BAB 5. KESIMPULAN DAN SARAN

5.1. Kesimpulan

Dalam bab ini menyajikan kesimpulan penelitian tentang integrasi *Building Information Modeling* dengan *Value Engineering* untuk memilih alternatif terbaik dari desain yang dilakukan. Dari analisis integrasi BIM dengan VE yang dilakukan dapat menyimpulkan Teknologi BIM membantu *clash dectection*, mengurangi *rework*, mendukung hitungan RAB awal, dan *output* QTO pada tahap evaluasi untuk membantu dalam VE dengan berbagai desain alternatif. Dengan BIM juga bisa melakukan simulasi secara visual waktu 4D dan biaya 5D, sehingga bisa mengurangi potensi konflik antara pekerjaan.

Perbandingan alternatif dalam penelitian ini didasarkan dua kriteria utama melalui model BIM 3D yaitu Waktu 4D dan biaya 5D. Rencana penjadwalan 4D pekerjaan yaitu 281 hari kerja atau 41 minggu kerja tidak ada perubahan antara *Existing*, Alternatif 1 Dan Alternatif. Hasil studi VE terhadap pelat dengan menaikkan dari Mutu Beton *Existing* K300, Alternatif 1 K350, dan Alternatif 2 K400 tidak ada penurunan signifikan terhadap rasio tulangan. Berikut perbandingan Jarak tulangan *cost* antara *Existing*, Alternatif 1, dan Alternatif 2:

	Existing		Alternatif 1		Alternatif 2	
Jarak tulangan	D10-170	D170-200	D10-170	D8-200	D10-175	D8-200
Cost	Rp 5,603,997,968.60		Rp 5,407,013,239.69		Rp 5,431,481,626.88	

Estimasi biaya alternatif 1 terjadi penghematan biaya sebesar Rp. 196,984,728.90 atau 3.52% dari *Existing* dan Alternatif 2 penghematan biaya sebesar Rp 172,516,341.72 atau 3.08 % dari *Exisitng*. Hasil perbandingan menunjukkan

Alternatif 1 lebih kecil dari Alternatif 2, sebab dibatasi dengan row (ρ) sesuai dengan SNI 2847:2013 Pasal 7.12. rasio tulangan susut tidak boleh kecil dari 0.002 [47], jadi penambahan mutu beton tidak memberi pengaruh terhadap jarak tulangan. Oleh sebab itu, dalam biaya alternatif 1 lebih hemat dari alternatif 2.

5.2. Saran

Penelitian saat ini bukanlah upaya pertama, tetapi diindonesia belum banyak melakukan penelitian tentang integrasi BIM dengan VE. penelitian tersebut menunjukkan bagaimana kedua konsep tersebut dapat diterapkan dengan sukses dalam proyek studi kasus di setiap tahapan proyek. Dalam temuan penelitian ini dapat memberikan informasi terhadap industri konstruksi untuk menerapkan integrasi BIM dengan VE dan meningkatkan proses manajemen konstruksi. Meskipun tujuan penelitian ini telah tercapai, tapi masih banyak kekurangan dan keterbatasan dalam penelitian. Sebab penelitian tersebut dilakukan gedung bertingkat berfokus pada elemen struktur. oleh karena itu, hasilnya mungkin berbeda dengan menggunakan proyek lain. Penelitian lanjutnya bisa berfokus pada analisis penjadwalan dengan integrasi BIM dan VE.

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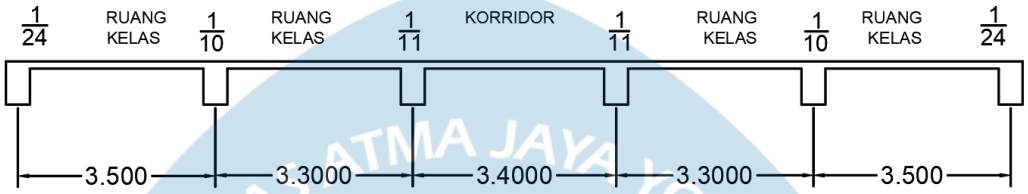
LAMPIRAN 1

Hitungan Struktur Pelat

A. Hitungan Pelat Alternatif 1

Perencanaan tebal pelat koridor sebagai, karena memiliki beban hidup terbesar yaitu 4.79 kN/m^2 acuan untuk perhitungan tebal pelat dan tulangan pada pelat.

1. Hitungan Tebal Pelat



Ly = 7000 mm = 7.000 m

Lx = 3400 mm = 3.400 m

β $= \frac{Ly}{Lx} = \frac{7000}{3000}$ =2.05 > 2, maka hitugan pelat menggunakan tipe pelat satu arah (*One-ways slab*)

Karena tipe pelat satu arah (*one ways slab*), maka pemodelan perhitungan untuk pelat jenis ini dapat dilakukan sebagaimana lataknya sebuah balok persegi dengan tinggi pelat sebagai berikut:

h $= \frac{l}{20} = \frac{34000}{28}$

= 121.4 mm = 120 mm

2. Pembebanan Pelat Atap sesuai dengan 5.1.7.5 beban pelat kolom renang

a. Beban Mati (QD) = 3.900 kN/m^2

b. Beban Hidup (QL) = 4.790 kN/m^2

3. Beban Ultimit (QU)

Qu1 = 1.4×QD

= 1.4 × 3.900 = 5.4600 kN/m²

Qu2 = 1.2 × QD + 1.6 × QL

= 1.2 × 3.900 + 1.6 × 4.790 = 12.344 kN/m² (terpakai)

4. Distribusi Momen

Mlx $= \frac{1}{11} \times Qu \times l^2 = \frac{1}{11} \times 12.344 \times 3.400^2$

= 12.344 kN-m

5. Hitungan tulangan pelat arah x

Tebal Plat (h) = 120 mm

Selimut Beton = 20 mm

Diameter tulangan pokok (D) = 10 mm

d $= h - s - D - \frac{1}{2} \times D = 200 - 20 - \frac{1}{2} \times 10$

= 95.000 mm

d' $= s + \frac{1}{2} \times D = 20 + \frac{1}{2} \times 10$

= 25.000 mm

Mu = 12.344 kN-m

Mn $= \frac{Mlx}{\emptyset} = \frac{12.344}{0.8}$ = 16.2155 kNm = 16.2155 $\times 10^6$ N-mm

ρb $= 0.85 \times \beta \times \frac{f'c}{fy} \times \frac{600}{600+fy}$

Dari SNI-03-1847-2013 Pasal 10.2.7.3, jika f'c = 30 MPa > 28 MPa, maka β harus dihitung:

β1 $= 0.85 - \frac{0.05(f'c-28)}{7} = 0.85 - \frac{0.05(28.489-28)}{7}$

= 0.847

ρb $= 0.85 \times 0.847 \times \frac{3028.489}{400} \times \frac{600}{600+400}$

= 0.0307

ρ_{max} = 0.75× ρb = 0.75×0.0307

= 0.0231

ρ_{min} $= \frac{1.4}{fy} = \frac{1.4}{400}$ = 0.0035

m $= \frac{fy}{0.85f'c} = \frac{400}{0.85 \times 28.489}$ = 16.5182

Rn $= \frac{Mn}{bd^2} = \frac{16.2155 \times 10^6}{1000 \times 95.000^2}$

= 1.797 N/mm^2

ρ_{perlu} $= \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mRn}{fy}}\right) = \frac{1}{16.5182}\left(1 - \sqrt{1 - \frac{2 \times 16.5181 \times 1.797}{400}}\right)$

= 0.00467

Dari hitungan rasio tulangan (ρ) diatas di peroleh:

ρ_{max} = 0.0231

ρ_{min} = 0.0035

ρ_{perlu} = 0.00467

Karena $\rho_{perlu} > \rho_{min}$ dipakai ρ_{perlu} = 0.00467

As_{perlu} = ρ×b×d

= 0.00467×1000×95.000 = 443.8516 mm^2

Dipakai tulangan D =10

As_{tul} $= \frac{1}{4}\pi D^2 = \frac{1}{4} \times \pi 10^2$

= 78.5398 mm^2

Jarak tulangan (s)

S $= \frac{(As_{tul} \times b)}{AS_{perlu}} = \frac{78.5398 \times 1000}{443.8516}$

= 175.678 mm ≈ 170 mm

Control tulangan

As $= As_{tul} \times \frac{1000}{S} = 78.5398 \times \frac{1000}{170}$

= 461.9989 mm^2

= 461.9989 mm^2 > As_{perlu} = 443.8516 mm^2…OK

Jadi tulangan lapangan arah X dipakai D10-170

6. Kontrol kapasitas Momen:

Ts = As × fy = 461.9989 × 400

= 184799.5679 N

a $= \frac{Ts}{0.85 \times fc' \times b} = \frac{184799.5679}{0.85 \times 28.489 \times 1000}$ = 7.6314 mm

Mn_{tot} $= Ts\left(d - \frac{1}{2}a\right) = 184799.5679\ \left(95.000 - \frac{1}{2} \times\ 7.6314\ \right)$

= 16850818.257 N-mm = 16.851 kN-m

Mn_{tot} = 16.851 kN-m

Mu = ϕ × M_{ntotal} = 0.8 × 16.851

= 13.4806 kN-m

Mu = 13.4806 kN-m > Mn = 12.344 kN-m ... (Aman)

7. Kontrol tulangan geser arah x

Vuy $= \frac{1}{2} \times Qu \times ly = \frac{1}{2} \times 12.344 \times 7.000$

$= 43.204$ kN

Vcy $= \frac{1}{2}\sqrt{f'c} \times b \times d = \frac{1}{2}\sqrt{30} \times 1000 \times 173.500$

$= 253531.667$ N $= 253.532$ kN

Syarat:

ØVcy > Vuy = 0.75 × 253.532 = 190.148 kN > 47.088 kN ... (Aman)

8. Tulangan susut dan tulangan suhu

Perhitungan tulangan susut dan suhu pada pelat satu arah mengacuh dapa Pasal 7.12 SNI 2847:2013, sehingga dalam perencanaan ini dipakai ρ = 0.002

$\rho_{terpakai} = 0.002$

$\rho_{perlu} = \rho \times b \times h = 0.0020 \times 1000 \times 120$

$= 216.000$ mm^2

$As_{tul} = \frac{1}{4} \times \pi \times D^2 = \frac{1}{4} \times \pi \times 8^2$

$= 40.212$ mm^2

S $= \frac{As_{tul} \times b}{p_{perlu}} = \frac{50.265 \times 1000}{216.000}$

$= 232.407$ mm ≈ 200 mm

$S/_{1m} = \frac{b}{s} = \frac{1000}{200}$

= 5 buah

$As_{total} = As_{tul} \times S_{/1m} = 50.265 \times 5$

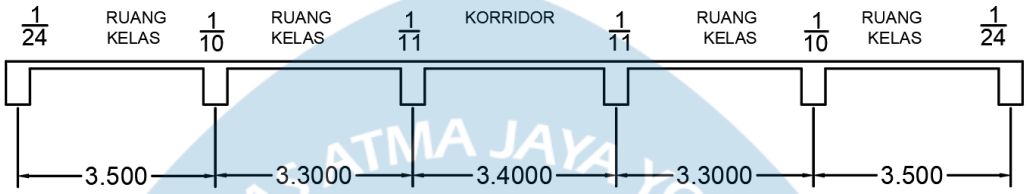
$= 251.212$mm^2

$As_{tul} = 251.327$ mm^2 > Asperlu = 216.000 mm^2 ... (aman)

B. Hitungan Pelat Alternatif 2

Perencanaan tebal pelat koridor sebagai, karena memiliki beban hidup terbesar yaitu 4.79 kN/m^2 acuan untuk perhitungan tebal pelat dan tulangan pada pelat.

1. Hitungan Tebal Pelat



Ly = 7000 mm = 7.000 m

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β $= \frac{Ly}{Lx} = \frac{7000}{3400}$ =2.667 > 2, maka hitugan pelat menggunakan tipe pelat satu arah (*One-ways slab*)

Karena tipe pelat satu arah (*one ways slab*), maka pemodelan perhitungan untuk pelat jenis ini dapat dilakukan sebagaimana lataknya sebuah balok persegi dengan tinggi pelat sebagai berikut:

h $= \frac{l}{20} = \frac{34000}{28}$

= 121.4 mm = 120 mm

2. Pembebanan Pelat Atap sesuai dengan 5.1.7.5 beban pelat kolom renang

C. Beban Mati (QD) = 3.900 kN/m^2

D. Beban Hidup (QL) = 4.790 kN/m^2

3. Beban Ultimit (QU)

Qu1 = 1.4×QD

= 1.4 × 3.900 = 5.4600 kN/m²

Qu2 = 1.2 × QD + 1.6 × QL

= 1.2 × 3.900 + 1.6 × 4.790 = 12.344 kN/m² (terpakai)

4. Distribusi Momen

Mlx $= \frac{1}{11} \times Qu \times l^2 = \frac{1}{8} \times 12.344 \times 3.400^2$

= 12.344 kN-m

5. Hitungan tulangan pelat arah x

Tebal Plat (h) = 120 mm

Selimut Beton = 20 mm

Diameter tulangan pokok (D) = 10 mm

d $= h - s - D - \frac{1}{2} \times D = 200 - 20 - \frac{1}{2} \times 10$

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= 1.797 N/mm^2

ρ_{perlu} $= \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mRn}{fy}}\right) = \frac{1}{16.5182}\left(1 - \sqrt{1 - \frac{2 \times 16.5181 \times 1.797}{400}}\right)$

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S $= \frac{(As_{tul} \times b)}{AS_{perlu}} = \frac{78.5398 \times 1000}{443.8516}$

= 175.678 mm ≈ 170 mm

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As $= As_{tul} \times \frac{1000}{S} = 78.5398 \times \frac{1000}{170}$

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= 461.9989 mm^2 > As_{perlu} = 443.8516 mm^2…OK

Jadi tulangan lapangan arah X dipakai D10-170

6. Kontrol kapasitas Momen:

Ts = As × fy = 461.9989 × 400

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Mn_{tot} $= Ts\left(d - \frac{1}{2}a\right) = 184799.5679\ \left(95.000 - \frac{1}{2} \times\ 7.6314\ \right)$

= 16850818.257 N-mm = 16.851 kN-m

Mn_{tot} = 16.851 kN-m

Mu = ϕ × M_{ntotal} = 0.8 × 16.851

= 13.4806 kN-m

Mu = 13.4806 kN-m > Mn = 12.344 kN-m ... (Aman)

7. Kontrol tulangan geser arah x

Vuy $= \frac{1}{2} \times Qu \times ly = \frac{1}{2} \times 12.344 \times 7.000$

$= 43.204$ kN

Vcy $= \frac{1}{2}\sqrt{f'c} \times b \times d = \frac{1}{2}\sqrt{30} \times 1000 \times 173.500$

$= 253531.667$ N $= 253.532$ kN

Syarat:

ØVcy > Vuy = 0.75 × 253.532 = 190.148 kN > 47.088 kN ... (Aman)

8. Tulangan susut dan tulangan suhu

Perhitungan tulangan susut dan suhu pada pelat satu arah mengacuh dapa Pasal 7.12 SNI 2847:2013, sehingga dalam perencanaan ini dipakai ρ = 0.002

$\rho_{terpakai} = 0.002$

$\rho_{perlu} = \rho \times b \times h = 0.0020 \times 1000 \times 120$

$= 216.000$ mm^2

$As_{tul} = \frac{1}{4} \times \pi \times D^2 = \frac{1}{4} \times \pi \times 8^2$

$= 40.212$ mm^2

S $= \frac{As_{tul} \times b}{p_{perlu}} = \frac{50.265 \times 1000}{216.000}$

$= 232.407$ mm ≈ 200 mm

$S/_{1m} = \frac{b}{s} = \frac{1000}{200}$

= 5 buah

$As_{total} = As_{tul} \times S_{/1m} = 50.265 \times 5$

$= 251.212$mm^2

$As_{tul} = 251.327$ mm^2 > Asperlu = 216.000 mm^2 ... (aman)