FAILURES IN CONCRETE STRUCTURES
Case Studies in Reinforced and Prestressed Concrete

Robin Whittle
Contents

Foreword ix
Acknowledgements xi
Introduction xiii

1 Failures due to Design Errors 1

1.1 Edge Beam and Column Connection 2
1.2 Concrete Truss 5
1.3 Circular Ramps to Car Park 8
1.4 Transfer Beam with Eccentric Loading 10
1.5 Early Thermal Effects 10
1.6 Secondary Effects of Prestressing 14
1.7 Temperature Effects on Long-Span Hybrid Structure 16
1.8 Loading for Flat Slab Analysis 18
1.9 Precast Concrete Car Park 19
1.10 Arch Floor 21
1.11 Precast Concrete Stairflights 21
1.12 Shear Studs on Steel Column to Support Concrete Slab 24
1.13 Piled Raft for Tower Block 26
1.14 Floating Pontoon for Residential Building 27
1.15 Precast Column Joint Detail 27

2 Problems and Failures due to Errors in Structural Modelling 31

2.1 Reinforced Concrete Transfer Truss 31
2.2 Modelling Rigid Links 31
2.3 Assessing Model Limits and Limitations 32
2.4 Empirical Methods 34
2.5 Initial Sizing of Slabs 35
2.6 Analysis of Flat Slabs with Finite Element Programs 35
2.7 Scale Effects 37
3 Failures due to Inappropriate Extrapolation of Code of Practice Clauses
   3.1 Cooling Towers 39
   3.2 Design Bending Moments 41
   3.3 Piles with High Strength Reinforcement 42
   3.4 Shear Capacity of Deep Sections 43

4 Failures due to Misuse of Code of Practice Clauses 47
   4.1 Flat Slab and Two-Way Slab Behaviour 47
   4.2 Ribbed Slab Supported on Broad Beam 48
   4.3 Car Park Columns 50

5 Problems and Failures due to Inadequate Assessment of Critical Force Paths 53
   5.1 Heavily Loaded Nibs 53
   5.2 Shear Wall with Holes and Corner Supports 53
   5.3 Design of Boot Nibs 56

6 Problems and Failures due to Poor Detailing 57
   6.1 Concrete Offshore Platform 57
   6.2 Assembly Hall Roof 60
   6.3 University Building Roof 62
   6.4 Minimum Reinforcement and Cracking 64
   6.5 Precast Concrete Panel Building 65
   6.6 Footbridge 67

7 Problems and Failures due to Inadequate Understanding of Materials' Properties 69
   7.1 Changes over Time 69
   7.2 Rebending of Reinforcement 71
   7.3 Tack Welding of Reinforcement 73
   7.4 High Alumina Cement 73
   7.5 Calcium Chloride 74
   7.6 Alkali–Silica Reaction 75
   7.7 Lightweight Aggregate Concrete 77

8 Problems and Failures due to Poor Construction 79
   8.1 Flat Slab Construction for Hotel 79