SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE
www.sathyabama.ac.in

SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF AUTOMOBILE ENGINEERING

SAU1504 – VEHICLE BODY ENGINEERING

UNIT I - CAR BODY DETAILS

UNIT 1

CAR BODY DETAILS

Importance of vehicle body engineering

1. Vehicle body contributes about 40% to 60% of total weight in the case of cars and about 65 to 70% in the case of buses. Payload is determined by body weight.
2. Reduction in body weight not only improves capacity but also fuel consumption.
3. Aerodynamic characteristics determine the fuel consumption of high speed and stability in cross wind. +ve pressure on the front and –ve pressure on the rear of the car should be minimized.
4. Safety of driver, passenger and pedestrians should be considered.
5. In direct test body contributes about 50 to 70% of total cost. In indirect cost expected life influence the price.

Types of car bodies

Classification of cars:

1. four door saloon
2. Limousine
3. Convertibles
4. Estate car
5. Sports coupe

Four door saloon

This is the most common passenger car, passenger comforts such as well designed seats, ease of entry and exit, good seating and ventilation system and better styling are the features of this model Drag coefficient of this model is about 0.35 to 0.5 The features of 2 door saloon and pillar less saloon are the same as that of 4 door saloon. However is pillarless saloon there will not ba a center pillar.

Limousine

It is a luxury car. It is provided with components and equipments of high quality and with better finish. It is usually provided with a partition between the driver and the passengers. Cushioned seats, air conditioning cooling glasses etc. are the other features of this model.

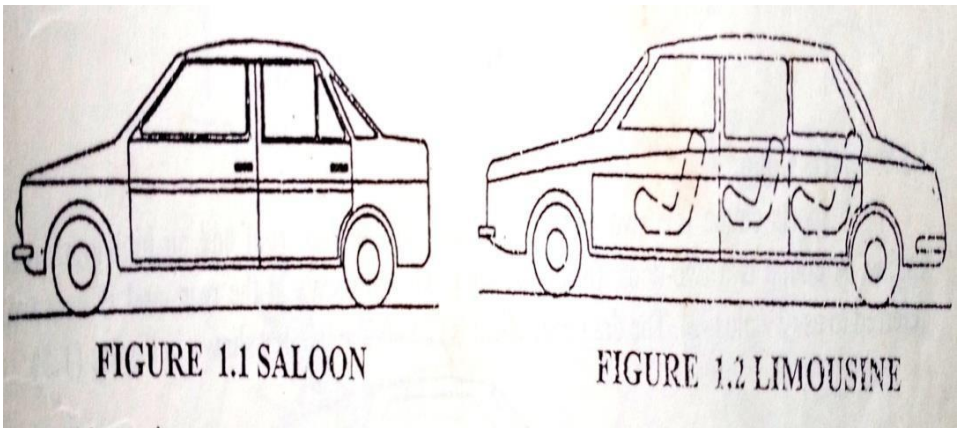


Fig:1 Saloon & limousine

Sports coupe

It is a small car with two seats better aerodynamics shape and better acceleration are the features of this model. Styling is not important. Lightness and rigidity are also the features of this model CD =0.2 to 0.3.Coupe is similar to sports coupe but with two extra seats at the back and hence can be used as a small family car.

Estate car

The luggage compartment is the continuation of passenger compartment without partition between them.Thus more luggage space and longer wheel base are the spatiality of the model.The other names of this model are universal, station wagon and break van.

Convertibles

These models are provided with wind up windows and folding roof.

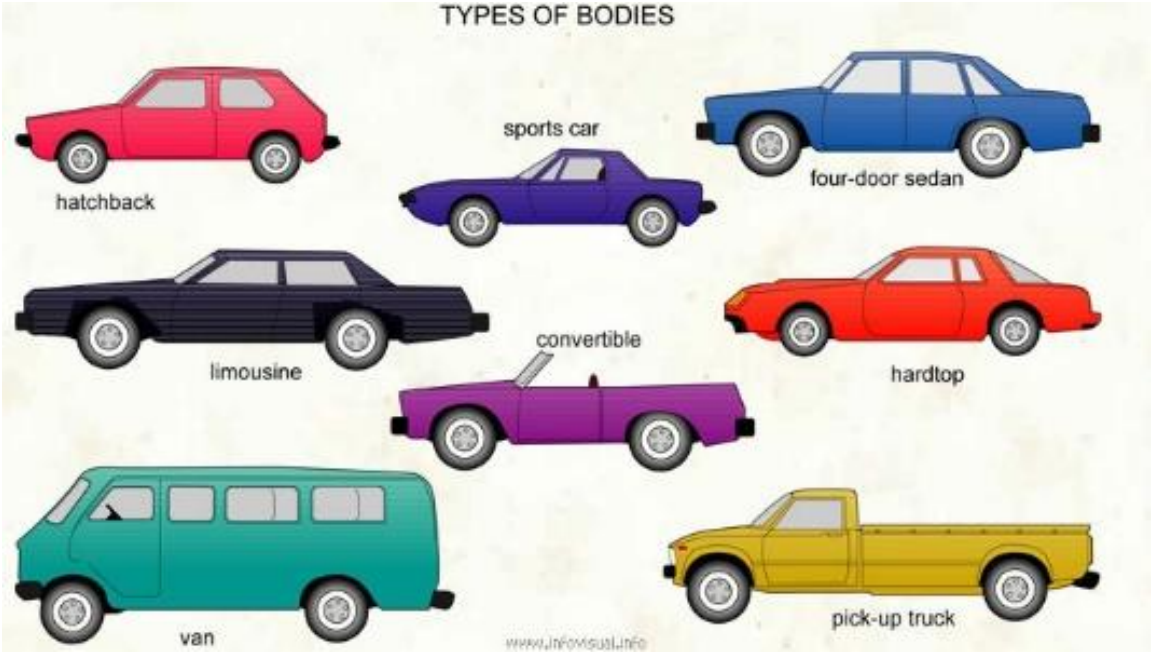


Fig:2 Different types of cars

VISIBILITY:

- Good all round visibility is now one of the main requirements of the body design.
- This clearly depends on the window opening and their position relative to theiroccupants.
- Fig 1.6 shows the drivers eye position and fig 1.7 shows the method by which theblinded axes can be determined.
- For example ,if the occupants is placed close to the wind screen the forward visibilityis considerably improved .
- On the other hand the problem of comfortable entry is increased since the dimension afig 1.7 between the pillar and seat is decreased.
- Ease of entry is possible by suitable shaping the door (as shown by the dotted line) atthe expense of a more complicated structure
- In military vehicles the downward visibility is important and the driver must be positioned as high as possible in relation to the tower edge of the windscreen.
- There are no strict regulation regarding visibility should be such as to enable the driver to see traffic at the lights etc. and this must be taken in to consideration at thedesign stage.
- Rearward visibility has assumed considerable importance in modern traffic condition and the increase in glass area required to maintain a give rear view vertical angle with a fast back window.

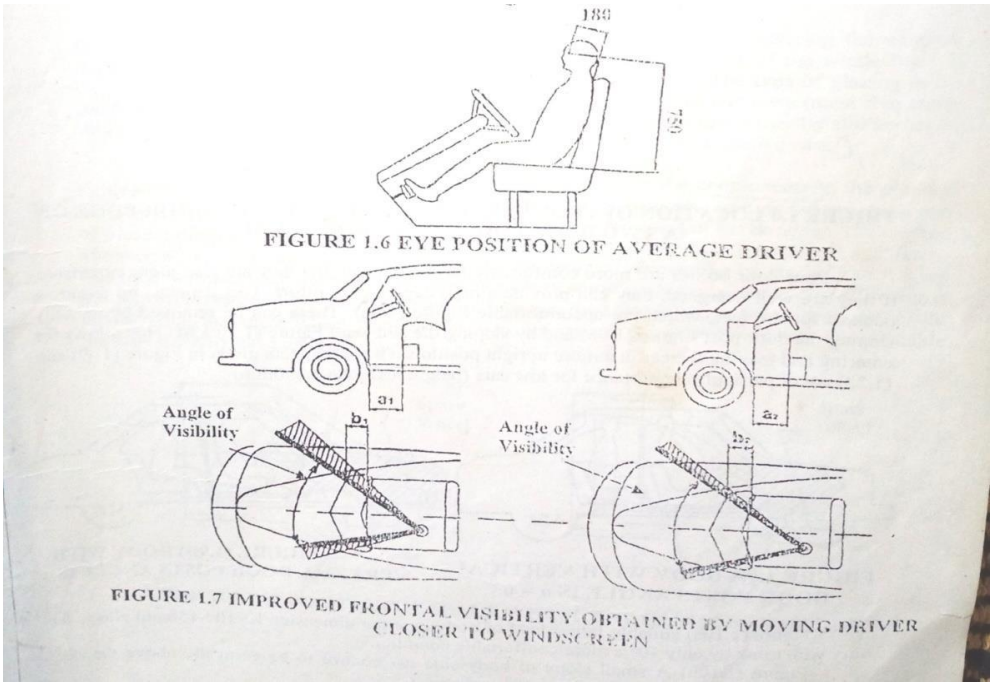


Fig:3 Eye position

Forward Visibility

This diagram shows the blocked view in a horizontal-plane in front of the driver.

The front-end blind spots caused by this can create problems in traffic situations, such as in roundabouts, intersections, and road crossings. Front-end blind spots are influenced by the following design criteria:

- Distance between the driver and the pillar
- Thickness of the pillar
- The angle of the pillar in a vertical plane side view
- The angle of the pillar in a vertical plane front view
- the form of the pillar straight or arc-form
- Angle of the windshield
- Height of the driver in relation to the dashboard
- Speed of the opposite car

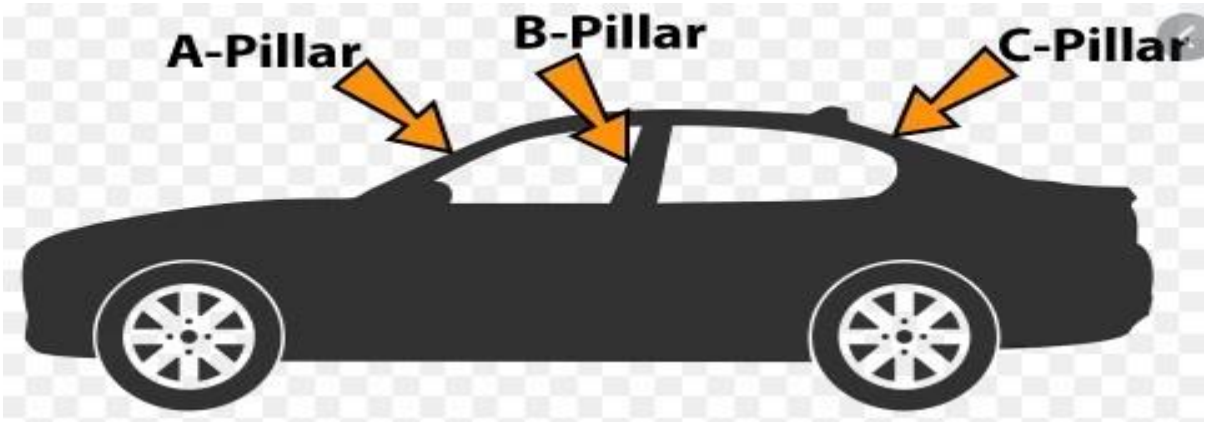


Fig:4 Effects of A-pillar angle on visibility

Effects of A-pillar angle on visibility

- Most passenger cars have a diagonal pillar as shown in this side view.
- The angle between the horizon and A-pillar is approximately 40 degrees with a straight pillar that is not too thick. This gives the car a strong, aerodynamic body withan adequately-sized front door.

Minimum space requirements and method of improving space in car:

- The amount of space can be allocated to passenger varies according to the dimensionand type of body of a given passenger car.
- The window openings should ensure good visibility and not cause any considerable reduction of the stiffness of the body shell.
- The main requirements of the door opening is comfort of entry ,but when dealing with a two door design it must be remembered that free passage way from the backseats must be ensured.
- The measurements of such passage way as given in fig in 1.8 are considered to be the minimum permissible, if these measurements are decreased ,entering and leaving the car becomes more difficult.

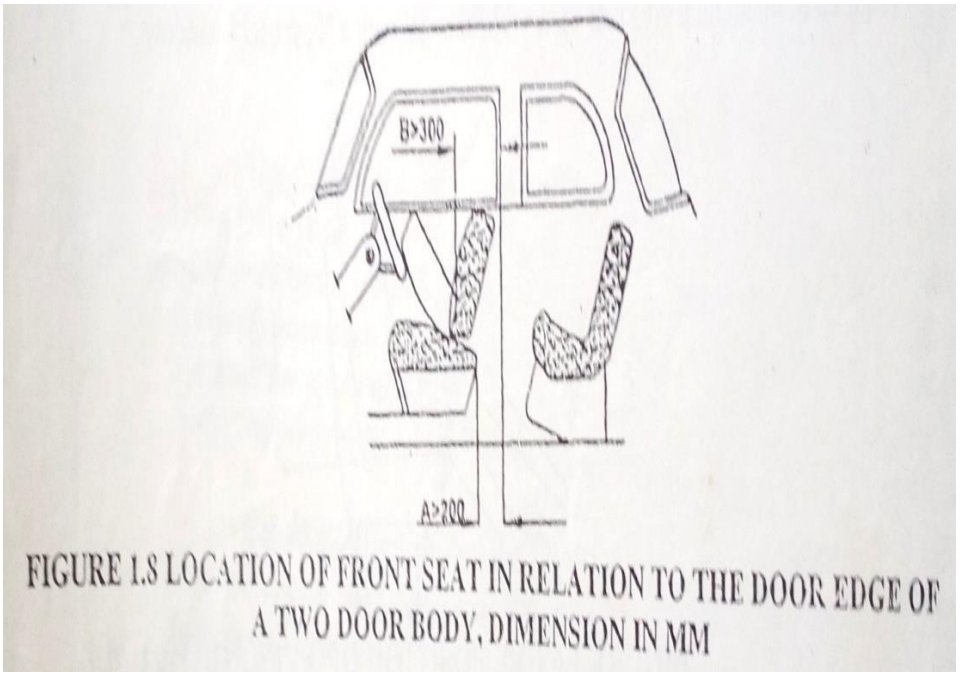


Fig:5 location of front seat

- Four door bodies are more comfortable for passengers, but they are also more expensive .
- If they are well designed they can provide a high degree of comfort.
- This depends on avoiding pockets for the feet, which are uncomfortable Fig 1.9a these can be removed by suitably sloping the door post fig 1.9b and by sloping the side wall

Position of space wheel under the bonnet cover

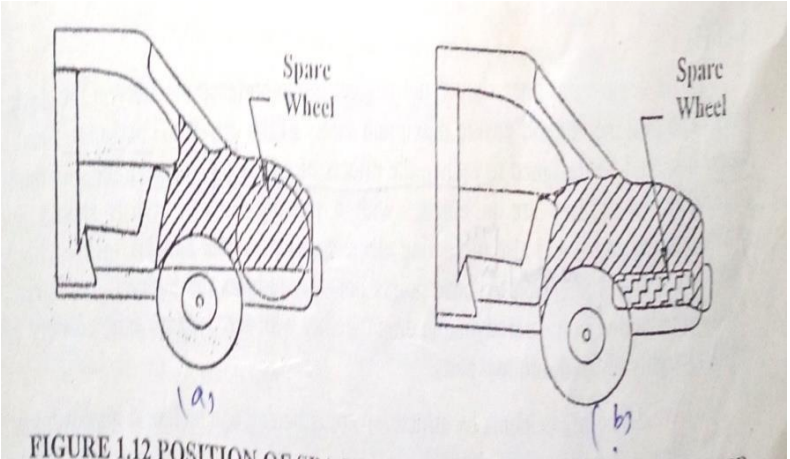


FIGURE 1.12 POSITION OF SPACE WHEEL UNDER THE BONNET COVER

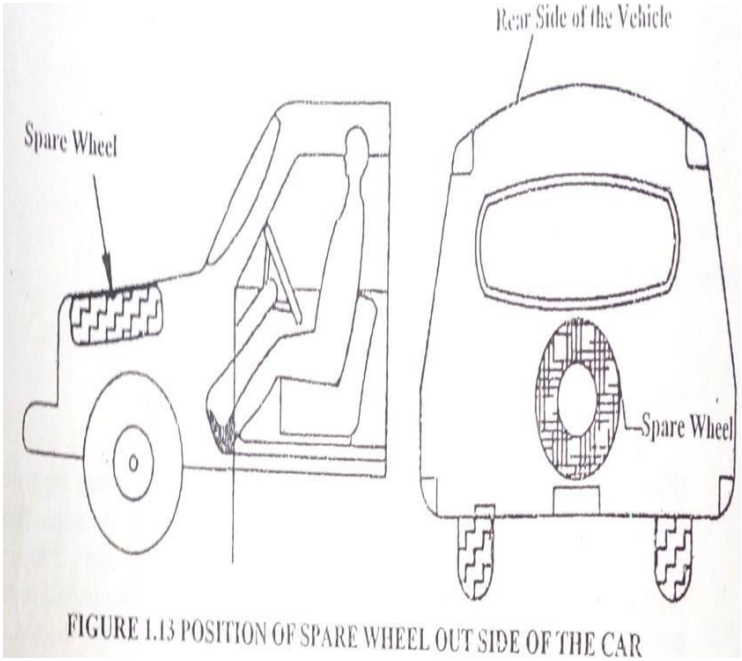


FIGURE 1.13 POSITION OF SPARE WHEEL OUT SIDE OF THE CAR

Fig:6 position of spare wheel

- The method of placing the spare wheel can be employed, depending on the position ofthe engine.
- The engine with the wheel fixed on the front cross member In second method asshown in fig 1.12.
- The wheel is mounded under the engine when the bonnet is raised.

- As both the compartments engine and luggage are often so designed that there is no room in either for an object as large as the spare wheel, the wheel can be stored underthe front seat or in the side wall.
- When trying to achieve a large boot, it is even possible to place the spare wheeloutside the car.
- As shown in fig 1.13 .this makes for good utilization of space and produces a smallercar which is also lighter, resuming in an improved power/ weight ratio.

Drivers Visibility:

- Driver can turn both eyes and head to gain a wider field of view, and
- Moreover can make use of peripheral vision to see objects or movements evenwithout turning eyes.
- In the horizontal plane, the binocular filed of view extends some **120 degrees**
- The eyes generally only turn by about **30 degrees** before the head is turned, which can comfortably give a further **45 degrees** view to either side.

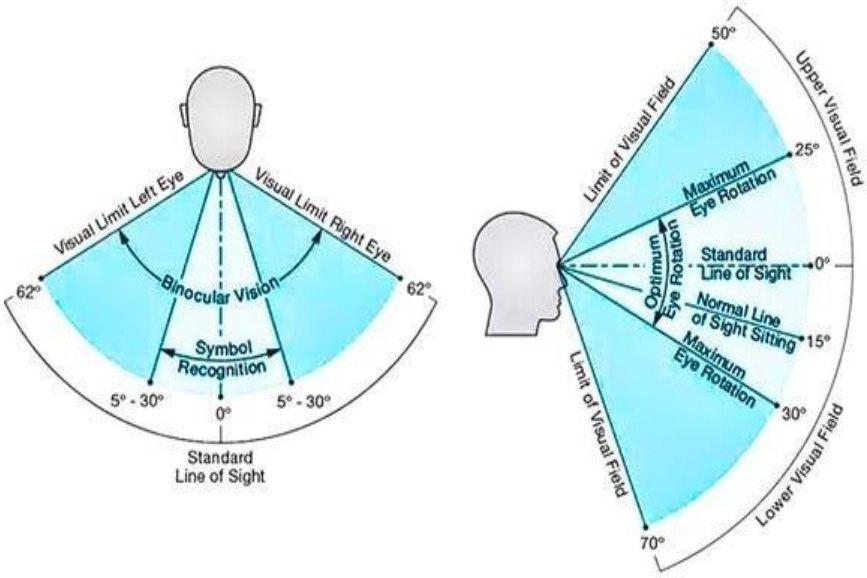


Fig:7 Drivers Visibility

- In the vertical plane eye movement is comfortable within **15 degrees** above or belowthe horizontal,
- Although the eye can see up to **45 degrees** upward or **65 degrees** downward if necessary. On the other hand, head can easily incline **30 degrees** upward or downward.

Visual needs:

- The view ahead through the wind shield has to be sufficient and clear for the driver .
- Rear and side views are important for maintaining speed, taking turn, exerting breakor during parking.
- Views close to the vehicle is equally important when turning left or right and maintainproper distance to avoid accidents.

Field of View of the Driver:

1. Direct view:
2. Indirect View:
3. Blind Spot

Direct view:

- The views observed by the driver directly through eyes are considered as direct views.
- It can be represented by sight lines drawn from the eye to all the points which can beseen, collectively defining the visible field of view .
- The viewing angle above the horizon can be considered for traffic signals and signs. The downwards view can be considered for road.
- Height of the dashboard and curvature of the bonnet are the two determining factor for downward view .

Indirect View:

- The views to the rear of the vehicle mainly obtained through the mirrors .
- This view provides information on passing vehicle, vehicle close to the rear when thedriver proposing to change the lane .
- The view of image is bounded by the frame of mirror.

Blind Spot :

- A blind spot in a vehicle is an area around the vehicle that cannot be directly observedby the driver while at the controls, under existing circumstances.
- Blind spots exist in a wide range of vehicles: cars, trucks, motorboats and aircraft. Other types of transport have no blind spots at all, such as bicycles, motorcycles andhorses.
- Blind spots may occur in the front of the driver when the windshield pillar, side-viewmirror, and interior rear-view mirror block a driver's view of the road.

Methods of Improving Visibility:

1. Windshield:

- The best way to improve visibility is to have car's windshield in a pristine condition. Windscreen is an essential component of the car.
- This helps improve or reduce driver's visibility based on how clean or shiny the windows and the windscreens are

2. Headlights:

- Check headlights for brightness. Headlights dim over time, which can diminish your visibility. Change bulbs to high-quality bulbs that burn brighter.
- Even if both bulbs do not need replacement, change both bulbs at the same time to getthe best results. Look at headlight lenses.
- If they are cloudy and dirty, clean them up to increase driving visibility in rain.
- Use low-beam headlights in the rain to improve visibility and to ensure that others areable to see the car.

3.Rear View Mirrors:

- Adjust side and rear-view mirrors. Make certain to day and night switch, typicallylocated on the rear-view mirror.
- The appropriate setting will help to improve visibility in rain.

4. Side View Mirrors:

- Correcting the problem is all in the angle of mirrors.
- Set side mirrors out fifteen degrees on both sides.
- On the right side, lean your head so that it's even with the driver's side window andadjust the mirror so you can just see the side of your car.
- For the left mirror, do the same while keeping your head in the center of the car.

5.Backup Camera:

- A backup camera removes the concern that your quick reversal out of the garage andin parking lots.
- To compensate for lack of vision at the rear of the car Rear visibility can be improved by getting backup camera .

6.Parking Sensors:

- Parking sensors audibly guide the driver through a ding-free parking experience.

- Like the backup camera, these are available as aftermarket parts or an option on newvehicles.

7.Driving Seat Adjustment:

- Adjust your seat so that you can see comfortably over the wheel and visibility is maximized.

8. Reducing of brightness of Instrument Panel:

- Reducing the brightness of the instrument panel to improve visibility.
- Many drivers set this overly bright, which forces their eyes to overcome the glare.

VISIBILITY REGULATION

- A correct driving position is important in the vehicle layout and the seating position in relation to the steering wheel, foot controls and other secondary controls is of fundamental importance in vehicle body design
- Seating position has an influence not only on the driver's comfort but also the road safety.
- At the design stage a celluloid model is most often used
- The driver's seat should be adjustable 45 mm horizontally and 30 mm 0vertically.

Geometrical relations of driver's seat

Class of vehicle	Cushion height above floor	Angle of cushion inclination	Angle of backrest inclination	Max. force on the pedals
	h (mm)	o	o	(kg)
Saloon	300-340	12	100	66
Light commercial	340-380	10	98	70
Normal control truck	400-470	9	96	74
Forward control truck	430-500	7	92	82

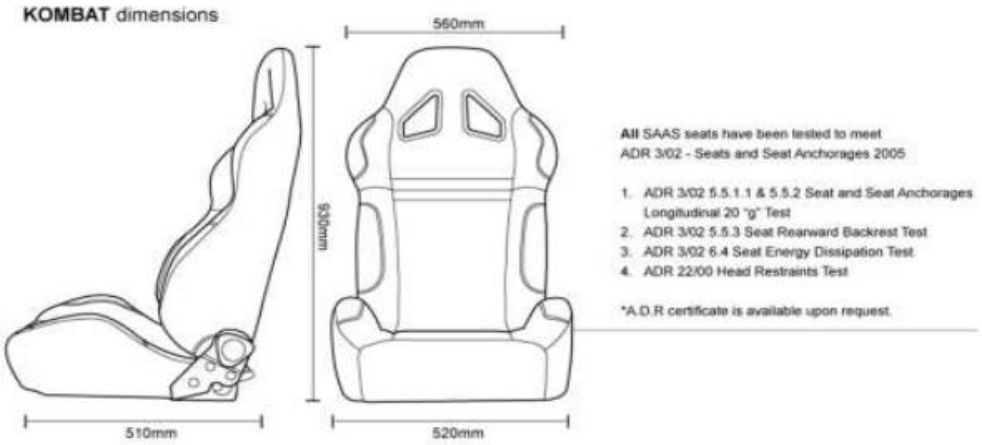


Figure 8: Driver seat regulation

VISIBILITY TEST

- Visibility testing of every vehicle is done from the driver's seat using hi-Tech equipment.
- Every car that passes test lab is assessed in a specially designed visibility rig, using lasers, digital cameras and sophisticated computer software to rate visibility from the driver's eye position
- By fixing a camera at a typical driver's head light, using a fixture in the front seat, we can pan a full 360 degrees around the car's interior, logging how much of the view is clear window
- and how much is obstructive- including the pillars, roof and headrests.
- A "line of sight" test is also carried out to work out whether you can see any low bollards, pets or other hazards while parking- this is affectionately known as the "sausage dog" test.
- Aspects such as the view in the mirrors, the size of the swept area of the windscreen, headlight beam pattern, reversing sensors and wind screen reflections all go towards our overall visibility score

Minimum space requirements and method of improving space in car:

- The amount of space can be allocated to passenger varies according to the dimension and type of body of a given passenger car.
- The window openings should ensure good visibility and not cause any considerable reduction of the stiffness of the body shell.
- The main requirements of the door opening is comfort of entry ,but when dealing with a two door design it must be remembered that free passage way from the back seats must be ensured.
- The measurements of such passage way as given in fig in 1.8 are considered to be the minimum permissible, if these measurements are decreased, entering and leaving the car becomes more difficult
- Four door bodies are more comfortable for passengers, but they are also more expensive .
- If they are well designed they can provide a high degree of comfort.
- This depends on avoiding pockets for the feet, which are uncomfortable and these can be removed by suitably sloping the door post and by sloping the side wall

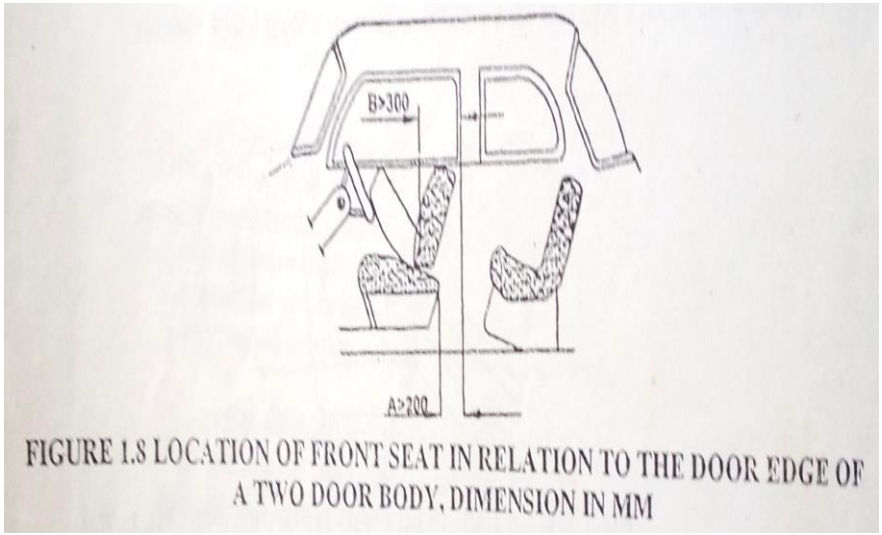


FIGURE 1.8 LOCATION OF FRONT SEAT IN RELATION TO THE DOOR EDGE OF A TWO DOOR BODY, DIMENSION IN MM

How to improve Space in Cars.

1. Put Your Cargo on the Roof:

Even if the car has not come with roof rails or racks, it can be installed for putting the additional luggage and free the space in side the car

2. Put your cargo behind the Back Bumper:

It would be much better to add the cargo to the back of the vehicle, so it can ride for

free in the slipstream behind the car.

3. Hook up a Trailer:

This is the most powerful option.

Luggage can be put in the trailer and free space in the car for seating and creating a space for additional passengers.

4. Designing of low floor cars:

By designing low floor of the car, space can be improved.

5. Designing of wheel arches:

By designing wheel arches properly, some extra space can be created which is highly desirable in passenger car.

Method of placing the spare wheel:

Placing the spare wheel in the car including on the top of fuel tank, in the rear boot, on the front cross member, on the bonnet, on the roof and outside the car

Placing wheel outside the car can create space inside the car.

7. Designing adjustable seats:

By designing adjustable seats, space can be created according to the requirement.

Rear seats backrest can be folded to accommodate more luggage.

8. Designing the car with respect to engine and drive wheels:

More space may be created with rear engine and rear wheel drive combination.

VEHICLE SAFETY

- The vehicle designer should not neglect the importance of safety in the design of body work.
- The designer should ensure maximum safety of the driver, the passengers and other road users.
- It should be designed to reduce the effects of collision.
- To ensure the minimum injury to pedestrians when they are in contact with a moving vehicle, stylists should avoid sharp ornaments and edges and also projecting elements, such as door handles, mirrors, hooks, control knobs etc. careful attention to these points not only reduces the injury to pedestrians but also effects a reduction in aerodynamic drag together with aerodynamic noise .

Safety engineering can be roughly divided in to two parts.

- Avoidance of accidents by structural strengthening and technical improvements in such areas as brakes and steering.
- Reduction in severity of such accidents as will occur. In the second factor the trim engineer will find sample room to exercise his ingenuity.

Safety and Safety Design Equipment for Car

Seat belts :

They prevent occupants being ejected from the vehicle and ensure that theyare in the correct position for the operation of the airbags.

Airbags :

The most important being the prevention of direct impact of the driver's headwith the steering wheel and door pillar.

Head injury protection :

These are designed to help protect occupants from injuries caused when theirhead strikes the upper interior of a vehicle.

Laminated windshields :

Tempered glass side and rear windows break into granules with minimallysharp edges, rather than splintering into jagged fragments as ordinary glassdoes.

Safety Cell :

The passenger compartment is reinforced with high strength materials, at places subject high loads in a crash, in order to maintain a survival space forthe vehicle occupants.

Side impact protection beams also called anti-intrusion bars.

Collapsible universally jointed steering columns:

This reduces the risk and severity of driver impact or even impalement on thecolumn in a frontal crash.

Cargo barriers:

These help prevent injuries caused by occupants being struck by unsecured cargo. They can also help prevent collapse of the roof in the event of a vehiclerollover.

Anti-lock braking system (ABS) :

Prevents skidding allowing the driver to remain in control. The vehicle stopsmore quickly as There's more friction between the road and tires.

Traction control:

Prevents skidding while accelerating so the car can quickly escape adangerous situation.

Daytime Running Lights (DRL):

(DRL) are multi-purpose or specially designed lights on the front of a vehiclefor use in daytime to increase its visibility and avoid multi-party crashes.

Impairment detection systems:

Several systems exist for detecting driver impairment caused by excess alcohol, drowsiness, illness, or drug abuse, which prevent the vehicle from starting or warn the driver or perform an emergency control function that willstop the vehicle

There are other features designed to help prevent accidents by reducing distractions while driving. They include:

- Electric windows – make it easier to open and close windows
- Cruise control – helps reduce accidental speeding
- Paddle shift controls – allows the driver to keep both hands on the steering wheel while changing gear or radio stations
- Adjustable seats – makes the driver more comfortable

Safety

- The vehicle designer should not neglect the importance of safety in the design of body work.
- The designer should ensure maximum safety of the driver, the passengers and other road users.
- It should be designed to reduce the effects of collision.
- To ensure the minimum injury to pedestrians when they are in contact with a moving vehicle, stylists should avoid sharp ornaments and edges and also projecting elements, such as door handles, mirrors, hooks, control knobs etc. careful attention to these points not only reduces the injury to pedestrians but also effects a reduction in aerodynamic drag together with aerodynamic noise**.**

Safety engineering can be roughly divided in to two parts.

- Avoidance of accidents by structural strengthening and technical improvements in such areas as brakes and steering.
- Reduction in severity of such accidents as will occur. In the second factor the trim engineer will find sample room to exercise his ingenuity.

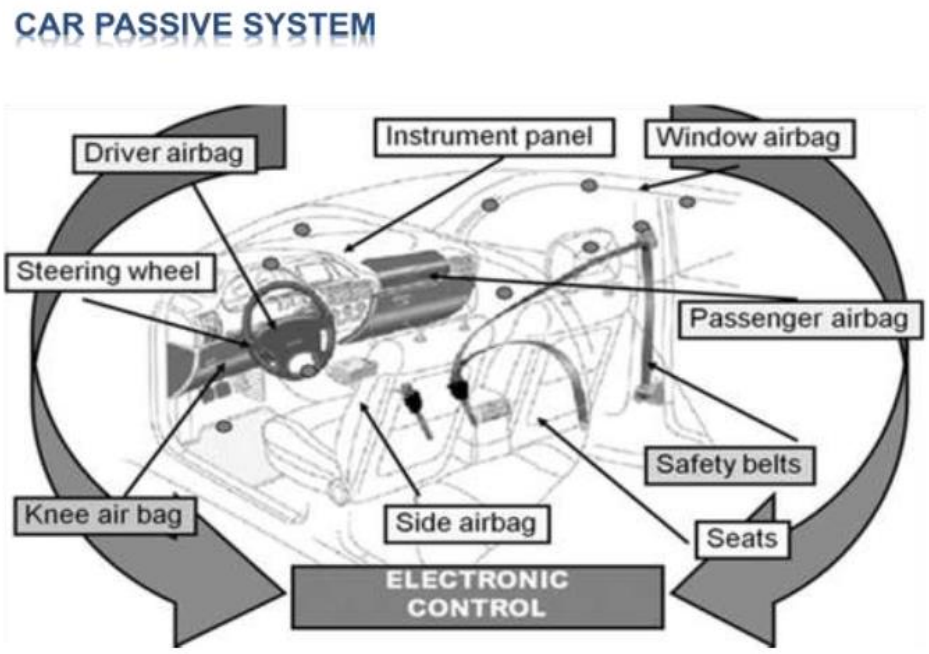
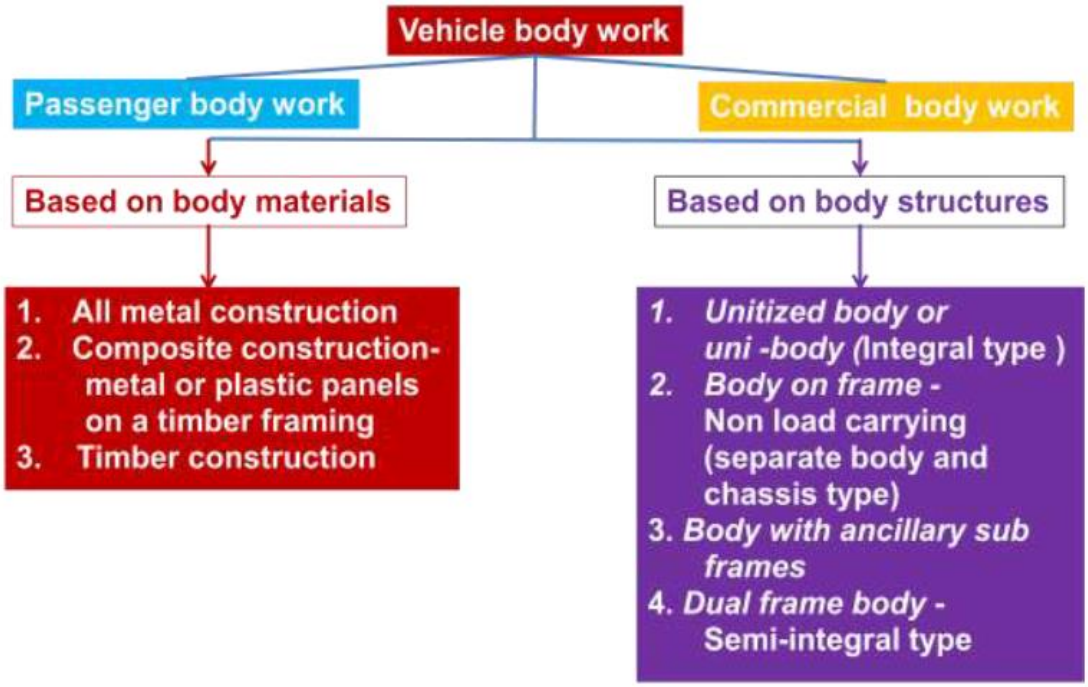


Figure 9: Various safety system in vehicle

CAR BODY CONSTRUCTION



UNI BODY CONSTRUCTION (INTEGRAL TYPE BODY)

- A Unitized body or unibody in which the chassis parts cannot be physically removed from the upper body part
- In the case all the units like suspensions and other mechanical parts are directly fitted (using brackets) to the body frame which is then directly attached to the vehicle body.

- The integral or frameless construction in which the structure is designed in such a manner that it combines the function of body and frame
- In the more modern unibody construction used in the cars today, the integral floor pan is the main structural elements

Advantages

- It is relatively low height

Disadvantages

- Low dimensional precision of suspension attachment
- Lower filtering performance of the suspension fitting
- Reducing the insulation of vibrations due to road wheel excitation.

BODY ON FRAME (CONVENTIONAL BODY)

- In this type of body the chassis frame is connected to the upper frame by bolts with or without the inter position of rubber bushes
- Body on frame construction means a vehicle body utilizes a rigid steel frame separate from the body
- The ladder type frames provides the vehicle strength and attachment points for the mechanical components

Advantages

- Allowing the adoption of one chassis for different body shapes.
- Providing mechanical parts standardization
- Simplification of the assembly process of a mechanical chassis before being matched to the upper body.

BODY WITH ANCILLARY SUB FRAMES

- In this type of car body, the power train and suspension systems are connected between the sub frame and the body can be either rigid or through elastic bushes
- The main advantages are modularity and division of the assembly process between parallel lines, enabling components to be mounted on the sub frames
- The resulting sub-assemblies can be tested before integration with main body
- Moreover, the relative ease in which elastic and damping devices between sub frame and body can be inserted, provide an improved insulation from noise and vibration.
- The main disadvantages is increased the weight but to a lower extent than configuration of previous body.

DUAL FRAME BODY

- In this case the body and chassis are separate and connected through elastic and damping bushes
- In this configuration, the structural, safety, propulsion and driving functions are concentrated and optimized in the chassis, with priority to front and rear crash absorption, torsional stiffness and resistance to stress induced through the suspension and power train

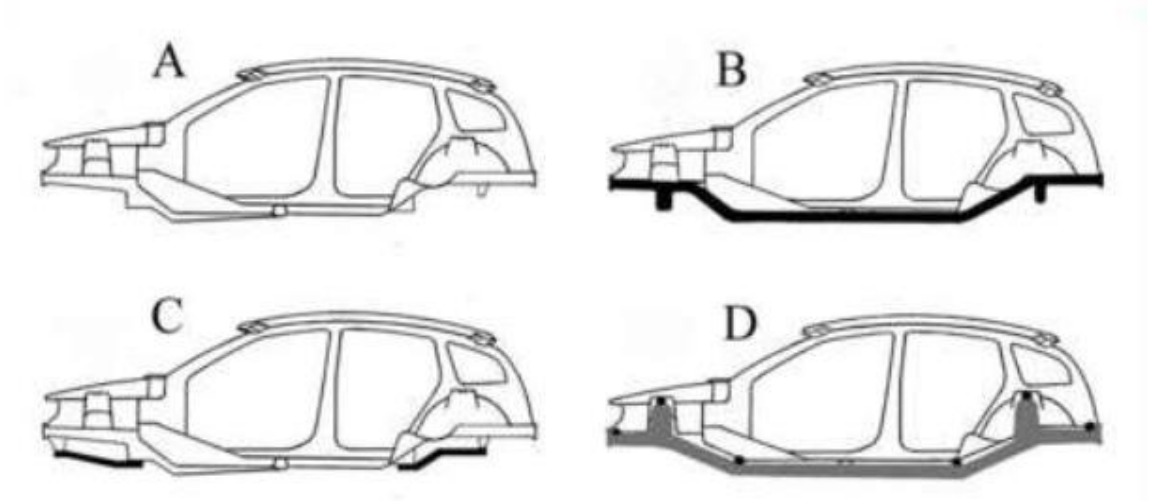


Figure 10: Various vehicle frame construction

CAR BODY TERMONOLOGY

Chassis- The basic frame for a motor vehicle

A Post- the post on which the front door hinges are fixed

Body Mounting- Fittings for mounting the body to the chassis for older types of car or heavier vehicles

Composite Construction- The chassis and body of the vehicle are built as two separate units

Integral Construction- Most modern light vehicles use this method, also called mono or unity construction. The body and chassis are combined

Car Derived Van- A van which is based on a similar car

Body Panels- Wings, Bonnet and door etc

BC post- The centre post, the B post has the front door striker plate and the C has the hinges for the rear doors. Only appropriate to four/five door vehicles

D post- The rear post on which the rear door striker is fitted. Front door striker if a two/three door vehicle

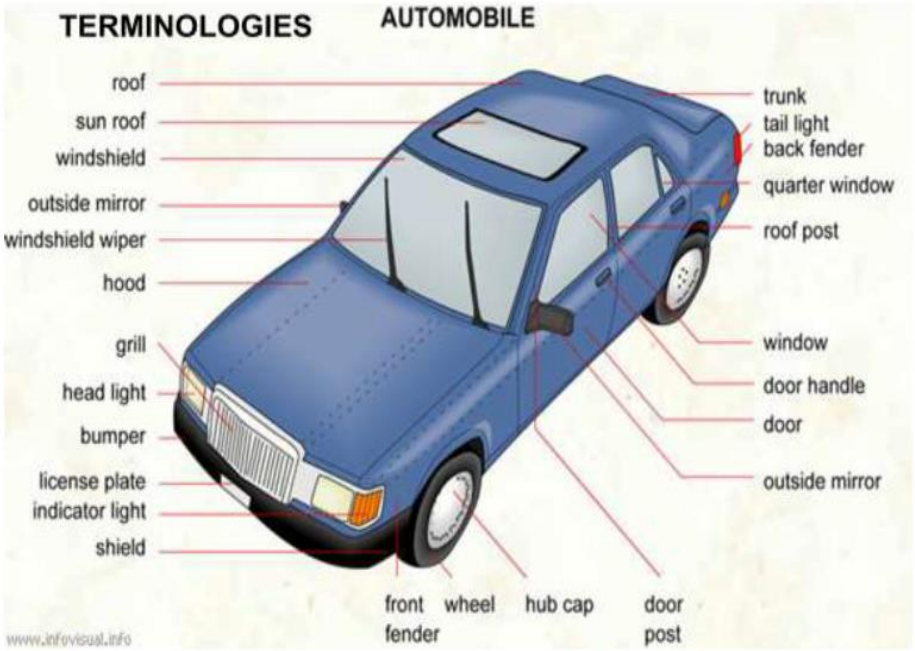


Figure 11: Vehicle Terminologies (External body)

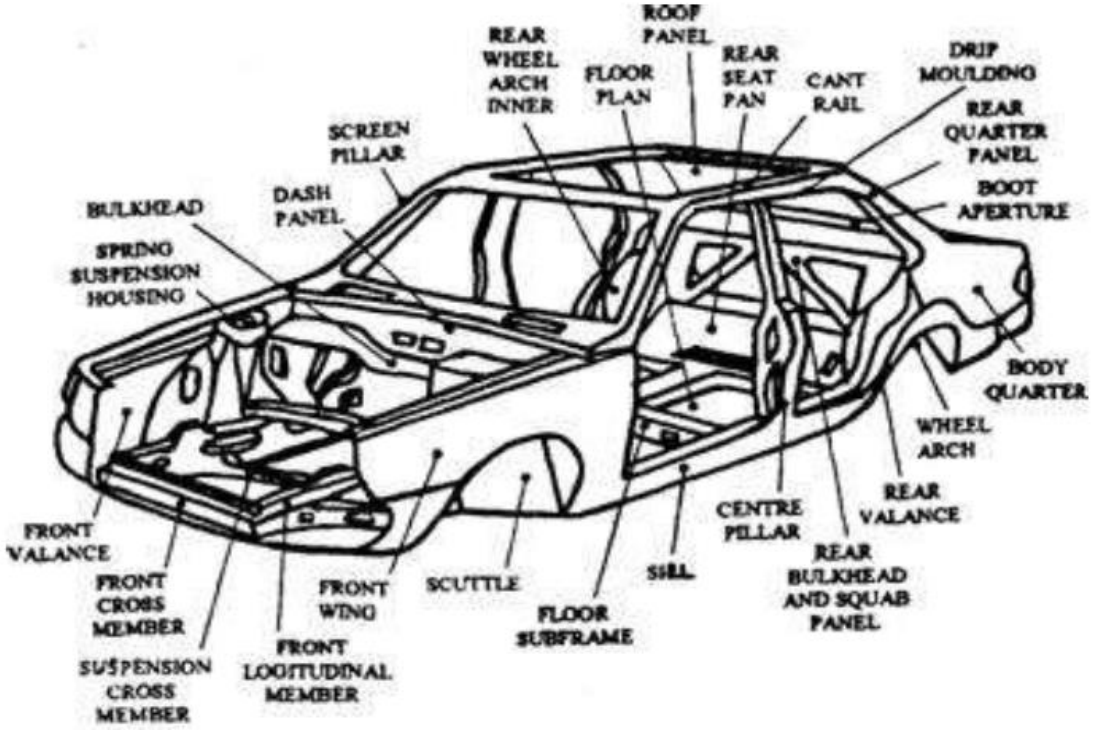


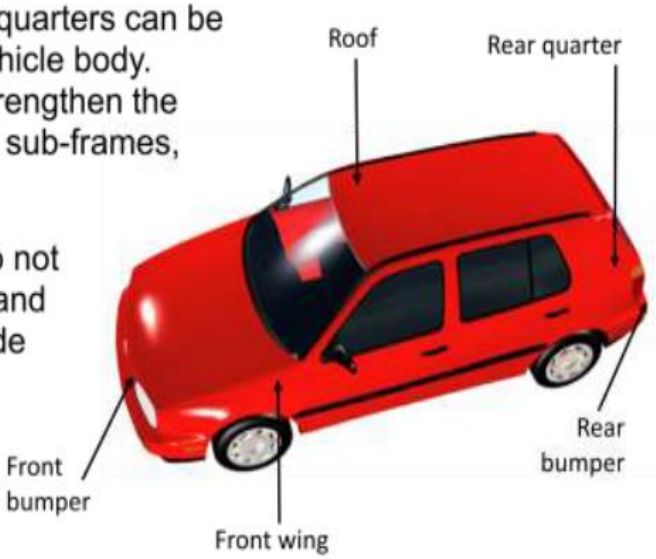
Figure 12: Vehicle Terminologies (Internal body)

All vehicle component locations are identified by sitting in the driving seat. These are front, rear, left and right. In the diagram below, the left front wing can easily be identified.

The roof, front wings and rear quarters can be used to help strengthen the vehicle body. Other parts can also help to strengthen the vehicle body e.g. glass, doors, sub-frames, chassis and floor-pan.

On convertible vehicles that do not have a rigid roof the floor pan and centre tunnel are normally made stronger and stiffer.

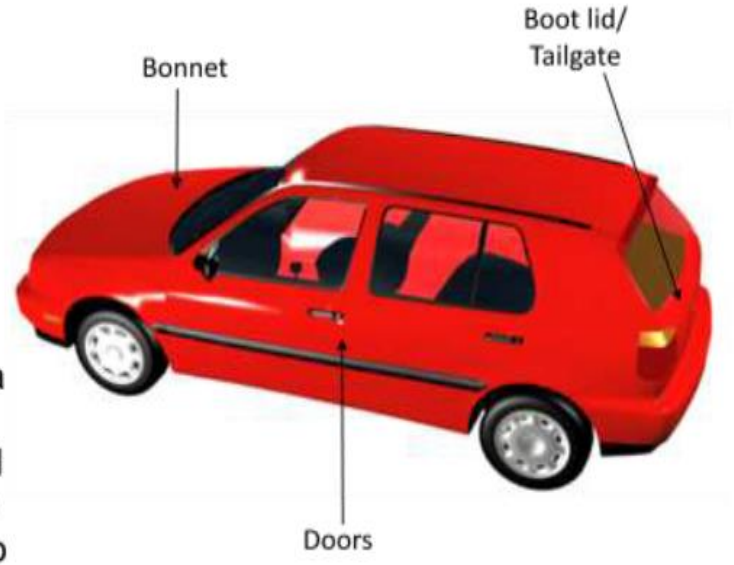
The front and rear bumpers offer some protection in low speed front or rear impacts.



The bonnet is a hinged cover for the engine compartment. It can be hinged to open toward the windscreen toward the front of the vehicle, or in some cases toward either wing.

The **boot lid** is a hinged cover over the boot. The boot is used as an area to store luggage or other items.

The doors are used as a means for the vehicle passengers to enter and leave the vehicle. When closed, the doors help to strengthen the vehicle.



DESIGN CONSIDERATIONS & BODY CONSTRUCTION

DESIGN CONSIDERATIONS

- Artistic Utilitarian Design:
- Aesthetically pleasing body shape is set out considering aerodynamics and other design requirements
- The design of a shape based on the elements of functions and logic together with an artistic appreciation of forms is called "artistic utilitarian design ". Such designs have advantage over irrational styling and is a necessary part of good design.
    1. Design Considerations
    2. Dummies & Models:

- The dimensionally complicated form of vehicle bodies require practical checking at all stages of design. These are carried out by means of dummies and models
- Dummies: Dummies are built to ensure that the principal dimensions are compatible. This includes dimensions of driver's position, passenger's seat, size of door & window openings, etc.
- Models: Inside dimensions of a vehicle body, having being checked & finalized with dummies, form the basis for developing models of the outside surfaces of the body.
- Scale models (say 1 in 20) are constructed using materials like plasticine or plaster of paris laid on a wooden base with tools such as knives & spatulas, etc. Some scribing devices are used as measuring

SUB- ASSEMBLIES & CONSTRUCTION OF BODY SHELL

Various sub-assemblies are :

- Underbody assembly
- Body side assembly
- Shroud and dash panel assembly
- Roof & back window aperture panels
- The Center pillar (B- C post)
- Rear Bulk-head and parcel shelf
- Front end work

- Front wings
- Door panel assembly
- Bonnet panel assembly
- Boot lid assembly
- Under body assembly

UNDER BODY ASSEMBLY

- This positions the engine, transmission, wheel- arches, seats, etc.
- Body sills provide longitudinal edge reinforcements
- The floor pan strengthened by; box members at right angles to the transmission tunnel; all cross members at the rear, front of the front seats, front of the rear seats, etc. joined together provide lateral reinforcements.
- The transmission tunnel, which acts like an inverted channel section provide central strength built into the floor
- The remaining area of flat metal is ribbed or dished below the seats and in the foot wells to add stiffness to the sub-assembly

BODY SIDE ASSEMBLY

- The side frames reinforcing the floor pan, body sills also transmit loads between them
- The center pillars are welded in between the body sill and the roof / cant rails.
- These are usually assembled as a box section using a 'top-hat' section and flat plate, with the flanges forming attachments for the door, weather seals, etc.
- The front hinge pillars extend forward to join with the dash panel, front bulkhead cross member. This provides strength by 'boxing' the front end**.**

SHROUD & DASH PANEL ASSEMBLY

- These assemblies are complex structures connecting the two body sides across the car
- The complete assembly is also called the firewall because it is the partition between the passenger and engine compartment, and carries part of the forces set up by the front suspension, weight of the power unit.
- The heating / cooling systems & its distribution chamber, instrument panel & its necessary controls, wiring, tubing, etc., the steering column are all attached to the front bulk head of the body and is usually formed by assembling together several smaller panels (dash & shroud) which are joined by welds to form an integral unit.
- The instrument panel connected to the cowl panel provides mountings for instruments.
- In some cases the wind screen opening is connected to the cowl panel. In this case the windscreen pillars, the narrow sloping construction at either side of the windscreen opening are part of the cowl. Upper edge of the cowl panel forms the front edge of the roof

DOOR PANEL ASSEMBLY

- The window channel may be welded or bolted to inner door panel to provide support & direction to the window glass.
- The inner panel has holes or apertures drilled, punched or formed for attachment of door trims.
- The thickness of the door is due to the depth of the inner panel which accommodate door catch, window mechanism, etc.
- The inner panel forms the lock pillar and the hinge pillar sections of the door. Small reinforcement angles are usually used between the outer and inner panels where lock is inserted through the door and the hinges are attached.
- The outer panel is provided with an opening through which outside door handle protrudes.

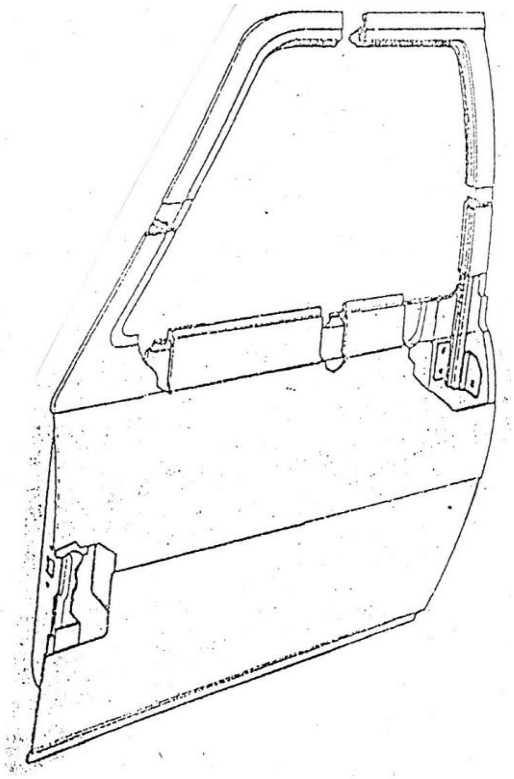


Figure 13: Door panel assembly

BONNET ASSEMBLY

- The bonnet is the panel covering the engine compartment.
- Most one-piece bonnets are hinged at the rear so that the front end swings up when opened. The catches are at front and in most cases controlled from inside the car.
- One-piece bonnets are quite large and, to make opening easier, the hinges are usually counter - balanced by means of tension or torsion springs.
- Smaller bonnets are held in place by a stay
- The bonnet consists of the outer panel and inner reinforcement constructed in the 'H' or cruciform pattern. The reinforcement is basically a top-hat section to give rigidity to the component.
- The main strength of the bonnet lies in the fact that the inner construction acts like a frame and the outer panel is formed round its edges, acting as flanges

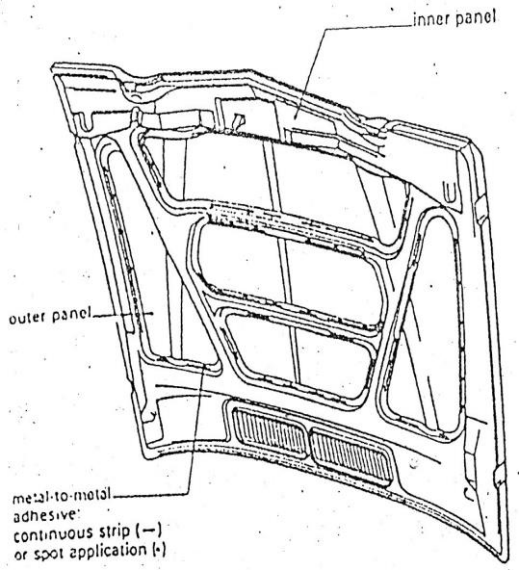


Figure 14: Bonnet Assembly

BOOT LID ASSEMBLY

- The boot lid is composed of an inner and an outer panel spot-welded together along their flanged edges to form a single unit.
- Both type of hinges; external & concealed are used.
- A catch is provided at the bottom rear of the boot lid and controlled by an external handle. In some models handles are not provided. The hinges are spring loaded so that lid rises automatically by the hinge mechanism for opening & holding it in place.

TEXT / REFERENCE BOOKS

1. Powloski J, "Vehicle Body Engineering", Business Books Ltd., London 1989.
2. John Fenton, "Vehicle body layout and analysis", Mechanical Engg. Publication ltd, London, 1982.
3. Kohli P. L, "Automotive Chassis & Body", Papyrus Publishing House, New Delhi, 2010.
4. Wolf-Heinrich Hucho, "Aerodynamics of Road Vehicles" SAE International,USA,1998.
5. Robinson A.,Livesey W. A, "The Repair of Vehicle Bodies", Butterworth - Heinemann Ltd,1989
6. Sumantran V. and Gino Sovram, "Vehicle Aerodynamics", SAE International, USA, 1994.
7. John Fenton, "Vehicle Body Layout & Analysis", Hutchinson, London, 1998.

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE
www.sathyabama.ac.in

UNIT 2 - VEHICLE AERODYNAMICS

UNIT-2

VEHICLE AERODYNAMICS

INTRODUCTION

When objects move through air, forces are generated by the relative motion between air and surfaces of the body, study of these forces generated by the motion of air is called aerodynamics.

IMPORTANCE OF AERODYNAMIC STUDY:

- To reduce drag force and achieve max speed and acceleration for the same power output.
- If drag force is reduced, fuel consumption of the vehicle can be reduced, to the max about 35% of fuel cost could be reduced by proper stream lining.
- Good aerodynamic design gives better appearance and styling.
- by reduce the various forces and moments ,good stability and safety can be achieved.
- This study helps to provide proper ventilation system.
- Helps to understand the direct flow and exhaust gas flow.
- With proper aerodynamic design, aerodynamic noise could be redused, which results in quite running of the vehicle.

FIELD OF APPLICATION:-

1. Aerospace Engineering
2. Design of Automobile
3. Prediction of forces & moments in ships and sails
4. In design of bridges and buildings for calculating wind loads

Lift:-

It is the sum of all fluid dynamic forces on a body normal to the direction of external flow around the body. it is caused by Bernoulli's effect . It results body to rise by creating pressure difference.

Drag:-

It is the sum of all external forces in the direction of fluid flow, so it acts opposite to the direction of the object. it is the force which opposes forward motion of the body through fluid.

Weight:-

It is actually just the weight of the object that is in motion. i.e. the mass of the object multiplied by the magnitude of gravitational field.

Thrust:-

When a body is in motion a drag force is created which opposes the forward motion of the object so thrust can be the force produce in opposite direction to drag. it must be higher than that of drag so that the body can move through the fluid.

STUDY OF AERODYNAMICS IN CARS:

In order to improve the aerodynamics of cars, we must know how the flow of air past a car. The major forces which affecting the motion of car in fluid flow are,

Drag Force 2.Lift or Down force.

1. Drag Force:-

some energy are lost to move the car through the air & this energy is used to overcome a Drag force. In vehicle aerodynamics drag is due to Frontal pressure and Rear vacuum.

For calculating drag force following formula is use

$$F = \frac{1}{2} CDAV^2$$

Where, F - Aerodynamic drag force

A - Frontal area

C - Coefficient of drag
V - Velocity of object
D - Density of air

Coefficient of drag:-

The drag coefficient is a common measure of aerodynamic efficiency in a automotive design.

The drag coefficient is a unit less value that denotes how much an object resists movement

through a fluid such as water or air.

FRONT END OF CAR

Drag Force due to Frontal pressure:-

This Drag force is caused by the air attempting to flow around the front of the car.

When Air molecules approach the front of the car they begin to compress and raise

the air pressure in front of car. Frontal pressure is reduced by minimizing exposed

frontal surface area and making front end smooth, continuous curve originating

from the line of front bumper allowing the air molecules to pass smoothly

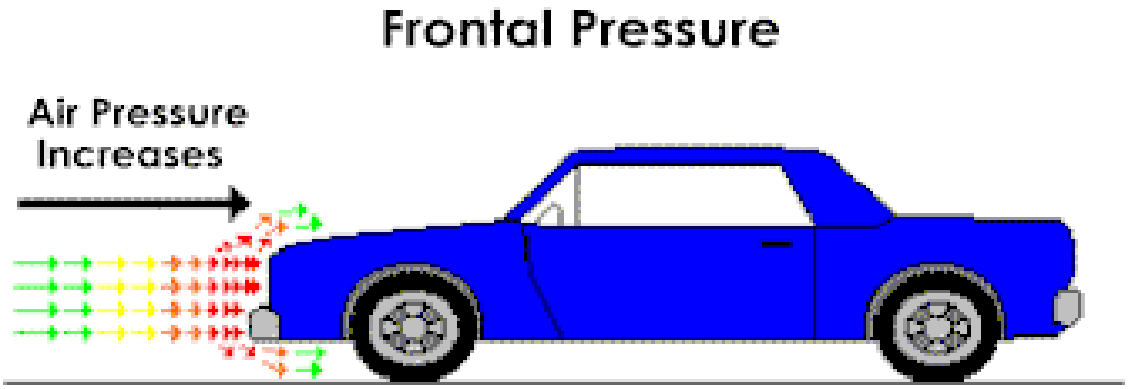


Fig:1 frontal pressure

REAR END OF CAR

Drag Force due to Rear Vacuum:-

Rear vacuum is caused by the Flow Detachment in the air flow as the car passes through it. Flow Detachment is inability of air molecules to fill the empty zones which are created at the rear end of vehicle.

This results in continuous vacuum zone in the opposite direction of Vehicle motion in the rear area Drag forces are increases due to turbulence in the rear end which is caused due to flow detachment.

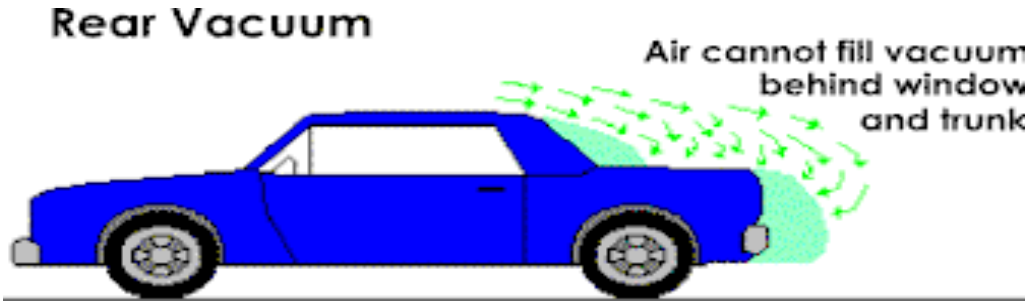


Fig:2 Rear vacuum

LIFT OR DOWN FORCE:-

Every object travelling through air creates either a lifting or down force situation. Down force is the same as the lift experienced by airplane wings, only the difference is, it acts to press down, instead of lifting up.

It is calculated as

$$F = (1/2)\, CLdV2A$$

For a given volume of air, the higher the speed of air molecules, the lower is the pressure and vice-versa This creates low pressure over hood, roof and trunk which increase the chances of rise of vehicle.

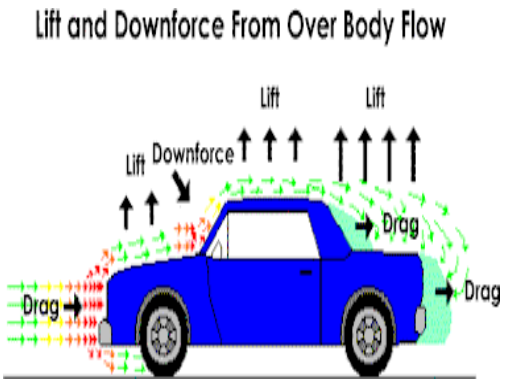


Fig:3 lift and downforce

The underside of the car is also responsible for creating lift or down force. If a car's front end is lower than the rear end, then the widening gap between the underside and the road generates vacuum or low pressure area, and therefore suction is created that equates to down force. Overall to increase the performance of car aerodynamically. It is necessary to Generate right amount of Down Force While keeping Drag Force to a minimum level

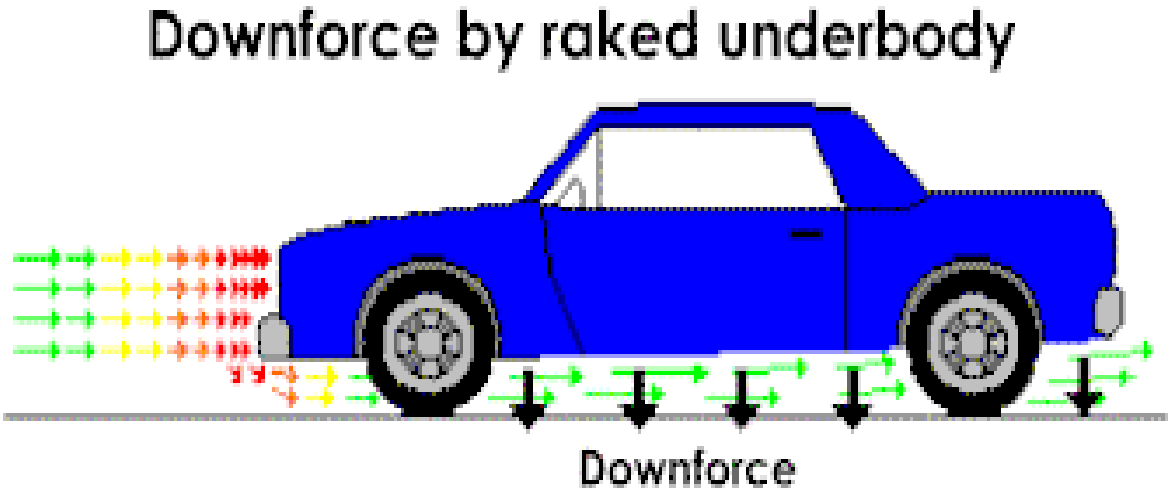


Fig:5 Downforce

AERODYNAMICS DEVICES IN CARS:

- WINGS
- SPOILER
- SCOOPS

WINGS:-

Probably the most popular form of aerodynamic device is the wing. Wings perform very efficiently and generating lots of down force in the car. The wings works by differentiating pressure on the top and bottom surface.

Air molecules approaching the leading edge of the wings are forced to travel different distances over and below the wings. Which results in lower pressure area under the wing and allows the higher pressure area above the wing to "push" down on the wing, and hence the car is stable during high speed.

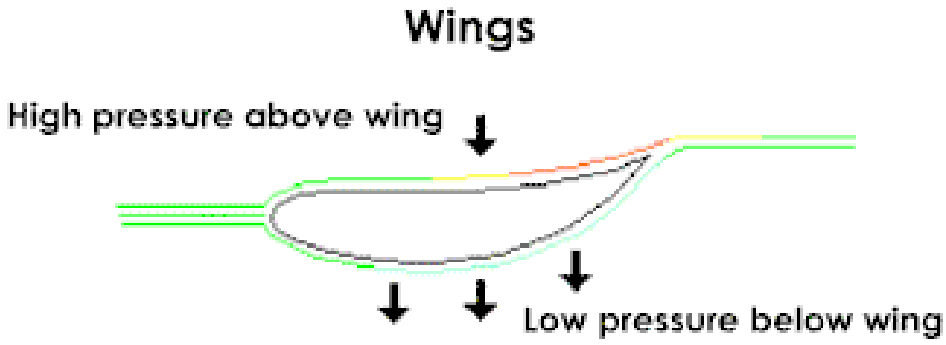


Fig:6 Wings

Spoiler:-

They act like barriers to air flow, in order to build up higher air pressure in front of the trunk of car.

It is mostly used in race cars which are lighter in rear end because low pressure created above the trunk which lifts the rear end of car.

Hence spoilers are use to create high pressure that pushes down the car and also it gives stability at corners.

Fig:7 Spoiler

Scoops:-

Scoops or positive pressure intakes consist of the air box which has an opening that permits an adequate volume of air to directly enter. Its main function is to provide high pressure, denser and adequate volume of outside air directly into the engine compartment.

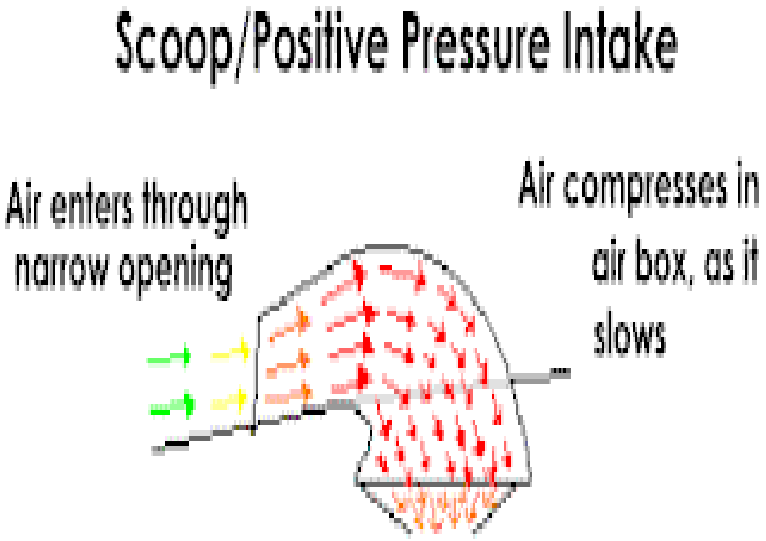


Fig:9 scoop

Aerodynamic Forces and Moments:

- The profile of the vehicle is the principle component of aerodynamic drag and is governed by the way in which vehicle disturbs the air stream.
- Its behavior has been found not to accord with established aerodynamic theory evolved

in aviation since vehicle has to maintain contact with the ground.

- The importance of a good aerodynamic parameters in the design of a vehicle is being increasingly recognized. The designer must have knowledge of the forces and the laws governing them in order to produce body shapes which will have acceptable aerodynamic characteristics The car body profile shown having smooth streamlines which are continuous and with no separation of boundary layers & vortices. However, like an aerofoil, the streamlines over the upper part have a higher velocity than the streamlines below the car.
- For complete description of aerodynamic effects on the motion of the vehicle it should be considered as a mass having six degree of freedom and the aerodynamic forces and moments acting on the vehicle are balanced by the wheel reactions

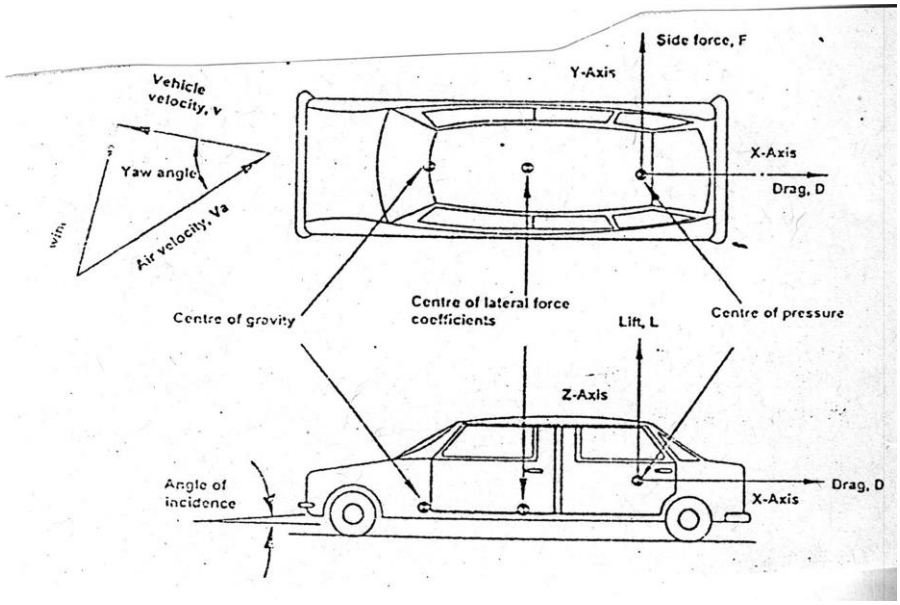


Fig:10 wind tunnels

Wind tunnels:

Wind tunnels are large tubes with air blowing through them. The tunnels are used to replicate the actions of an object flying through the air or moving along the ground. Researchers use wind tunnels to learn more about how an aircraft will fly. NASA uses wind tunnels to test scale models of aircraft and spacecraft. Some wind tunnels are large enough to contain full-size versions of vehicles. The wind tunnel moves air around an object, making it seem as if the object is really flying.

Most of the time, large powerful fans blow air through the tube. The object being tested is held securely inside the tunnel so that it remains stationary and does not move. The object can be a small model of a vehicle, or it can be just any part of a vehicle. It can be a full-size aircraft or spacecraft. It can even be a common object like a tennis ball. The air moving around the stationary object shows what would happen if the object was moving through the air. The motion of the air can be studied in different ways; smoke or dye can be placed in the air and can be seen as it moves around the object. Coloured threads can also be attached to the object to show how the air moves around it. Special instruments can often be used to measure the force of the air exerted against the object.

The earliest wind tunnels were invented towards the end of the 19th century, in the early days of aeronautic research, when many attempted to develop successful heavier-than-air flying machines. The wind tunnel was envisioned as a means of reversing the usual paradigm: instead of the air standing still and an object moving at speed through it, the same effect would be obtained if the object stood still and the air moved at speed past it. In that way a stationary observer could study the flying object in action, and could measure the aerodynamic forces being imposed on it.

The development of wind tunnels accompanied the development of the airplane. Large wind tunnels were built during World War II. Wind tunnel testing was considered of strategic importance during the Cold War development of supersonic aircraft and missiles.

Later, wind tunnel study came into its own: the effects of wind on man-made structures or objects needed to be studied when buildings became tall enough to present large surfaces to the wind, and the resulting forces had to be resisted by the building's internal structure. Determining such forces was required before building codes could specify the required strength of such buildings and such tests continue to be used for large or unusual buildings.

Still later, wind tunnel testing was applied to automobiles, not so much to determine aerodynamic forces per se but more to determine ways to reduce the power required to move the vehicle on roadways at a given speed. In these studies, the interaction between the road and the vehicle plays a significant role, and this interaction must be taken into consideration when interpreting the test results. In an actual situation the roadway is moving relative to the vehicle but the air is stationary relative to the roadway, but in the wind tunnel the air is moving relative

to the roadway, while the roadway is stationary relative to the test vehicle. Some automotive-test wind tunnels have incorporated moving belts under the test vehicle in an effort to approximate the actual condition, and very similar devices are used in wind tunnel testing of aircraft take-off and landing configurations.

Effects of side winds:

1. The series effects of side winds are illustrated in fig.
2. If the center of wind pressure is in front of the center of gravity, the car will try to turn round like a wind vane.
3. Even allowing for a rapid reaction time, a considerable must be applied.
4. when the center of gravity lies in front of the center pressure however, the car will tend to right itself.

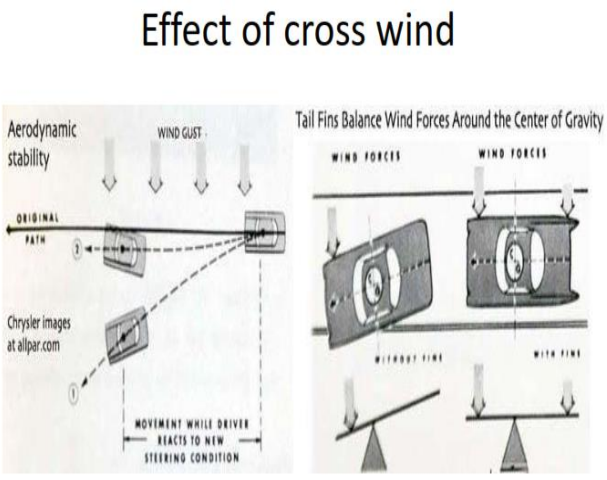


Fig:11 Effect of cross wind

Flow visualization method:

- Flow visualization is a very useful technique with aerodynamic air flow pattern amount the vehicle and inside the vehicle is basically responsible for all aerodynamic characteristics of a vehicle.

- Hence if one wants to evolve a new aerodynamic design. The must understand the air flow pattern around and inside the vehicle to fulfill this objective flow visualization of the methods are used flow pattern car be obtained by using smoke or tuft method and oil coating method

Smoke method:

- Dence white smoke lines can be created in the tunnel near test section.

- When the tunnel is operated.

- This clearly visible lines are deflected based on the shape of the model and flow pattern can be photographed by providing transparent side walls of the test section

Tuft method:

- In this method small about one which woolen threads will be fixed on the model with proper gaps between threads.

- With the model mounted and tunnel operated the tufts will truly deflects along the air direction .

- By photographing the tufts on the model the flow pattern can be obtained.

Oil coating method:

- A thin layer of special oil can be coated on the model.

- on operating the tunnel a definite impression can be formed on the model.

- All types of vortex formation and flow separation can be judged based on the off impression any one method can be used depending on the facility.

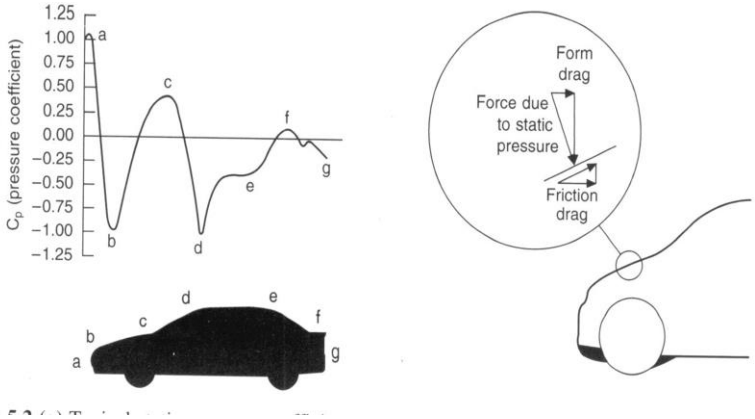


Fig:12 coefficient of pressure

Table:1 Values of Aerodynamic Resistance

TABLE 3.3 Values of Aerodynamic Resistance Coefficient for Various Types of Vehicle

Vehicle Type	Aerodynamic Resistance Coefficient C_D
Passenger cars	0.3–0.52
Vans	0.4–0.58
Buses	0.5–0.8
Tractor-semitrailers	0.64–1.1
Truck-trailers	0.74–1.0

Source: Reference 3.10.

TEXT / REFERENCE BOOKS

1. Powloski J, "Vehicle Body Engineering", Business Books Ltd., London 1989.
2. John Fenton, "Vehicle body layout and analysis", Mechanical Engg. Publication ltd, London, 1982.
3. Kohli P. L, "Automotive Chassis & Body", Papyrus Publishing House, New Delhi, 2010.
4. Wolf-Heinrich Hucho, "Aerodynamics of Road Vehicles" SAE International,USA,1998.
5. Robinson A.,Livesey W. A, "The Repair of Vehicle Bodies", Butterworth - Heinemann Ltd,1989
6. Sumantran V. and Gino Sovram, "Vehicle Aerodynamics", SAE International, USA, 1994.
7. John Fenton, "Vehicle Body Layout & Analysis", Hutchinson, London, 1998.

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE
www.sathyabama.ac.in

UNIT 3 - BUS BODY AND COMMERCIAL VEHICLE DETAILS

UNIT 3

BUS BODY AND COMMERCIAL VEHICLE DETAILS

CLASSIFICATION OF BUSES

Passenger carrying buses are classifies based on:

1) Distance traveled by the vehicle
2) Capacity of the vehicle
3) Shape and Style of the vehicle

1**. Distance traveled by the vehicle**:

1. Mini bus 2.Town bus 3.Suburban bus 4.Long Distance Coaches 5.Touring Coaches 6.Midi bus

1. MINI BUS:

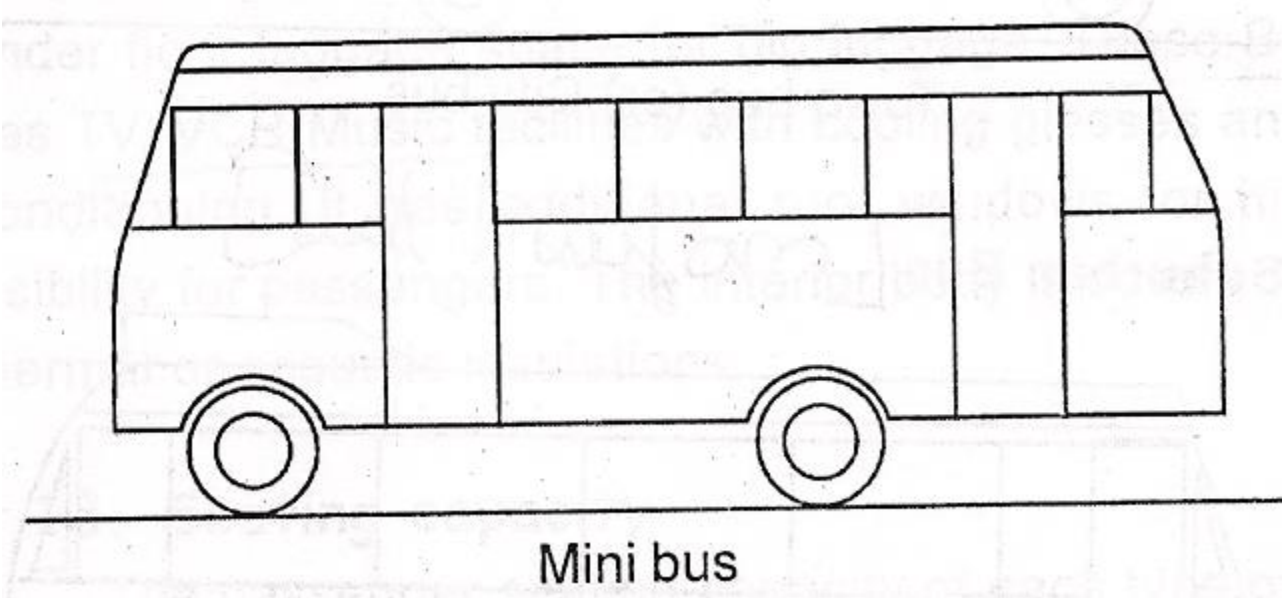


Fig:1 mini bus

Fig:2 Mini bus

- It should have a seating capacity upto 25.
- It built on light duty truck chassis.
- It has front mounted engine and rear axle drive.
- It has soft and comfort suspension.
- It has reasonably comfortable seat.
- It has fairly small entry platforms.

2. Town bus

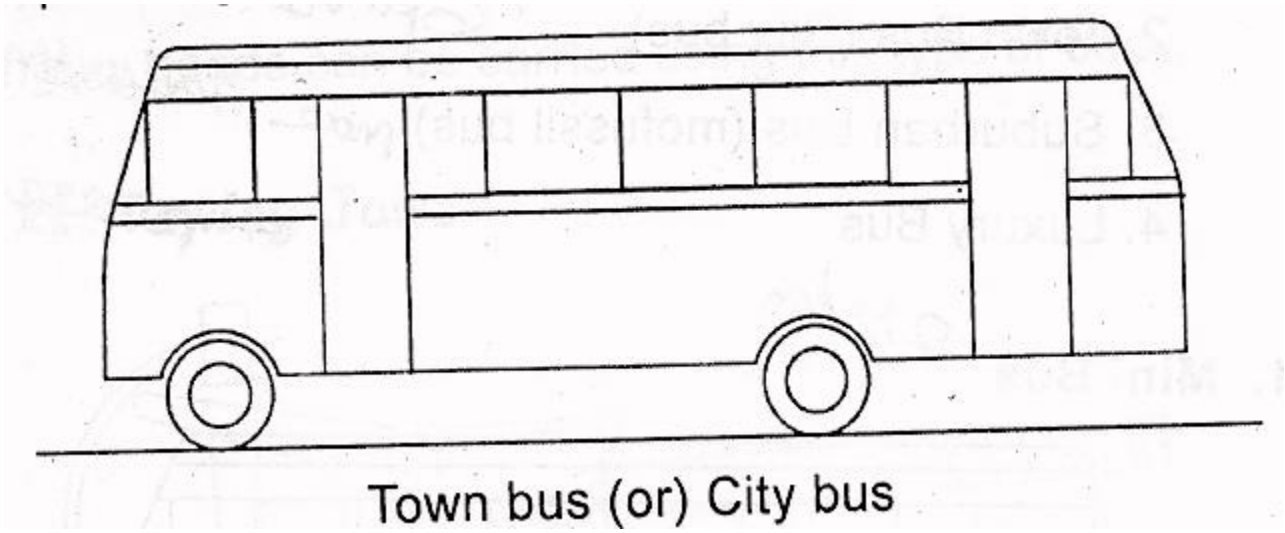


Fig:3 Town bus

Fig:4 Town bus

- These buses are used for a short distance of about 20kms.
- They are provided with large number of standing places two places, wide doors with large entry and exit platform and hard seats covered with durable plastic materials.

3. Suburban bus

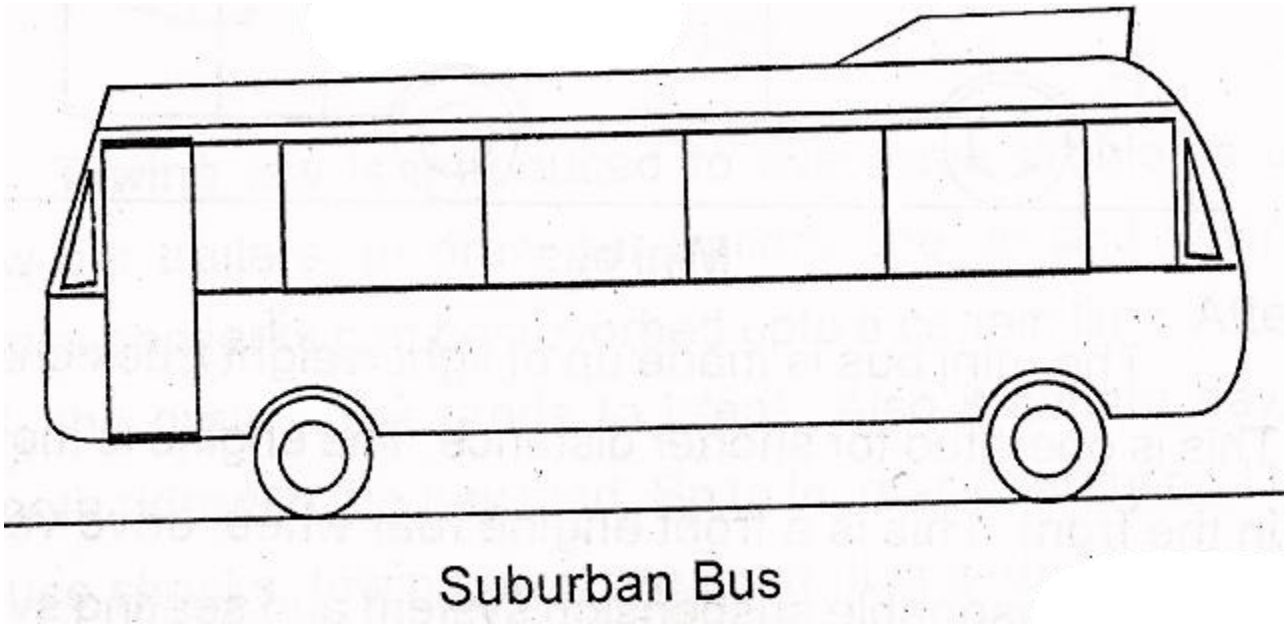


Fig:5 Suburban bus

- These buses are used for a distance of about 40 to 50 kms. They usually have reasonably comfortable seats.
- Fairly small entry platform for the extra space can be used for luggage and extra standing passengers.
- Usually one door is sufficient for this type of operation.

4. Long Distance Coaches

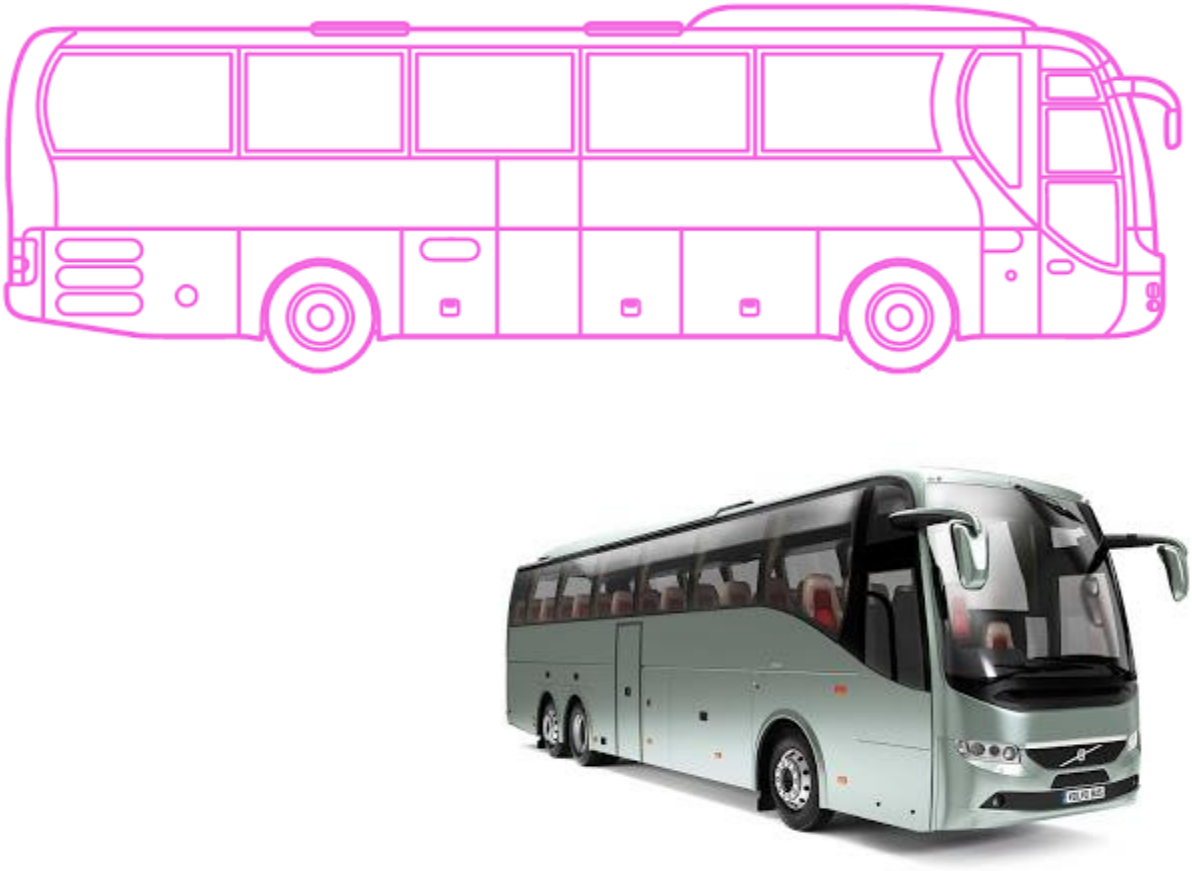


Fig: 6 Long distance bus

- These buses are used for a distance of about 200 kms and above. They have comfortable seats with under floor luggage space and roof racks for large items of luggage.

5.Touring Coaches

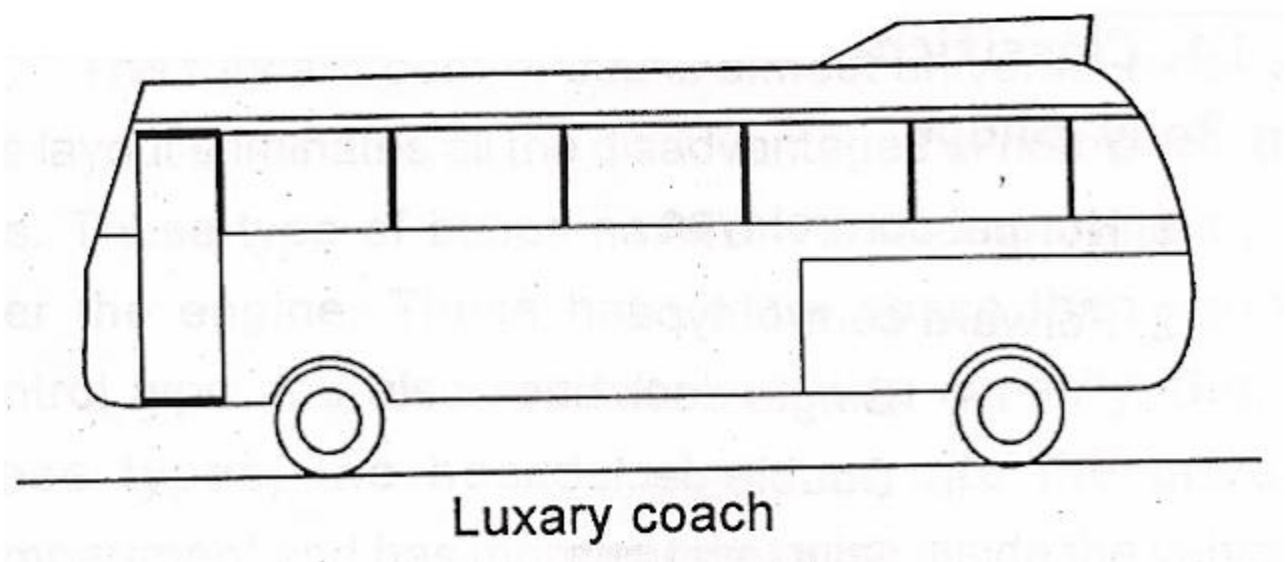


Fig: 7 Touring Coaches

-
- For longer distance touring coaches, very comfortable reclining seats are used.
- Toilets, air conditioners, TV,etc are provided.
- Additional windows in the roof are used to improve visibility for the passengers.
- Thermal and acoustic insulation is usually elaborate and spacious luggage compartments are provided under the floor and on the roof

6. Midi bus

- A midibus is a classification of single-decker minibuses which are generally larger than a traditional minibus but smaller than a full-size single decker and can be anywhere between 8 metres and 11 metres long.

Fig:8 Midi bus

2.**Based on the capacity of the vehicle**

a)	Mini bus	8 to 15
b)	Small coaches for long distance	16 to 30
c)	Small buses for town	upto 40
d)	Medium coach for long distance	31 to 45
e)	Medium buses for town	41 to 60
f)	Large coaches for long distance	46 to 60
g)	Large buses for town	61 to 80
h)	Very large buses for town	> 80

3. Based on Shape and Style of the vehicle

- Classic type
  Single Decker
  Double Decker
  Split-level bus

Two-level single Decker
Articulated bus

1. Classic type

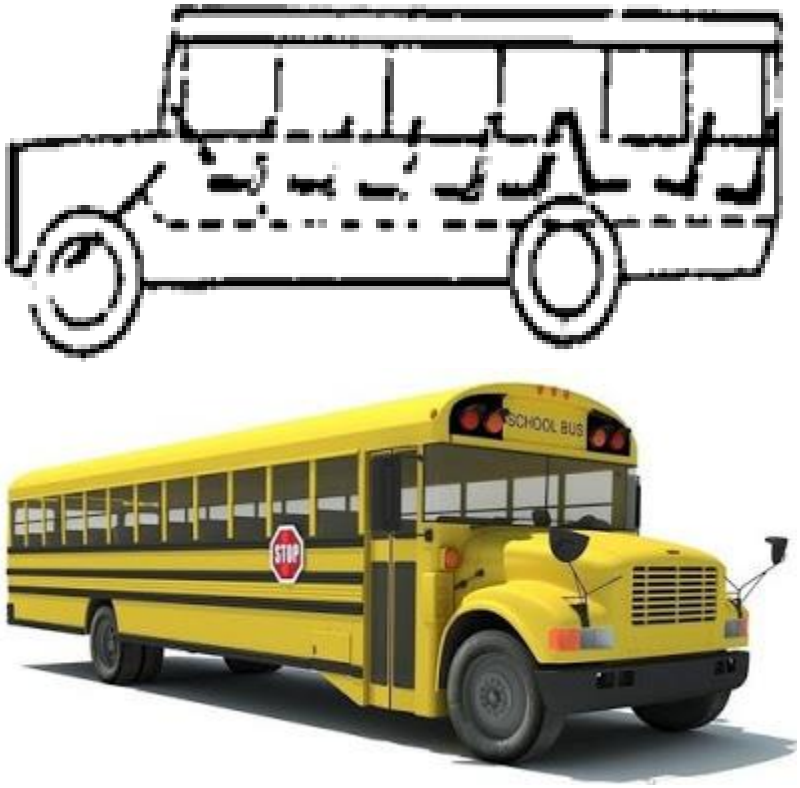


Fig: 9 The Classic or normal

- The Classic or normal control bus has the engine in front of the passenger carrying compartment.
- This design, which was almost universal at one time, has practically disappeared and is mainly of historical interest.
- Low ratio of useful length to overall length.
- It also has a high tare weight and poor aerodynamic shape.

2. Single Decker

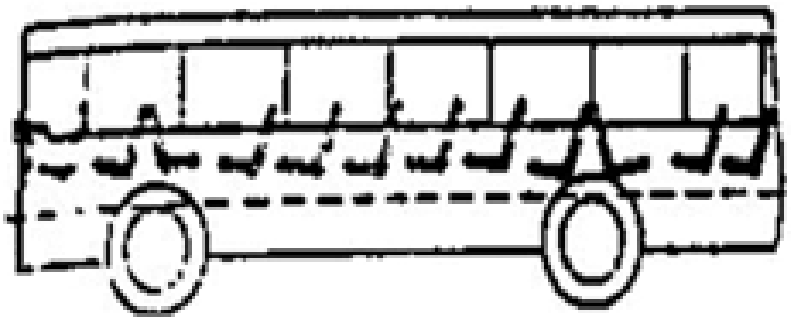


Fig:12 Single Decker

- In this type of buses engine is mounted either inside or below the driver's cab enabling additional length available for more seats and a better angle of vision. - Such buses may have one or two doors. - Many single deck models have seating capacity of fifty two which in city buses is reduced to have more space for standing. This enable transportation of more passengers for short duration.

- The full-length bodywork, i.e. single deck bus or coach is almost universal today as this layout eliminates all the disadvantages of classic type.

3.Double Decker

Fig:13 Double decker

- These buses have a greater number of seats for a given overall length than a single Decker but stability is not so high as for the single Decker.

4.Split-level bus

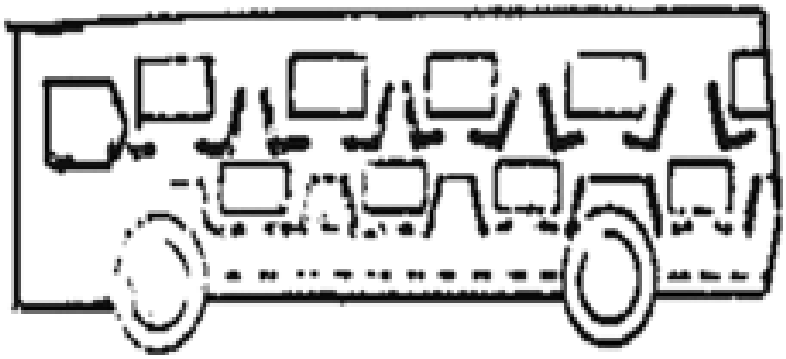


Fig:13 Split-level bus

- An intermediate solution between the two is the split-level layout.This layout has more seats than a single Decker and more stability than the double Decker.
- However, owing to the small number of variations that can be made from this basic design, it has not been widely accepted.

5.Two-level single Decker

Fig: 14 Two-level single Decker has been used for luxury coaches.

- This layout provides good forward visibility for all passengers, good luggage space and easy installation of an under-floor or rear engine.
- Again this type is only made for special orders, as it is not easy to make derivations from the same body shell.

6.Articulated bus

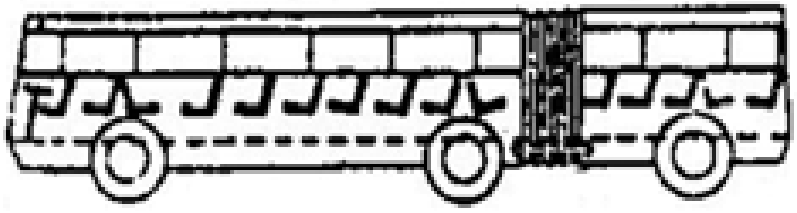
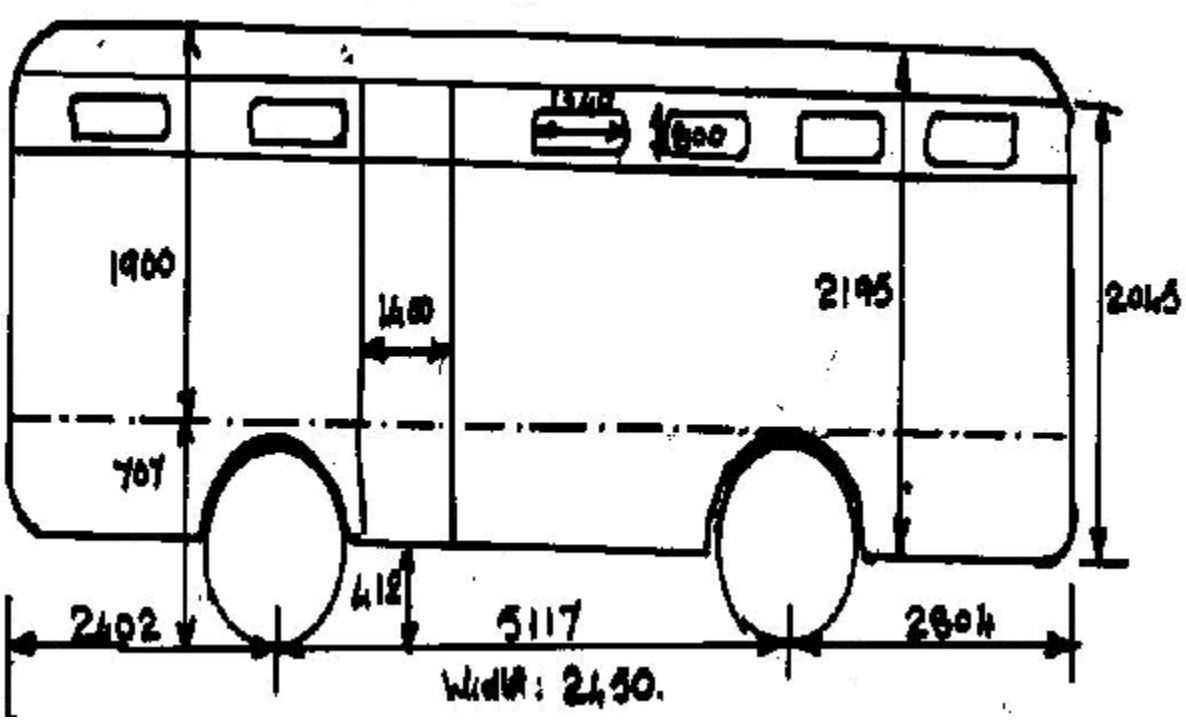


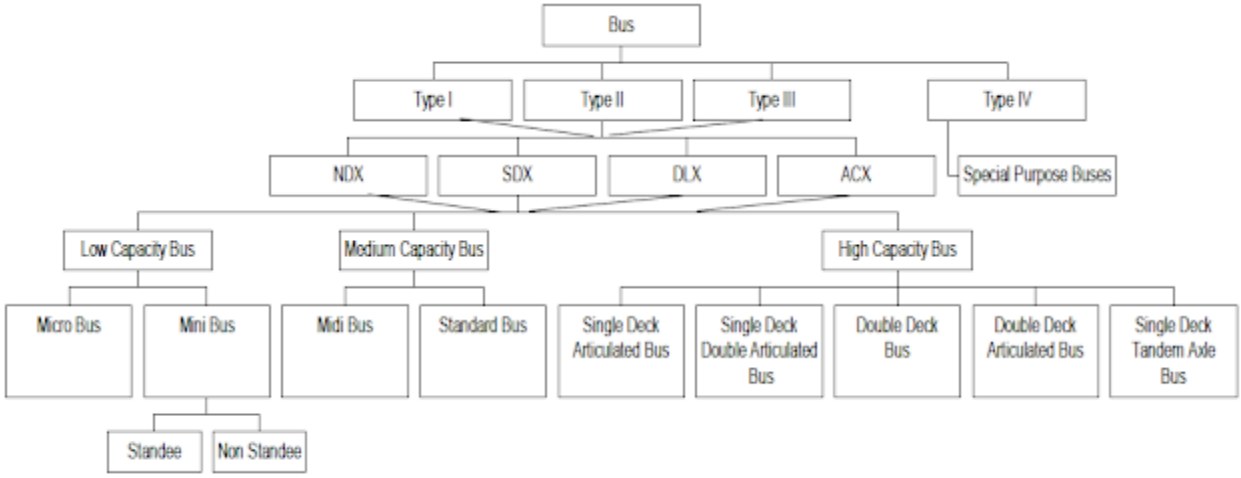
Fig:15 Articulated bus

- ‘Articulated Vehicle/Bus’ means a vehicle which consists of two or more rigid sections which articulate relative to each other; the passenger compartments of each section is interconnected by an articulate section allowing free movement of passengers between them.
- Bodies for very large coaches or in particular, city buses are often made in two parts because of axle load limitations. The rear portion is articulated to the main vehicle by a covered pivot allowing easy access between the two sections.
- A bi-articulated bus or double articulated bus is an extension of an articulated bus in that it has three passenger compartment sections instead of two.
- This also involves the addition of an extra axle. Due to the extended length, bi-articulated buses tend to be used on high frequency core routes or bus rapid transit schemes rather than conventional bus routes.

Bus body Regulations:



Classification of buses:



Buses are categorized into four Types,
namely,

1) Type I
2) Type II
3) Type III
4) Type IV

Type I

- Vehicles are the medium and high capacity vehicles designed and constructed for urban and sub urban / city transport with area for standing passengers.

Type II

- Vehicles are those designed and constructed for inter-urban/inter-city transport without specified area for standing passengers

Type III

- Vehicles are those designed and constructed for long distance passenger transport, exclusively designed for comfort of seated passengers and not intended for carrying standing passengers.

Type IV

'Type IV' Vehicles are those designed and constructed for special purpose use such as the following :-

(1) School Bus: means vehicles designed and constructed specially for schools, college, and other educational Institutions.

(2) Sleeper Coaches: means vehicles designed and constructed specially berth to accommodate sleeping passengers.

(3) Tourist Bus: means vehicles designed and constructed for the purpose of transportation of passengers as tourists and may be classified in any one Type of comfort levels.

- **Non Deluxe Bus(NDX)** means bus designed for basic minimum comfort level.
- **Semi Deluxe Bus(SDX)** means a bus designed for a slightly higher comfort level and with provision for ergonomically designed seats.
- **Deluxe Bus(DLX)** means a bus designed for a high comfort level and individual seats and adjustable seat backs, improved ventilation and pleasing interiors.
- **A.C. Deluxe Bus(ACX)** means a Deluxe Bus which is air conditioned.

Number of Service Doors

	NDX	SDX	DLX	ACX
Type I	2	2	1	1
Type II	1	1	1	1
Type III	N.A.	1	1	1

Minimum dimensions of Service Doors

Category		**Height Min. (mm)**	**Width min. (mm) (As Applicable)****		
			Front	**Rear**	**Middle#**
Type I	**NDX**	1800	650 mm for single door and 1200 mm for double door	650 mm for single door and 1200 mm for double door	650 mm for single door and 1200 mm for double door
	SDX				
	DLX				
	ACX				
Type II	**NDX**	1650			-
	SDX				-
	DLX				-
	ACX				-
Type III	**SDX**				-
	DLX				-
	ACX				-

Window:

- The window panes shall be of sliding type for all buses except ACX buses.
- However, in ACX buses the provision for adequate ventilation in case of A.C. failure shall be made.
- The minimum width of the window aperture (clear vision zone) shall be 550 mm.
- The minimum height of the sliding part of the window aperture (clear vision zone) shall be 550mm

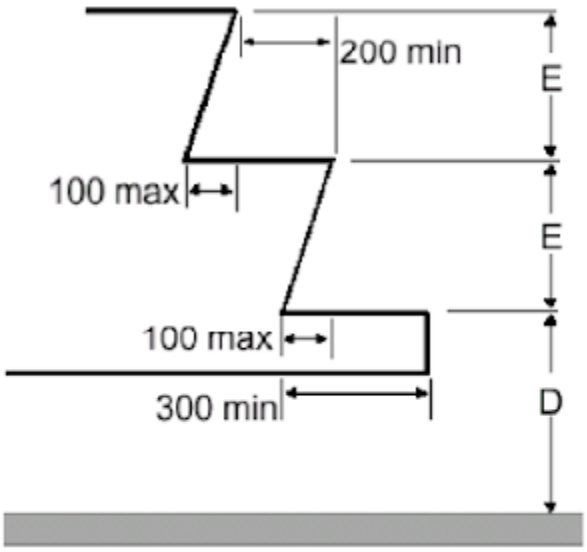
Emergency Exits:

- At least one emergency exit shall be situated on the opposite side of the service door.
- In case of more than one emergency exit, one of the emergency exit shall be situated in the front half of the vehicle, opposite to the service door and the second emergency exit shall be either on the rear half or at the rear side of the bus.

Minimum dimensions of the emergency exits:

Category	Height (mm)	Width (mm)
Type I	1250	550
Type II	1250	550
Type III	1250	550

Steps:



Classes		I	II, III
First step from ground 'D'	Max. height (mm)	340	380
	Min. depth (mm)	300	
Other steps 'E'	Max. height (mm)	250	350
	Min. height (mm)	120	
	Min. depth (mm)	200	

CONSTRUCTIONAL DETAILS:

1.Frame construction
2.Double skin construction

1.FRAME CONSTRUCTION:

The design of bus body is based on the use of a light metal frame, braced by stressed metal panels.
The main framing is of light members of thin gauge material formed by folding, pressing, stretch forming, rolling, extrusion and connected by gussets generally riveted to the structure framework which is applied to the inside face of the framing.

Sequence of Bus body building operation:

- Chassis Preparation
- Side and front framing
- Roof framing and rear end
- Truss panel riveted
- General inspection
- Roof panels
- Paneling and moulding
- final finish

1.Chassis Preparation:

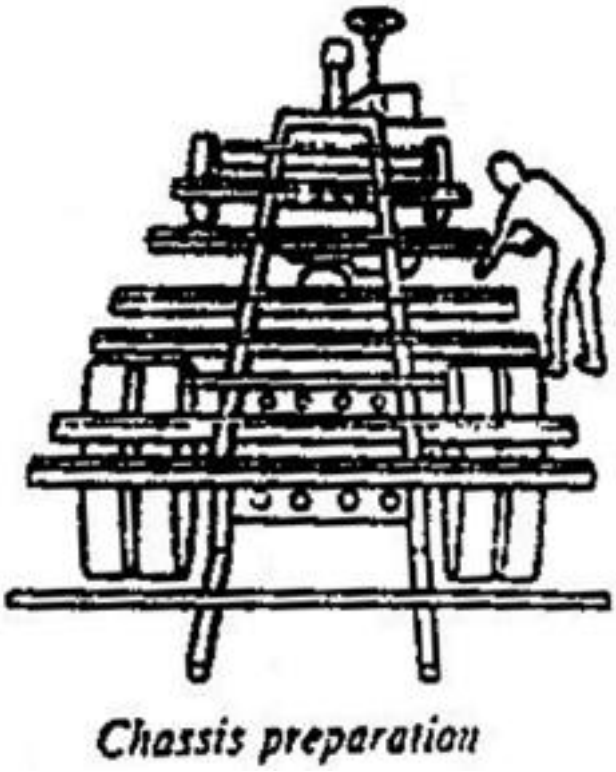


Fig:16 Chassis preparation

The floor frame is placed in position, holding down and fixed with bolts or rivets and all parts of the chassis are painted.

2.Side and front framing:

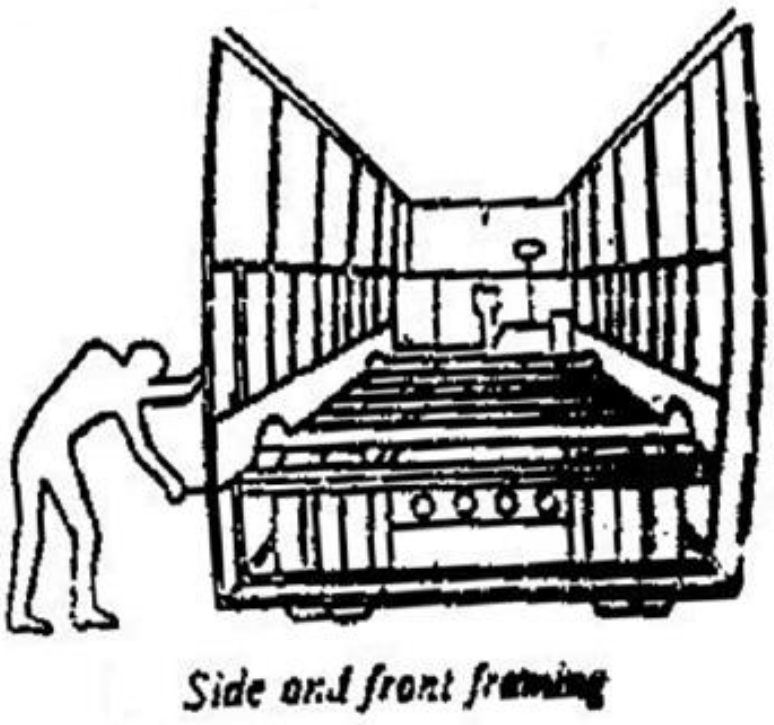


Fig:17 side and front framing

The body side framing and front end is assembled. Truss panels bolted into position, the body lined up with the waist rail and the lower bolts tightened.

3.Roof framing and rear end:

Fig:17 roof framing

The body ends and roof framing are positioned and fixed, the wheel boxes and entrance steps

installed.

4.Truss panel riveted:

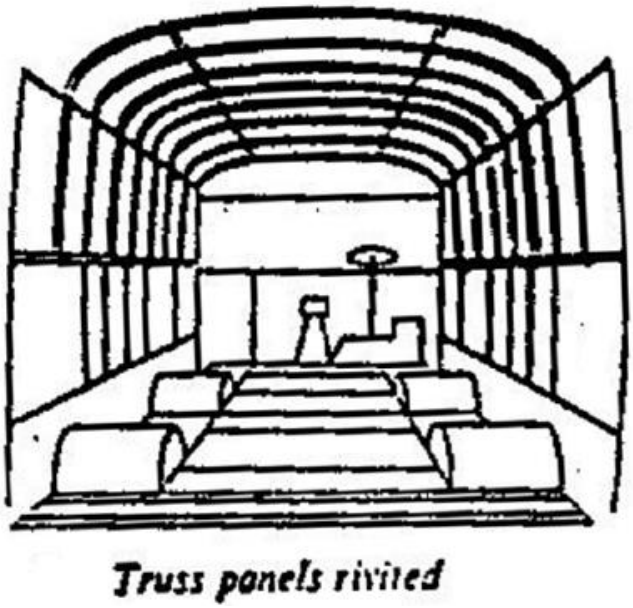


Fig:18 truss panels

Truss panels between the waist rail and seat rail over the wheel arches are riveted into position.

5.General inspection:

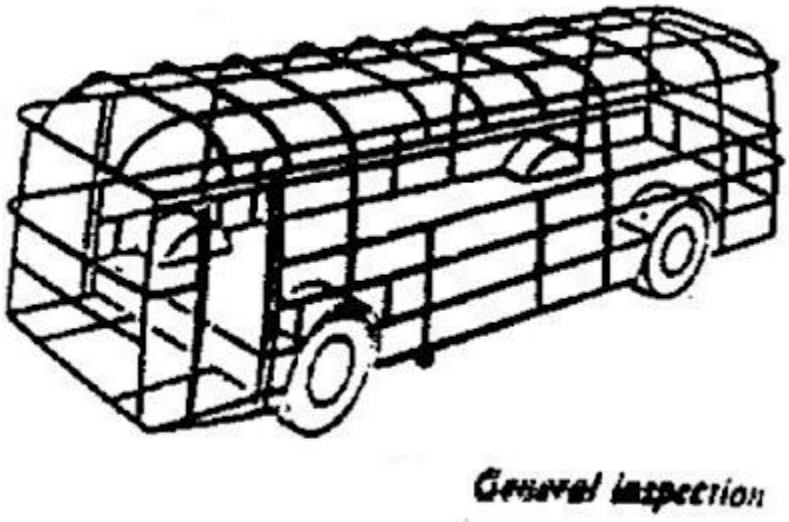


Fig:19 General inspection:

General inspection of finished framing to ensure all structural bolts are tight and truss panels

securely riveted.

6.Roof panels:

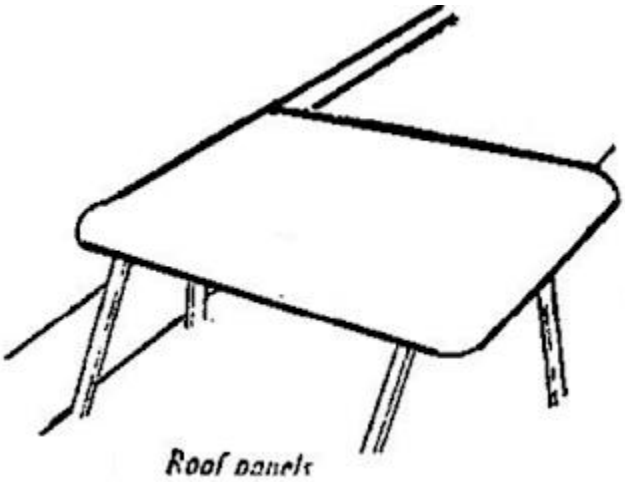
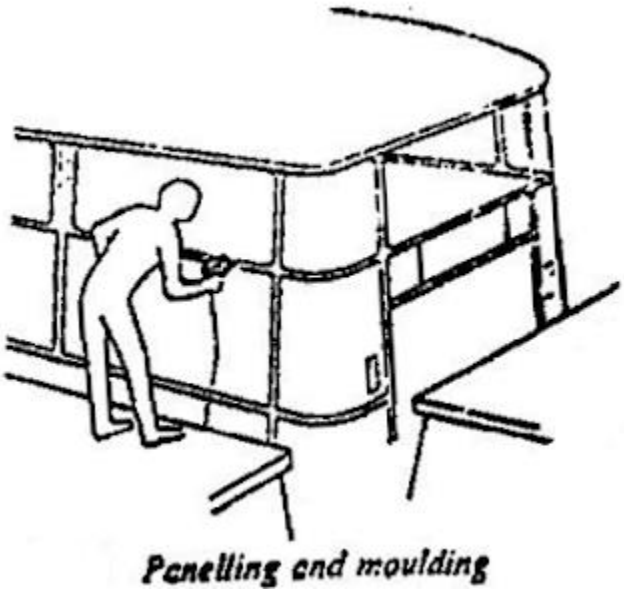
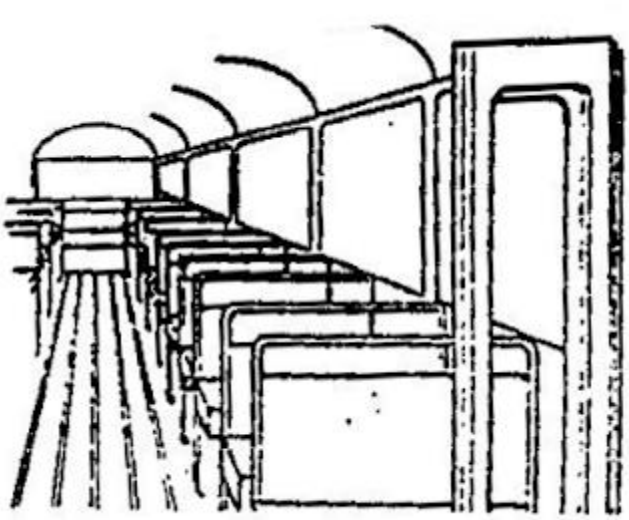


Fig:20 Roof panels:
Roof panels are fixed and riveted.

7.Paneling and moulding:



8.final finish:



Final finishing

2.DOUBLE SKIN CONSTRUCTION DETAILS:

- Normally inner skin will take part in load carrying ,Outer skin will be fixed in such a way that it can be replaced easily.

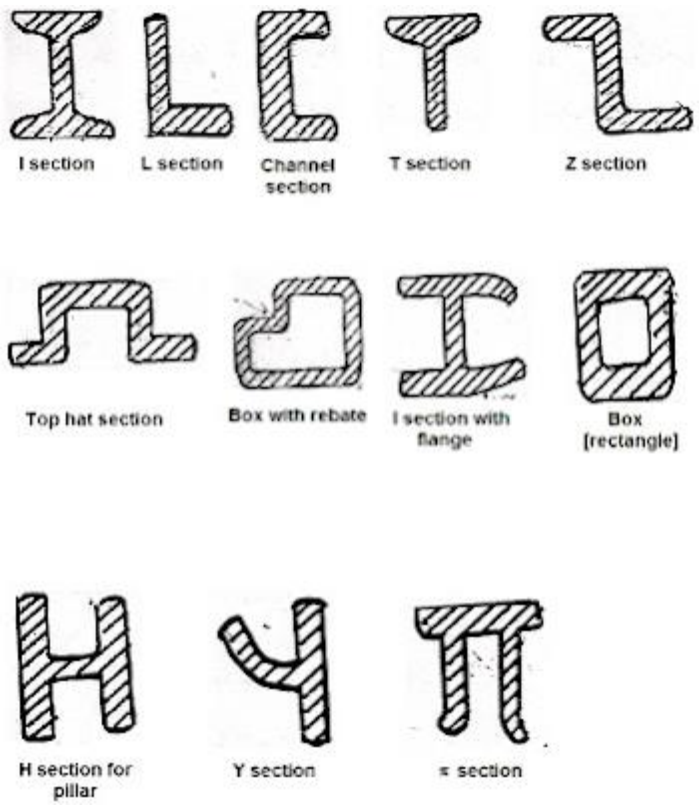
(a)Interior paneling:

- This is the paneling done in side the vehicle.
- The paneling inside the body gives comfort to the passengers.
- The factors to be considered during paneling are safety, easy maintenance, easy cleaning.
- Decorated laminated sheet are used for this. When laminated sheet and aluminium and stainless steel are combined give the good look.
- GRPF (glass reinforced plastic fiber) can also be used for this purpose.
- Floor side panel and roof has to be thermal insulated or sprayed.

(b) Exterior paneling:

- The paneling done on the exterior is called as exterior paneling.
- This is also called as skin of the vehicle.
- This does not take any load.
- This is done by galvanized steel sheet coated with zinc coating.
- The galvanized steel sheet is welded or riveted to form panel.
- The body paneling is done by two ways.
- Small panels are attached together according to the requirement.
- To make a single big panel for the whole length.
- Steel sheets are used in the uneven surface. This increase the beauty.
- To avoid corrosion, leak and vibration, the panel should be made with plastic trim fillet.
- The normally used material for exterior paneling is aluminium.

TYPES OF METAL SECTION USED:



a. Channel Section -Good resistance to bending

b. Tabular Section-Good resistance to Torsion

c. Box Section-Good resistance to both Bending and Torsion

CHASSIS AND BODY BUILDING TECHNIQUES:

- The basic under structure is fabricated out of thin mild steel cold rolled channel sections fully galvanized for corrosion protection.
- The structure is provided with cross members and outriggers at specified intervals so that they will form complete ring frames along with body side pillars and roof sticks.
- Pillars and roof sticks are made of sheet metal pressed sections.
- Pillars are bolted to the sole bar of the under structure and the roof ticks are connected to the pillar by stiff pressed steel corner brackets and the joining of them done using solid rivets
- All inner panels and wheel arch truss panels are of sheet metal and solid steel riveted to the pillars and longitudinals.
- All outer panels and roof panels are of aluminium and pop riveted.

CONVENTIONAL TYPE CONSTRUCTION:

Fig:21 CONVENTIONAL TYPE CONSTRUCTION

(It also called as “Separate body and chassis type”, “Orthodox type”)

- The body and chassis will be as separate unit.
- Bolts are used to join the body and chassis together.
- The separate part of body will be placed over the top of the chassis.
- A rubber block will be placed in between these two parts to avoid the vibration.
- The conventional type building involves in building up of a ladder type frame with two long side members interconnected by cross members at intervals.
- The units like engine, gear box, radiator, axles, steering wheel, fuel tank are mounted on the frame.
- The whole body and passenger load is transmitted to the chassis by means of spring.
- Chassis should be built strong so that it can withstand the weight of the body.
- The basic under body structure is fabricated only thin mild steel cold rolled channel sections
- It is fully galvanized for corrosion protection
- It is provided with cross members and out riggers at specified intervals.
- The pillar and roof shocks are made of sheet steel.
- Pillars are bolted to the sole bar of the under structure.
- The roof sticks are connected to the pillars by stiff pressed steel corner brackets and joined by solid rivets.
- All the inner panels and wheel arch truss panels are sheet steel and solid steel riveted to the pillars.
- All the outer panels and roof panels are pop riveted.

Advantage:

1.This is used in heavy vehicle.
2.This is of simple construction.
3.The change of designing and the alteration of frame length is easy.
4.Servicing is easy in case of any damage.
5.There is no need for more expenditure for preventing corrosion.

Disadvantage:

1.The weight of the frame is more, due to this the vehicle speed is decreased. More fuel is also required.
2.Since the floor height is more, the centre of gravity from the ground will also be more. Due to this, the stability will be decreased.

CONSTRUCTION OF INTEGRAL BUS BODY(MONOCOQUE / UNIBODY) :

Fig;22 Monocoque

- **Monocoque,** meaning '**single shell**' in French, is a construction technique that utilizes the external skin to support some or most of the load. The technique may also be called **structural skin** or **stressed skin**.
- The semi-monocoque is a hybrid of a mutually reinforcing tensile shell and compressive structure.
- Unitary body / unit body - uses a system of box sections,bulkheads and tubes to provide most of the strength of the vehicle,to which the stressed skin adds relatively little strength or stiffness.
- In integral bus construction, a base structure is formed with 4 long Side members, cross members, outriggers and wheel arch supports.
- Units like engine , gear box, axles etc are mounted on the flexible Under structure, which is fabricated by welding.
- These under structures are painted with suitable colors to prevent corrosion .
- The body pillars which are ring frames are attached to the two extreme Side members called sole bars by bolting.
- The panelling is done as per specifications to give good integral Structure.
- The under and body structure act as a single structure to carry the Load.Thus for a given load the integral structure will withstand more stress which indicates that every member of the structure is sharing the load.

DESIGN OF INTEGRAL BUS:

Chassis under structure

- Unit weights like engine, gear box, radiator,steering box, batteries and fuel tank acting as point loads at the mounting points.
- Weight of under stucture considered as uniformly distributed load.
- Considering the vertical and lateral bending,moment is calculated and a section required to carry the weights is decided allowing for a reservefactor depending on the road conditions.

Chassis body structure

- Body weight considered as uniformly distributed load.
- Payload considered as uniformly distributed load
- Considering bending , torsion and combination of both, the body structure is designed allowing for a

reserve factor depending in the road conditions.

Advantages:

1.Light in weight compared with conventional type of body construction. so fuel consumption is less.
2.Easy entry/ exit and lower floor height is to be achieved.
3.Greater strength.
4.Free from squeaks and rattles caused by the working of bolted joints which are absent in this construction.
5.Reduction in heat in the driver and passenger area.
6.Low noise and vibration level.
7.Lowered wind screen level and better visibility for driver.
8.Assembling of component is easy.
9.Mainly this type is used in car construction.

Disadvantages:

1.when a car is involved in an accident, it is more expensive to repair the large panel sections.
2.There is a greater liability of injury to the driver.
3.It is more expensive to introduce changes in body styling to keep abreast of the times.
4.Initial cost is more.
5.Thick gauge material should be used.
6.More cost to avoid corrosion.

FLOOR HEIGHT:

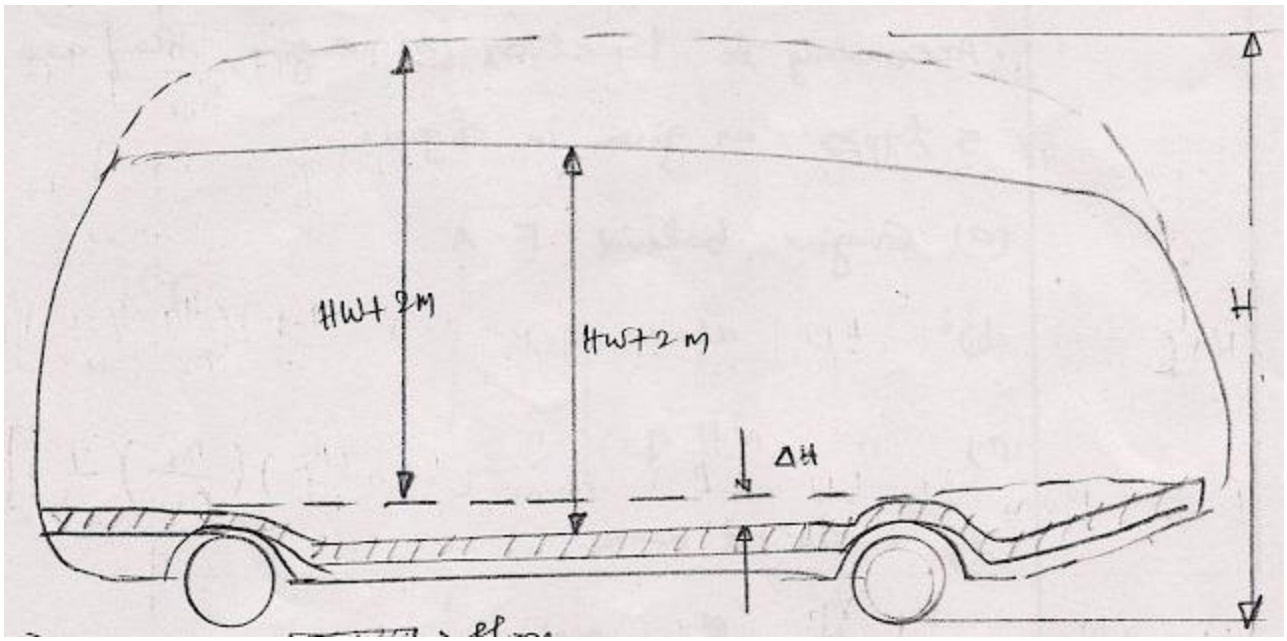
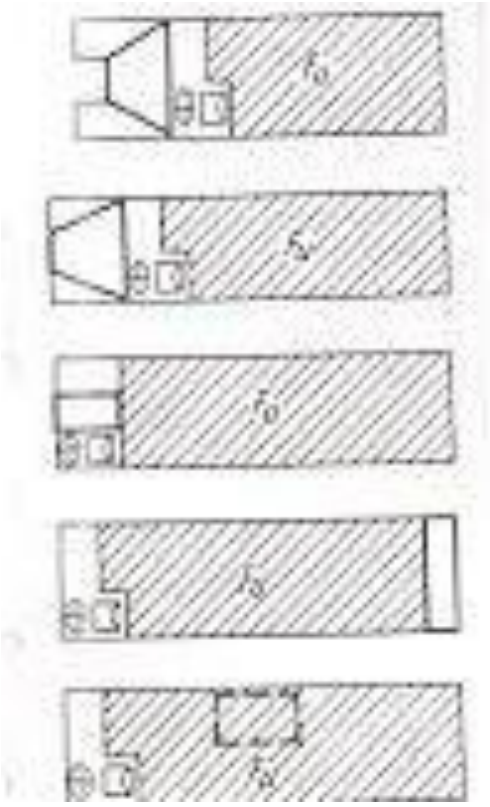


Fig:23 Floor height

- The floor should be placed as low as possible so that distance of centre of gravity of bus from road surface is small.
- The stability of the bus gets increased.
- It gives easy entry to the bus.
- It is easy to place luggage in bus.
- Due to the lower height, the Bus design is more complicated in separate chassis and body construction.
- Considering floor level, the chassis frame are made specially shaped.
- If an integral body is used, low floor level becomes much easier to design.
- Large number of passengers can be seated in the bus.

ENGINE LOCATION:



According to location of engine, there are five types as given in figure.

a)Engine behind front axle.
b)Engine above front axle.
c)Engine in front of front axle.
d)Engine at rear.
e)Under – floor engine.

- Advantages of different engine locations are to improve visibility (i.e.) forward and side visibility.
- Reducing extra placing space of engine.
- It improves space for passenger in bus.

ENTRANCE AND EXIT LOCATION:

- Generally in all types of buses, back side door is for entrance.
- Front side door (nearer to driver) is exit.
- In city bus, back and front door are as usual. But middle door is for easy exit for more number of passengers at a time.
- In city bus, the door width is more.
- In sub – urban bus, the entrance is at the middle and exit is at the front.
- In long distance bus, the back door is for entrance and front door is for exit.
- In long distance bus, the door size (i.e.) width of the door is less.

SEATING DIMENSIONS:

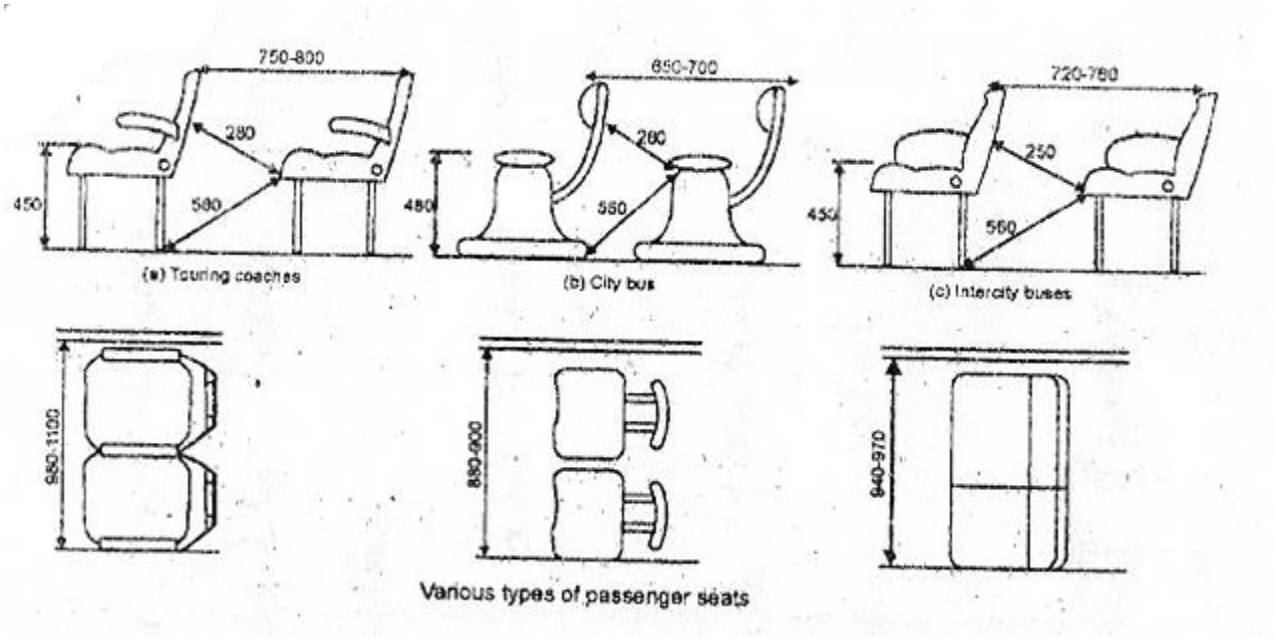


Fig:24 passenger seat

If the seat is comfortable, the journey may be a pleasure trip ,But it will be a trouble some, tiring, agony, if the seat is uncomfortable. The design of seat is designed to the structure of human. Passenger seat is designed for comfort and also described according to distance between the consecutive seats.

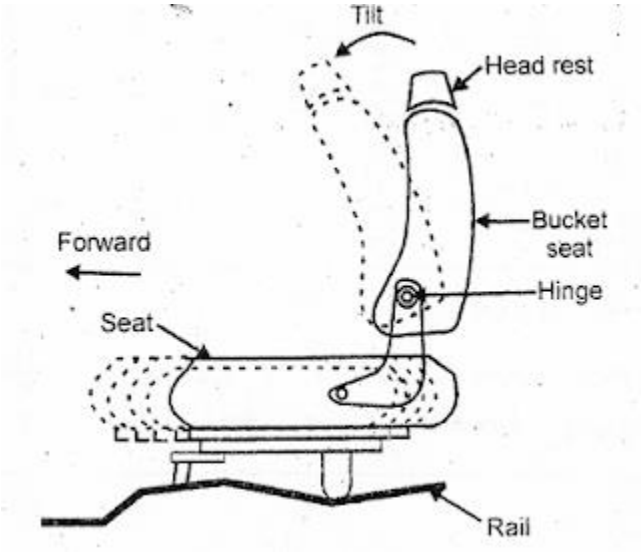
Seats are manufactured by the materials

a)Natural rubber latex

b)Cold – cure polyester (or) urethane

c)Hot – cure foams (or) chip forms.

- In passenger seat, the seating angle ranges from 50 to 100
- In push back seating, the seating angle is included to 60deg



TEXT / REFERENCE BOOKS

1. Powloski J, “Vehicle Body Engineering”, Business Books Ltd., London 1989.
2. John Fenton, “Vehicle body layout and analysis”, Mechanical Engg. Publication ltd, London, 1982.
3. Kohli P. L, “Automotive Chassis & Body”, Papyrus Publishing House, New Delhi, 2010.
4. Wolf-Heinrich Hucho, “Aerodynamics of Road Vehicles” SAE International,USA,1998.
5. Robinson A.,Livesey W. A, “The Repair of Vehicle Bodies”, Butterworth - Heinemann Ltd,1989
6. Sumantran V. and Gino Sovram, “Vehicle Aerodynamics”, SAE International, USA, 1994.
7. John Fenton, “Vehicle Body Layout & Analysis”, Hutchinson, London, 1998.

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE
www.sathyabama.ac.in

UNIT 4 - INTERIOR ERGONOMICS

UNIT 4

INTERIOR ERGONOMICS

1. Introduction:

The word "**Ergonomics**" originated from two Greek words "**Ergon**" means "**work**" and"**Nomos**" means"**natural laws**" International Ergonomics Association (IEA) defined Ergonomics (or human factors) as the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. An ergonomist is an individual whose knowledge and skills concern the analysis of human-system interaction and the design of the system in order to optimize human well-being and overall system performance (IEA, 2000).

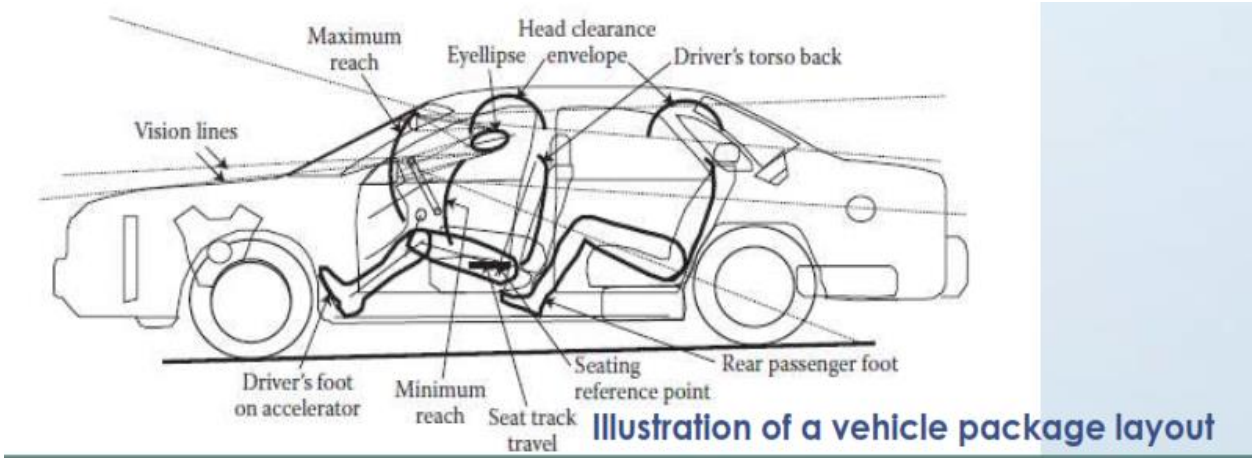


Fig: 1 vehicle package layout

Ergonomics:

Ergonomics is concerned with the health of the people and the productivity of the system. It is to get proper fit between people and their technological tools and environments. It takes account of the user's capabilities and limitations in seeking to ensure that tasks, equipment, information and

the environment suit each user. Simply expressed we can say that Ergonomics is fitting the task to the person rather than fitting the person to the task.

Domains of Specialization:

According to international Ergonomics Association (IEA) ergonomics can be broadly classified into:

• Physical Ergonomics

• Cognitive Ergonomics

• Organizational Ergonomics

Physical Ergonomics:

It is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they related to physical activity. Relevant topics may include working postures, material handling, repetitive movements, work related musculoskeletal disorders, workplace layout, health and safety.

Cognitive Ergonomics:

A proper fit of a product to a user does not end with physical interfaces. Cognitive / perceptual ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system and Human computer interaction design.

Organizational Ergonomics*:*

It is concerned with the optimization of socio technical systems, including their organizational structures, policies, and processes. Relevant topics include communication, crew resource management, and work design, design of working times, teamwork, community ergonomics, cooperative work, new work programs, virtual organizations, telework, and quality management.

Applications and Benefits:

Applications:

Ergonomics continues to be successfully applied in the fields of workplace design, occupational health, safety, product design, aerospace engineering, mechanical engineering, health care, IT sectors, transportation, training, nuclear power plant, virtual environments, industrial design and so on.

Benefits:

Application of ergonomic principles in various fields provides to better man-machine interaction, healthy and comfortable working environments, enhancement of human performance and efficiency and thus ultimately leads to overall improvement of system's (man-machine-environment) productivity with reduction of error and accidents.

Key benefits of application of ergonomics are listed below:

• Human fatigue and error can be reduced.
• increase productivity and safety
• Increase work quality
• Decrease risk of accidents
• Improve people attitude
• More user satisfaction
• Less absenteeism
• Reduced lost time, etc.

Aspects of Ergonomics:

Study of compatibility issues for proper man-machine interface is very important in ergonomics. Here, focus is generally made on user's requirement, user's characteristics and user's capabilities/limitations for user friendly design. Human compatibility with machine/instrument/work elements are discussed in terms of anthropometric, biomechanical, physiological and cognitive/ psychological aspects.

Anthropometry:

Anthropometry is the subject which deals with the measurements of the human external body dimensions in static and dynamic conditions. Anthropometric data is used for product and workplace design.

Anthropometry is of two types:

• Static Anthropometry
• Dynamic Anthropometry

Static Anthropometry:

External human body dimensional measurement taken when a man is placed in a rigid static position i.e. standing, sitting, or other adopted postures.

Dynamic Anthropometry:

The dimensional measurement of human body with various movements taken into consideration in different adopted postures which the work context demands are termed dynamic anthropometry.

Introduction to Automotive Ergonomics:

Automotive ergonomics focuses on the role of human factors in the design and use of automobiles. This includes analysis of accommodation of driver and/or passengers; their comfort; vision inside and outside vehicle; control and display design; pedal behavior information processing and cognitive load during driving etc. In the present module attempt will be made to discuss various physical aspect of occupant packaging for providing comfortable driving posture, clearance dimensions, proper view field, easy reach of the controls etc. to
The driver.

This module highlights the following:

- Spatial accommodation
    - Seating Position
    - Leg Room
    - Head Clearance
    - Lateral Clearance
- Sitting comfort /discomfort
- Reach and limitations of human
- Visual field and Visual Obstruction.

To establish the required interior space and arranging the interior and structural components, the design methods relies on the human factors data base through years of research and practical applications. The anthropometry for automotive design is consistent with the driver and passenger safety, comfort, convenience and accommodation. The study of human capabilities and limitations gives the measurements for designing automobiles. The anthropometry for automotive design is consistent with the driver and passenger safety, comfort, convenience and

accommodation. The study of human capabilities and limitations gives the measurements for designing automobiles.

Anthropometric Measurements for Automotive Ergonomics:

Automobile is designed as per the anthropometry of the targeted user population. Measurement process can be broadly classified into two categories.

Conventional Static Measurements:

The measurements taken on human body with the subjects in rigid, standardized position (fig.10). They are typically length, width, height and circumferences. These measurements includes standing height, seated height, seated eye height, upper leg length, knee height, seat length, upper and lower arm length, reach (total arm length), shoulder width, hip or seat width, weight, etc. These measurements are referenced to non-deflecting horizontal or vertical surfaces supporting the subject.

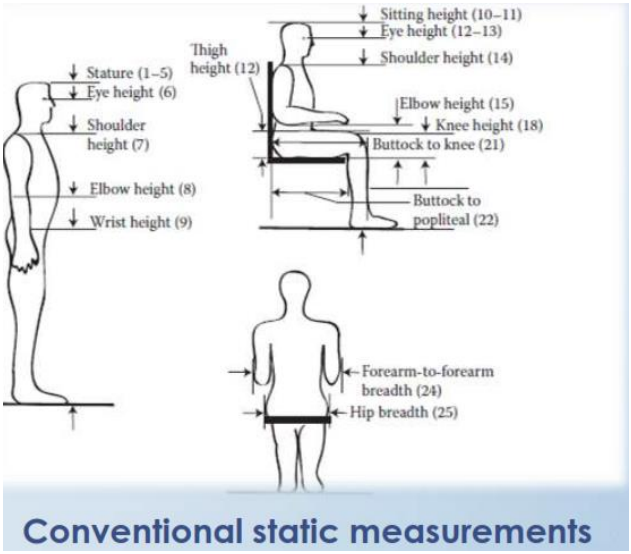


Fig: 2 conventional static measurements

Functional Task Oriented Measurements:

The measurements are taken with the human body dimensional co-ordinates x, y, z with respect to body land marks as reference points. At work or motion in the workspace (fig. 11). Typically they are represented in three dimensional co-ordinates x, y, z with respect to body land marks as reference points.

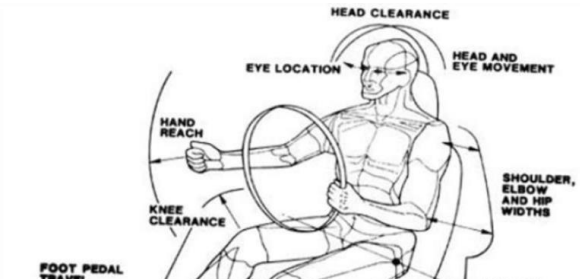


Fig:3 Seat measurements

Functional Task Oriented Measurements:

Few reference points e.g. H-point, BOF, AHP etc. are used as standard practice to define driver's position while SRP, NSRP and SgRP are generally used to define seat position in relation to driver.

• H-point (Hip pivot): Mid point of the line connecting two hip joints.

• BOF (Ball of Foot): Ball joint of Foot.

AHP (Accelerator Heel Point): position of the heel while placed on the accelerator.

• SRP (Seat Reference Point): Intersection point between midline of compressed seat back and compressed seat pan.

• NSRP (Neutral Seat Reference Point): 50th percentile person selected SRP.

• SgRP: 95th percentile person selected SRP.

These landmarks relate the occupant to components in the vehicle interior such as foot controls, seat and floor. For example, the foot is related to the ball of foot and accelerator heel point, where as hip, elbow and shoulder width are related to the h-point location. To accommodate wide range of target population, 5th and 95th percentile anthropometric data are used in general.

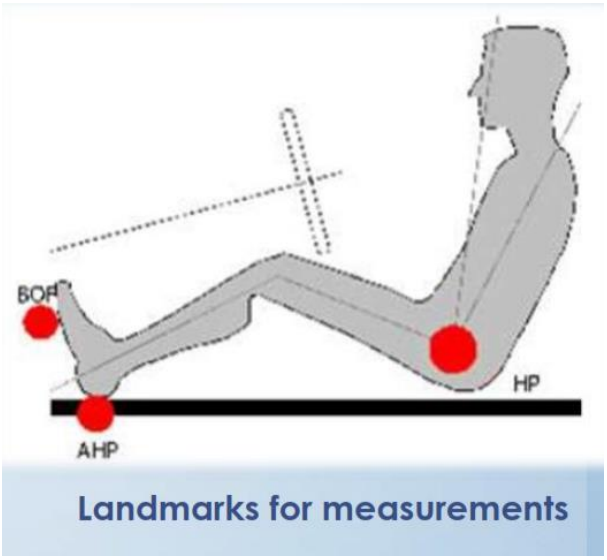


Fig:4 Landmarks for measurements

Seat Track Travel Limit:

Seat track travel limit is decided in such a way so that individuals with smaller body dimensions as well as larger body dimensions can seat comfortably on the seat and can access all the controls Including accelerator, break and clutch. Seat track travel limits in forward-backward and upward-down ward direction are decided as per operational requirement. Figure depicts forward-backward movement of the seat as per the different percentile driver selected seat position.

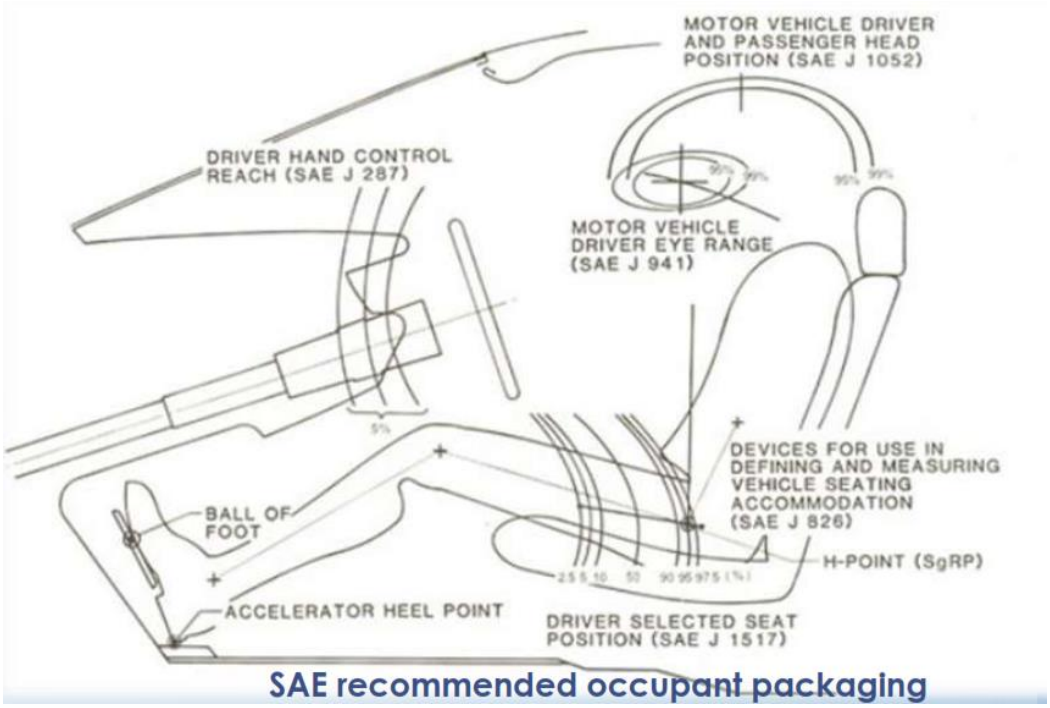


Fig:6 Seat Track Travel Limit:

Spatial Arrangement:

After defining the position of the driver on the seat, all other interior and structural components inside the vehicle are arranged accordingly with the intension to provide sufficient clearance dimensions around him/her. This process relies on human factor database. Larger anthropometric data (95th percentile value) are generally considered for this purpose. Spatial arrangement includes the positioning of driver's seat and passenger's seat in the allocated space in side,

arrangement of various controls/components according to seating arrangements. In this module leg room, head room and lateral space are to be described in brief.

Legroom: The sufficient space for keeping legs of the driver/passenger in a comfortable position in an automobile. Proper legroom enables drivers to access structural component with ease. There should not be any obstacle to keep feet comfortably and at the same time for accessing controls like pedals (break/accelerator/clutch). Measurement of horizontal distance between H-Point and AHP is useful for this purpose. Care should be taken to ensure that any parts of lower body like thighs/knees should not touch with steering wheel or dash board or any other component.

Headroom:

The height. It is the vertical clearance space above the head of driver/passenger in an automobile. A minimum 5.0 cm head clearance for jolt in a vehicle is recommended (Galer 1987, Woodson et al. 1992). In vehicular workstation, available head clearance must be sufficient for wearing and removing the helmet in seated posture in seat.

Lateral Space:

Lateral space is the space pertaining to the side of driver/passenger. Lateral space is important for physical or psychological comfort. Conventionally, 95th percentile bi-deltoid breadth of the population with an additional allowance of 10% on each side can be considered adequate for lateral clearance during normal sitting side by side.

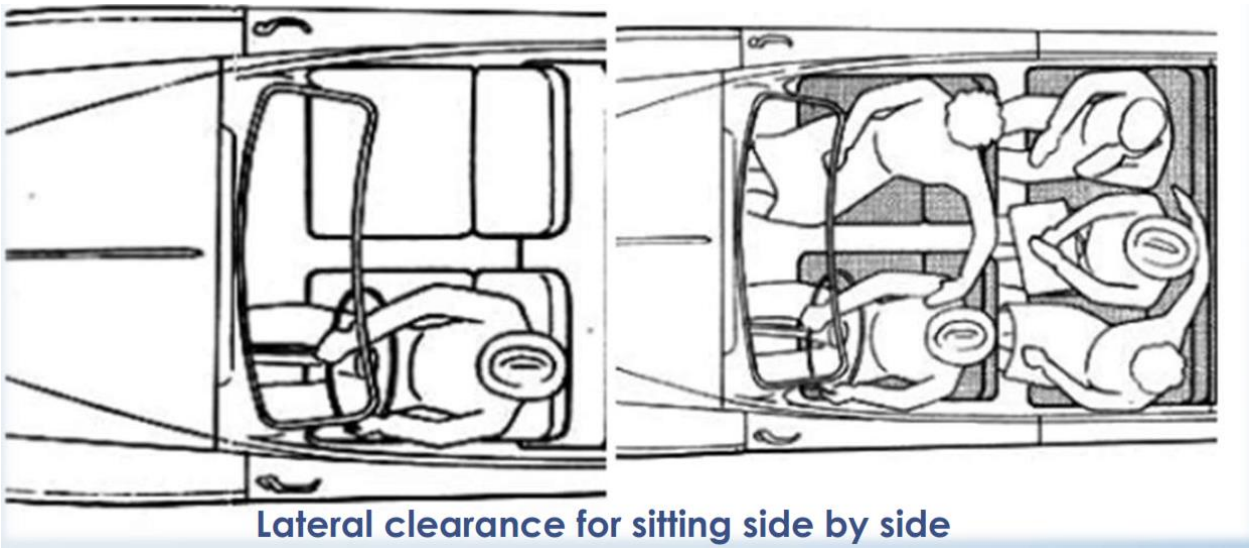


Fig:7 Reach and Limitation of Human:

In many work situations, individuals perform their activity within a specified 3D space of fixed location which is sometimes referred to as ‘work-space envelope’ (Sanders and McCormick 1993). This envelope preferably should be circumscribed by the functional arm reach of the operator and most of the things they need to handle should be arranged within this envelope. In figure describe human capabilities and limits in terms of reach on horizontal work-surface with their measurements.

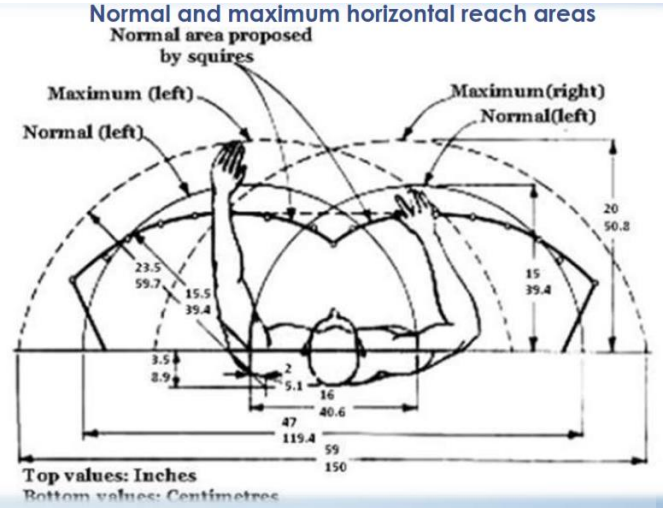


Fig:8 Maximum reach areas

Normal and maximum horizontal arm reach does not correlate with reach capabilities in actual vehicle workstation. Factors such as seat position, seat deflection, shoulder articulation, and lean allowed by lack in a shoulder harness (if one is worn) affects a drivers reach capabilities. Forward arm reach of the driver according to anthropometry and seat track travel as described in SAE J287 shown in figure.

Strength Capability

Strength for Control Operation:

Strength is one type of human performance limiting factor and concerns the application of force in the operation of controls and in other physical tasks. Often, limitation of strength imposes a one-way constraint and it is sufficient to determine the level of force that is acceptable for a weak limiting user. The capabilities of human body are considered to make the operational components in the vehicle while driving. For example, the force is required for the ease of

operation of clutch, steering, opening and closing of doors etc. Actuating force limits for some important tractor controls for Indian male agricultural workers (CIAE, Bhopal, 2009) are given Below:

- Brake Pedal:
- 5th p Rt leg strength (male)=261 N.
- Maximum actuating force for break operation should be less than 260 N.
- Clutch Pedal:
- 5th p Lt leg strength (male)=247 N.
- Frequently operated compared to break pedal.
- 50% of 5th p Lt leg strength (male)= 123.5 N.
- Maximum actuating force for Clutch operation should be less than 124 N.

Accelerator Pedal:

5th p Rt foot strength (male)=163 N.

Continuously operated, 30% of 5th p Rt foot strength (male)=49 N (upper limit). Maximum actuating force for accelerator operation should be less than 49 N. Weight of leg = 9%= .09 of body wt., part of this wt. is supported by heel. Lower limit of force exertion for accelerator= 54.7kg x9.81x.09x0.5=24N.

Steering Wheel:

5th p torque strength with both hands, sitting (male) =36 Nm (force 171 N with lever arm of 0.21 m). Frequently operated, 30% of 5th p = 51 N. Maximum actuating force for steering wheel operation should be less than 51 N.

Gear Selection/ Speed Selection Lever: 5th p RT hand push strength = 49 N, limiting force for operation. Maximum actuating force for gear operation should be less than 49 N.

INTRODUCTION TO DRIVER SEAT

Driver seat is an inseparable part of any automobile. Its main function is not only to provide a seating space to driver but also support, protect and to provide comfortable seating posture to the occupants. Today driver seat design has been given very importance because poorly designed seat affect badly on human health as well as psychological condition of driver hence increases the chances of accidents. It is evolved after evolution of first car at the start of nineteenth century. Following table shows the evolution of driver seats with period and car where it is used.

1.1 Parts of Driver seat

Driver seat is very complicated, consists of large number of parts and mechanisms. Main parts of driver seat are frame, padding, seat pan, head restraints system, reclining mechanism with lever, trim (seat cover), and suspension system, air bags, seat belt, fore and aft adjustment, height adjustment etc.

Fig:11 Seat

1.2 Function of Major Components of Seat

1.2.1 Seat Frame

It is most important part of any seat over which all other adjustment systems and components are mounted. It is made from HSLA (High Strength low alloy steel) tube

1.2.2 Anchorage

It is nothing but the space at which driver seat is mounted.

1.2.3 Seat Cushion/ Padding

It is that part of seat on which driver sit. It is soft and made from a resilient material such as PU foam of varying stiffness. Base and back cushions are used for seat.

1.2.4 Seat Back

It is that part of seat which is vertical or somewhat inclined and supports the driver lumbar, shoulder and head. At the top of seat back generally a head restraint system is mounted. Angle of seat back can be adjusted with the help of back reclining mechanism.

1.2.5 Seat Adjustments

It includes height, fore and aft as well as back reclining adjustment systems used to adjust height, fore and aft distance and angle of back respectively.

1.2.6 Head Restraint

It is mounted over the seat back at top, its main function is to support head also restrict the backward displacement and protect the cervical vertebrae. There are four types of head restraints namely integrated, detachable, separate and proactive head restraints .Proactive is advanced version of head restraint.

1.2.7 Suspension

Generally at two places suspension is used namely seat base and seat back. For suspension springs are used. Main purpose of suspension system is to attenuate the vibrations from road at driver seat and his body.

1.2.8 Trim

It is nothing but outermost covering of a driver seat, made from a cloth or leather of good quality. It has pleasant colour, appearance as well as styling.

PARAMETER AFFECTING DRIVER SEAT DESIGN

2.1 Ergonomics Related

Ergonomics is branch of design engineering applied to driver seat design requires that we take into consideration how the products we design fit the people that are using them. When seat fit to the driver it gives more comfort, less stress and maintains good psychological and health condition of driver. Ergonomics can be an integral part of design, manufacturing and use. Knowing how the study of anthropometry, posture, repetitive motion, and work space design

affects the user is critical to a better understanding of ergonomics as they relate to end-user needs.

2.1.1 Comfort Related Parameters

Comfort is feelings like relief, encouragement, enjoyment and stable. Comfort is dependent on pressure distribution over the seat, thermal comfort, vibration at driver body, geometric parameters.

2.1.1.1 Pressure Distribution Over Seat

For better comfort and proper maintenance of driver health uniform pressure distribution along the human body over the seat is very important parameter. Pressure distribution over a seat is dependent on the properties of cushion material such as stiffness, deflection and design of cushion. Also it depends on nature of loading, seat pan design and backrest design. A proper seat pan contour distributes a uniform pressure over seat and avoids concentration of stress in human buttocks. Properly inclined back rest avoids stresses at buttocks.

2.1.1.2 Thermal Comfort

It is most important ergonomic parameter on which comfort as well as health of driver dependent. Generally seat cushion materials (seat cover, PU foam and coconut fibers) absorb heat from driver body any acts as heat reservoir, this phenomenon is good for health in winter season but responsible for un-comfort in summer season. This problem can be overcome by using different types of seat covers depending on seasons.

2.1.1.3 Vibration

Road surface is not uniform everywhere yet it is constructed properly by advanced technology. Such surface is responsible for vibrations at driver seats. Human body can sustain 4-7 Hz frequency vibrations. Some tractor semi active hydraulic and active mechanical hydraulic actuators (i.e. suspension systems) are used to attenuate vibration transferred to the driver. Driver seat is so designed that very less vibrations transferred to driver.

2.2 Geometric Parameters

It includes the parameters like lumbar support, backrest slope angle, seat width, depth and height, seat pan angle.

2.2.1 Lumbar Support

Driver works extended periods of times therefore proper lumbar support is very important in order to maintain the position of vertebrae. Large number of anthropometric data is required for proper design of seat which provides support to lumbar. Proper lumbar support can be achieved by maintaining profile of seat cushions of PU foam material.

2.2.2 Other Adjustments

It includes other parameters apart from lumbar support. Seat adjustments totally depend on driver body shape and size i.e. anthropometry. Therefore seat designer must study the huge amount of data related to anthropometry before building a first prototype. Seat angle is also responsible for Pressure distribution over seat. Seat pan can be tilted in between 0-10 0 angle depending on driver body shapes and sizes.

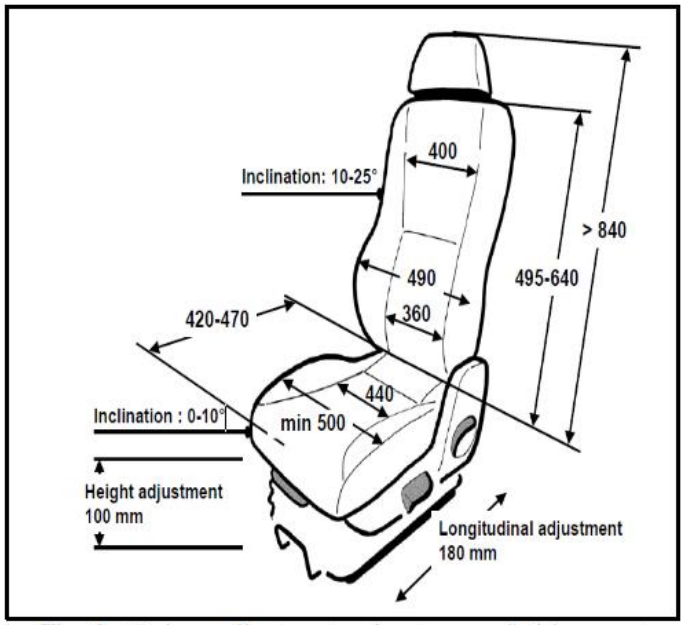


Fig -3: Various adjustments of motor coach driver seat

Dash board instruments:

- Speedometer tells you the speed of your vehicle in MPH and KPH.
- Tachometer shows how many rotations your engine is making per minute.
- Odometer shows how many miles your car has traveled in its lifetime.
- Fuel Gauge shows how much fuel remains in your car's tank.
- Gear Display shows which gear your car is currently in.
- Turn Signal Indicators flash when your turn signals are on; both will flash if you turn on your hazard lights.

- Active System Lights alert you to parts of the vehicle that are activated, such as an open trunk or door.

Automotive displays:

Sharp's ground-breaking Free Form Display has set the automotive world abuzz. Now, automakers and OEM suppliers can integrate display panels in shapes and sizes never seen before. With 25 years of experience developing and manufacturing high-end displays and other components for automotive applications, Sharp Devices Europe also supplies the European automotive industry with a full line of LCD technologies.

And there are more innovations waiting for you at Sharp, such as our 3D displays. Or our progressive super view technology (PSV), which increases sunlight readability to enhance safety and comfort. Pioneering Sharp Dual View displays allow drivers and co-pilots to view different content on the same screen simultaneously.

These pioneering technologies combined with Sharp's extensive consumer electronics experience enable OEMs to succeed at what may be their toughest challenge: delivering in-vehicle experiences that live up to the standards set by the latest consumer electronics.

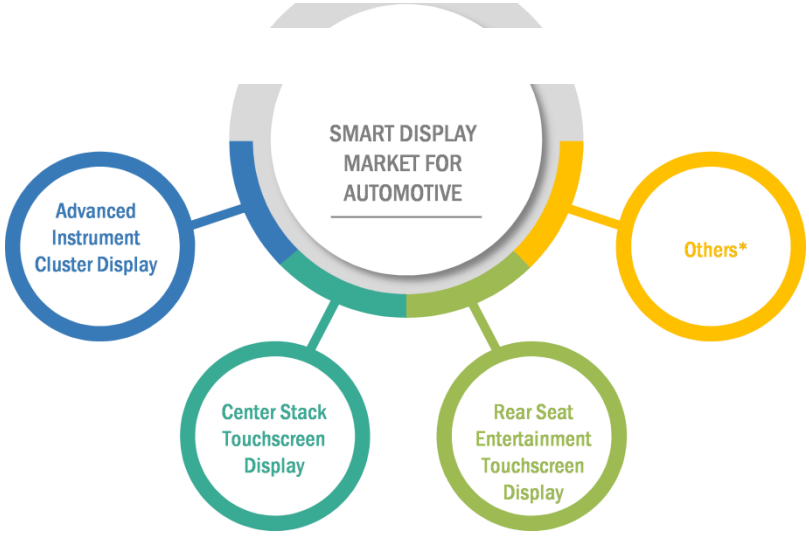


Fig:4 Automotive displays

Electronic Stability Control

Electronic Stability Control (ESC), also called an Electronic Stability Program (ESP), or Dynamic Stability Control (DSC), or Vehicle Stability Control (VSC), depending on the automaker and the market it is being offered in. To summarize, VSC uses the vehicle's brakes to help steer the vehicle during times of slipping or possible spinout. Braking is applied to wheels individually to counter over or understeer. Most VSC systems also reduce engine power automatically during these operations to further improve traction. Toyota calls its systems VSC or Vehicle Dynamics Integrated Management (VDIM).

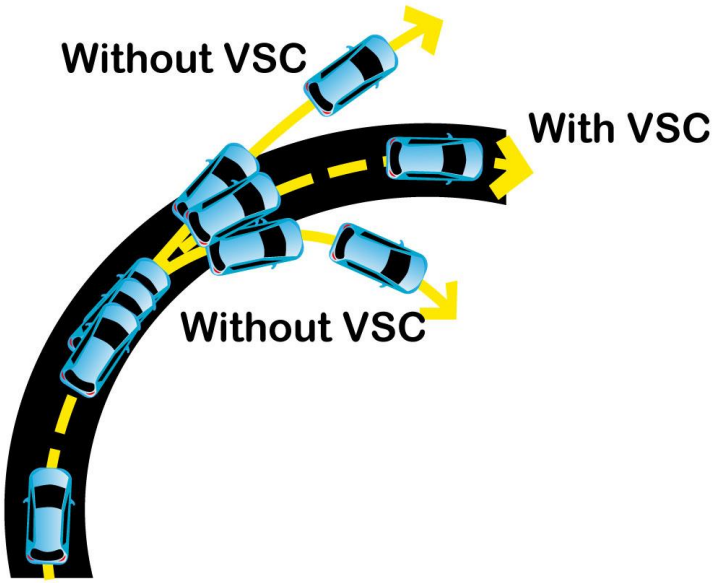


Fig:5 Electronic Stability Control

About one third of fatal traffic accidents could be avoided if a VSC system were employed, according to both the Insurance Institute for Highway safety (IIHS) and the National Highway Traffic Safety Administration (NHTSA). As of 2009, ESC is mandated in vehicles of 10,000 pounds gross vehicle weight or lower sold in the United States on a rolling scale with all vehicles of this size being required to have it after November, 2013.

ESC and VSC first appeared in production vehicles in 1995. It was introduced simultaneously that year by Mercedes-Benz, BMW, Volvo and Toyota. Suppliers included Bosch and ITT Automotive (now owned by Continental Automotive). By the end of 2009, both Ford (which gained their ESC from Volvo) and Toyota had made ESC/VSC standard in all vehicles sold in North America, with Toyota rolling it into all of their brands (including Scion) by 2011.

How VSC Works

In the background, as the vehicle is driven, VSC continually monitors the driver's intended direction (steer) with the vehicle's actual direction (lateral acceleration, yaw, and wheel speeds). When these become disjointed, with the driver's intended direction not being the same as the vehicle's actual direction, VSC intervenes appropriately.

Most commonly, VSC will engage during misjudged cornering (understeer or oversteer due to excessive speed), evasive swerves, and hydroplaning. It operates on all driving surfaces and has proven effective as a means of maintaining vehicle control and reducing accidents.

The system works through a combination of vehicle sensors, control of the anti-lock braking system (ABS), and traction control systems (TSC/ASR) for drive wheels. Unlike these individual systems, VSC considers input from the driver to add stability or correct for steering loss.

The VSC computer, usually located in the vehicle's main fuse box or as part of the ABS system computer, continuously measures yaw (rotation around vertical axis, or left-right spin), individual wheel spin rates, and traction. On most Toyotas with VSC, four sensors are incorporated in this system:

- Steering wheel angle sensor
- Yaw rate sensor
- Lateral acceleration sensor
- Wheel speed sensor

Some larger vehicles will also include a roll rate sensor for rollover prevention. Input from these sensors determines what the VSC is to do, if anything, based on the computer's comparison of data with a total vehicle "state space" (equations used to model vehicle dynamics in real-time).

Commands are issued appropriately to vehicle components such as the ABS. A hydraulic modulator in each wheel measures and dynamically adjusts brake pressure individually to the wheel according to instructions from the VSC computer. The driver's steering wheel angle as well as traction sensing is used to determine the amount of correction required.The VSC "Off Switch"

Most sport models of vehicles and some offroad-capable vehicles will have switches to allow the driver to disable VSC. In many sport driving conditions, such as on the track, in rally driving, and some hard offroad applications, VSC can interfere with advanced driving techniques. Corner drifting, for example, common in both track and dirt GT driving, is countered by VSC and thus counterproductive to the sport driver's wishes. Lateral sliding is also sometimes used as a maneuvering tool in offroad driving as a means of avoiding obstacles or gaining traction.

In addition, on some vehicles, the VSC may interfere with the use of a smaller spare tire, which will often give a different wheel spin rate than the other wheels on the car. Some newer Toyotas will compensate for a small spare automatically, however, if the sensed difference is constant (as it should be under normal driving). VSC is also automatically disabled when any of the four wheel speed sensors is disabled, so many shop and tow truck service persons will unplug the wheel speed sensor on the wheel onto which the spare has been temporarily mounted.

TEXT / REFERENCE BOOKS

1. Powloski J, “Vehicle Body Engineering”, Business Books Ltd., London 1989.
2. John Fenton, “Vehicle body layout and analysis”, Mechanical Engg. Publication ltd, London, 1982.
3. Kohli P. L, “Automotive Chassis & Body”, Papyrus Publishing House, New Delhi, 2010.
4. Wolf-Heinrich Hucho, “Aerodynamics of Road Vehicles” SAE International,USA,1998.
5. Robinson A.,Livesey W. A, “The Repair of Vehicle Bodies”, Butterworth - Heinemann Ltd,1989
6. Sumantran V. and Gino Sovram, “Vehicle Aerodynamics”, SAE International, USA, 1994.
7. John Fenton, “Vehicle Body Layout & Analysis”, Hutchinson, London, 1998.

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE
www.sathyabama.ac.in

UNIT 5 BODY MATERIALS, TRIM AND MECHANISMS

UNIT 5

BODY MATERIALS, TRIM AND MECHANISMS

Body materials:

1. Timber
2. Steel sheet
3. Plastic
4. GRP

1. Timber:

Before the introduction of plastics, timber was used in vehicle body construction, because it is readily available, easily worked and economically competitive, so far as the smaller manufacturer.

2. Steel sheet:

The vehicle body building industry uses many different types of steel. Low carbon steel is used for general construction members. High tensile steels are used for bolts and nuts which will be subjected to heavy load. The steel sheet thickness various from 0.08mm to 1.5mm. This type of sheet metal is mostly used in vehicle body construction.

3. GRP:

It is a combination of two basic materials. One is glass fiber and other is thermoplastic resign. The resign materials are relatively low strength, brittle but when combined with glass fiber it becomes strong material.

4. Plastic:

The use of plastics for interior trim is well established, and new applications are being found for components associated with the running gear, examples including reservoirs, air cleaner housings, belt covers etc.

Corrosion and Anti-corrosion:

A vehicle body exposed to corrosion throughout its life and because of the load carrying structure determines the service life of the vehicle, it is essential that it should be properly protected against such effects.

There are three types of vehicle body corrosion.

1. Chemical corrosion
2. Electro chemical corrosion
3. Fretting corrosion

Anti-Corrosion treatment

Corrosion can be prevented by three basic methods

1. Improve materials.
2. Protective coating.
3. Correct design.

Selection of paint:

The colors for finishing the vehicle should be based on scientific principles of colouring, which can be briefly outlined as follows,

- All shades are based on three colours i.e Blue, yellow and red. The basic concepts of colour technology are as follows,

TONE: The tone of colour can be defined by its position in the spectrum. i.e Wave length

VALUE: Value can be measured by the mixture of a natural grey, value corresponds to the concept of brightness or darkness of colours

INTENSITY: Intensity is defined by the mixture of white in the colours, where full colour has no white mixed with it.

Modern Automotive Coating Processes

Modern automotive coating methods consist of five main steps. They include the following:

- Pretreatment: removes and cleans excess metal and forms an appropriate surface structure enabling bonding of a corrosion protection layer.
- The next step is electrodeposition (ED) of the anti-corrosion or rust prevention layer.
- A sealer like Poly Vinyl Chloride (PVC) is applied for anti-corrosion, elimination of water leaks, and minimization of chipping and vibrational noise.
- A primer is then applied to promote adhesion between the surface and the basecoat; it also imparts a smoother surface for subsequent layers and has anti-chipping properties.
- Finally, the topcoats that include a basecoat and clearcoat are applied; they

provide surface properties that are sought after, including color, appearance, gloss, smoothness, and weather resistance.

The areas of an automobile depicted in Figure1show where these five steps of coating and other additional coatings are used. As can be realized when examining this figure, a significant number of specific coatings and materials are needed in addition to the above-listed steps to manufacture a salable automobile.

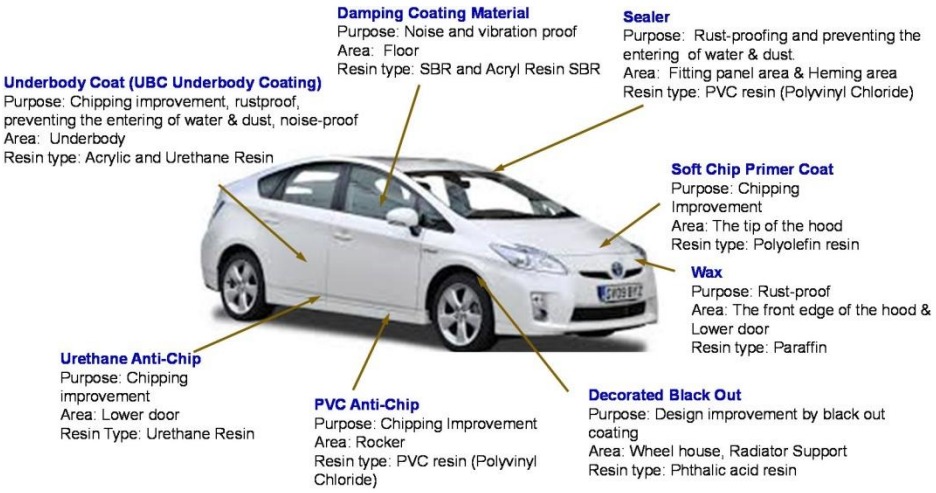


Fig:1 Modern Automotive Coating Processes

Pretreatment

When the automobile body sheet metal components are welded together, the resulting structure is referred to as the body-in-white (BIW). The first sequence in preparing the BIW for subsequent coating is pretreatment sees Figure3. Pretreatment consists of cleaning the body surface to remove remaining oils from the stamping process and welding residues through three primary liquid dip processes of degreasing, conditioning, and phosphating. An additional pretreatment cleaning that employs ~pH 9 hot water can also be used. Pretreatment helps the primer to bond onto the metal. A phosphate treatment applies an inert layer of metal phosphate, providing resistance to corrosion spread . The degreasing solution is composed of alkaline salts and surfactants and can include caustic soda, trisodium phosphate, and sodium carbonate. The surfactants are types of detergents for emulsifying oils and lubricants on the BIW. The degreasing zone typically consists of at least two sequences, including a spray stage known as knock-off-degrease (KOD) and a dip sequence. The advantage of using these two is that a significant portion of the oil and dirt will be removed by the high-pressure spray, thereby leaving a relatively lower load for the dip sequence to clean.

The next sequence is surface conditioning (also called activation), which creates nucleation sites for phosphate crystal growth. It increases the number of crystallization

nuclei on the metal surface that enhance bonding mechanisms for the subsequent phosphate sequence.

In conditioning, an aqueous dispersion of titanium orthophosphate with pH between 8 and 10 is typically used. Finally, the liquid dip phosphate solution is composed of phosphoric acid, phosphate ions, nitrate ions, zinc and other divalent metal ions, hydrogen ions, and an accelerating compound. The free acid etches the steel surface, causing hydrogen to be released while metal phosphate ions are precipitated onto the surface in a crystalline form. The primary objective during phosphating is to deposit a thin, dense and uniform conversion layer on the cleaned and prepared metal surface.

Electrodeposition (ED)

The metal underbody and frames of automobiles are coated to prevent corrosion, whereas other areas like the roof are not rust-proofed. When not coated to prevent corrosion, the structural metals (or other materials) are primed before applying additional coatings. Figure4displays types of corrosion protection coatings for cold rolled steel.

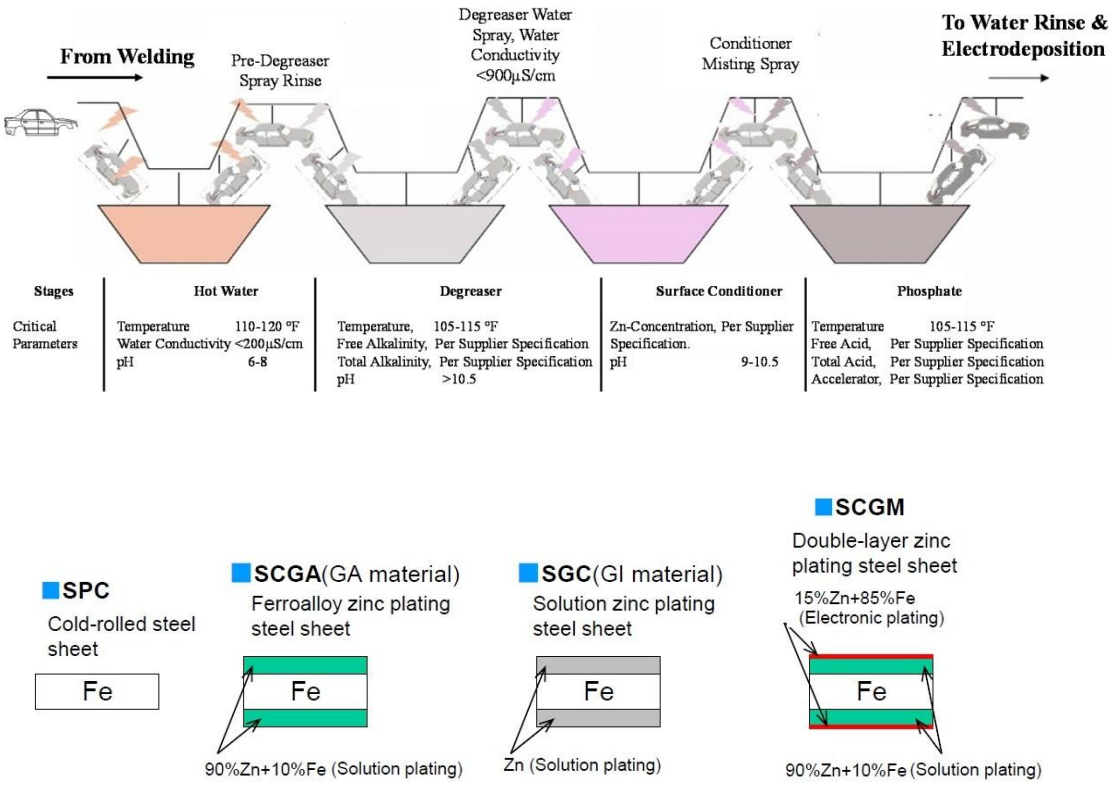


Fig:2 Electrodeposition (ED)

An SCGA electrodeposition solution having a 90% Zn–10% Fe composition (GA material) is the primary coating used in modern automobiles to prevent corrosion. In comparison to the SGC solution, i.e., GI material, with 100% Zn during electrodeposition,

the GA material minimizes ED gas pin (paint quality defects) and maximizes spot welding performance; however, the SGC process is still used in Europe. The SCGM corrosion protection method was used in previous decades, and it did enable minimization of ED gas pin. However, its cost was higher than the GA material coating.

The electrodeposition coat or E-coat provides rust and corrosion protection and was first introduced in the 1960s. Since then the use of E-coat has grown at a rapid pace. By 1970, 10% of all cars were electrocoated and by 1990, 90% of all cars were electrocoated. Today, it is the most conventional coating process used in vehicle manufacturing.

The E-coat process has not only grown at a rapid rate but has changed significantly since it was first introduced. From 1964 to 1972 an anodic E-coat process was used, and from 1976 to the present, a cathodic E-coat has been used. The E-coat film thickness has also varied during this time frame. Thicknesses started at 25 µm and remained that way until 1976 when the cathodic process was adopted, and an 18 µm thickness was established; it remained at this value until 1984, when the film thickness was increased to 35 µm. This relatively thick film was used until 1992 when E-coat film thicknesses were decreased to the current value of 20 µm [5].

The E-coat solution consists of a mixture of resin, binder, a paste containing the pigments, and a solvent. During anodic electrodeposition, metal parts are positively charged while the paint is negatively charged; because small amounts of metal ions migrate into the paint film, it limits the performance properties of the coating. Hence, anodic coatings are mainly used for interiors and offer excellent color and gloss control. In cathodic electrodeposition, the metal part is negatively charged while the paint is positively charged. In contrast to the anodic process, the cathodic process reduces the amount of iron that can enter into the paint film. Hence, cathodic coatings offer high performance and excellent corrosion resistance and have mostly replaced anodic coatings in North America. The E-coat process is considered to be relatively environmentally friendly; it uses only a 0.5% solvent solution [28].

The pH of the solvent in the ED tank is a measure of the balance of acidic and caustic components in the tank. The balance is dominated by the functional groups in the resin and the neutralizing agents. A decreased pH in the cathodic ED tank lowers film thickness so that higher voltage needs to be applied with the danger of rupture effects [5]. The pH can be influenced by the pretreatment chemicals in a detrimental way. In such a case, conductivity and pH drift to values outside of the specification and corrections have to be made by replenishing ultrafiltrate with deionized water (D.I.) water.

As shown in Figure5, E-coating involves dipping automobile bodies into the coating solution and passing an electric current through the body and the liquid ED paint solution. Because of the charged nature of this coating process, the ED paint penetrates into places a spray would not reach. The ED paint is promoted to bond with the metal substrate, and a uniform coating thickness is produced. The result is an insoluble, deposited layer with a very high solids content and firm adherence to the pretreated body [25].

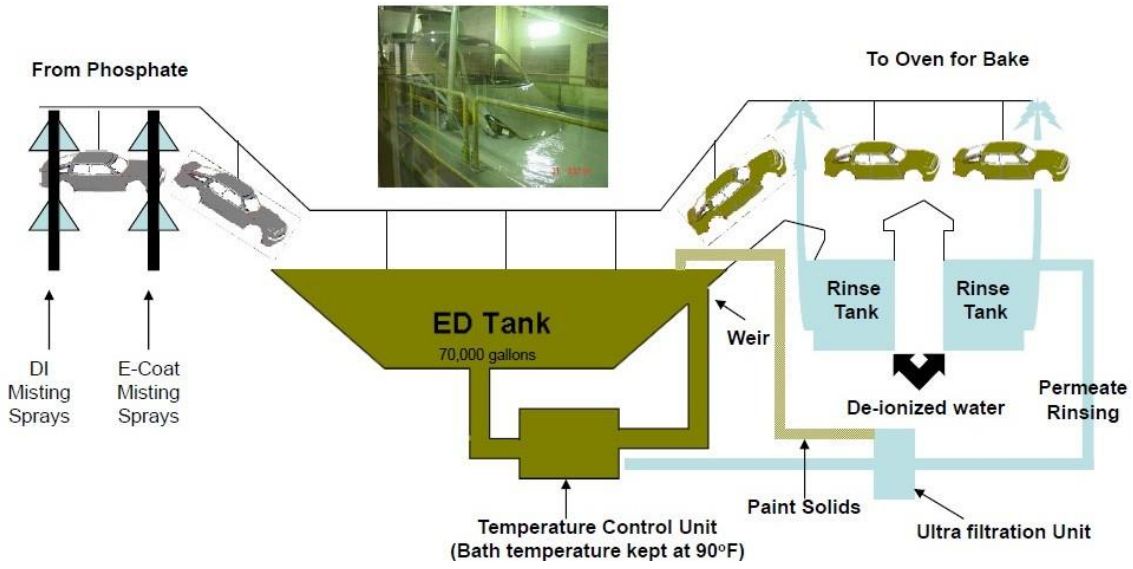


Figure 3. Electrocoating process.

During operation, a mixture of resin, binder, and a paste containing the pigments is fed into the electrodeposition tank. The automobile body is lowered into the tank, and an electric current applied; the solution in the tank consists of 80%–90% deionized water and 10%–20% paint solids (consisting of resin, binder, and pigment). The deionized water acts as a carrier for the paint solids, which are under constant agitation. The resin is the backbone of the final paint film and provides corrosion protection, durability, and toughness. Pigments are used to provide color and gloss. To control paint performance during cathodic E-coating, purging of the paint and regulating the amount of applied voltage are essential. As the coating grows in thickness, it becomes more and more insulating, thereby causing the deposition process to slow. As an automobile body exits the tank, paint solids adhering to the surface but not bound

to the surface are rinsed off to recover the ED solids via an ultra filtration unit to ensure surface smoothness.

After the E-coat, the automobile body enters a bake oven, in which heating and keeping at a temperature of 160 ″C for 10 min causes film curing to promote maximum performance properties. The oven temperature and heating time primarily enhance chip resistance and film adhesion to the body; corrosion protection is affected less by these conditions. Because surface roughness influences the smoothness and brilliance of the topcoat, some sanding of the surface is usually performed to remove or eliminate defects before the body enters the next application step.

A common challenge in the current E-coating process is that of water spots that contaminate coated surfaces. These spots can appear on the air-dried surface if water droplets from the conveyor or other sources fall on the body, especially if the water in the tanks is not deionized properly and has high conductivity; the water spots are usually a remnant of unwanted ions in the water and will cause problems in subsequent coating applications and their adherence and appearance. If water spots are present, they have to be removed by sanding. Hence, it is necessary to use well-deionized water and routinely monitor its conductivity. Alternately, operators also add surfactants or ultrafiltrates to the water rinse zone to eliminate or manage water spots.

Pigment

Pigments are granular solids incorporated in the paint to contribute colour. The pigments impart toughness, texture to give the paint special properties. It does not allow the main vehicle to loosen the paint particles. Titanium dioxide is used as pigment inmost paints Silica, Alumina ,Zirconium are also used as pigments .These materials give better exterior durability or better hiding performance.

Enamel

The enamel portion of paint is mixed with vehicle and pigment to give it glazing appearance.

Drier

The drier in the paint allows the paint to dry as fast as possible so that the paint may not slip down from the body of the automobile to give it a uniform appearance at all parts of the body. Driers are oxygen carrying catalysts. They accelerate the drying of the oil film by oxidation , polymerization and condensation. Most effective driers used are resinates, linoleates , tungstates and naphthalenes of copper, manganese, lead and zinc.

Thinners

The thinner in the paint is used to make it thin while mixing the vehicle, pigments and drier . It enables the paint to spread easily and also to be sprayed as the case may be. It is a volatile substance. Therefore evaporates after the paint has been applied. Popularly used thinners are turpentines , mineral, spirits, benzene, dipentene, napthalene, xylot, kerosene, methylated naphthalene etc.

Methods of Painting

Different types of painting methods are being applied for painting of automobiles

(i) Brushing

(ii) Dipping

(iii) Roller coating

(iv) Spraying

(v) Tumbling

Brushing

In automobiles some of the inner parts which can not be in reach of spray gun, can be painted by brushing with automobiles paints using paint brush.

Dipping

The parts of irregular shape and small in size can either be sprayed nor brushed. Such parts can be removed from the vehicle and dipped in a drum filled with paint.

Roller Coating

In automobiles the parts which are in sheet shaped can be painted by roller coating . The sheet

shaped articles are passed though the rollers which are dipped in paint. By rotating the rollers on the sheets, the paint will be applied uniformly.

Spraying

The entire outer surface of the vehicle body is painted by means by spraying the paint with spray gun. In this method the paint is atomized by the force of compressed air or by the action of high pressure compression of paint and turning of paint into small particles which travel to the article to be painted.

Tumbling

Small sized articles are painted by this method. They are put in a rotating barrel containing properly mixed paint . The barrel is closed and rotated for a suitable amount of time. Articles get coated with paint and after taking out, they will be finally dried.

Painting Procedure

As anyone who's ever detailed by hand can tell you, painting a car is anything but simple. However, automotive manufacturers have developed several different techniques for body painting that yield effective, reliable results. The process is completely automated and works mainly through sealed chambers built onto the assembly line

Step 1: Electrocoating

To keep the paint from peeling off or forming unsightly "bubbles" of rust underneath, the entire exterior must be protected from corrosion. Getting into each and every crevice with aerosol-sprayed paint can be difficult and expensive, even with a completely automated system. Instead, chains are attached to the chassis and the body is lowered by machine into a solution of ionically charged paint particles. The chain is electrically conductive and linked to a larger circuit. Meanwhile, the vat containing the paint solution is equipped with electrodes linked to the same circuit. When the body gets submerged, the circuit is completed, causing the current to flow from the vat electrodes, into the metal exterior and up the chain. In the process, this electrical field pulls the ionic paint particles toward the metal exterior, completely coating it.

After about 15 minutes of electrocoating, the body is hoisted out of the vat and carried (via a ceiling-mounted track) to a "drying chamber" where heat lamps dry the excess paint.

Step 2: Primer

Once the anti-corrosive layer has been electroplated on, primer is applied to add smoothness and allow a top paint layer to stick to the body. First, the body is lowered off the chains to rest on a floor apparatus attached to a track. To apply the primer, the body moves down the track into a special sealed room called a "flow chamber" (Figure 1). The flow chamber features a constant flow of air that takes vaporized primer particles from openings in the ceiling where they gently deposit on the exterior for a uniform thickness. Meanwhile, the bottom of the chamber has several outlet openings attached to a vacuum, removing excess primer to be collected and reused. After about 10 minutes, the body is moved down the track to another drying room.

Step 3: Base Coat

Once the primer has dried, the body moves into another flow chamber for the application of the base coat. The base coat constitutes the actual "color" of the car, including textural details like aluminum flakes for a sparkle effect. Like the primer, the base coat's application involves the continual flow of vaporized paint across the body for about 10 minutes, followed by a trip to a drying room. Automobile Engineering 146 Technician

Step 4: Clear Coat

Just as the electrocoating protects metal from corrosion, the clear coat protects the base coat against light scratches, organic solvents, water and UV sun damage. As the name suggests, it is transparent, showcasing the base coat like glass does a picture. Typically, a flow chamber applies the clear coat as well.

TEXT / REFERENCE BOOKS

1. Powloski J, "Vehicle Body Engineering", Business Books Ltd., London 1989.
2. John Fenton, "Vehicle body layout and analysis", Mechanical Engg. Publication ltd, London, 1982.
3. Kohli P. L, "Automotive Chassis & Body", Papyrus Publishing House, New Delhi, 2010.
4. Wolf-Heinrich Hucho, "Aerodynamics of Road Vehicles" SAE International,USA,1998.
5. Robinson A.,Livesey W. A, "The Repair of Vehicle Bodies", Butterworth - Heinemann Ltd,1989
6. Sumantran V. and Gino Sovram, "Vehicle Aerodynamics", SAE International, USA, 1994.

7. John Fenton, “Vehicle Body Layout & Analysis”, Hutchinson, London, 1998.