

### **Elevated Track System**

The invention relates to an elevated track system with elevated tracks running above ground level.

Ground-based traffic networks are increasingly reaching their limits in strongly growing urban centres due to the continuously increasing traffic volume. In order to reduce the burden on the traffic network and to create an independent traffic level, underground railways or subways are built in many residential areas, but, unfortunately, these are associated with immense costs. Moreover, the construction of railway systems in the underground of existing urban centres is associated with an enormous expenditure of time and with technical difficulties. Consequently, above all in development areas there is a great need of alternative traffic concepts by means of which the burden on existing traffic networks can be reduced and efficient new traffic systems can be established. There has already been proposed a wide variety of forms of elevated track systems which in practice, however, have not yet led to satisfactory traffic solutions.

Moreover, in prior art there are known conventional, ground-based road networks which are formed with crossovers, flyovers or bridges at the junctions in order to enable a free flow of traffic. Such crossing systems are, however, a part of the existing traffic systems and, thus, cannot achieve a sufficient ease of the traffic burden. Examples for such road systems are shown in CN 10218062 A and WO 2007/028307 A1.

Therefore, the invention has the object to create an elevated track system of the above-mentioned kind, by means of which an efficient traffic network independent of the ground-based traffic is provided, by which it is possible to travel over longer distances quickly and unimpeded.

In accordance with the invention, the elevated tracks comprise transit routes crossing one another and running one above the other at the crossing areas, and circulating transfer routes surrounded by transit route sections between the crossing areas, wherein the transit route sections are connected to the circulating transfer routes along transfer areas.

Accordingly, the inventive elevated track system comprises at least two different kinds of elevated tracks. On the one

hand, there are provided transit routes which are used to transport the regional traffic preferably without impediments or interruptions. The transit routes cross one another at different height levels so that, advantageously, no controlled intersections are required which would slow down the traffic flow. Thus, a quick progress on the transit routes is ensured. The transit routes can be separated constructionally from one another so that vehicles cannot get directly from one transit route into another transit route. Accordingly, the traffic can flow substantially in an unimpeded manner along the transit routes which run at least in two different directions. Hence, the transit routes spread out a traffic network which covers a certain residential area. On the other hand, circulating transfer routes are provided in order to get from one transit route to another transit route. For changing the driving direction, the vehicle turns off from the transit route, on which it is currently driving, via the transfer area into the associated transfer route. The transfer route forms a closed traffic loop along which can be driven in the same manner as along a roundabout. For turning off into another transit route, the transfer route will be driven through circularly until the respective transfer area is reached at which the transfer route will be left. Thus, advantageously, it will be distinguished between transit routes by means of which the regional traffic is transported over longer distances free from controlled intersections, and comparatively short transfer routes by means of which the change of direction within the traffic network is performed. Thereby the efficiency of the mastering of the traffic volume can be considerably increased. Advantageously, furthermore an additional traffic level is created which can be used independently of the ground-based road network in order to cope with the traffic volume in urban centres. In development areas, the elevated track system has also the advantage that risks due to road crime can be eliminated to a large extent.

For the realization of local and locally limited transfer zones, it is advantageous if the transfer route is surrounded by transit route sections between adjacent crossing areas. Accordingly, in relation to the traffic level, the transfer routes extend within the adjacent crossing areas of the transit routes which set the grid points of the traffic network. Thus, the

transfer routes are substantially shorter than the transit routes which represent long arterial roads which comprise several, preferably a plurality of transit route sections between the individual crossing areas. In a less preferred embodiment, the transfer route can, however, extend over more than one transit route section, for instance over two transit route sections.

For the optimization of the traffic routes within the elevated track system, it is favourable if the transfer route is surrounded by substantially straight running transit route sections. Accordingly, the regional traffic can be guided via the fastest possible routes between the junctions or hubs of the traffic network.

According to a preferred embodiment, the transfer route is surrounded by four transit route sections. If the transit route sections run in straight lines in the area of the transfer route, the transit route sections, when seen from above, are arranged in a polygon-like manner around the transfer route. Thereby an advantageous network structure is obtained by means of which the traffic routes of the elevated track system are optimized.

In order to obtain a chequered or lattice-like traffic network, it is favourable if the transfer route is surrounded by transit route sections running substantially at right angles to one another. Thus, the transfer route is enclosed by a rectangular or square arrangement of transit route sections, when seen from above, which are formed by the crossing areas of the respective transit routes.

For the minimization of delays when turning into the transfer route, it is advantageous if the transit route sections, at least in the transfer areas, run substantially in parallel to the transfer route. The transfer areas each have a lane change zone at which the transit route section and the transfer route run side by side at the same height.

In order to obtain a close-meshed traffic network, it is favourable if each transit route section adjoins at least one, preferably exactly one, transfer route. If each transit route section is connected to a transfer route, depending on the length of the transit route section only a relatively short distance has to be covered before the transit route section can be left via the corresponding transfer area.

In order to obtain the circulating transfer route, it is favourable if the transfer route has substantially straight running transfer sections which are connected to one another via curve sections running in an arc-shaped manner. Hence, the transfer route forms a closed traffic loop which is bounded towards the outside by the transit route sections.

When the transfer route is connected to each adjacent transit route section via at least one, preferably two transfer area(s), advantageously a lane change between the transfer route and the transit route can be performed at all transit route sections.

In order to minimize the space requirements of the elevated track system, it is favourable if the transit routes are formed as one-way roads which have one single lane, respectively. Preferably, transit one-way routes running approximately in parallel to one another are driven through alternately in opposite directions.

In order to obtain comparatively narrow arterial roads, it is advantageous if the transit routes have a width of 1.5 to 3 meters, preferably substantially 2 meters.

In order to be able to quickly reach or leave the elevated track system, it is advantageous if the transfer route, preferably at each transfer section, is connected to at least one access or entry road leading to the ground. The particularly ramp-shaped access roads are preferably designed as one-way roads. Apart from the accesses or the exits, however, the elevated tracks always run above ground level.

In order to control the traffic flow on the transfer route, it is favourable if the transfer route has at least one deceleration or stop section extending at a lower height than the adjacent transit route section. The stop sections are intended primarily for the quick getting on and off of the passengers. The deceleration or stop section, on the one hand, is also used to integrate entering or exiting vehicles into the traffic of the transfer route. Preferably, each deceleration or stop section is also connected to at least one access road leading to the ground in order to reach or leave the elevated track system. Furthermore, the deceleration or stop section can comprise a parking lot or a car park for the parking of vehicles.

According to a preferred embodiment, the elevated tracks are

formed by precast elements made of fibre reinforced concrete, preferably ultra high performance fibre reinforced concrete. Fibre reinforced concrete has particularly advantageous material properties for the manufacture of the elevated track, which include a substantially longer durability and a higher compressive strength than a conventional concrete.

According to a particularly preferred embodiment, at least several of the elevated tracks comprise guiding devices for suspended vehicles, in particular maglev (magnetic levitation) cabins, at the bottom side thereof. The suspended vehicles are preferably designed for the individual traffic. Such passenger transport systems, often called PRT ("Personal Rapid Transport"), are commonly known in prior art so that no details with respect to the technical implementation will be mentioned here. Those implementations are preferred in which the individual suspended vehicles are driven electrically or inductively with linear motors. In this connection, the physical principle is comparable to the one of maglev trains. Such a system has for instance been developed under the designation "SkyTran". One example for a maglev train can also be found in DE 10 2006 012 423 B3. For the present disclosure, however, only the recognition is essential that the efficiency or performance of the inventive traffic system can further be increased by the fact that, in addition to the lanes running on top of the elevated tracks for wheeled passenger vehicles or wheeled light-duty trucks (with a total load of less than 3.5 tons), also the bottom side of the elevated tracks is used for arranging guiding devices for the suspension and guidance of the suspended vehicles. Therefore, advantageously, the same elevated tracks can be used for two different traffic concepts. Thereby the traffic throughput can be substantially increased, in particular substantially doubled. Said combination results in a particularly efficient traffic system which is particularly well-suited for traffic-congested large cities.

The invention will be explained below in more detail by reference to embodiments represented in the drawings, without being limited thereto, in which:

Fig. 1 shows a plan view of an inventive elevated track system made of transit routes crossing one another which enclose circulating transfer routes;

Fig. 2 shows a plan view of a traffic junction or hub of the elevated track system shown in Fig. 1;

Fig. 3 shows a plan view of a segment of the traffic junction of Fig. 2;

Fig. 4 shows a lateral view of the elevated track system corresponding to Fig. 3;

Fig. 5 shows a deceleration or stop section of the elevated track system according to Figs. 1 to 4;

Fig. 6 shows an alternative deceleration or stop section of the elevated track system according to Figs. 1 to 4;

Fig. 7 shows a view of a preferred embodiment of the elevated track system with elevated tracks made of ultra high performance fibre reinforced concrete;

Fig. 8 shows a plan view of the elevated track made of ultra high performance fibre reinforced concrete according to Fig. 7, in which guardrails are provided as a safeguard against falling down;

Fig. 9 and Fig. 10 show a sectional view along line XI-XI and X-X in Fig. 8, respectively;

Figs. 11 to 13 show several sectional views through the transfer area between transit route and transfer route;

Fig. 14 shows a detailed view of the connection area between transit route and transfer route; and

Figs. 15a, 15b show views of a preferred embodiment in which the elevated tracks comprise guiding devices for suspended vehicles, in particular for maglev cabins, at the bottom side thereof.

In the drawing there is shown an elevated track system 1 which forms a traffic network by elevated tracks 2 running above a ground area 3 (see Fig. 7). On the one hand, transit routes 4 are provided as elevated tracks 2, said transit routes 4 having straight-lined longitudinal roads 5 and transverse roads 6 which cross one another at right angles so that, when viewed from above, a chequered traffic network is obtained. At the crossing areas 7, the transit routes 4 run at different height levels (see Fig. 4). According to that, the traffic flows are not impeded by the crossing areas 7 for which, consequently, no traffic control with traffic lights, rules for right of way or the like is required.

As becomes further obvious from Figs. 1 to 3, the transit

routes 4 are formed as narrow one-way roads having a width of for instance approximately 2 meters and having one single lane 4'. The longitudinal roads 5 or the transverse roads 6 are oriented alternately in opposite directions 5', 5'' or 6', 6''.

As can also be seen from Fig. 1, the elevated tracks 4 also have circulating transfer routes 8 which form closed traffic loops. The transfer routes 8 run between sections 9 of the transit routes 4, which are formed between adjacent crossing areas 7. In the shown embodiment, each transfer route 8 is limited by four transit route sections 9 all-round. Equivalent to the transit routes 4, the transfer routes 8 are formed as one-way roads which are driven through in the same driving direction as the adjacent transit route sections 9 (see arrows 10 in Fig. 1). The edge length 1 of the traffic network, i.e. the length of the transit route sections 9, ranges from 0.25 to 4 kilometres, preferably from 0.5 to 2 kilometres, in particular preferably from 0.75 to 1.25 kilometres, or is in particular approximately 1 kilometre.

As further becomes obvious from Fig. 1, each transit route section 9 adjoins exactly one transfer route 8 so that a close-meshed traffic network is obtained which has a plurality of access or transfer junctions. For getting from a starting point A to a destination B, it can be chosen between different routes, as is schematically shown in Fig. 1. This can preferably be supported by a traffic guidance system or traffic control system.

As becomes obvious from Fig. 2, the transit route sections 9 are connected to the circulating transfer routes 8 along transfer areas 11. The transfer areas 11 each have a lane change zone at which the transit route 4 and the transfer route 8 run side by side at the same height so that, on the one hand, vehicles can turn off from the transit route 4 onto the transfer route 8 (see arrows 12), and, on the other hand, vehicles can leave the transfer route 8 towards the transit route 4 (see arrows 13).

As further becomes obvious from Fig. 2, each transfer route 8 has substantially straight running transfer sections 14 which include the transfer areas 11. The transfer sections 14 are connected to one another by means of arc-shaped curved curve sections 15. In the shown embodiment, the transfer sections 14 run in parallel to the adjacent transit route sections 9. The transfer routes 8 are connected to the transit route sections 9 at

all four transfer sections 14 via two transfer areas 11, respectively.

As becomes obvious from Figs. 3, 4, the transfer routes 8 have deceleration or stop sections 16 running at a lower height than the adjacent transit route sections 14, but above the ground area 3. In the shown embodiment, each transfer section 14 has a deceleration or stop section 16. At the deceleration or stop sections 16 the vehicles are guided between the transfer areas 11 with a speed which is lower than the one in the transit routes 4. Furthermore, vehicles 23 can be parked at the deceleration or stop sections 16 (see Fig. 6).

As becomes further obvious from Fig. 4, the transfer routes 8 are connected to access roads 17 which lead to the ground area 3. In this connection, a first access road 17' is used for driving up into the deceleration or stop section 16 of the transfer route 8. For leaving the deceleration or stop section 16 of the transfer route 8 there is provided a second access road 17''. Accordingly, each transfer section 14 is connected to two access roads 17. Furthermore, in Fig. 4 there are schematically shown escalators 33 by means of which passengers can get to the deceleration or stop section 16.

As becomes obvious from Fig. 5, the deceleration or stop section 16 has a slip lane 18 and a pedestrian area 18', 18'' as a getting-on or getting-off zone for passengers, wherein the slip lane 18 is connected to the first access road (on-ramp or integrating zone) 17' so that the vehicles can be integrated into the traffic flow of the circulating transfer route 8 when slowing down, for instance according to the principle of alternation (zip merge). For this purpose, the transfer route 8 comprises a deceleration distance 8 in the driving direction before the deceleration or stop section, and an acceleration distance 20 in the driving direction after the deceleration or stop section. The deceleration or stop section also has an exit lane (exit ramp or off-ramp) 21 (as a pedestrian zone or a getting-off zone for passengers) which is connected to the second access road (or exit ramp or off-ramp) 17'' and via which the elevated track system 1 can be left (for instance via the staircases or escalators for passengers 33). In the deceleration or stop section 16 the vehicles move with a low speed. Furthermore, a traffic guidance or control system can be provided by means of which

the vehicles are guided through the deceleration or stop section 16. Such systems are for instance known from mountain lift facilities.

As is shown in Fig. 6, the deceleration or stop section 16 can also comprise parking spaces 22 for parking vehicles 23. In this connection, the vehicles 23 can turn off from the deceleration or stop section 16 in the driving direction 24 into the individual parking spaces 22.

As becomes obvious from Fig. 7, the elevated tracks 2 are arranged by means of supports or supporting pillars 25 at a height  $h$  of more than 4.5 meters above the ground area so that the normal traffic running below them can function in an unimpeded manner. The width  $b$  of the elevated track 2 is approximately 2 meters. In the shown embodiment, the elevated tracks 2 are formed by precast elements made of ultra high performance fibre reinforced concrete which distinguishes itself by a particularly high strength and durability. The use of ultra high performance fibre reinforced concrete (UHPFRC) enables the use of thin-walled precast elements with a central cavity 26.

As becomes obvious from Figs. 8 to 10, the elevated tracks 2 have guardrails 27 on both sides (not shown in Fig. 8), by means of which the lane 4' is safeguarded. The guardrails 27 are connected at regular intervals to vertical posts or uprights 28, said posts 28 being anchored at widenings 29 of the lane 4'. The guardrails are arranged preferably at a height of approximately 75 centimetres.

In Figs. 11 to 14 there are shown different sectional views along the transfer area 11 between transit route 4 and transfer route 8. In the curve section 15 according to Fig. 11, the transit route 4 runs at a distance to the transfer route 8. As is shown in Fig. 12, in the driving direction before the transfer area 11 the transit route 4 and the transfer route 8 run side by side. Here the lanes 4' are still separated from one another by guardrails 27. As is shown in Fig. 13, within the transfer area 11 the transit route 4 and the transfer route 8 are firmly connected to one another. In the shown embodiment, a deformation coupling 30 is provided in the connection area between the transit route 4 and the transfer route 8. As becomes obvious from Fig. 14, the transit route 4 as well as the transfer route 8 have a sealing foam 31 and UHPFRC 32 in the connec-

tion area.

In Figs. 15a, 15b there is shown another embodiment of the elevated track system 1, in which at the bottom side of the elevated tracks 2 opposite to the lanes 4' there are provided guiding devices 34 at which suspended vehicles 35 (schematically shown in the drawing) can be guided. The suspended vehicles 35 are preferably designed as maglev cabins for individual traffic, which are suspended in (schematically illustrated) mounting rails 36. In this embodiment, on the one hand the lanes 4' at the top of the elevated tracks 2 are used for the transport of wheeled passenger cars 37. On the other hand, the capacity of the elevated track system 1 is further increased by the suspension of suspended vehicles 35 at the bottom side of the elevated tracks 2. Here, the elevated tracks 2 are formed by precast elements made of concrete, in particular of ultra high performance fibre reinforced concrete, and comprising a central cavity 26. Furthermore, in Fig. 15 there are shown supports or supporting pillars 25 for supporting the elevated tracks 2, wherein in the embodiment according to Fig. 15a there are provided two elevated tracks 2 at the same height level, and wherein in the embodiment according to Fig. 15b there are provided two elevated tracks 2 at different height levels. It is self-evident that the arrangement of the elevated tracks 2 can be modified in a great variety of ways, wherein for the present disclosure it is of importance that the elevated tracks 2, on the one hand, are formed by transit routes 4 crossing one another, and, on the other hand, by circulating transfer routes 8.

Claims

1. An elevated track system (1) with elevated tracks (3) running above ground level, characterized in that the elevated tracks (3) have transit routes (4) crossing one another, running one above the other at the crossing areas (7), and circulating transfer routes (8) surrounded by transit route sections (9) between the crossing areas (7), wherein the transit route sections (9) are connected to the circulating transfer routes (8) along transfer areas (11).
2. The elevated track system (1) according to claim 1, characterized in that the transfer route (8) is surrounded by transit route sections (9) between adjacent crossing areas (7).
3. The elevated track system according to claim 1 or 2, characterized in that the transfer route (8) is surrounded by substantially straight running transit route sections (9).
4. The elevated track system according to anyone of claims 1 to 3, characterized in that the transfer route (8) is surrounded by four transit route sections (9).
5. The elevated track system according to anyone of claims 1 to 4, characterized in that the transfer route (8) is surrounded by transit route sections (9) running substantially at right angles to one another.
6. The elevated track system according to anyone of claims 1 to 5, characterized in that, at least in the transfer areas (11), the transit route sections (9) run substantially in parallel to the transfer route (8).
7. The elevated track system according to anyone of claims 1 to 6, characterized in that each transit route section (9)

adjoins at least one, preferably exactly one, transfer route (8).

8. The elevated track system according to anyone of claims 1 to 7, characterized in that the transfer route (8) has substantially straight running transfer sections (14) connected to one another via curve sections (15) running in an arc-shaped manner.
9. The elevated track system according to anyone of claims 1 to 8, characterized in that the transfer route (8) is connected to each adjacent transit route section (9) via at least one, preferably two transfer area(s) (11).
10. The elevated track system according to anyone of claims 1 to 9, characterized in that the transit routes (4) are formed as one-way roads which have one single lane (4'), respectively.
11. The elevated track system according to anyone of claims 1 to 10, characterized in that the transit routes (4) have a width of 1.5 to 3 meters, preferably substantially 2 meters.
12. The elevated track system according to anyone of claims 1 to 11, characterized in that the transfer route (8), preferably at each transfer section (14), is connected to at least one access road leading to the ground.
13. The elevated track system according to anyone of claims 1 to 12, characterized in that the transfer route (8) has at least one deceleration or stop section (16) running at a lower height than the adjacent transit route section (9).
14. The elevated track system according to anyone of claims 1

to 13, characterized in that the elevated tracks (2) are formed by precast elements made of fibre reinforced concrete, preferably ultra high performance fibre reinforced concrete.

15. The elevated track system according to anyone of claims 1 to 14, characterized in that at least several of the elevated tracks (2) have guiding devices (34) for suspended vehicles (35), in particular for maglev cabins, at the bottom side thereof.