / 8085
6	-0.3233	0.4360	0.0000	L / 6720
7	-0.2853	0.9312	0.0000	L / 3146
8	-0.3163	-0.1532	0.0000	L / 9264
9	-0.2647	0.0190	0.0000	L / 11069
10	-0.2931	0.7072	0.0000	L / 4143
11	-0.2845	0.8914	0.0000	L / 3287
12	-0.2915	0.6333	0.0000	L / 4626
13	-0.2915	0.6333	0.0000	L / 4626
14	-0.2882	0.1188	0.0000	L / 10165
15	-0.1820	0.7752	0.0000	L / 3780
16	-0.2129	-0.3092	0.0000	L / 9475
17	-0.2052	-0.0852	0.0000	L / 14276
18	-0.1897	0.5512	0.0000	L / 5316
19	-0.1811	0.7354	0.0000	L / 3984
20	-0.2138	-0.2694	0.0000	L / 10875
21	-0.1881	0.4773	0.0000	L / 6139
22	-0.2068	-0.0113	0.0000	L / 14166

4360. FINISH

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     *********** END OF THE STAAD.Pro RUN ***********

       **** DATE= JUL  9,2015   TIME= 15:30:54 ****

 ************************************************************
 *   For technical assistance on STAAD.Pro, please visit    *
 *   http://selectservices.bentley.com/en-US/               *
 *                                                          *
 *   Details about additional assistance from               *
 *   Bentley and Partners can be found at program menu      *
 *   Help->Technical Support                                *
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Beam End Force Summary

The signs of the forces at end B of each beam have been reversed. For example: this means that the Min Fx entry gives the largest tension value for an beam.

				Axial	**Shear**		**Torsion**	**Bending**	
	Beam	**Node**	**L/C**	**Fx** (kg)	**Fy** (kg)	**Fz** (kg)	**Mx** (kNm)	**My** (kNm)	**Mz** (kNm)
Max Fx	77	54	6:1,2 DL +1,6 L	**557E+3**	-5.96E+3	30.715	-0.025	1.641	65.902
Min Fx	6297	4484	19:0,9 DL + 1 E	**-40.4E+3**	-326.593	-360.169	0.210	-0.132	-3.669
Max Fy	406	187	6:1,2 DL +1,6 L	11.3E+3	**35.1E+3**	83.763	-10.021	0.039	445.089
Min Fy	3411	118	6:1,2 DL +1,6 L	-4.44E+3	**-33.7E+3**	5.448	11.431	0.067	453.751
Max Fz	1302	756	11:1,2 DL + 1 L	246.897	53.856	**32E+3**	7.346	39.015	-8.397
Min Fz	1302	4483	19:0,9 DL + 1 E	-204.688	51.019	**-32E+3**	3.359	-35.246	-4.932
Max Mx	201	102	6:1,2 DL +1,6 L	-3.39E+3	20.9E+3	672.903	**82.735**	-2.723	281.614
Min Mx	4415	3109	6:1,2 DL +1,6 L	473.078	-21.9E+3	-178.089	**-94.296**	0.213	211.912
Max My	428	207	6:1,2 DL +1,6 L	45.5E+3	-8.36E+3	12.8E+3	-0.574	**271.405**	162.535
Min My	375	188	6:1,2 DL +1,6 L	72E+3	-13.1E+3	-15.6E+3	1.683	**-309.762**	258.209
Max Mz	228	113	6:1,2 DL +1,6 L	-2.74E+3	34.3E+3	-128.491	-13.654	0.294	**478.242**
Min Mz	379	192	6:1,2 DL +1,6 L	65.8E+3	25.1E+3	130.684	0.289	-12.383	**-493.426**

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