CHAPTER 7
CONCLUSIONS

7.1 AIR BLAST SIMULATION AND APPLICATION

7.1.1 Simulation

1. Inexpensive laboratory experiments are possible for investigating blast loading and response of structures subjected to blast, enabling research workers to simulate the conditions of air blast environment in the laboratory for model studies.

2. The pressure-time history produced by the simulated blast is governed by the quantity of the charge and the distance of the blast.

3. Diaphragm type pressure transducers are effective in monitoring the pressure-time history of the blast.

7.1.2 Application

1. The laboratory simulated blast can be applied on structural models such as plates and frames, in order to obtain their response to blast loading.

2. The flexibility of the joints in the frame influences its dynamic response, with irregular local oscillations. This influence is considerable when the flexibility of the joint is more than 75% of the flexibility of the member.

3. Damping is found to influence the elastic dynamic response of the frames by 10% to 60% for a change of 1 to 10% in the damping.
4. The cladding in frames has a definite influence on their blast response. This influence is significant when cladding stiffness is between 0.14 to 0.53 of the stiffness of a cladding which limits any lateral sway (Δ) of the frame. Within this range, the interaction equation between the cladding thickness and the frame sway is proposed as

\[
\Delta / \Delta_m = 1.19 - 1.888 \frac{t}{t_m}
\]

where the ratios of response and stiffness are defined with reference to the maximum values.

7.2 USE OF FERROCEMENT FOR BLAST AND IMPACT RESISTANCE

1. Ferrocement has more energy absorption capacity and hence it is better suited than reinforced concrete in situations involving transfer of large amount of energy in a short duration, a typical characteristic of blast and impact loadings.

2. Under similar conditions, ferrocement absorbs 30 % more energy than reinforced concrete in resisting the blast loads.

3. Under similar conditions, ferrocement absorbs 30 % more energy than reinforced concrete in resisting impact loads.

4. The cracking in ferrocement is found to be 15 to 20 % lesser than a similar reinforced concrete specimen tested under similar blast or impact conditions.

5. Ferrocement has 15 to 25 % higher ductility ratio than reinforced concrete under blast and impact loads.

Hence it is suggested that ferrocement can be used as a cladding, covering or cushioning material in structures, so that it can absorb instantaneous energy during blast or impact and transmit only the damped reactive forces to the underlying structure.
7.3 CONTACT BLAST AND IMPACT

1. Similarities exist between contact blast and impact with respect to the following observations.

(i) Deflection-time history
(ii) The variation of maximum response with respect to the input energy.
(iii) The variation of permanent set with respect to the input energy.
(iv) Cracking.

2. Based on the observations listed above, contact blast loading is concluded to be similar to impact load and further detailed studies are recommended to obtain a quantitative equivalent which can replace contact blast by a less hazardous impact test. This will relieve large amount of hardship in the part of the research and testing organizations in arranging to conduct large scale blast tests.

7.4 NONLINEAR ANALYSIS FOR BLAST LOADING

1. A design-oriented computer programme for the elastic-plastic dynamic analysis including second order effects, for plane frames subjected to blast loading has been developed. This programme utilizes two dimensional beam elements and takes into account both the material and geometrical nonlinearities. The programme has been implemented in VAX 11/780. In addition to the above, this programme takes only 5 minutes for a single storey frame analysis when subjected to blast load, in VAX 11/780, whereas any general purpose programme would take at least twice as much time.

2. The programme has been validated using an example problem given in [35] and also by a sample problem solved by other standard packages called SAP-IV for elastic analysis and ANSYS for the elastic-plastic analysis.
3. The programme developed is useful in the blast analysis so as to incorporate the material and geometric nonlinearities in the time step solution for blast response in order to proceed with the design of framed structures for blast loading.

7.5 SUGGESTIONS FOR FUTURE RESEARCH

1. The nonlinear analysis developed in this work is applicable for plane frames only. This is valid only for the normal blast waves which act on the structure symmetrically. However when quartering waves which act diagonally on the structure are considered, torsional mode of vibration in the structure will be significant. To account this torsion, a three dimensional analysis with a space frame model is essential. Hence the programme developed for plane frames can be extended for space frames subjected to blast loading.

2. As it has been proved that the joint flexibilities considerably affect the dynamic response of the frame, it would be interesting to examine the support influence on the response. This can be investigated for different types of foundation systems incorporating the soil system also in to the model.

3. The laboratory experiments were carried out on frame models with frontal plate for the transfer of blast pressures. It would be interesting to test a model with claddings so as to find the effect of reflected pressures also on the response.

4. More elaborate experiments are needed to quantify the contact blast loading and to propose a numerical equivalent in terms of impact energy.

5. Design equations for various blast loadings in terms of varying pressure-time histories may be formulated to predict the response of structures. Response spectrum for blast involving the magnitude and distance of blast and the design forces on the structure may be proposed.