Double wishbone
MacPherson strut

FIGURE 3-40 Typical stabilizer bar installation.
Strut bars

The load on the chassis where the struts are attached to the chassis will be quite large. With aggressive driving, there will be deformations that have a negative effect on the handling of the car. In order to stiffen the chassis up at the strut mounts, a so-called strut bar (fjäderbensstag) may be used. Strut bars are rarely original equipment, although some cabriolets are delivered with it.

Whereas MacPherson suspensions are very common as front suspensions, they are seldom found in rear suspensions. Obviously, it is quite impractical to use a strut bar in the rear since it takes up a lot of space in the trunk.
Roll centers for some cars

Audi A4 (2007):
Front: 86.3 mm
Rear: 115 mm

Mercedes C-class (2007):
Front: 39.6 mm
Rear: 100 mm

Mercedes E-class (2009):
Front: 38.9 mm
Rear: 98 mm

BMW 7-class (2008):
Front: 85.4 mm
Rear: 81 mm

Audi Q5 (2008):
Front: 86.3 mm
Rear: 91.1 mm

Mercedes GLK-class (2008):
Front: 113 mm
Rear: 157 mm
Camber and track width changes

For a car with an independent suspension, the camber and the track width change when cornering and hitting bumps. On the contrary, with a solid axle, the tires on an axle always remain parallel. As we have seen in lecture 12, the lateral grip of a tire varies with the camber angle. If a car hits a bump when traveling straight-ahead, there will be lateral tire forces if the track width changes. That means that the maximum possible value of the longitudinal tire forces decreases (compare Kamm's circle from lecture 12). On icy winter roads it is especially advantageous to have a constant, and hence predictable, maximum grip. That is the reason why Volvo and Saab stuck with rear solid axles for so long.

We have seen that if the roll center height \( h_R \) is large, a car will roll less; if \( R = G \) there is no roll at all. One might therefore think that it would be a good idea to use a high roll center. However, that results in extreme camber changes when hitting bumps. In addition, when cornering, the moment of the lateral tire force on the outer tires causes these tires to “dig” into the road and lift the chassis – so-called jackling.
When cornering, the tires tend to tilt to the outside of the corner. As we have seen in lecture 12, you would like the tires to instead tilt to the inside of the corner so that the tires “want” to turn in the same direction the car turns, but not too much since that increases tire wear. Since the outer tires carry the highest load, one should focus on preventing these tires from having a large tilting angle to the outside of the corner. One can make the tires tilt less in the wrong direction by designing the suspension so that the wheels go into negative camber in bump, and positive camber in rebound. The reason for that is that the outer wheel, which is in bump, will then be more vertical, maybe even have a small negative camber. The inner wheel, which is in rebound, will also be more vertical, or have a positive camber, i.e. tilt to the inside of the corner. The figure below shows how the camber varies with the vertical wheel travel for the front double wishbone suspension of the BMW 7-series. As seen, the camber is negative in bump, and positive in rebound.
The figures on the following pages illustrate the camber and track width changes for different double wishbone suspension designs. Note that for parallel, horizontal control arms, the roll center is on the road level:

\[ \Delta F_s = \Delta F_z \]

Euler I in the vertical direction gives \( \Delta F_s = \Delta F_z \). Comparison with (8), proves that \( h_R = 0 \).

The figures show that with equal length, parallel control arms, the camber change in bump/rebound (droop) is zero, and that the tires tilt to the outside of the corner by the same amount as the chassis rolls. The longer the control arms, the smaller the track width change becomes.

By using parallel control arms, where the upper arm is the shorter, the camber changes in bump/rebound. When cornering, the outer tire tilts less to the outside of the corner, and the track width change is kept small.

With non-parallel control arms of different length, the outer tire can be made to tilt even less to the outside of the corner (the particular design shown in the last page is too extreme since it gives huge camber changes in bump).
Figure (24): Equal length and parallel link system with short links.
Figure (26): Unequal length parallel links.
Figure (27): Unequal and non-parallel links.