ALTERNATIVE CONSTRUCTION FOR BODY SUBASSEMBLIES AND MODEL VARIANTS
This chapter discusses variations from the basic ‘standard sedan’ structure at 2 levels:

- **Body subassemblies**
  - Major subassemblies can take many different forms such as suspension mountings and passenger compartment

- **Vehicle model variants**
  - Vehicle model may be produced in a range of variants
    - (E.g.: station wagon, hatchback, convertible, pick-up truck, etc.)
  - Structural features are significantly different from sedan
ALTERNATIVE CONSTRUCTION FOR MAJOR BODY SUBUNITS

- In standard sedan:
  - Suspension loads ($R_F$ & $R_R$)
    - Carried by the end structures
  - Shear panel reactions
    - Carried by the front or rear compartment bulkhead
  - Flange reactions
    - Taken by parcel shelves and floor
In this section,
  ◦ Alternative end structures at front & rear are considered

  ◦ Variations are based on the standard sedan

  ◦ All discussions are in relation to the *explanation of torsion and bending load case* on the standard sedan
Rear Structures

- Rear Suspension Supported on Floor Beam

Floor beams:

\[ Q_8 = \frac{R_R L_2}{(L_1 + L_2)} \]
\[ Q_9 = \frac{R_R L_1}{(L_1 + L_2)} \]

Rear valance:

\[ Q_{10} = Q_9 S_R / B \]

Sideframes:

\[ Q_{X2} = Q_{10} \left( \frac{L_1 + L_2}{h_2} \right) \]
Load applied to the compartment by rear floor beams
- **Suspension Towers at Rear**
  - Some vehicles have strut type rear suspension
  - This requires rear suspension towers, and these are often incorporated into the rear wheel boxes
Brace to balance moment from offset suspension force
Frontal Structures

Grillage Type Frontal Structure

\[ T = R_F S_F \]
\[ R_F + P_4 - P_1 = 0 \]

Moment about H:
\[ R_F L_1 = P_4 L_2 \]
\[ \therefore P_4 = R_F \frac{L_1}{L_2} = \frac{L_1}{S_F L_2} T \]

\[ P_1 = R_F \left( 1 + \frac{L_1}{L_2} \right) = \left( 1 + \frac{L_1}{L_2} \right) \frac{T}{S_F} \]

\[ P_1 > R_F \]
\[ P_4 S_F = P_3 B \]
\[ \therefore P_3 = P_4 \frac{S_F}{B} = \frac{L_1}{L_2 B} T \]
BMD & SFD

(a) Front rail

(b) Cross-member
Grillage Type Frontal Structure With Torque Tubes

\[ P_1 = \pm R_F \]
\[ M_1 = \pm R_F L_1 \]
Free body diagrams

Torque diagrams

(a) Vehicle torsion case

(b) Vehicle bending case
Missing or Flexible Shear Web in Inner Fender
Missing Shear Web in Inner Fender: Upper Rail Direct to A-pillar
\[ R_1 = R_F \frac{b}{a + b} \]
\[ R_F = R_1 + R_2 \]
\[ R_2 = R_F \frac{a}{a + b} \]
CLOSED INTEGRAL STRUCTURES

- Different closed body configurations mounted on a common floor pan assembly will be discussed.

- Standard sedan floor is often used for:
  - Estate car
  - Hatchback

- Rear structure experienced a little change:
  - Extended for estate car
  - Shortened for hatchback
Bending load case can be treated in the same way as before

- Rear door frame for estate car will function in a similar way to the rear panel in standard sedan

- The sill of the rear door will:
  - Carry bending & shear loads
  - Transfer forces to the sideframe
- Torsion load case must be treated differently than the standard sedan
- Special care must be taken when analyzing the rear frame for estate/hatchback
Estate Car/Station Wagon

- Modern station wagon has a rear door that is near vertical & constructed in a single or near single plane
  - Can be treated as single SSS
  - Primary structural function in torsion case is to transfer shear from the roof panel to the floor
Hatchback

- This style of body has caused particular structural problems

  - To minimize drag, hatchback rear frames are constructed with a sloping backlight with a short horizontal surface at waist height & a vertical surface between waist and rear bumper

  - No longer a plane structure but 3 planes

  - Structural function remains the same as estate car (i.e. to transfer shear from roof to floor during torsion)
\[ Q_1a - Q_2w = 0 \]
\[ Q_1c - Q_3w = 0 \]
\[ 2M_Z - Q_1b/2 \]
\[ P_{RU}w - 2M_R = 0 \]
\[ P_{RLX}w - 2M_Z = 0 \]
\[ P_{RLZ}w - 2M_X = 0 \]
OPEN VEHICLE: bending load case

The sidewalls are the major members carrying bending moment. Thus it needs extra care to stiffen the structure.

All edge loads are well supported by the components.
The open car suffers in the torsion case due to not having a closed box. This creates out-of-plane forces to the floor and thus breaks down the SSS.
Torsion stiffening measures:
- Adding in a torsionally stiff grillage
  - a) Cruciform braced members in the floor
  - b) Tubular backbone members
  - c) Full underfloor grillage structure
City car cabriolet conversion
Adding in torsion box-type members at the following areas:

- a) luggage or engine compartments
- b) region of engine bulkhead, parcel shelf and lower A-pillar
- c) region under the rear seat or near fuel tank
Open vehicle with torsion box in dash region

Front inner fenders

$S_F = 1040 \text{ mm}$
$L_1 = 480 \text{ mm}$
$B = 1360 \text{ mm}$

$h_1 = 640 \text{ mm}$
$L_4 = 1080 \text{ mm}$
$L = 1620 \text{ mm}$
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Q_B \\
Q_X \\
Q_F
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