

DESIGN OF 500 KG CAPACITY MATERIAL HANDLING TO SUPPORT THE ASSEMBLY PROCESS AT PT. XYZ USING THE VDI 2221 METHOD

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ABSTRAK

Perancangan Material Handling Kapasitas 500 Kg untuk Mendukung Proses Perakitan di Tilting Table PT. XYZ dengan Menggunakan Metode VDI 2221, merupakan pengembangan dari material handling yang sebelumnya sudah digunakan di PT. XYZ. Perancangan ini bertujuan untuk memaksimalkan mekanisme kerja material handling agar mempermudah operator saat proses perakitan Towing di Tilting Table. Dimana pada proses sebelumnya pemindahan motor compartment, platform, dan steering ke line assembly total masih secara manual dengan menggunakan tenaga manusia. Maka dari itu perancangan ini memaksimalkan cara kerja dari material handling dengan memodifikasi rangka IWF (girder) agar mampu memindahkan motor compartment, platform, dan steering ke line assembly total dengan mudah. Metode penelitian yang digunakan untuk Perancangan Material Handling Kapasitas 500 Kg Untuk Mendukung Proses Perakitan di Tilting Table PT. XYZ adalah metode VDI (Verein Deutsche Ingenieure) 2221. Urutan kerja untuk merancang suatu desain menggunakan metode VDI 2221 secara umum adalah merencana, mengkonsep, merancang, dan penyelesaian. Hasil perhitungan dan analisa pada perancangan ini merupakan pembandingan dari rancangan sebelumnya apakah struktur konstruksi sudah sesuai dengan standar kekuatan yang berlaku terhadap perhitungan dan analisa yang sudah dilakukan dengan mempertimbangkan standar yang sesuai dengan tujuan agar mampu menahan beban maksimal 500kg.

Kata kunci: Crane; Electric Hoist; Material Handling; Metode VDI 2221

ABSTRACT

The design of Material Handling with a Capacity of 500 Kgs to Support the Assembly Process at the Tilting Table of PT XYZ Using the VDI 2221 Method is a development of material handling that was previously used at PT XYZ. This design aims to maximize the material handling mechanism to make it easier for operators during the Towing assembly process on the Tilting Table. Where previously moving the motor compartment, platform, and steering to the total assembly line was still manual using human labor. Therefore, this design maximizes the workings of the material handling by modifying the IWF frame (girder) to be able to move the motor compartment, platform, and steering to the total assembly line easily. The research method used for the Design of Material Handling with a Capacity of 500 Kg to Support the Assembly Process at the Tilting Table of PT Senzo Feinmetal is the VDI (Verein Deutsche Ingenieure) 2221 method. The sequence of work to design a design using the VDI 2221 method in general is planning, conceptualizing, designing, and completing. The results of the calculation and analysis in this design are a comparison of the previous design whether the construction structure is in accordance with applicable strength standards. The calculations and analysis that have been carried out by considering the appropriate standards are intended to be able to withstand a maximum load of 500 Kgs.

Keywords: Crane; Electric Hoist; Material Handling; VDI 2221 Method

INTRODUCTION

Electric Towing Tractor (Orbit) is a towing vehicle used to pull goods or materials using a trolley that resembles a railway car in the process of moving products in intralogistics activities [1]. The creation of Towing Orbit went through several manufacturing processes and through an assembly process that was carried out at the Tilting Table and

ended in the assembly process in the total assembly section.

Tilting Table is a lifting aid used at PT. XYZ to assist with the Orbit Towing assembly process. Towing Orbit is divided into 3 main parts, namely the motor compartment, platform, and steering part, this is a sub-part that will be assembled on the Tilting Table before entering the

total assembly section, where the Orbit is assembled using other supporting components so that the Orbit is ready for testing, the following is the layout and direction of the Towing Orbit assembly process.

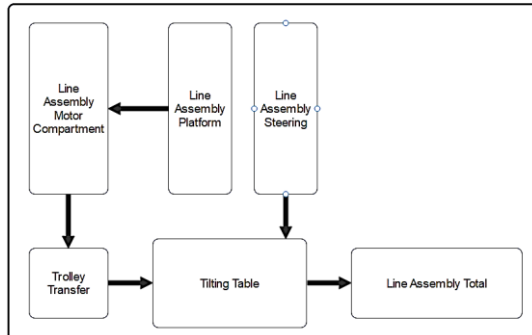


Figure 1. Layout and direction of the Orbit Towing assembly process

Problems that often occur in the assembly process of Towing Orbit on the Tilting Table are: 1) the operator has difficulty in the process of moving the motor compartment and platform to the Tilting Table because the component has a fairly heavy load, which is 355 kg, so it requires the help of other operators to be able to lift the component, 2) the dependence of the assembly operator on the other operators to assist if the assembly process at the Tilting Table has been completed or is about to begin. Seeing several problems that often occur during the assembly process, the researcher designed and modified the Tilting Table for the Orbit Towing assembly process which can be controlled by 1 operator without the need for the help of other operators [2], [3].

RESEARCH METHODS

The research method used for the Design of Material Handling with a Capacity of 500 Kg to Support the Assembly Process at the Tilting Table of PT. XYZ is the VDI (Verein Deutsche Ingenieur) 2221 method. The VDI 2221 method is a systematic approach to design to formulate design variations into one best model based on research activities [4],[5]. The work sequence for designing a design using the VDI 2221 method is generally planning, conceptualizing, designing, and completion. The VDI 2221 method is also one of the widely used methods in designing to solve engineering problems through step-by-step analysis and synthesis compiled by Gerhard Pahl and Wolfgang Beitz [6]. The systematic VDI 2221 design method is expected to make it easier for designers to master the design system without

having to master the details and also help the process of designing a product and is easy to use [7].

The determination of the concept to find out the main problem and get the solution can be seen in the specification of the list of requirements for designing can be seen in table 1. [8].

1. Planning Stage

The planning stage is carried out by identifying needs and formulating a list of construction demands that will be the main reference in the design of this material handling. The principle of modifying the Tilting Table in general is to make it easier for the operator to move the Orbit sub assembly to be moved to the total assembly line. The IWF frame with a length of 2500 mm has an important role in the process of moving the Orbit sub assembly, because from the trolley transfer to the total assembly line using an electric hoist that depends on the IWF frame.

2. Conceptualization Stage

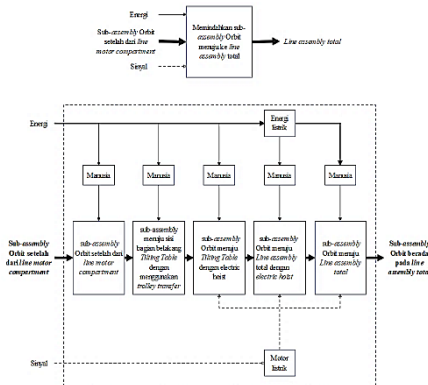
Table 1. Requirements List

LAB. RIM	Daftar Persyaratan		Permasalahan Tanggal : 18 April 2026
	untuk: PERANCANGAN MATERIAL HANDLING		Halaman ke : 1 dari 1
Tanggal Perubahan	Tuntutan Harapan	Persyaratan – persyaratan	Penanggung Jawab
		Geometri :	Didan
	D	1. Tinggi Tilting Table = 2500 mm	
	D	2. Lebar Tilting Table = 1800 mm	
	D	3. Panjang Tilting Table = 1500 mm	
	D	4. Panjang Grider = 2500 mm	
		Kinematika :	
	D	1. Gerakan Maju Mundur dengan panjang grider 2500 mm	
	D	2. Gerakan Naik Turun dengan tinggi 2100 mm	
		Gaya :	
	D	1. Kapasitas angkat beban aktual 345 kg	
	D	2. Kapasitas angkat Hoist 500 kg	
		Energi :	
	W	1. Pergerakan maju mundur, serta naik turun menggunakan electric hoist	
		Material :	
	D	1. Square Pipe Hollow	
	D	Menggunakan Girder II beam	
		Kekuatan :	
	W	1. Frame mampu menahan beban 500 kg	
		Penggunaan :	
	D	1. Pengoperasian pada proses assembly Orbit	
		Perawatan :	
	W	1. Pengcekaman label baja	
	W	2. Pemberian pelumas pada roda hoist	

The analysis stage is the foundation for the next stage, namely the product concept development stage. Design specifications include product technical requirements that are compiled based on a measurable list of user needs. The structure of the function is described taking into account the sub-functions that are considered important and can be varied in the design.

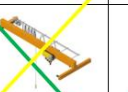
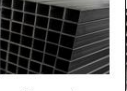
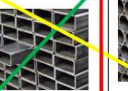
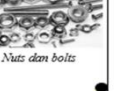
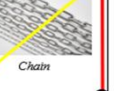
The study of literacy produces alternatives, variations, assessments and choices of concepts. The determination of the design concept is carried out using a morphology box based on several sub-functions of material handling construction.

Alternative variants are assessed based on technical and economic aspects with the aim of getting the best concept variant.



Gambar 2. Struktur Fungsi

Tabel 2. Morfologi

Morfologi Desain			
Parameter	Alternatif 1	Alternatif 2	Alternatif 3
Jenis Rangka Utama Tilting Table	 Gantry crane	 Jib crane	 Overhead crane
Jenis girder	 Double girder	 Single girder	 Overhead crane
Jenis Frame tilting table	 Square pipe	 Rectangular pipe	 Pipe
Jenis hoist	 Electric hoist	 Manual hoist	 Pneumatic hoist
Sambungan frame	 Welding	 Nuts dan bolts	 Overhead crane
Jenis tali hoist	 Sling baja	 Chain	 Overhead crane
Jenis pengait hoist	 Swivel hook	 Safety latch hook	 Grab hook

The best option is chosen based on the choice closest to the diagonal line. The diagram shows that option 2 is the best option because its

classification is closest to the diagonal line, and like the chosen concept, it is manifested in the form of sketches and design plans.

Variant alternatives are assessed based on technical aspects and economic aspects. The weighting of the criteria is based on the needs of the design. The technical assessment criteria in Table 3 consist of 10 aspects with a value weight of 10 and the economic assessment criteria in Table 4 with a value weight of 10. The value of the variant is multiplied by the weight of the assessed aspect. Rating range 1 to 10.

Variants are sorted by value with a rating of 1 being the best variant.

Table 3. Technical Assessment

Penilaian Ekonomis Varian Konsep									
Kriteria Penilaian Ekonomi	Bobot	Varian 1		Varian 2		Varian 3		Nilai Ideal	
		Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Nilai	Bobot x Nilai
Biaya Bahan Baku Material	5	8	40	8	40	8	40	10	50
Biaya Standard Part	4	10	40	6	24	9	36	10	40
Biaya Permesinan	3	6	18	7	21	8	24	10	30
Biaya Perakitan	3	9	27	6	18	7	21	10	30
Biaya Perawatan	2	7	14	6	12	8	16	10	20
Biaya Desain	2	8	16	7	14	7	14	10	20
Total	19	48	155	40	129	47	151	60	190
Nilai Teknis		8.2		6.8		7.9		10	
Presentase		81.6		67.9		79.5		100	
Peringkat		2		3		1			

Table 4. Economic Assessment

Penilaian Ekonomis Varian Konsep									
Kriteria Penilaian Ekonomi	Bobot	Varian 1		Varian 2		Varian 3		Nilai Ideal	
		Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Bobot x Nilai	Nilai	Bobot x Nilai
Biaya Bahan Baku Material	5	8	40	8	40	8	40	10	50
Biaya Standard Part	4	10	40	6	24	9	36	10	40
Biaya Permesinan	3	6	18	7	21	8	24	10	30
Biaya Perakitan	3	9	27	6	18	7	21	10	30
Biaya Perawatan	2	7	14	6	12	8	16	10	20
Biaya Desain	2	8	16	7	14	7	14	10	20
Total	19	48	155	40	129	47	151	60	190
Nilai Teknis		8.2		6.8		7.9		10	
Presentase		81.6		67.9		79.5		100	
Peringkat		2		3		1			

3. Planning Stage

The material handling design to help the assembly process on the tilting table is the result of modification or development from the previous design. The development of this tool aims to make it easier for operators to assemble the assembly process carried out on the tilting table. This design has dimensions of 1500 mm long, 1600 mm wide, and 2500 mm high, which has a max load capacity of 600 kg.

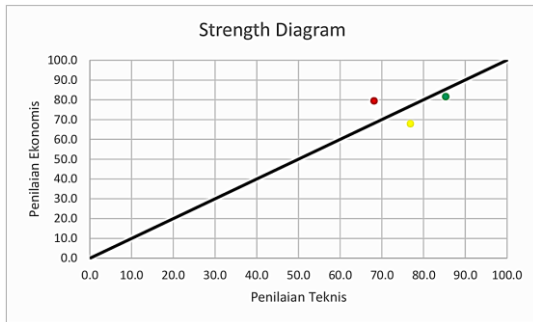


Figure 3. Rating Chart

4. Completion Stage

The final finishing stage is to make an array drawing and make a detailed drawing.



Figure 4. Material Handling Design

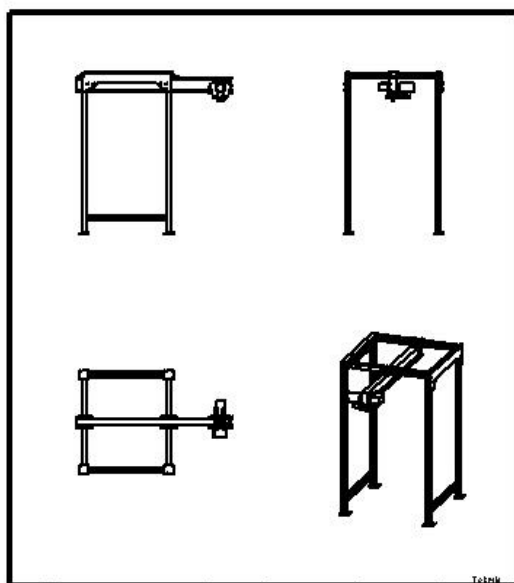


Figure 5. 2D Material Handling Drawings

RESULTS AND DISCUSSION

The design results show that the modified part is the IWF frame which is indicated by the letters A, B, and C. IWF frame is the main part of the material handling that functions to move the sub assembly from trolley transfer to the total assembly line.

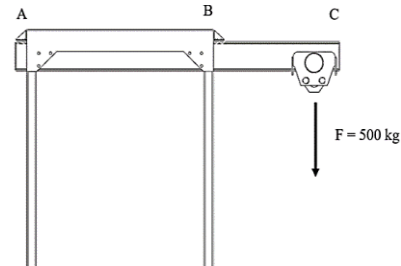


Figure 6. Frame IWF

1. Calculation of load on each supporting column of scheme 1 and 2

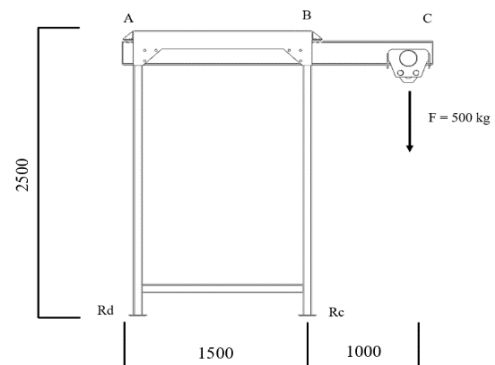


Figure 7. Scheme Load 1

Remarks: $R_c = 2$ Columns
 $= R_{c1} = R_{c2}$
 $R_d = 2$ Columns
 $= R_{d1} = R_{d2}$

Load F is a vertical force

- Load conversion

$$w = 500 \text{ kg} \times 9,81 \text{ m/s}^2 \\ = 4,905 \text{ N}$$

- Load in column Rc

$$\sum M_A = 0 \\ R_c \times 1500 \text{ mm} = 4,905 \text{ N} \times (1500 + 1000) \\ R_c \times 1500 \text{ mm} = 4,905 \text{ N} \times 2500 \text{ mm} \\ R_c = 8,175 \text{ N} \\ R_{c1} = R_{c2} = 8,175 \text{ N} / 2 \\ = 4,087 \text{ N}$$

- Load in the Rd column

$$\sum M_B = 0 \\ R_d \times 1500 \text{ mm} = 4,905 \text{ N} \times 1000 \text{ mm} \\ R_d = 3,270 \text{ N} \\ R_{d1} = R_{d2} = 3,270 \text{ N} / 2 \\ = 1,635 \text{ N}$$

- Compressive load on column Rc and tensile load on column Rd with load scheme 1

Load in columns Rc= 4,087 N

Load in columns Rd= 3,270 N

Actual cross-sectional area

$$A_{out} = 75 \text{ mm} \times 75 \text{ mm} \\ = 5625 \text{ mm}^2$$

$$A_{in} = 67 \text{ mm} \times 67 \text{ mm} \\ = 4489 \text{ mm}^2$$

$$A_{act} = A_{out} - A_{in} \\ = 1136 \text{ mm}^2$$

Actual compressive stress on the column Rc

$$\sigma_D = F/A_{act} \\ = 4,087 \text{ N}/1136 \text{ mm}^2 \\ = 3,597 \text{ N/mm}^2$$

Actual tensile pressure on the column Rd

$$\sigma_t = F/A_{act} \\ = 3,270 \text{ N}/1136 \text{ mm}^2 \\ = 2,87 \text{ N/mm}^2$$

Tension Pressure Permit

$$\overline{\sigma_D} = \sigma_B/v \\ = (370 \text{ N/mm}^2)/1,5 \\ = 246,6 \text{ N/mm}^2$$

Tension withdraw permission

$$\overline{\sigma_t} = \sigma_B/v \\ = (370 \text{ N/mm}^2)/1,5 \\ = 246,6 \text{ N/mm}^2$$

σ_B is a fracture in the ST.37 material of 370 N/mm²

v is the safety number for the material ST.37 that is valued 1,3-1,8.

Based on the calculation results, the compressive tension in the Rc column and the tensile tension in the Rd column are declared safe because the resulting tension does not exceed the allowable tension. $\sigma_D = 3,597 \leq \overline{\sigma_D} = 246,6$ tension Pressure Allows

Load conversion

$$w = 500 \text{ kg} \times 9,81 \text{ m/s}^2 \\ = 4,905 \text{ N}$$

- Load in columns Rc

$$\sum M_A = 0$$

$$Rc \times 1500 \text{ mm} = 4,905 \text{ N} \times 750 \text{ mm}$$

$$Rc = 2,452 \text{ N}$$

$$Rc_1 = Rc_2 = 2,452 \text{ N} / 2 \\ = 1,226 \text{ N}$$

- Load in columns Rd

$$\sum M_B = 0$$

$$Rd \times 1500 \text{ mm} = 4,905 \text{ N} \times 750 \text{ mm}$$

$$Rd = 2,452 \text{ N}$$

$$Rd_1 = Rd_2 = 2,452 \text{ N} / 2 \\ = 1,226 \text{ N}$$

- Compressive loads on Rd and Rc columns with scheme loading 2

Load in columns Rd = 2,452 N

Actual cross-sectional area

$$A_{out} = 75 \text{ mm} \times 75 \text{ mm} \\ = 5625 \text{ mm}^2$$

$$A_{in} = 67 \text{ mm} \times 67 \text{ mm} \\ = 4489 \text{ mm}^2$$

$$A_{ef} = A_{out} - A_{in} \\ = 1136 \text{ mm}^2$$

Actual compressive tension

$$\sigma_D = F/A_{act} \\ = 2,452 \text{ N}/1136 \text{ mm}^2 \\ = 2,158 \text{ N/mm}^2$$

Tension Pressure Permit

$$\overline{\sigma_D} = \sigma_B/v \\ = (370 \text{ N/mm}^2)/1,5 \\ = 246,6 \text{ N/mm}^2$$

Based on the results of the calculation, the compressive stress in the column (Rc and Rd) is declared safe because the actual cross-sectional area produced does not exceed the allowable cross-sectional area because the compressive stress $\sigma_D = 2,154 \leq \overline{\sigma_D} = 246,6$ tension Pressure Permits.

Compressive load on the column Rc

$$I_{min} = (\frac{1}{2} \times 75 \times 75^3) - (\frac{1}{2} \times 67 \times 67^3) \\ = 15820312 - 10075560$$

$$I_{min} = 5744752 \text{ mm}^4$$

- Actual cross-sectional area

$$A_{act} = (75 \text{ mm} \times 75 \text{ mm}) - (67 \text{ mm} \times 67 \text{ mm}) \\ = 5265 \text{ mm}^2 - 4489 \text{ mm}^2$$

$$A_{act} = 1136 \text{ mm}^2$$

- Inertia radius

$$i = \sqrt{(I_{min}/A)} \\ = \sqrt{(5744752 \text{ mm}^4/1136 \text{ mm}^2)} \\ = 71,1 \text{ mm}$$

- Bending length

$$L_k = C \times L \\ = 0,5 \times 2500 \text{ mm} \\ = 1250 \text{ mm}$$

- Slimming Rc

$$\lambda = L_k/i \\ = 1250 \text{ mm}/71,1 \text{ mm} \\ = 17,5$$

- Bending tension for materials ST.37

$$\sigma_k = 310 - 1,14 \times \lambda \\ = 310 - 1,14 \times 17,5 \\ = 290,05 \text{ N/mm}^2$$

- Bend style on columns Rc

$$F_k = \sigma_k \times A_{act} \\ = 290,05 \text{ N/mm}^2 \times 1136 \text{ mm}^2 \\ = 329,496 \text{ N}$$

- Compressive load on the column Rd

$$I_{min} = (\frac{1}{2} \times 75 \times 75^3) - (\frac{1}{2} \times 67 \times 67^3) \\ = 15820312 \text{ mm}^4 - 10075560 \text{ mm}^4 \\ = 5744752 \text{ mm}^4$$

- Actual cross-sectional area

$$A_{act} = (75 \times 75) - (67 \times 67) \\ = 5265 \text{ mm}^2 - 4489 \text{ mm}^2 \\ = 1136 \text{ mm}^2$$

- Inertia radius

$$i = \sqrt{(I_{min}/A)}$$

- $$= \sqrt{(5744752 \text{ mm}^4 / 1136 \text{ mm}^2)}$$
- $$= 71,1 \text{ mm}$$
- Bending length

$$L_k = C \times L$$

$$= 0,5 \times 2500 \text{ mm}$$

$$= 1250 \text{ mm}$$
 - Slimming Rd

$$\lambda = L_k / i$$

$$= 1250 \text{ mm} / 71,1 \text{ mm}$$

$$= 17,5$$
 - Bending tension for materials ST.37

$$\sigma_k = 310 - 1,14 \times \lambda$$

$$= 310 - 1,14 \times 17,5$$

$$= 290,05 \text{ N/mm}^2$$
 - Bend style on columns Rd

$$F_k = \sigma_k \times A_{act}$$

$$= 290,05 \times 1136$$

$$= 329,496 \text{ N}$$

Based on the results of the calculation, the force in the Rd column is equal to $F=1,635 \text{ N} \leq F_k=329,496 \text{ N}$ declared safe.

2. Calculation of curved moment

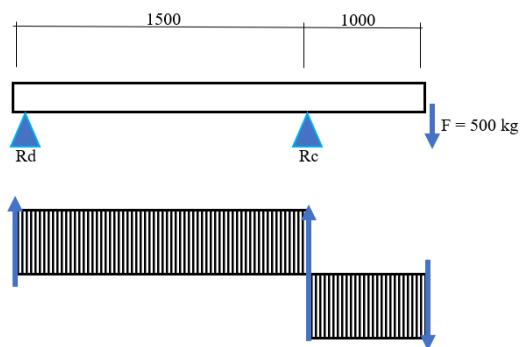


Figure 9. Curved Moment On IWF Frame

- Load Conversion

$$F = 500 \text{ kg} \times 9,81 \text{ m/s}^2$$

$$= 4,905 \text{ N}$$
- Allowable tension on the material ST. 37

$$\sigma_B = (370 \text{ N/mm}^2) / 1,5$$

$$= 246,6 \text{ N/mm}^2$$
- Transverse Style

$$R_c = (2500 \text{ mm} \times F) / 1500 \text{ mm}$$

$$= 8,175 \text{ N}$$

$$R_{c1} = R_{c2} = 8,175 \text{ N} / 2$$

$$= 4,08 \text{ N}$$

$$R_d = (1000 \text{ mm} \times F) / 1500 \text{ mm}$$

$$= 3,270 \text{ N}$$

$$R_{d1} = R_{d2} = 3,270 \text{ N} / 2$$

$$= 1,63 \text{ N}$$
- Maximum Curve Moment

$$M_{max} = F \times 1000 \text{ mm}$$

$$= 4,905 \text{ N} \times 1000 \text{ mm}$$

$$= 4,905 \text{ Nmm}$$

- Cross-sectional area IWF

$$A_f = 2 \times w \times t_f$$

$$= 2 \times 110 \times 9$$

$$= 1980 \text{ mm}^2$$

$$A_w = (H - 2 \times t_f) \times t_w$$

$$= (220 - 2 \times 9) \times 6$$

$$= 1212 \text{ mm}^2$$

$$A_{act} = A_f + A_w$$

$$= 1980 \text{ mm}^2 + 1212 \text{ mm}^2$$

$$= 3192 \text{ mm}^2$$

$$C = A_{act} / 2$$

$$= 3192 \text{ mm}^2 / 2$$

$$= 1596 \text{ mm}^2$$

- External IWF moment of inertia

$$I_{out} = (1/12) \times W \times H^3$$

$$= (1/12) \times 110 \text{ mm} \times 220 \text{ mm}^3$$

$$= 97936666 \text{ mm}^4$$

$$I_{in} = (1/12) (W - t_w) \times (H - 2 t_f)^3$$

$$= (1/12) (104 \text{ mm}) (202 \text{ mm})^3$$

$$= 71434202 \text{ mm}^4$$

$$I_{act} = I_{out} - I_{in}$$

$$= 97936666 \text{ mm}^4 - 71434202 \text{ mm}^4$$

$$= 26502464 \text{ mm}^4$$

- Moment of the permit curve at the IWF

$$M = (\sigma_B \times I_{act}) / C$$

$$= 246,6 \text{ N/mm}^2 \times 26502464 \text{ mm}^4 / 1596$$

$$= 41000 \text{ Nmm}^2$$

Based on the calculation where

$$M_{max} (4,905 \text{ N/mm}^2) \leq \bar{M} (41000 \text{ N/mm}^2)$$

So the condition of the IWF with a length of 2500 mm with a flange height of 220 mm and a web width of 110 mm is safe to use for electric hoist support with a hoist capacity of 500 kg.

3. Calculating the shear force on the IWF

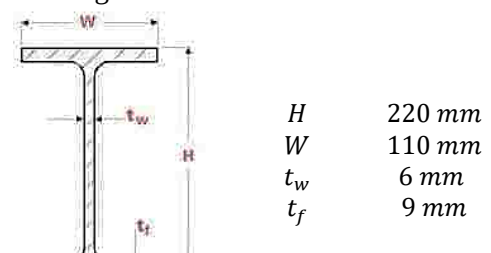


Figure 9. Girder (IWF Frame)

- Load

$$F = 500 \text{ kg} \times 9,81 \text{ m/s}^2$$

$$= 4,905 \text{ N}$$
- Actual cross-sectional area

$$A_{web} = \text{Tebal}_{web} \times \text{Tinggi}_{web}$$

$$= 6 \text{ mm} \times 202 \text{ mm}$$

$$= 1212 \text{ mm}^2$$
- Web Height

$$\text{Height}_{web} = \text{Height}_{web} - 2 \times \text{Thick}_{flens}$$

$$= 220 \text{ mm} - 2 \times 9 \text{ mm}$$

$$= 202 \text{ mm}$$

- Actual Shear Tension

$$\begin{aligned}\tau_s &= F/A_{web} \\ &= 4,905 \text{ N} / 1212 \text{ mm}^2 \\ &= 4,05 \text{ N/mm}^2\end{aligned}$$

- Shear Tension Permit

$$\begin{aligned}\bar{\tau}_s &= (\sigma_u \times \sigma_{St.37} \text{ N/mm}^2) / v \\ &= 104,8 \text{ N/mm}^2\end{aligned}$$

Based on the results of the calculation: $\tau_s = 4,05 \text{ N/mm}^2$, so that $\tau_s \leq \bar{\tau}_s$, so these conditions are very safe for the design of this material handling.

4. Calculation of M14 bolts for IWF joints

In this material handling design, the connection between the IWF frame and the support column uses M14 bolts with a number of 16 bolts, so each bolt withstands a load of:

$$\sigma_t = \frac{43,391 \text{ N/mm}^2}{16} = 2,707 \text{ N/mm}^2$$

Based on the calculation, each bolt receives $\sigma_t = 2,707 \text{ N/mm}^2$, so that with the condition $\sigma_t \leq \bar{\sigma}_t$ baut with the size of M14 it is very safe to use for this material handling design connection.

5. Calculation of dynabolts on each support column

To prevent shear forces in this material handling frame, each support column (Rc and Rd) must be supported using 16 M10 dynabolts, so each bolt holds the load:

$$\sigma_t = \frac{113,5 \text{ N/mm}^2}{16} = 7,10 \text{ N/mm}^2$$

While based on calculations, each dynabolt receives $\sigma_t = 7,10 \text{ N/mm}^2$ with the condition $\sigma_t \leq \bar{\sigma}_t$, maka dynabolt with size M10 can be used to be the basis of the Rc and Rd columns.

CONCLUSION

The design of this Material Handling has been able to meet the needs of the transfer process from trolley transfer to total assembly line by modifying the IWF frame with a length of 2500 mm so that it can move sub-assembly from trolley transfer to total assembly line. At the base of the support column, a dyna bolt of M10 size is used to withstand a tensile load of 113.5 N with a permissible tensile stress of 246.6 N. Square Hollows measuring 75 mm x 75 mm with a thickness of 4 mm receive a maximum load of 4905 N while the maximum acceptable limit on the

column is 41000 N, this load represents the greatest force accepted on the column. The M14 bolts used for IWF joints are declared safe because the actual tensile stress of 43.5 N acting on the bolt is less than the permissible tensile stress of 246.6 N. This calculation needs to be done in structural design and analysis to ensure the column can withstand such loads without experiencing structural failure [9].

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