evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

KKS/ZDMT
Braking

Lecture 9

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2011, UWB Pilsen

Lecture for project CZ.1.07/2.2.00/15.0383
Inovace studijního oboru Dopravní a manipulační technika s ohledem na potřeby trhu práce

Braking

- Braking is understood to be controlled reduction of speed or limiting the moving off of a stationary vehicle

- Movement energy is converted into heat

Function and kinds of braking

The ‘braking system’ is a unit of parts whose function is to gradually reduce the speed of a moving vehicle, or to stop it, or to keep it stationary if it’s already stopped. Braking equipment must fulfill the following functions:

- Service braking system – to slow and stop the vehicle
  - The service braking system shall make it possible to control the movement of the vehicle and to halt it safely, speedily and effectively, whatever its speed and load, on any up or down gradient. It shall be possible to graduate this braking action. The driver shall be able to achieve this braking action from his driving seat without removing his hands from the steering control.
- Secondary braking system – if brakes fail, must carry out the same function (e.g. double circuit brakes),
  - The secondary braking system shall make it possible to halt the vehicle within a reasonable distance in the event of failure of the service braking system. It shall be possible to graduate this braking action. The driver shall be able to obtain this braking action from his driving seat while keeping at least one hand on the steering control. For the purposes of these provisions it is assumed that not more than one failure of the service braking system can occur at one time.

Function and kinds of braking

- Parking braking system – secures a parked or stopped vehicle against moving without presence of driver,
  - The parking braking system shall make it possible to hold the vehicle stationary on an up or down gradient even in the absence of the driver, the working parts being then held in the locked position by a purely mechanical device. The driver shall be able to achieve this braking action from his driving seat.
- endurance braking system – maintain or lower the required speed on a slope
- Self braking – auto-braking of a towed vehicle in case of accidental decoupling.

Requirements of a braking system

- Must automatically brake all vehicle's wheels
- The action of the service braking system shall be distributed between the wheels of one and the same axle symmetrically in relation to the longitudinal median plane of the vehicle.
- Worn brakes must be easy to adjust manually or automatically
- Braking force should not exceed 700N
- Fulfillment of these requirements is verified by three different tests
- The performance prescribed for braking systems is based on the stopping distance and/or the mean fully developed deceleration. The performance of a braking system shall be determined by measuring the stopping distance in relation to the initial speed of the vehicle and/or by measuring the mean fully developed deceleration during the test.

Braking unit

Braking unit is composed of the following:

- Power supply – muscle power, compressed air
- Control device– brake pedal-brake cylinder, hand brake lever, etc.
- Transmission equipment – transmission medium (mechanical, hydraulic, pneumatic), brake pipes, hoses, valves,
- Additional equipment for trailers– control equipment for trailer,
- Equipment for regulating braking force (e.g. ABS etc.),
- Wheel braking equipment – to create force opposite to the direction of movement, most often by friction – drum and disc brakes.

Power source

Braking units can be divided in terms of power sources into :

- direct braking units – necessary power is supplied only by the muscle power of the driver
- braking units with booster – another power source s added to the driver's muscle power (e.g. vacuum intake manifold),
- machinery braking units – an external power source is used (compressed air), the flow of which is controlled by the driver using a brake pedal.

Requirements of braking systems

- UNECE Regulations :
  - 13 – Braking of vehicles in categories M,N,O
  - 13H - Braking of vehicles in category M1
  - 78 – Motorcycle braking
  - 90 - Replacement brake linings
- Directive EEC/EU:
  - 71/320,74/132,75/524,79/489,85/647,85/647,88/194,91/422,98/12 – Braking of vehicles in categories M,N,OM,N,O
  - 93/14-Braking of vehicles in category L
- Standards
  - ISO 611:1980(E) Braking of motor vehicles and trailers
  - ISO 6597:1980(E) Passenger car braking systems-measuring braking performance

Requirements of a braking system

- Category M_1 vehicles
  - Minimum mean braking deceleration during testing with disconnected engine is 6.43 m/s^2, max. braking distance $s \leq 0.1.v + 0.0060.v^2$ [m], v = 100 $km.h^{-1}$
  - Minimum mean braking deceleration during testing with connected engine is 5.76 m/s^2 , max. braking distance $s \leq 0.1.v + 0.0067.v^2$ [m], v = 80 $\%.v_{max} \leq 160$ $km.h^{-1}$
  - For emergency braking mean deceleration must be 2.44 m/s^2
  - Handbrake must hold a stationary loaded vehicle on a 20% slope.
  - For vehicles connected to trailers, handbrake must hold the connected vehicle on a 12% slope.

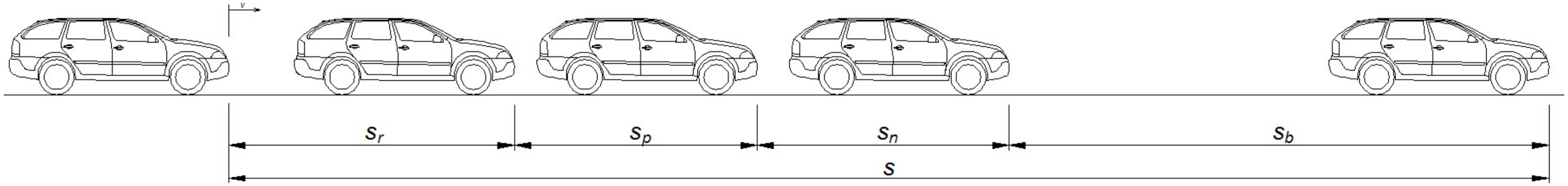
- Category M_2, M_3 and N vehicles
  - Minimum mean braking deceleration during testing with disconnected engine is 5 m/s^2
  - Minimum mean braking deceleration during testing with connected engine is 4 m/s^2
  - For emergency braking mean deceleration must be for vehicles in categories M_2 and M_3 2.5 m/s^2 and for vehicles in category N 2.2 m/s^2
  - The handbrake, even if it is combined with other brakes, must hold a stationary loaded vehicle on a 18 % slope.
  - For vehicles connected to trailers, handbrake must hold the connected vehicle on a 12% slope.

Stopping distance

Stopping distance is the distance travelled by a vehicle from the moment an obstacle is sighted by the driver to the moment the vehicle stops.

Stopping distance can be broken down into 4 parts:

- Driver's reaction time
- Braking delay
- Initial braking
- Braking to complete stop



Stopping distance

- Distance travelled during reaction time of driver (vehicle moving with uniform motion)

$$s_r = v.t_r \quad [m]$$

where v is initial speed of vehicle [$m.s^{-1}$]

t_r – reaction time of driver [s]

Reaction time of driver is the time period from the moment of sighting an obstacle to the moment of first touching the brake pedal.

Reaction time is usually from 0.5 to 1.5 s and depends on many factors.

Stopping distance

- Distance travelled during braking delay (vehicle moving with uniform motion)

$$s_p = v.t_p \qquad [\mathrm{m}]$$

Where t_p is braking delay[s]

Braking delay is the time period from the first contact of brake pedal by driver to moment of first contact of friction surface of brake.
Braking delay is usually 0.03 až 0.06 s.

Stopping distance

- Distance travelled during initial braking (vehicle moving with deceleration)

$$s_n = v.t_n - \frac{1}{2}.a_n.t_n^2 \quad [\mathrm{m}]$$

Where t_n is time of initial braking[s]

a_n – ave. deceleration during initial braking [m.s^{-2}]; $a_n = \frac{a}{2}$

Initial braking is the time period from first contact of friction surface of brake to moment of complete braking, i.e. moment when tyres are at a complete stop on road surface.

Initial braking time varies from 0.07 to 0.5 s.

Stopping distance

- Distance travelled to complete braking (vehicle moves with deceleration)

$$s_b = \frac{v_n^2}{2.a} \quad [\mathrm{m}]$$

Where *a* is deceleration to complete braking[m.s^{-2}]

v_n – speed of vehicle after initial braking[m.s^{-1}]

$$v_n = \sqrt{v^2 - 2.a_n.s_n}$$

Stopping distance

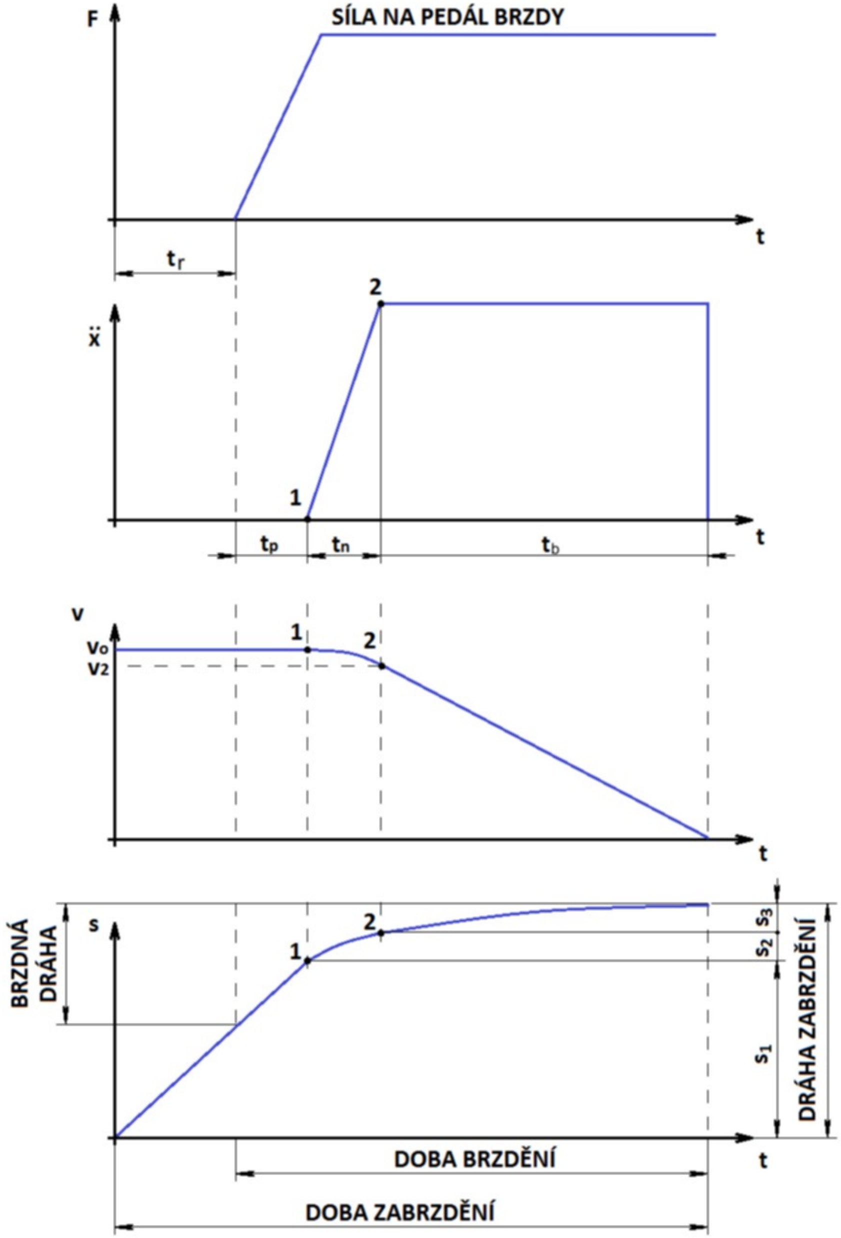
- Total stopping distance required to stop a vehicle:

$$s = s_r + s_p + s_n + s_b = v.\left(t_r + t_p + t_n\right) - \frac{1}{2}.a_n.t_n + \frac{v_n^2}{2.a}$$

Stopping distance

- Division of individual phases of driver activity during emergency braking.

Boundaries of time periods		**Name of time period**	
1	Initial optical sighting of dangerous object	Optical reaction	driver reaction time
2	Initial sharp optical sighting of object	Psychological reaction	
3	Initiation of muscular reaction	Muscle reaction	
4	Contact with brake pedal	Braking delay	Vehicle response
5	First contact of friction surface of brake	Initial braking	
6	Initialization of skid marks on road		



Braking:

-forces on brake controls

- braking forces

-speed during braking

- stopping distance

Stopping distance

During movement in a straight line friction force between tyre and road F_t [N] is in equilibrium with inertia F_s [N] (i.e. force acting to keep vehicle moving in uniform motion).
From conditions of equilibrium of forces is valid:

$$F_t = F_s$$

After inserting

$$m.g.\mu_v = m.a$$

And from this formula we obtain the limit for maximum achievable deceleration a [$m.s^{-2}$] on a horizontal road:

$$a \leq g.\mu_v$$

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Acknowledgements

This project is co-financed by
European Social Fund and the state budget of the Czech Republic

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