Motor Vehicle Structures

Concepts and Fundamentals

List of Chapters

Glossary of 'body-in-white' components Acknowledgements About the authors Disclaimer

1 Introduction

- 1.1 Preface
- 1.2 Introduction to the simple structural surfaces (SSS) method
- 1.3 Expectations and limitations of the SSS method
- 1.4 Introduction to the conceptual design stage of vehicle body-in-white design
- 1.5 Context of conceptual design stage in vehicle body-in-white design
- 1.6 Roles of SSS with finite element analysis (FEA) in conceptual design
- 1.7 Relationship of design concept filtering to FEA models
- 1.8 Outline summary of this book
- 1.9 Major classes of vehicle loading conditions - running loads and crash loads

2 Fundamental vehicle loads and their estimation

- 2.1 Introduction: vehicle loads definition
- 2.2 Vehicle operating conditions and proving ground tests
- 2.3 Load cases and load factors
- 2.4 Basic global load cases
 - 2.4.1 Vertical symmetric ('bending') load case
 - 2.4.2 Vertical asymmetric case (and the pure torsion analysis case)
 - 2.4.3 Longitudinal loads
 - 2.4.4 Lateral loads
- 2.5 Combinations of load cases 2.5.1 Road loads

3 Terminology and overview of vehicle structure types

- 3.1 Basic requirements of stiffness and strength
 - 3.1.1 Strength
 - 3.1.2 Stiffness
 - 3.1.3 Vibrational behaviour
 - 3.1.4 Selection of vehicle type and concept
- 3.2 History and overview of vehicle structure types
 - 3.2.1 History: the underfloor chassis frame
 - 3.2.2 Modern structure types

- 4 Introduction to the simple structural surfaces (SSS) method
 - 4.1 Definition of a simple structural surface (SSS)
 - 4.2 Structural subassemblies that can be represented by a simple structural surface (SSS)
 - 4.3 Equilibrium conditions
 - 4.4 A simple box structure
 - 4.5 Examples of integral car bodies with typical SSS idealizations
 - 4.6 Role of SSS method in load-path/stiffness analysis
 Appendix Edge load distribution for a floor with a simple grillage

5 Standard sedan (saloon) - baseline load paths

- 5.1 Introduction
 - 5.1.1 The standard sedan
 - 5.2 Bending load case for the standard sedan (saloon)
 - 5.2.1 Significance of the bending load case
 - 5.2.2 Payload distribution
 - 5.2.3 Free body diagrams for the SSSs
 - 5.2.4 Free body diagrams and equilibrium equations for each SSS
 - 5.2.5 Shear force and bending moment diagrams in major components design implications
- 5.3 Torsion load case for the standard sedan
 - 5.3.1 The pure torsion load case and its significance
 - 5.3.2 Overall equilibrium of vehicle in torsion
 - 5.3.3 End structures
 - 5.3.4 Passenger compartment
 - 5.3.5 Summary baseline closed sedan

Motor Vehicle Structures

Concepts and Fundamentals

- 5.3.6 Some notes on the standard sedan in torsion
- 5.3.7 Structural problems in the torsion case
- 5.4 Lateral loading case
 - 5.4.1 Roll moment and distribution at front and rear suspensions
 - 5.4.2 Additional simple structural surfaces for lateral load case
- 5.5 Braking (longitudinal) loads
- 5.6 Summary and discussion

6 Alternative construction for body subassemblies and model variants

- 6.1 Introduction
- 6.2 Alternative construction for major body subunits
 - (a) Rear structures
 - 6.2.1 Rear suspension supported on floor beams
 - 6.2.2 Suspension towers at rear
 - (b) Frontal structures
 - 6.2.3 Grillage type frontal structure
 - 6.2.4 Grillage type frontal structure with torque tubes
 - 6.2.5 Missing or flexible shear web in inner fender
 - 6.2.6 Missing shear web in inner fender: upper rail direct to A-pillar
 - 6.2.7 Sloping inner fender (with shear panel)
 - 6.2.8 General case of fender with arbitrary-shaped panel
- 6.3 Closed model variants
 - 6.3.1 Estate car/station wagon
 - 6.3.2 Hatchback
 - 6.3.3 Pick-up trucks
- 6.4 Open (convertible/cabriolet) variants
 - 6.4.1 Illustration of load paths in open vehicle: introduction
 - 6.4.2 Open vehicle: bending load case
 - 6.4.3 Open vehicle: torsion load case
 - 6.4.4 Torsion stiffening measures for open car structures
 - 6.4.5 Simple structural surfaces analysis of an open car structure torsionally stiffened by 'boxing in' the engine compartment

7 Structural surfaces and floor grillages

- 7.1 Introduction
- 7.2 In-plane loads and simple structural surfaces

- 7.2.1 Shear panels, and structures incorporating them
- 7.2.2 Triangulated truss
- 7.2.3 Single or multiple open bay ring frames
- 7.2.4 Comparison of stiffness/weight of different simple structural surfaces
- 7.2.5 Simple structural surfaces with additional external loads
- 7.3 In-plane forces in sideframes
 - 7.3.1 Approximate estimates of pillar loads in sideframes
- 7.4 Loads normal to surfaces: floor structures
 - 7.4.1 Grillages
 - 7.4.2 The floor as a load gatherer
 - 7.4.3 Load distribution in floor members
 - 7.4.4 Swages and corrugations

8 Application of the SSS method to an existing vehicle structure

- 8.1 Introduction
- 8.2 Determine SSS outline idealization from basic vehicle dimensions
 - 8.2.1 Locate suspension interfaces to body structure where weight bearing reactions occur
 - 8.2.2 Generation of SSSs which simulate the basic structural layout
- 8.3 Initial idealization of an existing vehicle
- 8.4 Applied loads (bending case)
 - 8.4.1 Front suspension tower
 - 8.4.2 Engine rail
 - 8.4.3 Centre floor
 - 8.4.4 Dash panel
 - 8.4.5 Rear seat cross-beam
 - 8.4.6 Rear floor beams
 - 8.4.7 Rear panel
 - 8.4.8 Sideframe
 - 8.4.9 Bending case design implications
- 8.5 Applied loads (torsion case)
 - 8.5.1 Rear floor beams
 - 8.5.2 Front suspension towers and engine rails
 - 8.5.3 The main torsion box
 - 8.5.4 Torsion case design implications
- 8.6 An alternative model
 - 8.6.1 Front suspension towers and inner wing panels
 - 8.6.2 Rear floor beams
 - 8.6.3 The main torsion box

Motor Vehicle Structures

Concepts and Fundamentals

- Torsion case (alternative model) 8.6.4 design implications
- 8.7 Combined bending and torsion
- 8.8 Competing load paths
- Introduction to vehicle structure preliminary 9 design SSS method
 - 9.1 Design synthesis vs analysis
 - 9.2 Brief outline of the preliminary or conceptual design stage
 - 9.3 Basic principles of the SSS design synthesis approach
 - Starting point (package and part 9.3.1 requirements)
 - 9.3.2 Suggested steps
 - 9.3.3 Suggested priorities for examination of local subunits and components
 - Positioning of major members 9.3.4
 - Member sizing 9.3.5
 - 9.4 Relation of SSS to FEA in preliminary design
 - Scope of SSS method 9.4.1
 - 9.4.2 Limitations and assumptions of SSS method
 - Suggested role of SSS method 9.4.3
 - 9.4.4 Role of FEA
 - 9.4.5 Integration of SSS, FEA and other analyses
 - 9.5 The context of the preliminary design stage in relation to the overall body design process 9.5.1
 - Timing
 - 9.5.2 Typical analytical models (FEM etc.) used at different stages in the design cycle
- 10 Preliminary design and analysis of body subassemblies using the SSS method
 - 10.1 Introductory discussion
 - 10.1.1 Alternative 1: employ a bulkhead
 - 10.1.2 Alternative 2: move where the load is applied to a more favourable location
 - 10.1.3 Alternative 3: transfer the load to an SSS perpendicular to the rear compartment pan
 - 10.2 Design example 1: steering column mounting/dash assembly
 - 10.2.1 Design requirements and conflicts
 - 10.2.2 Attached components
 - 10.3 Design example 2: engine mounting brackets
 - 10.3.1 Vertical direction
 - 10.3.2 Lateral direction
 - 10.3.3 Fore-aft direction
 - 10.3.4 Summary

10.3.5 Discussion

10.4 Design example 3: front suspension mounting

- 10.4.1 Forces applied to and through the suspension
- 10.4.2 Forces on the body or subframe

11 Fundamentals and preliminary sizing of sections and joints

- 11.1 Member/joint loads from SSS analysis
- 11.2 Characteristics of thin walled sections
 - 11.2.1 Open sections
 - 11.2.2 Closed sections
 - 11.2.3 Passenger car sections
- 11.3 Examples of initial section sizing
 - 11.3.1 Front floor cross-beam
 - 11.3.2 The "A"-pillar
 - 11.3.3 Engine longitudinal rail
- 11.4 Sheet metal joints
 - 11.4.1 Spot welds
- 11.5 Spot weld and connector patterns
 - 11.5.1 Spot welds along a closed section
- 11.6 Shear panels
 - 11.6.1 Roof panels
 - 11.6.2 Inner wing panels (inner fender)
- 12 Case studies preliminary positioning and sizing of major car components
 - 12.1 Introduction
 - 12.2 Platform concept
 - 12.3 Factors affecting platform capability for new model variants
 - 12.4 Examples illustrating role of SSS method 12.4.1 Weight
 - 12.4.2 Vehicle type
 - 12.4.3 Sedan to station wagon/estate car - rear floor cross-member
 - 12.4.4 Closed structure to convertible
 - 12.4.5 Dimensions
 - 12.5 Proposal for new body variants from an existing platform
 - 12.5.1 Front end structure
 - 12.5.2 Dash
 - 12.5.3 Floor
 - 12.5.4 Cab rear bulkhead (pick-up truck)
 - 12.5.5 Sideframe and cargo box side
 - 12.5.6 Rear compartment pan and cargo box floor
 - 12.5.7 Steps for preliminary sizing of components

References Index

