REFERENCES

Brode H. L. (1955). *Numerical solution of spherical blast waves*, Journal of Applied Physics, American Institute of Physics, Vol. 26, Issue 6, pp. 766-775

Bajić Z, Dimitrijević R and Sirovatka R.(2007) *The dependence of shockwave parameters on scaled distance for plastic explosive PPE-01*. Proc. of 2nd symposium TEH, Belgrade, Serbia

Chandra N.,Ganpule S., Kleinschmit N. N., Feng R., Holmberg A. D., Sundaramurthy A., Selvan R. and Alai (2012). *Evolution of Blast Wave Profiles in Simulated Air Blasts: Experiment and Computational Modelling*. Shock Waves 22:403-415

Cranz C (1926), *Textbook of ballistics: Internal Ballistics*, Springer, Berlin, pp. x + 454. 37

Dewey M. *The Shape of the Blast Wave: Studies of the Friedlander Equation*. Retrieved from http://www.blastanalysis.com

Draganic H. and Sigmund V. (2012). *Blast Loading on Structures*. Technical Journal 19, 3, pp. 643-652

Federal Emergency Management Agency (FEMA 356).(2000). *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*. Prepaired by American Society of Civil Engineering for the Federal Emergency Management Agency, Washington, D.C.

Elvira, Mendis P., Lam N. and Ngo T. (2012). *Progressive Collapse Analysis of RC Frame Subjected to Blast Loading*. Australian Journal of Structural Engineering, Vol 7, Issue 01, pp. 47-55

Held M. (1983). Blast waves in free air. *Propellant. Explosieve, Pyrotechnices*, 8(1), pp.1-8.

Henrych J. (1979). *The dynamics of explosion and its use*. Development in civil engineering, Elsevier Science Publishers, Amsterdam, The Netherlands, pp. 558

Hopkinson, B. (1915), *British Ordnance Board Minutes*, 13565, 1915

Indian Standard.(2013). IS 4991: *Criteria for Blast Resistant Design of Structures for Explosions above Ground*. New Delhi, Bureau of Indian Standards

Kent D.C. and Park R. (1971). *Flexural Members with Confined Concrete*, Journal of the Structural Division, ASCE, Vol. 97, ST7, pp. 51-93

Kinney G. F., Graham K.J. (1985). *Explosive Shocks in Air*, 2nd ed., Springer, Berlin, pp. 269

Lam N., Mendis P. and Ngo T. (2004). *Response Spectrum Solution for Blast Loading*. Electronic Journal of Structural Engineering, 4(2004) pp. 28-44

Lumantarna R., Ngo T. and Mendis P. (2012). *Limitations in Simplified Approach in Assessing Performance of Façade under Blast Pressure*. Civil Engineering Dimension, Vol. 14, No. 3, (Special Edition), pp.147-155

Mander J. B., Priestley M. J. N. and Park R. (1988). *Theoretical Stress-Strain Model for Confined Concrete.* Journal of Structural Engineering, Vol. 114, No. 8, pp 1804-1826

Manmohan D.G, Vasant A. M., Anil K. G. and Steffen M. (2012) *An Abridged Review of Blast Wave Parameter.* Defence Science Journal, Vol. 62, No. 5, pp. 300-306

Mays G. C. and Smith P. D. (1995). *Blast Effects on Buildings*. London, Thomas Telford Publications

Mohammed S. and Al- Ansari. (2012). *Building Response to Blast and Earthquake Loading*. International Journal of Civil Engineering and Technology, Volume 3, Issue 2, pp. 327-346

Newmark N.M., Hansen R.J. (1961). *Design of blast resistant structures*, Shock and Vibration Handbook, Vol.3, New York, McGraw-Hill

Ngo T., Mendis P., Guptha A and Ramsay J. (2007). *Blast Loading and Blast Effects on Structures-An Overview*. EJSE Special Issue: Loading on Structures, pp 76-91

Ngo T. and Mendis P. (2008). Modeling *Reinforced Concrete Structure Subjected to Impulsive Loading Using Concrete Lattice Model*. Electronic Journal of Structural Engineering, (2008) 8, pp. 80-89

Nguyen T. P. and Tran M. T. (2011). *Response of Vertical Wall Structure under Blast Loading by Dynamic Analysis*. The Twelfth East Asia-Pacific Conference on Structural Engineering and Construction, Procardia Engineering, 14 (2011), pp. 3308-3316

Mills C. A. (1987). *The design of concrete structures to resist explosions and weapon effects*. Proceedings of the 1st Int. Conference on concrete for hazard protections, Edinburgh, UK, pp. 61-73

Oswald, C. J., and Bazan, M. (2014) *Performance and Blast Design for Non-Load Bearing Precast Concrete Panels*. SEI Structures Congress, Boston, MA

Remennikov A.(2003). *A Review of Method for Predicting Bomb Blast Eeffects on Buildings*. Journal of Battlefield Technology, 6(3) pp. 5-10

Rueda J. E. M. and Elnashai A. S. (1997). *Confined Concrete Model under Cyclic Load*. Materials and Structures, Vol. 30(197), pp. 139-147

Sadovskiy M.A. (2004). *Mechanical effects of air shockwaves from explosions according to experiments*. Symposium No 4, Nauka Press, Moscow

Tiwari A.K., Tiwari A. K. and Dhiman A. (2016). *Analysis of Concrete Wall under Blast Loading*. International Conference on Advances in Emerging Technology (ICAET 2016) Vol. 07, pp. 12-23

Unified Facilities Criteria. (2008). *UFC 03-340-02 Structures to Resist the Effect of Accidental Explosions*. United States of America, Department of Defense

Yandzio E. and Gough M. (1999). *Protection of Buildings against Explosions*, Berkshire, Steel Construction Institute Publication 244

Appendix A

Design Calculations

Reference	Calculation	Output
	Modulus of Elasticity at 28 of Normal Weight Concrete	

BS 8110
Part 2
Cl 7.2

$$E_{28} = K_0 + 0.2\, f_{cu,28}$$

$$K_0 = 20\ \text{N/mm}^2$$

$$f_{cu,28} = 30\ \text{N/mm}^2$$

$$E_{28} = 20 + 0.2 \times 30$$

$$= 26\ \text{N/mm}^2$$

Output: $E_{28} = 26\ \text{N/mm}^2$

Feature		
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Job Code	Page	69

D R D

Reference	Calculation	Output

Material Strength Enhancements

Enhancements are calculated based on the equations given in the book Blast Effects on Buildings.

Blast Effects on Buildings

Type of stress	Concrete	Reinforcing bars		Structural steel	
	f_{dcu}/f_{cu}	f_{dy}/f_y	f_{du}/f_u	$f_{dy}/f_y{}^*$	f_{du}/f_u
Bending	1·25	1·20	1·05	1·20	1·05
Shear	1·00	1·10	1·00	1·20	1·05
Compression	1·15	1·10	—	1·10	—

* Minimum specified f_y for grade 50 steel or less may be enhanced by the average strength increase factor of 1·10.

Concrete Strength Enhancement

For Bending

f_{du}/f_{cu} = 1.25

f_{cu} = 30 N/mm^2

f_{du} = 30x1.25

= 37.5 N/mm^2

Steel Strength Enhancement

f_{dy}/f_y = 1.2

f_y = 500 N/mm^2

f_{dy} = 1.2x500

= 550 N/mm^2

f_{du}/f_u = 1.05

f_u = 600 N/mm^2

f_{du} = 1.05x600

= 630 N/mm^2

Output column:

f_{du} = 37.5 N/mm^2

f_{dy} = 550 N/mm^2

f_{du} = 630 N/mm^2

D R	D	**Feature**	
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		Job Code	**Page** 70

Reference	Calculation	Output

Calculation of Basic Cost of Structural Elements

Unit Cost of Construction Work

Concreting works $= $ Rs 19000.00 per m^3

Formwork $= $ Rs 1200.00 per m^2

Reinforcement work $= $ Rs 200.00 per kg

Calculation of Cost of 150x500 fin having 8T10

Calculation of cost for a one meter length is done in this analysis

Volume of the concrete $= $ 0.15x0.5

$= $ 0.075 m^3

Cost for concreting $= $ 0.075x19000

$= $ Rs 1425.00

Area of the formwork $= $ 0.15x1x2 + 0.5x1x2

$= $ 1.3 m^2

Cost for formwork $= $ 1.3x1200

$= $ Rs 1560.00

Weight of the reinforcement $= $ 0.617x8x1

$= $ 4.936 kg

Cost for Reinforcements $= $ 200x4.936

$= $ Rs 985.60

Total Cost for 150x500-8T10 $= $ 1425 + 1560 + 985.50

$= $ **Rs 3970.60**

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D **D** **R**		Designed	Date	
		Checked	Date	
		Job Code	Page	71

Reference	Calculation		Output

Calculation of Cost of 150x500 fin having 8T12

Calculation of cost for a one meter length is done in this analysis

Volume of the concrete	=	0.15x0.5	
	=	0.075 m^3	
Cost for concreting	=	0.075x19000	
	=	Rs 1425.00	
Area of the formwork	=	0.15x1x2 + 0.5x1x2	
	=	1.3 m^2	
Cost for formwork	=	1.3x1200	
	=	Rs 1560.00	
Weight of the reinforcement	=	0.888x8x1	
	=	7.104 kg	
Cost for Reinforcements	=	Rs 1420.80	
Total Cost for 150x500-8T10	=	1425 + 1560 + 1420.8	
	=	**Rs 4405.80**	

Calculation of Cost of 150x500 fin having 10T10

Calculation of cost for a one meter length is done in this analysis

Volume of the concrete	=	0.15x0.5	
	=	0.075 m^3	
Cost for concreting	=	0.075x19000	
	=	Rs 1425.00	
Area of the formwork	=	0.15x1x2 + 0.5x1x2	
	=	1.3 m^2	
Cost for formwork	=	1.3x1200	
	=	Rs 1560.00	

DR	D		Feature		
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			Job Code		Page 72

Reference	Calculation	Output
	Weight of the reinforcement $=$ 0.0.617x10x1	
	$=$ 6.16 kg	
	Cost for Reinforcements $=$ Rs 1232.00	
	Total Cost for 150x500-8T10 $=$ 1425 + 1560 + 1232	
	$=$ **Rs 4217.00**	
	Calculation of Cost of 150x500 fin having 10T12	
	Calculation of cost for a one meter length is done in this analysis	
	Volume of the concrete $=$ 0.15x0.5	
	$=$ 0.075 m^3	
	Cost for concreting $=$ 0.075x19000	
	$=$ Rs 1425.00	
	Area of the formwork $=$ 0.15x1x2 + 0.5x1x2	
	$=$ 1.3 m^2	
	Cost for formwork $=$ 1.3x1200	
	$=$ Rs 1560.00	
	Weight of the reinforcement $=$ 0.888x10x1	
	$=$ 8.88 kg	
	Cost for Reinforcements $=$ Rs 1776.00	
	Total Cost for 150x500-8T10 $=$ 1425 + 1560 + 1420.8	
	$=$ **Rs 4761.00**	
	Calculation of Cost of 150x600 fin having 10T10	
	Calculation of cost for a one meter length is done in this analysis	
	Volume of the concrete $=$ 0.15x0.6	
	$=$ 0.09 m^3	
	Cost for concreting $=$ 0.09x19000	
	$=$ Rs 1710.00	

		Feature		
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		Job Code	Page	73

Reference	Calculation	Output
	Area of the formwork $= 0.15 \times 1 \times 2 + 0.6 \times 1 \times 2$	
	$= 1.5 \text{ m}^2$	
	Cost for formwork $= 1.5 \times 1200$	
	$= \text{Rs } 1800.00$	
	Weight of the reinforcement $= 0.617 \times 10 \times 1$	
	$= 6.16 \text{ kg}$	
	Cost for Reinforcements $= \text{Rs } 1232.00$	
	Total Cost for 150x500-8T10 $= 1710 + 1800 + 1232$	
	$= \textbf{Rs 4742.00}$	

Calculation of Cost of 150x600 fin having 10T12

Reference	Calculation	Output
	Cost for concreting $= \text{Rs } 1710.00$	
	Cost for formwork $= \text{Rs } 1800.00$	
	Weight of the reinforcement $= 0.888 \times 10 \times 1$	
	$= 8.88 \text{ kg}$	
	Cost for Reinforcements $= 8.88 \times 200$	
	$= \text{Rs } 1776.00$	
	Total Cost for 150x500-8T10 $= 1710 + 1800 + 1776$	
	$= \textbf{Rs 5286.00}$	

Calculation of Cost of 150x600 fin having 12T10

Reference	Calculation	Output
	Cost for concreting $= \text{Rs } 1710.00$	
	Cost for formwork $= \text{Rs } 1800.00$	
	Weight of the reinforcement $= 0.617 \times 12 \times 1$	
	$= 7.404 \text{ kg}$	
	Cost for Reinforcements $= 7.404 \times 200$	
	$= \text{Rs } 1478.40$	

Reference	Calculation	Output
	Total Cost for 150x500-8T10 = 1710 + 1800 + 1478.40	
	= **Rs 4988.40**	
	Calculation of Cost of 150x600 fin having 12T12	
	Cost for concreting = Rs 1710.00	
	Cost for formwork = Rs 1800.00	
	Weight of the reinforcement = 0.888x12x1	
	= 10.656 kg	
	Cost for Reinforcements = 10.656x200	
	= Rs 2131.20	
	Total Cost for 150x500-8T10 = 1710 + 1800 + 2131.20	
	= **Rs 5641.20**	
	Calculation of Cost of 150x800 fin having 16T12	
	Calculation of cost for a one meter length is done in this analysis	
	Volume of the concrete = 0.15x0.8	
	= 0.12 m^3	
	Cost for concreting = 0.12x19000	
	= Rs 2280.00	
	Area of the formwork = 0.15x1x2 + 0.8x1x2	
	= 1.9 m^2	
	Cost for formwork = 1.9x1200	
	= Rs 2280.00	
	Weight of the reinforcement = 0.888x16x1	
	= 14.208 kg	
	Cost for Reinforcements = 14.208x200	
	= Rs 2841.6	

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		Job Code	Page	75

Reference	Calculation	Output

Total Cost for 150x500-8T10 = 2280 + 2280+ 2841.6

= **Rs 7401.60**

		Feature		
D **D** **R**		**Designed**		**Date**
		Checked		**Date**
		Job Code		**Page** 76