OPTIMIZATION OF REINFORCEMENT STEEL IN BUILDING CONSTRUCTION PROJECTS

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WASTAGES OF REINFORCEMENT IN BUILDING CONSTRUCTION

1. Unavoidable reinforcement waste
    i. Cutting bars waste after optimazation
    ii. Expenditure required to reduce waste is superior in economy
2. Avoidable waste
    i. Caused by disorganised operating technique
    ii. Using excessive bars or longer length than the required length
3. Un-optimised waste
    i. Delivered 12 m long bars were inefficiently cut
    ii. As a result, leftover pieces longer than 1 m may be economically un-usable
4. Rework
5. Design change
6. Production of defective or not complied with the standard of reinforcement

WASTE MINIMIZATION AT DIFFERENT CONSTRUCTION STAGES

1. **Pre-Designing - Feasibility study (marketing, financial and technical analysis)**
2. **Structural Design Stage – Selection of diameters among many**
3. **Construction Stage – Application an optimization system**

ECONOMIC EFFECT OF REBAR WASTAGE

1. **Amount of material to be procured–** how more from the <u>exact</u> designed BOQ
2. **Disposing cost of waste material from the site**
3. **Steel fixers wages (**Using excessive bars or longer length than the required length)

BOQ

Excell is used to calculate the Bill of Quantities of reinforcement

DESCRIPTION OF WORK	REINFORCEMENT QUANTITY				REINFORCEMENT BAR DIAMETERS						
	DIAMETER	LENGTH	NUMBER	SIMILAR	Ø8	Ø10	Ø12	Ø14	Ø16	Ø18	Ø20
BEAM K101 TOP BARS	12	5,95	2	1	0	0	11,9	0	0	0	0
BEAM K101 BOTTOM BARS	14	5,95	3	1	0	0	0	17,85	0	0	0
BEAM K101 BENT UP BARS	16	6,41	2	1	0	0	0	0	12,82	0	0
BEAM K101 STIR UPS	8	1,7	35	1	59,5	0	0	0	0	0	0
COLUMN S101 LONGITUDINAL BARS	16	4	6	1	0	0	0	0	24	0	0
COLUMN S101 STIR UPS	8	1,5	26	1	39	0	0	0	0	0	0
COLUMN S102 LONGITUDINAL BARS	16	4	8	1	0	0	0	0	32	0	0
COLUMN S102 STIR UPS	8	1,6	30	1	48	0	0	0	0	0	0
SUM OF LENGTH					146,5	0	11,9	17,85	68,82	0	0
WEIGHT PER UNIT LENTGH					0,395	0,617	0,888	1,209	1,578	2,0	2,47
SUM OF KG WEIGHT PER DIAMETER					57,87	0	10,57	21,58	108,6	0	0
TOTAL SUM (KG)					199						

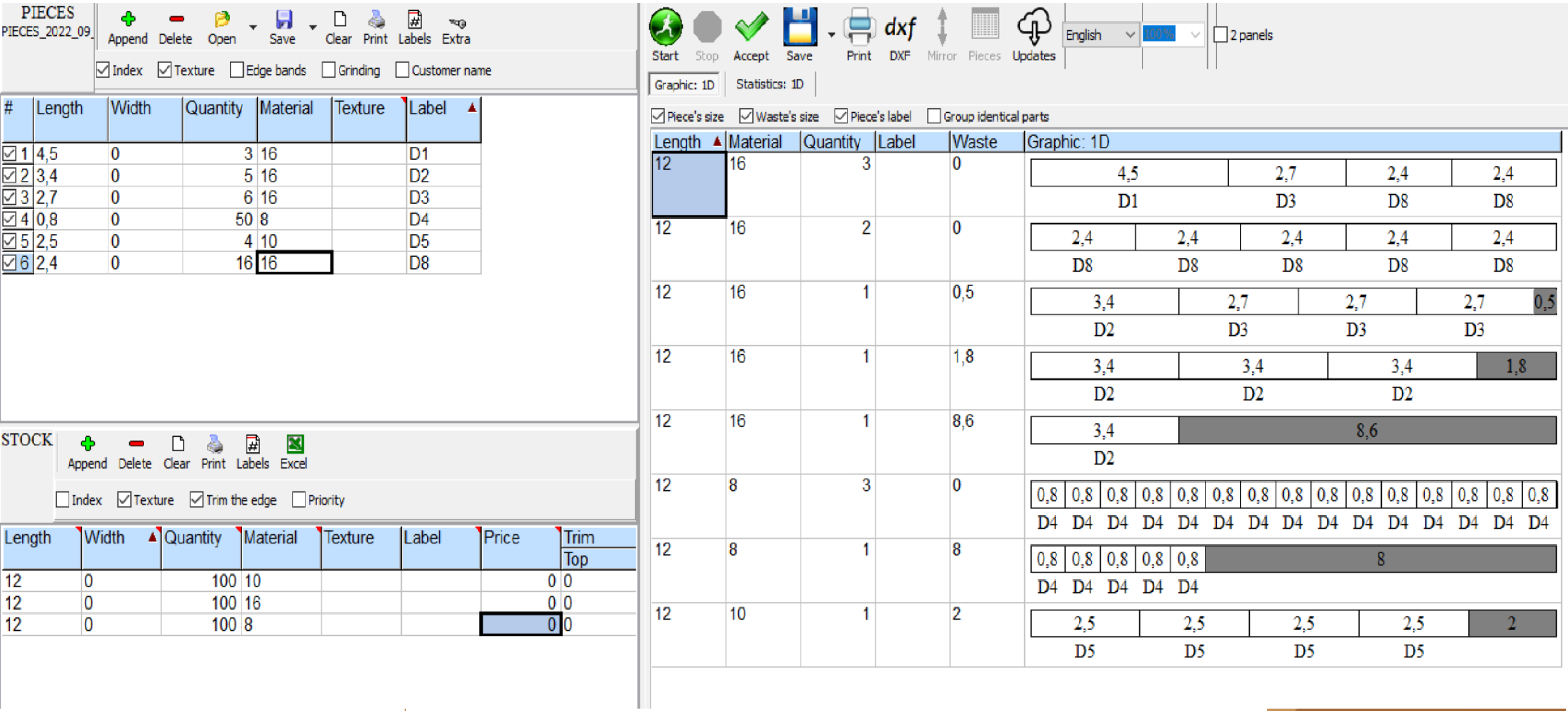
OPTIMIZATION

- One of the most fundamental definitions of optimization is **‘doing the most with the least’.**
- Reinforcement bars are manually or mechanically cut to the appropriate length and bent into the shapes specified on the project drawings.
- Before cutting rebars, a bar cutting Schedule needs to be developed and given to Steel Fixers.
- Therefore, the process of generating a bar-cutting pattern that meets demand while producing the least amount of waste is referred to as optimization.
- In literature, it is mentioned that the waste in reinforcement can me more than 10-15%.

PRO OPTIMIZATION

- There are numerous tools to be used in optimization.
- Cutting Optimization Pro is a software that creates cutting and nesting patterns for one-dimensional (1D) and two-dimensional (2D) materials.
- Reduces waste and costs by specifying a maximum cut length from a steel bar.
- Import data from Microsoft Excel

An interface of a cutting optimization pro software 1D



#	Length	Width	Quantity	Material	Texture	Label
1	4,5	0	3	16		D1
2	3,4	0	5	16		D2
3	2,7	0	6	16		D3
4	0,8	0	50	8		D4
5	2,5	0	4	10		D5
6	2,4	0	16	16		D8

Length	Width	Quantity	Material	Texture	Label	Price	Trim Top
12	0	100	10			0	0
12	0	100	16			0	0
12	0	100	8			0	0

Length	Material	Quantity	Label	Waste	Graphic: 1D
12	16	3		0	4,5 D1 / 2,7 D3 / 2,4 D8 / 2,4 D8
12	16	2		0	2,4 D8 / 2,4 D8 / 2,4 D8 / 2,4 D8 / 2,4 D8
12	16	1		0,5	3,4 D2 / 2,7 D3 / 2,7 D3 / 2,7 D3 / 0,5
12	16	1		1,8	3,4 D2 / 3,4 D2 / 3,4 D2 / 1,8
12	16	1		8,6	3,4 D2 / 8,6
12	8	3		0	0,8 D4 (×15)
12	8	1		8	0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 8
12	10	1		2	2,5 D5 / 2,5 D5 / 2,5 D5 / 2,5 D5 / 2

REINFORCEMENT STEEL CUTTING GRAPGHIC

Length ▲	Material	Quantity	Label	Waste	Graphic: 1D
12	16	3		0	4,5 D1 / 2,7 D3 / 2,4 D8 / 2,4 D8
12	16	2		0	2,4 D8 / 2,4 D8 / 2,4 D8 / 2,4 D8 / 2,4 D8
12	16	1		0,5	3,4 D2 / 2,7 D3 / 2,7 D3 / 2,7 D3 / 0,5
12	16	1		1,8	3,4 D2 / 3,4 D2 / 3,4 D2 / 1,8
12	16	1		8,6	3,4 D2 / 8,6
12	8	3		0	0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4
12	8	1		8	0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 0,8 D4 / 8
12	10	1		2	2,5 D5 / 2,5 D5 / 2,5 D5 / 2,5 D5 / 2

CASE STUDY - OPTIMIZATION FOR REINFORCEMENT STEEL USAGE OF A TWO STOREY (230m2) VILLA

REINFORCEMENT CALCULATIONS

Item	Reinforcement Place	Reinforcement Quantity				Diameters				
		Diameter (Ø)	Number of steel	Similar steel	Length (m)	Ø8	Ø10	Ø12	Ø14	Ø16
D1	Foundation T1 Fe-X	14	22	1	2.50	0.0	0.0	0.0	55.0	0.0
D2	Foundation T1 Fe-Y	14	15	1	2.00	0.0	0.0	0.0	30.0	0.0
D3	Foundation T3 Fe-X	14	15	1	4.30	0.0	0.0	0.0	64.5	0.0
D4	Foundation T3 Fe-Y	14	30	1	2.00	0.0	0.0	0.0	60.0	0.0
D5	Foundation T4	14	14	2	1.90	0.0	0.0	0.0	53.2	0.0
D6	Foundation T15 Fe-X	14	14	1	4.40	0.0	0.0	0.0	61.6	0.0
D7	Foundation T15 Fe-Y	14	25	1	2.00	0.0	0.0	0.0	50.0	0.0
D8	Foundation T6 Fe-X	14	15	1	2.10	0.0	0.0	0.0	31.5	0.0
D9	Foundation T6 Fe-Y	14	15	1	2.60	0.0	0.0	0.0	39.0	0.0
D10	Foundation T7 Fe-X	14	15	1	2.80	0.0	0.0	0.0	42.0	0.0
D11	Foundation T7 Fe-Y	14	16	1	2.70	0.0	0.0	0.0	43.2	0.0
D12	Foundation T8 Fe-X	14	15	1	1.60	0.0	0.0	0.0	24.0	0.0

D13	Foundation T8 Fe-Y	14	14	1	2.19	0.0	0.0	0.0	30.7	0.0
D14	**Foundation T9 Fe-X**	**14**	**14**	**1**	**1.90**	**0.0**	**0.0**	**0.0**	**26.6**	**0.0**
D15	**Foundation T9 Fe-Y**	**14**	**18**	**1**	**2.80**	**0.0**	**0.0**	**0.0**	**50.4**	**0.0**
D16	**Foundation T10 Fe-X**	**14**	**18**	**1**	**2.50**	**0.0**	**0.0**	**0.0**	**45.0**	**0.0**
D17	**Foundation T10 Fe-Y**	**14**	**14**	**1**	**3.40**	**0.0**	**0.0**	**0.0**	**47.6**	**0.0**
D18	**Foundation T11**	**14**	**14**	**2**	**2.00**	**0.0**	**0.0**	**0.0**	**56.0**	**0.0**
D19	**Foundation T12 Fe- X**	**14**	**14**	**2**	**1.90**	**0.0**	**0.0**	**0.0**	**53.2**	**0.0**
D20	**Foundation T12 Fe- Y**	**14**	**15**	**1**	**2.90**	**0.0**	**0.0**	**0.0**	**43.5**	**0.0**
D21	**Foundation T14 Fe- X**	**14**	**16**	**1**	**2.20**	**0.0**	**0.0**	**0.0**	**35.2**	**0.0**
D22	**Foundation T14 Fe- Y**	**14**	**16**	**1**	**2.70**	**0.0**	**0.0**	**0.0**	**43.2**	**0.0**
D23	**Foundation T16 Fe- X**	**14**	**17**	**1**	**2.10**	**0.0**	**0.0**	**0.0**	**35.7**	**0.0**
D24	**Foundation T16 Fe- Y**	**14**	**15**	**1**	**3.10**	**0.0**	**0.0**	**0.0**	**46.5**	**0.0**
D25	**Beam K101 Top Bars**	**12**	**28**	**1**	**5.95**	**0.0**	**0.0**	**166.6**	**0.0**	**0.0**
D26	**Beam K101 Bottom Bars**	**14**	**18**	**1**	**5.95**	**0.0**	**0.0**	**0.0**	**107.1**	**0.0**
D27	**Beam K101 Bent Up Bars**	**16**	**16**	**1**	**6.41**	**0.0**	**0.0**	**0.0**	**0.0**	**102.6**
D28	**Beam K101 Stir Ups**	**8**	**85**	**1**	**1.70**	**144.5**	**0.0**	**0.0**	**0.0**	**0.0**

CASE STUDY - GRAPHICS PRODUCED BY PRO CUTTING PROGRAM

Length	Material	Quantity	Label	Waste	Graphic: 1D
12	14	9		0.1	5.95 D26 | 5.95 D26
12	14	73		0.06	3.98 D90 | 3.98 D90 | 3.98 D90
12	14	1		0.06	3.98 D90 | 3.98 D91 | 3.98 D91
12	14	26		0.06	3.98 D91 | 3.98 D91 | 3.98 D91
12	14	2		0	2 D2 | 2 D2 | 2 D2 | 2 D2 | 2 D2 | 2 D2
12	14	1		0	2 D2 | 2 D2 | 2 D2 | 2 D4 | 2 D4 | 2 D4
12	14	4		0	2 D4 | 2 D4 | 2 D4 | 2 D4 | 2 D4 | 2 D4
12	14	1		0	2 D4 | 2 D4 | 2 D4 | 2 D7 | 2 D7 | 2 D7
12	14	3		0	2 D7 | 2 D7 | 2 D7 | 2 D7 | 2 D7 | 2 D7
12	14	1		0	2 D7 | 2 D7 | 2 D7 | 2 D7 | 2 D18 | 2 D18
12	14	1		0	2 D18 | 2 D18 | 2 D18 | 2 D18 | 2 D18 | 2 D18
12	14	14		0	5.1 D113 | 3.5 D101 | 3.4 D17
12	14	15		0	5.1 D113 | 4.3 D3 | 2.6 D9
12	14	1		0	3.5 D101 | 2.7 D11 | 2.1 D8 | 2.1 D8 | 1.6 D12
12	14	6		0	5.1 D113 | 2.7 D11 | 2.1 D8 | 2.1 D8
12	14	1		0	5.1 D113 | 2.7 D11 | 2.1 D8 | 2.1 D23
12	14	2		0.01	[illegible]

CASE STUDY - OPTIMIZATION FOR REINFORCEMENT STEEL USAGE OF A TWO STOREY VILLA HOUSE

Reinforcement Diameter (mm)	Kg/m	Purchased (Kg)	Actually used on the site	Actually remained Kg on the site	Required by Pro Optimization (Kg)
8	0.395	4,000	2,986	1,014	2,531
10	0.617	4,000	3,585	415	3,510
12	0.88	2,800	2,789	11	148
14	1.208	4,000	4,000	0	3,870
16	1.578	1,500	1,462	38	1,212
TOTAL		**16,300**	**14,823**	**1,477**	**11,271**

CASE STUDY - OPTIMIZATION FOR REINFORCEMENT STEEL USAGE OF A TWO STOREY VILLA HOUSE

- Required exact reinforcement by design program (prostructure) = 10,445kg
- Actual used on the site = 14,823kg
- Wasteage based on design program = 14,823 – 10,445 = 4,378kg
- Pro optimization program usage weight = 11,271kg
- Wastage of pro optization = 11,271-10,445 = 826kg (unavoidable)
- Saving of pro optimization program = 14,823 - 11,271 = 3,552kg
- % Saving of pro optimization program = 3,552 / 14,823 = **24%**

ECONOMIC ADVANTAGES

- In the Case Study, the wastage is %24
- This ratio may change an amount depending on the selected reinforcement steel diameters
- How much ????
- Steel fixers, rather than cutting and generating many small pieces of reinforcment, prefer fixing unnecessarily longer bars in.
- Therefore, the ecomonical impact of that amount of steel is not only purchasing, but includes workmanship price as well.

YEARLY IMPORTED REINFORCEMENT IN TRNC
(Statistics - Economy and Energy Ministry)

Year	Tons	($-USA)
2016	95,199	39,696,158
2017	115,471	55,890,520
2018	113,935	63,172,996
2019	85,910	41,358,655
2020	67,244	30,667,497

CONCLUSIONS

- TRNC uses roughly 100,000 tons of reinforcement in a year
- Applying optimization for reinforcement cutting will save roughly 24,000t/year
- Including the steel fixers wages, this makes more than $28,000,000 / year
- Therefore:
- Reinforcement cutting optimization should be obligatory in TRNC
- Strucural design sofwares can also do reinforcement optimization
  - ✓ During selecting the best reinforcement diameter for elements
  - ✓ After selecting reinforcement diameter, making an optimization and produce a reinforcement graphic for cutting bars
- This could be maintained by Chamber of Civil Engineers through Visa Operation of the projects.

THANKS FOR YOUR ATTENTION

QUESTIONS ?????