Lecture 1: Introduction to Automotive Structure

1. The main purpose is to:
   a) Support all the major components and sub-assemblies making up the complete vehicle
   b) Carry the passengers and/or payload in a safe and comfortable manner

2. Types of automotive structure:

   a) **Body-on-frame** is an *automobile* construction technology. Mounting a separate body to a rigid frame which supports the *drivetrain* was the original method of building automobiles, and its use continues to this day. The original frames were made of wood (commonly *ash*), but steel *ladder frames* became common in the 1930s.

   In the USA the frequent changes in *automobile design* made it necessary to use a ladder frame rather than *monocoque* to make it possible to change the design without having to change the *chassis*, allowing frequent changes and improvements to the car’s bodywork and interior (where they were most noticeable to customers) while leaving the chassis and driveline unchanged, and thus keeping cost down and design time short. It was also easy to use the same chassis and driveline for several very different cars. Especially in the days before *computer-aided design*, this was a big advantage.

   Most small passenger vehicles switched to *Body Frame Integral* construction in the 1960s, leaving just *trucks*, some *bus manufacturers* and large cars using conventional frames. The switch continued for several decades - even small *SUVs* typically use unibody construction today. Body-on-frame remains the preferred construction method for heavy-duty commercial vehicles, especially those which are intended to carry and pull heavy loads, such as trucks.
Advantages
Easier to design, build and modify (less of an issue now that CAD is commonplace, but still an advantage for coachbuilt vehicles). More suited for heavy duty usage and can be more durable. Easier to repair after accidents. Overall better ride quality [2] for SUVs.

Disadvantages
Heavier than unibody - lower performance and/or higher fuel consumption. Center of gravity is usually higher - compromising stability and handling. Less resistant to torsion (flexing of the whole car in corners) - compromising handling and roadholding. No crumple zone - higher rate of death and serious injury. Higher production costs.

b) Body frame integral is a methodology for manufacturing within the automotive industry. It has become the main technique for chassis assembly for most vehicles except trucks and large sport utility vehicles, replacing the traditional approach of body-on-frame (BOF).

BOF utilizes an independent frame that is used to connect the suspension to the body frame. The main advantage of this is that soft mounts are used to reasonably isolate the body from the vibrations endured by both the frame and the suspension system. BFI was developed for the main purposes of reducing weight and drag, as well as lowering the center of gravity. Front end cradles are still used in BFI, which allows soft mounts to be implemented in the engine compartment. However, most rear ends are hard mounted, but
technological advancements allow the associated effects of **noise, vibration, and harshness** to be suitably managed.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Effects</th>
<th>Disadvantages</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fewer parts and less weight</td>
<td>Better fuel efficiency</td>
<td>Difficult components to integrate</td>
<td>Harder to assemble and repair</td>
</tr>
<tr>
<td>Lower center of Gravity</td>
<td>Less likely to roll vehicle</td>
<td>Noise, Vibration, and Harshness</td>
<td>Customer satisfaction issue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>increased</td>
<td></td>
</tr>
<tr>
<td>Less drag</td>
<td>Better fuel efficiency</td>
<td>Passengers do not sit as high</td>
<td>Customer satisfaction issue</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better wheel clearance</td>
<td>Allows diverse selection</td>
<td>Less durable than BOF; cab and bed need to be connected</td>
<td>Most trucks not applicable for BFI</td>
</tr>
</tbody>
</table>

---

c) **Monocoque** *(French for "single" (mono) and "shell" (coque)) is a construction technique that supports structural load using an object's external skin. This stands in contrast with using an internal framework (or **truss**) that is then covered with a non-load-bearing skin. Monocoque construction was first widely used in **aircraft**, starting in the 1930s.*
Structural skin is another term for the same concept.

Unibody, or unitary construction, is a related construction technique for automobiles in which the body is integrated into a single unit with the chassis rather than having a separate body-on-frame. The welded "Unit Body" is the predominant automobile construction technology today.

d) A space frame or space structure is a truss-like, lightweight rigid structure constructed from interlocking struts in a geometric pattern. Space frames usually utilize a multidirectional span, and are often used to accomplish long spans with few supports. They derive their strength from the inherent rigidity of the triangular frame; flexing loads (bending moments) are transmitted as tension and compression loads along the length of each strut.
Structural Requirements
The structural requirements of any vehicle structure can be summarized as follows:

1. The structure must be sufficiently stiff to react the static loads and dynamic loads without excessive deformation.
2. The structure must be sufficiently strong to withstand many cycles of the applied loading without suffering from fatigue or other forms of material failure.
3. The structure should deform in such a manner under impact load conditions so as to minimize the risk of injury to the occupants and other road users.