References:

[1] Gabor JAKAB. "Analysis and Design of Cold-Formed C –Section Members and Structures," PhD Dissertation, Budapest University of Technology and Economics, Budapest, 2009.

[2] http://www.toolbase.org/Construction-Methods/Steel-Framing/designing-homes-cold-formed-steel.

[3] Design of Buildings For High Winds Sri Lanka, Ministry of Local Government, Housing and Construction, July 1980.

[4] Structural use of steelwork in building-Part 5. Code of practice for design of cold formed thin gauge sections, BS 5950-5, 1998.

[5] Australia/New Zealand Standard Cold-formed steel structures, AS/NZS 4600, Sydney, Australia, 2005.

[6] Jeyaragan, S and Mahendran, M. "Lateral Distortional Buckling Design Rules for Back to Back LiteSteel Beams," Proceedings for the 3rd Smart Systems Postgraduate Student Conference, Queensland University of Technology, Brisbane, Australia. 2009.

[7] Keerthan, P and Mahendran, M. "Ultimate Shear Strength of LiteSteel Beams," Proceedings for the 3rd Smart Systems Postgraduate Student Conference, Queensland University of Technology, Brisbane, Australia. 2009.

[8] Keerthan, P and Mahendran, M. "Experimental Studies of the Shear Behaviour of LiteSteel Beams," 9th International Conference on Steel Concrete and Hybrid Structures, Leeds, UK, 8-10 July 2009.

[9] Jeyaragan, S and Mahendiran, M. "Strength of Improvement Methods for Back to Back LiteSteel Beams," 4th International Conference on Steel & Composite Structures, Sydney, Australia, July 2010.

[10] Hazlan, A.H, Tahir M.Md. and Sulaiman, "A. Bolted beam-column Moment Connections between Cold-formed steel Members," 21st Australasian Conference on the Mechanics of Structures and Materials (ACMSM 21), Victoria University, Melbourne, Australia, 2010.

[11] Yu, W.K., Chung, K.F. and Wong, M.F. "Analysis of Bolted Moment Connections in Cold-formed Steel Beam–column sub-frames," Journal of Constructional Steel Research 61 (2005) 1332-1352. Available: www.sciencedirect.com/science/article/pii/S0143974X05000568

[12] Chung, K.F., Lau, L. "Experimental investigation on bolted moment connections among cold formed steel members," Engineering Structures 21 (1999)898-911.Available: http://www.sciencedirect.com/science/article/pii/S0141029698000431

[13] Wilkinson Tim and Hancock Gregory J. "Tests of Portal Frames in Cold-Formed RHS," 8th International Symposium on Tubular Structures, Singapore, August 1998, (Balkema, publ.), (Choo, Van der Vegte editors), pp 521-529.

[14] Code of Basic data for the design of buildings CP3 : Chapter V : Part 2 : September 1972.

[15] The Steel Construction Institute, "Case Studies on Light Steel Framing," SCI Publication 176, ISBN: 85942 045.

[16] Department of Civil Engineering, University of Moratuwa. "Short course on Structural Analysis and Design of Large Structures (Part E)," December 2005.

[17] Steel framing Alliance 25, Massachusetts Avenue, N.W. Suite 800, Washington, D.C. 20001-7400, (2012, February 10). [Online]. Available: http://www.steelframing.org

[18] The British Constructional Steelwork Association Ltd, (2012, February 10). [Online]. Available: http://www.steelconstruction.org

[19] Lite Steel Technologies, Onesteel Australian Tube Mill (ATM), Queensland, (2012, February 10). [Online]. Available: http://www.onesteel.com

[20] The Hong Kong Institute of Steel Construction, (2012, August 10). [Online]. Available: http://www.hkisc.org

[21] Queensland University of Technology, (2012, August 10). [Online]. Available: http://www.eprints.qut.edu.au

Annex A

A. Costing of CFS structural skeleton

A.1.1

Span=	6m	
Height=	3m	
Bay Distance=	4m	
Column:	C10023	8.05 kg/m
Rafter:	C10016	5.67 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.443	200,000.00	88,590.39
2	MS Plates	MT	0.05	150,000.00	7,973.14
3	Bolts & Nuts	MT	0.01	285,000.00	3,156.03
4	Roof Purlins	Lmtrs	72.00	700.00	50,400.00
5	Bracing	Lmtrs	81.60	450.00	36,720.00
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	0.76	35,000.00	26,621.70
3	Erection	sqft	774.72	40.00	30,988.80
4	Transport	MT	0.76	5,000.00	3,803.10
	TOTAL				**267,621.16**
	Sqft Rate				345.44

A.1.2

Span=	9m	
Height=	3m	
Bay Distance=	4m	
Column:	C15020	9.73 kg/m
Rafter:	C10020	7.04 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.699	200,000.00	139,733.30
2	MS Plates	MT	0.08	150,000.00	12,576.00
3	Bolts & Nuts	MT	0.02	285,000.00	4,978.00
4	Roof Purlins	Lmtrs	96.00	700.00	67,200.00
5	Bracing	Lmtrs	89.77	450.00	40,394.87
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	1.14	35,000.00	39,826.26
3	Erection	sqft	1,162.08	40.00	46,483.20
4	Transport	MT	1.14	5,000.00	5,689.47
	TOTAL				**385,933.09**
	Sqft Rate				332.11

A.1.3

Span=	12m	
Height=	3m	
Bay Distance=	4m	
Column:	C20018	11.03 kg/m
Rafter:	C15016	7.83 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.955	200,000.00	190,902.22
2	MS Plates	MT	0.11	150,000.00	17,181.20
3	Bolts & Nuts	MT	0.02	285,000.00	6,800.89
4	Roof Purlins	Lmtrs	120.00	700.00	84,000.00
5	Bracing	Lmtrs	99.29	450.00	44,679.97
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	1.52	35,000.00	53,036.03
3	Erection	sqft	1,549.44	40.00	61,977.60
4	Transport	MT	1.52	5,000.00	7,576.58
	TOTAL				**504,890.50**
	Sqft Rate				325.85

A.1.4

Span=	15m	
Height=	3m	
Bay Distance=	4m	
Column:	C25023	15.86 kg/m
Rafter:	C15020	9.73 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	1.452	200,000.00	290,421.35
2	MS Plates	MT	0.17	150,000.00	26,137.92
3	Bolts & Nuts	MT	0.04	285,000.00	10,346.26
4	Roof Purlins	Lmtrs	144.00	700.00	100,800.00
5	Bracing	Lmtrs	109.60	450.00	49,320.00
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	2.17	35,000.00	75,933.98
3	Erection	sqft	1,936.80	40.00	77,472.00
4	Transport	MT	2.17	5,000.00	10,847.71
	TOTAL				**689,699.22**
	Sqft Rate				356.10

A.2.1

Span=	6m	
Height=	6m	
Bay Distance=	4m	
Column:	C20016	9.82 kg/m
Rafter:	C10018	6.36 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.752	200,000.00	150,301.01
2	MS Plates	MT	0.09	150,000.00	13,527.09
3	Bolts & Nuts	MT	0.02	285,000.00	5,354.47
4	Roof Purlins	Lmtrs	72.00	700.00	50,400.00
5	Bracing	Lmtrs	99.29	450.00	44,679.97
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	1.11	35,000.00	38,986.97
3	Erection	sqft	774.72	40.00	30,988.80
4	Transport	MT	1.11	5,000.00	5,569.57
	TOTAL				**359,175.88**
	Sqft Rate				463.62

A.2.2

Span=	9m	
Height=	6m	
Bay Distance=	4m	
Column:	C20023	14.02 kg/m
Rafter:	C12520	7.91 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	1.196	200,000.00	239,117.82
2	MS Plates	MT	0.14	150,000.00	21,520.60
3	Bolts & Nuts	MT	0.03	285,000.00	8,518.57
4	Roof Purlins	Lmtrs	96.00	700.00	67,200.00
5	Bracing	Lmtrs	107.46	450.00	48,354.84
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	1.71	35,000.00	59,740.43
3	Erection	sqft	1,162.08	40.00	46,483.20
4	Transport	MT	1.71	5,000.00	8,534.35
	TOTAL				**528,521.82**
	Sqft Rate				454.81

A.2.3

Span=	12m	
Height=	6m	
Bay Distance=	4m	
Column:	C25018	12.47 kg/m
Rafter:	C15020	9.73 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	1.456	200,000.00	291,146.68
2	MS Plates	MT	0.17	150,000.00	26,203.20
3	Bolts & Nuts	MT	0.04	285,000.00	10,372.10
4	Roof Purlins	Lmtrs	120.00	700.00	84,000.00
5	Bracing	Lmtrs	116.98	450.00	52,639.94
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	2.09	35,000.00	73,122.52
3	Erection	sqft	1,549.44	40.00	61,977.60
4	Transport	MT	2.09	5,000.00	10,446.07
	TOTAL				**648,644.11**
	Sqft Rate				418.63

A.2.4

Span=	15m	
Height=	6m	
Bay Distance=	4m	
Column:	C25023	15.86 kg/m
Rafter:	C20020	12.23 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	2.108	200,000.00	421,609.30
2	MS Plates	MT	0.25	150,000.00	37,944.84
3	Bolts & Nuts	MT	0.05	285,000.00	15,019.83
4	Roof Purlins	Lmtrs	144.00	700.00	100,800.00
5	Bracing	Lmtrs	127.29	450.00	57,279.97
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	2.92	35,000.00	102,220.76
3	Erection	sqft	1,936.80	40.00	77,472.00
4	Transport	MT	2.92	5,000.00	14,602.97
	TOTAL				**875,369.67**
	Sqft Rate				451.97

A.3.1

Span=	6m	
Height=	3m	
Bay Distance=	6m	
Column:	C15016	7.83 kg/m
Rafter:	C10018	6.36 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.351	200,000.00	70,209.76
2	MS Plates	MT	0.04	150,000.00	6,318.88
3	Bolts & Nuts	MT	0.01	285,000.00	2,501.22
4	Roof Purlins	Lmtrs	72.00	900.00	64,800.00
5	Bracing	Lmtrs	108.93	450.00	49,019.07
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	0.75	35,000.00	26,340.68
3	Erection	sqft	774.72	40.00	30,988.80
4	Transport	MT	0.75	5,000.00	3,762.95
	TOTAL				**273,309.36**
	Sqft Rate				352.78

A.3.2

Span=	9m	
Height=	3m	
Bay Distance=	6m	
Column:	C20016	9.82 kg/m
Rafter:	C15016	7.83 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.565	200,000.00	112,953.50
2	MS Plates	MT	0.07	150,000.00	10,165.82
3	Bolts & Nuts	MT	0.01	285,000.00	4,023.97
4	Roof Purlins	Lmtrs	96.00	900.00	86,400.00
5	Bracing	Lmtrs	115.27	450.00	51,869.53
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	1.11	35,000.00	38,996.26
3	Erection	sqft	1,162.08	40.00	46,483.20
4	Transport	MT	1.11	5,000.00	5,570.89
	TOTAL				**385,515.17**
	Sqft Rate				331.75

A.3.3

Span=	12m	
Height=	3m	
Bay Distance=	6m	
Column:	C25020	13.83 kg/m
Rafter:	C15023	11.15 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.986	200,000.00	197,128.44
2	MS Plates	MT	0.12	150,000.00	17,741.56
3	Bolts & Nuts	MT	0.02	285,000.00	7,022.70
4	Roof Purlins	Lmtrs	120.00	900.00	108,000.00
5	Bracing	Lmtrs	123.15	450.00	55,416.55
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	1.71	35,000.00	59,953.61
3	Erection	sqft	1,549.44	40.00	61,977.60
4	Transport	MT	1.71	5,000.00	8,564.80
	TOTAL				**554,541.26**
	Sqft Rate				357.90

A.3.4

Span=	15m	
Height=	3m	
Bay Distance=	6m	
Column:	C25023	15.86 kg/m
Rafter:	C20023	14.02 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	1.443	200,000.00	288,678.17
2	MS Plates	MT	0.17	150,000.00	25,981.04
3	Bolts & Nuts	MT	0.04	285,000.00	10,284.16
4	Roof Purlins	Lmtrs	144.00	900.00	129,600.00
5	Bracing	Lmtrs	132.10	450.00	59,446.41
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	2.35	35,000.00	82,388.69
3	Erection	sqft	1,936.80	40.00	77,472.00
4	Transport	MT	2.35	5,000.00	11,769.81
	TOTAL				**7343,040.28**
	Sqft Rate				379.00

A.4.1

Span=	6m	
Height=	6m	
Bay Distance=	6m	
Column:	C20023	14.02 kg/m
Rafter:	C15016	7.83 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	0.763	200,000.00	152,678.33
2	MS Plates	MT	0.09	150,000.00	13,741.05
3	Bolts & Nuts	MT	0.02	285,000.00	5,439.17
4	Roof Purlins	Lmtrs	72.00	900.00	64,800.00
5	Bracing	Lmtrs	123.15	450.00	55,416.55
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	1.22	35,000.00	42,865.32
3	Erection	sqft	774.72	40.00	30,988.80
4	Transport	MT	1.22	5,000.00	6,123.62
	TOTAL				**391,420.84**
	Sqft Rate				505.24

A.4.2

Span=	9m	
Height=	6m	
Bay Distance=	6m	
Column:	C25018	12.47 kg/m
Rafter:	C15023	11.15 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	1.001	200,000.00	200,289.33
2	MS Plates	MT	0.12	150,000.00	18,026.04
3	Bolts & Nuts	MT	0.03	285,000.00	7,135.31
4	Roof Purlins	Lmtrs	96.00	900.00	86,400.00
5	Bracing	Lmtrs	129.48	450.00	58,267.01
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	1.61	35,000.00	56,496.17
3	Erection	sqft	1,162.08	40.00	46,483.20
4	Transport	MT	1.61	5,000.00	8,070.88
	TOTAL				**510,219.95**
	Sqft Rate				439.06

A.4.3

Span=	12m	
Height=	6m	
Bay Distance=	6m	
Column:	C25023	15.86 kg/m
Rafter:	C20020	12.23 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	1.379	200,000.00	275,803.98
2	MS Plates	MT	0.17	150,000.00	24,822.36
3	Bolts & Nuts	MT	0.03	285,000.00	9,825.52
4	Roof Purlins	Lmtrs	120.00	900.00	108,000.00
5	Bracing	Lmtrs	137.36	450.00	61,814.03
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	2.16	35,000.00	75,718.22
3	Erection	sqft	1,549.44	40.00	61,977.60
4	Transport	MT	2.16	5,000.00	10,816.89
	TOTAL				**667,514.59**
	Sqft Rate				430.81

A.4.4

Span=	15m	
Height=	6m	
Bay Distance=	6m	
Column:	C25023	15.86 kg/m
Rafter:	C25023	15.86 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	B2B Lipped Channel Portal	MT	1.881	200,000.00	376,167.27
2	MS Plates	MT	0.23	150,000.00	33,855.05
3	Bolts & Nuts	MT	0.05	285,000.00	13,400.96
4	Roof Purlins	Lmtrs	144.00	900.00	129,600.00
5	Bracing	Lmtrs	146.32	450.00	65,843.88
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	2.85	35,000.00	99,919.32
3	Erection	sqft	1,936.80	40.00	77,472.00
4	Transport	MT	2.85	5,000.00	14,274.19
	TOTAL				**858,952.67**
	Sqft Rate				443.49

Annex B

B. Costing of HRS structural skeleton

B.1.1

Span=	6m	
Height=	3m	
Bay Distance=	4m	
Column:	100x50x	9.3 kg/m
Rafter:	100x50x	9.3 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	0.524	175,000.00	91,746.67
2	MS Plates	Ton	0.06	150,000.00	9,436.80
3	Bolts & Nuts	Ton	0.01	285,000.00	3,735.40
4	Roof Purlins	Lmtrs	72.00	700.00	50,400.00
5	Bracing	Lmtrs	81.60	450.00	36,720.00
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	0.85	35,000.00	29,880.39
3	Erection	sqft	774.72	55.00	42,609.60
4	Transport	MT	0.85	5,000.00	4,268.63
	TOTAL				**288,165.48**
	Sqft Rate				371.96

B.1.2

Span=	9m	
Height=	3m	
Bay Distance=	4m	
Column:	150x75x	14 kg/m
Rafter:	100x50x	9.3 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	0.788	175,000.00	137,851.00
2	MS Plates	Ton	0.09	150,000.00	14,178.96
3	Bolts & Nuts	Ton	0.02	285,000.00	5,612.51
4	Roof Purlins	Lmtrs	96.00	700.00	67,200.00
5	Bracing	Lmtrs	89.77	450.00	40,394.87
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	1.24	35,000.00	43,395.08
3	Erection	sqft	1,162.08	55.00	63,914.40
4	Transport	MT	1.24	5,000.00	6,199.30
	TOTAL				**407,798.12**
	Sqft Rate				350.92

B.1.3

Span=	12m	
Height=	3m	
Bay Distance=	4m	
Column:	200x100x	18.3 kg/m
Rafter:	150x75x	14 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.322	175,000.00	231,412.53
2	MS Plates	Ton	0.16	150,000.00	23,802.43
3	Bolts & Nuts	Ton	0.03	285,000.00	9,421.80
4	Roof Purlins	Lmtrs	120.00	700.00	84,000.00
5	Bracing	Lmtrs	99.29	450.00	44,679.97
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	1.94	35,000.00	67,777.47
3	Erection	sqft	1,549.44	55.00	85,219.20
4	Transport	MT	1.94	5,000.00	9,682.50
	TOTAL				**594,731.89**
	Sqft Rate				383.84

B.1.4

Span=	15m	
Height=	3m	
Bay Distance=	4m	
Column:	200x100x	18.3 kg/m
Rafter:	200x100x	18.3 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.854	175,000.00	324,515.42
2	MS Plates	Ton	0.22	150,000.00	33,378.73
3	Bolts & Nuts	Ton	0.05	285,000.00	13,212.41
4	Roof Purlins	Lmtrs	144.00	700.00	100,800.00
5	Bracing	Lmtrs	109.60	450.00	49,320.00
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	2.63	35,000.00	92,054.83
3	Erection	sqft	1,936.80	55.00	106,524.00
4	Transport	MT	2.63	5,000.00	13,150.69
	TOTAL				**781,376.08**
	Sqft Rate				403.44

B.2.1

Span=	6m	
Height=	6m	
Bay Distance=	4m	
Column:	150x75x	14 kg/m
Rafter:	150x75x	14 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.159	175,000.00	202,793.26
2	MS Plates	Ton	0.14	150,000.00	20,858.74
3	Bolts & Nuts	Ton	0.03	285,000.00	8,256.58
4	Roof Purlins	Lmtrs	72.00	700.00	50,400.00
5	Bracing	Lmtrs	99.29	450.00	44,679.97
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	1.58	35,000.00	55,310.06
3	Erection	sqft	774.72	55.00	42,609.60
4	Transport	MT	1.58	5,000.00	7,901.44
	TOTAL				**452,177.65**
	Sqft Rate				583.67

B.2.2

Span=	9m	
Height=	6m	
Bay Distance=	4m	
Column:	200x100x	18.3 kg/m
Rafter:	150x75x	14 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.596	175,000.00	279,241.90
2	MS Plates	Ton	0.19	150,000.00	28,722.02
3	Bolts & Nuts	Ton	0.04	285,000.00	11,369.13
4	Roof Purlins	Lmtrs	96.00	700.00	67,200.00
5	Bracing	Lmtrs	107.46	450.00	48,354.84
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	2.16	35,000.00	75,773.59
3	Erection	sqft	1,162.08	55.00	63,914.40
4	Transport	MT	2.16	5,000.00	10,824.80
	TOTAL				**614,452.69**
	Sqft Rate				528.75

B.2.3

Span=	12m	
Height=	6m	
Bay Distance=	4m	
Column:	200x100x	21.3 kg/m
Rafter:	200x100x	18.3 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	2.222	175,000.00	388,787.53
2	MS Plates	Ton	0.27	150,000.00	39,989.57
3	Bolts & Nuts	Ton	0.06	285,000.00	15,829.21
4	Roof Purlins	Lmtrs	120.00	700.00	84,000.00
5	Bracing	Lmtrs	116.98	450.00	52,639.94
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	2.97	35,000.00	103,816.35
3	Erection	sqft	1,549.44	55.00	85,219.20
4	Transport	MT	2.97	5,000.00	14,830.91
	TOTAL				**823,848.71**
	Sqft Rate				531.71

B.2.4

Span=	15m	
Height=	6m	
Bay Distance=	4m	
Column:	200x100x	21.3 kg/m
Rafter:	200x100x	21.3 kg/m
Purlin:	C10020	3.52 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	2.721	175,000.00	476,120.67
2	MS Plates	Ton	0.33	150,000.00	48,972.41
3	Bolts & Nuts	Ton	0.07	285,000.00	19,384.91
4	Roof Purlins	Lmtrs	144.00	700.00	100,800.00
5	Bracing	Lmtrs	127.29	450.00	57,279.97
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	3.62	35,000.00	126,772.43
3	Erection	sqft	1,936.80	55.00	106,524.00
4	Transport	MT	3.62	5,000.00	18,110.35
	TOTAL				**1,002,384.74**
	Sqft Rate				517.55

B.3.1

Span=	6m	
Height=	3m	
Bay Distance=	6m	
Column:	150x75x	14 kg/m
Rafter:	150x75x	14 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	0.592	175,000.00	103,584.95
2	MS Plates	Ton	0.07	150,000.00	10,654.45
3	Bolts & Nuts	Ton	0.01	285,000.00	4,217.39
4	Roof Purlins	Lmtrs	72.00	900.00	64,800.00
5	Bracing	Lmtrs	108.93	450.00	49,019.07
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	1.03	35,000.00	35,993.35
3	Erection	sqft	774.72	55.00	42,609.60
4	Transport	MT	1.03	5,000.00	5,141.91
	TOTAL				**335,388.72**
	Sqft Rate				432.92

B.3.2

Span=	9m	
Height=	3m	
Bay Distance=	6m	
Column:	150x75x	14 kg/m
Rafter:	150x75x	14 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	0.749	175,000.00	131,122.42
2	MS Plates	Ton	0.09	150,000.00	13,486.88
3	Bolts & Nuts	Ton	0.02	285,000.00	5,338.56
4	Roof Purlins	Lmtrs	96.00	900.00	86,400.00
5	Bracing	Lmtrs	115.27	450.00	51,869.53
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	1.33	35,000.00	46,390.23
3	Erection	sqft	1,162.08	55.00	63,914.40
4	Transport	MT	1.33	5,000.00	6,627.18
	TOTAL				**434,201.20**
	Sqft Rate				373.64

B.3.3

Span=	12m	
Height=	3m	
Bay Distance=	6m	
Column:	200x100x	18.3 kg/m
Rafter:	200x100x	18.3 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.185	175,000.00	207,391.15
2	MS Plates	Ton	0.14	150,000.00	21,331.66
3	Bolts & Nuts	Ton	0.03	285,000.00	8,443.78
4	Roof Purlins	Lmtrs	120.00	900.00	108,000.00
5	Bracing	Lmtrs	123.15	450.00	55,416.55
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	1.94	35,000.00	67,946.57
3	Erection	sqft	1,549.44	55.00	85,219.20
4	Transport	MT	1.94	5,000.00	9,706.65
	TOTAL				**602,191.57**
	Sqft Rate				388.65

B.3.4

Span=	15m	
Height=	3m	
Bay Distance=	6m	
Column:	200x100x	21.3 kg/m
Rafter:	200x100x	18.3 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.450	175,000.00	253,781.56
2	MS Plates	Ton	0.17	150,000.00	26,103.25
3	Bolts & Nuts	Ton	0.04	285,000.00	10,332.54
4	Roof Purlins	Lmtrs	144.00	900.00	129,600.00
5	Bracing	Lmtrs	132.10	450.00	59,446.41
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	2.36	35,000.00	82,660.78
3	Erection	sqft	1,936.80	55.00	106,524.00
4	Transport	MT	2.36	5,000.00	11,808.68
	TOTAL				**728,677.21**
	Sqft Rate				376.23

B.4.1

Span=	6m	
Height=	6m	
Bay Distance=	6m	
Column:	200x100x	18.3 kg/m
Rafter:	150x75x	14 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	6nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.039	175,000.00	181,893.95
2	MS Plates	Ton	0.12	150,000.00	18,709.09
3	Bolts & Nuts	Ton	0.03	285,000.00	7,405.68
4	Roof Purlins	Lmtrs	72.00	900.00	64,800.00
5	Bracing	Lmtrs	123.15	450.00	55,416.55
	Workmanship				
1	Design, Engineering & Supervision	sqft	774.72	25.00	19,368.00
2	Fabrication	MT	1.54	35,000.00	53,926.11
3	Erection	sqft	774.72	55.00	42,609.60
4	Transport	MT	1.54	5,000.00	7,703.73
	TOTAL				**451,832.71**
	Sqft Rate				583.22

B.4.2

Span=	9m	
Height=	6m	
Bay Distance=	6m	
Column:	200x100x	21.3 kg/m
Rafter:	150x75x	14 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	8nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.316	175,000.00	230,221.42
2	MS Plates	Ton	0.16	150,000.00	23,679.92
3	Bolts & Nuts	Ton	0.03	285,000.00	9,373.30
4	Roof Purlins	Lmtrs	96.00	900.00	86,400.00
5	Bracing	Lmtrs	129.48	450.00	58,267.01
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,162.08	25.00	29,052.00
2	Fabrication	MT	1.97	35,000.00	69,083.91
3	Erection	sqft	1,162.08	55.00	63,914.40
4	Transport	MT	1.97	5,000.00	9,869.13
	TOTAL				**579,861.09**
	Sqft Rate				498.99

B.4.3

Span=	12m	
Height=	6m	
Bay Distance=	6m	
Column:	200x100x	21.3 kg/m
Rafter:	200x100x	18.3 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	10nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	1.666	175,000.00	291,590.65
2	MS Plates	Ton	0.20	150,000.00	29,992.18
3	Bolts & Nuts	Ton	0.04	285,000.00	11,871.91
4	Roof Purlins	Lmtrs	120.00	900.00	108,000.00
5	Bracing	Lmtrs	137.36	450.00	61,814.03
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,549.44	25.00	38,736.00
2	Fabrication	MT	2.49	35,000.00	87,228.26
3	Erection	sqft	1,549.44	55.00	85,219.20
4	Transport	MT	2.49	5,000.00	12,461.18
	TOTAL				**726,913.40**
	Sqft Rate				469.15

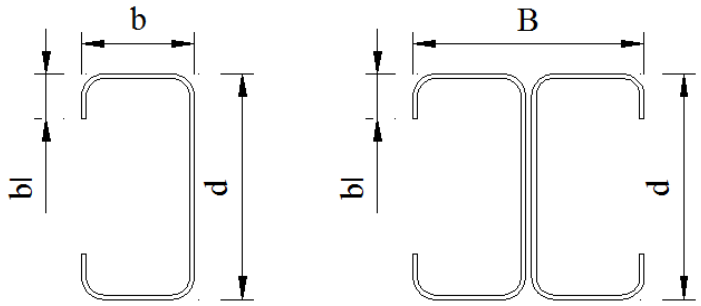
B.4.4

Span=	15m	
Height=	6m	
Bay Distance=	6m	
Column:	250x125x	25.7 kg/m
Rafter:	200x100x	21.3 kg/m
Purlin:	C15020	4.87 kg/m
Purlin Lines:	12nos.	

No	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Main Structure				
1	I Beams	Ton	2.215	175,000.00	387,582.50
2	MS Plates	Ton	0.27	150,000.00	39,865.63
3	Bolts & Nuts	Ton	0.06	285,000.00	15,780.14
4	Roof Purlins	Lmtrs	144.00	900.00	129,600.00
5	Bracing	Lmtrs	146.32	450.00	65,843.88
	Workmanship				
1	Design, Engineering & Supervision	sqft	1,936.80	25.00	48,420.00
2	Fabrication	MT	3.24	35,000.00	113,301.19
3	Erection	sqft	1,936.80	55.00	106,524.00
4	Transport	MT	3.24	5,000.00	16,185.88
	TOTAL				**923,103.23**
	Sqft Rate				476.61

Annex C

C.1. Specimen calculation for section properties and design strength of back to back CFS lipped channel



	d	b	b1	t	B	
Section Size:	200	75	20	1.6	150	mm

Yield Strength Ys: 450 N/mm^2

Tensile Strength Us: 510 N/mm^2

Eff. Length of Member / Distance between: 3000 mm

Single Section Properties:

I_x =	3848234	mm^4	Z_x =	38482.34	mm^3
I_y =	423579	mm^4	Z_y =	11295.4	mm^3
A =	613.76	mm^2	$\underline{x}$ =	74.2	mm
r_x =	79.18	mm	Z_c =	22784	mm^3
r_{cy} =	26.27	mm	($Z_c = 0.5*A\underline{x}$)		

Shear Centre, e = 35.69 mm

$$e = \frac{d^2 b b_1 t}{I_{xx}} \left(\frac{1}{2} + \frac{b}{4b_1} - \frac{2{b_1}^2}{3d^2} \right)$$

Compound Section Properties:

I_{xx} =	7696469	mm^4	Z_{xx} =	76964.69	mm^3
I_{yy} =	1548907	mm^4	Z_{yy} =	20652.1	mm^3
A =	1227.52	mm^2	Z_c =	45568	mm^3
r_{xx} =	79.18	mm	(Z_c = 0.5*A$\underline{x}$)		
r_{yy} =	35.52	mm			
s=	1313.52	mm			

$$spacing\ between\ two\ interconnections, S \leq 50\, r_{cy}$$

$L_E / r_y = 98.15$

$$\frac{L_E}{r_y} = \sqrt{\left(\frac{L_E}{r_1}\right)^2 + \left(\frac{s}{r_{cy}}\right)^2}$$

Average Yield Strength, Y_{sac} = 455.01 N/mm^2

$$Y_{sac} = Y_s + \frac{5Nt^2}{A}(U_s - Y_s)$$

N - No. of full 90 bends with radius < 5t

Design Strength, p_y = 428.4 N/mm^2

$$p_y = Y_s \ < 0.84\, U_s$$

Local Buckling Check: b/t < 60 => Local Buckling Satisfied

C.2 Specimen calculation for bending design

Bending Stress, p_o = 355.11N/mm^2

$$p_o = \left\{1.13 - 0.0019\ \frac{D_w}{t}\left(\frac{Y_s}{280}\right)^{1/2}\right\} p_y$$

Moment Capacity, M_c = 27.33kNm

Shear Capacity, P_v = 64.00 kN

Elastic Lateral Buckling Resistance,

M_E = 25.81 kNm

$$M_E = \frac{\pi^2}{2(L_E/r_y)^2} AED\ C_b \left\{1 + \frac{1}{20}\left(\frac{L_E}{r_y}\frac{t}{D}\right)^2\right\}^{1/2}$$

conservatively $\left\{1 + \frac{1}{20}\left(\frac{L_E}{r_y}\frac{t}{D}\right)^2\right\}^{1/2} = 1,\ \ C_b = 1$

Yield Moment capacity, M_y = 19.52 kNm

$$M_y = p_y Z_c$$

Perry coefficient, $\cap$ = 0.12

$$\frac{L_E}{r_y} < 40C_b \Rightarrow \cap = 0$$

$$\frac{L_E}{r_y} > 40C_b \Rightarrow \cap = 0.002\left(\frac{L_E}{r_y} - 40\ C_b\right)$$

$\emptyset_B$ = 24.17 kNm

$$\emptyset_B = \frac{M_y + (1 + \cap)M_E}{2}$$

Lateral Buckling Resistance Moment,

M_b = 15.21 kNm

$$M_b = \frac{M_E M_Y}{\emptyset_B + \sqrt{\emptyset_B^2 - M_E M_Y}} \leq M_c$$

C.3. Specimen calculation for compression design

Local Buckling stress, p_{cr} = 337.36 N/mm^2

$$p_{cr} = 0.904\, EK \left(\frac{t}{b}\right)^2$$

K=4, For stiffened elements

Effective cross sectional area,

A_{eff} = 855.01mm^2

$$A_{eff} = \left[1 + 14\left\{\left(\frac{p_y}{p_{cr}}\right)^{1/2} - 0.35\right\}^4\right]^{-0.2} A$$

Short strut capacity, Pcs = 366.29 kN

$$p_{cs} = A_{eff}\, p_y$$

Elastic flexural buckling, P_E = 348.22 kN

$$p_E = \frac{\pi^2 EI}{L_E^2}$$

Perry coefficient, $\cap$ = 0.16

$$\frac{L_E}{r_y} > 20 \;\Rightarrow\; \cap = 0.002\left(\frac{L_E}{r_y} - 20\right)$$

$$\frac{L_E}{r_y} < 20 \Rightarrow \cap = 0$$

$\emptyset$ = 384.46 kN

$$\emptyset = \frac{p_{cs} + (1 + \cap) p_E}{2}$$

Buckling resistance, p_c = 242.11 kN

$$p_c = \frac{p_E \, p_{cs}}{\emptyset + \sqrt{\emptyset^2 - p_E \, p_{cs}}}$$

β = 1

$$\beta = 1 - \left(\frac{x_0}{r_o}\right)^2 , x_o = 0$$

Elastic flexural buckling,

p_{EX} = 348.22 kN

$$P_{Ex} = \frac{\pi^2 \, EI_x}{L_E^2}$$

Warping constant, C_w = 3,308,940,000.00

$$C_w = \frac{b^3 d^2 t}{24}\left[1 + 6\frac{b_L}{b}\left\{1 + 2\frac{b_L}{d} + \frac{4}{3}\left(\frac{b_L}{d}\right)^2\right\}\right]$$

Polar radius of gyration, r_0 = 86.79 mm

$$r_o = \left(r_x^2 + r_y^2 + x_0^2\right)^{1/2}$$

Torsional buckling, P_T = 198.61 kN

$$P_T = \frac{1}{r_o^2}\left(GJ + 2\frac{\pi^2 EC_w}{L_E^2}\right)$$

$$St\ Venant\ torsion\ constant, \qquad J = \frac{bt^3}{3}$$

Torsional flexural buckling,

P_{TF} = 198.61 kN

$$P_{TF} = \frac{1}{2\beta}\left[(P_{Ex} + P_T) - \{(P_{Ex} + P_T)^2 - 4\beta P_{Ex} P_T\}^{\frac{1}{2}}\right]$$