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CONSTRUCTION LAYOUT OF STATIONS AND ITS IMPACT TO TRAIN DELAYS

Abstract. The paper focuses on construction layout of railway stations, mainly platforms for boarding passenger trains. Platform layout has significant impact to the operation of trains, because passengers cross some tracks horizontally, when the train boarding is necessary. Horizontal track crossings cause possible dangerous situations from passengers' point of view as well as operational problems from dispatcher point of view, because other trains have to slow or stop their ride. It may cause delays and it negatively influences timetable planning too. The problem is deeply analysed and described in a case study of Opatov railway station.
Keywords: railway transport, safety of passengers, station layout, train delay

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Introduction

Construction layout varies in each railway station, so scientific method of induction is the best way for the analysis and solution of the problem as well as way to prove the impact of the layout to train delays. Induction means that the general solution is found from particular examples therefore the case study of railway station Opatov is used in the paper.

In the railway station Opatov, there are three platforms for boarding passenger trains. It is necessary to cross some tracks horizontally, when passengers is going to get on or get off the train. Construction layout of the railway station Opatov is shown in the figure 1.

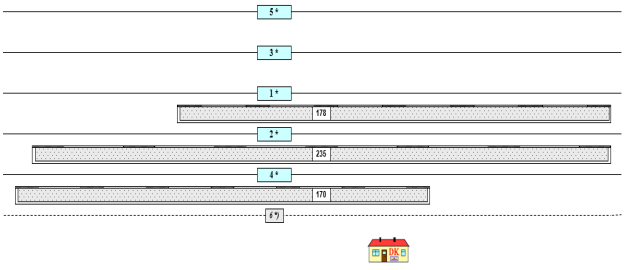

Fig. 1. Station tracks and platforms in railway station Opatov

In case when passenger trains stop there for boarding, it is necessary to decide the right point of stopping. If other train at the same time is arriving to the station or going through the station, it is also necessary to decide the right order of these trains. It may cause dangerous situation for passengers when they are crossing tracks horizontally, because the second train route could collide with passengers' movement. Simple solution is to indicate the train route of stopping train to those station tracks, which are closer to the station building as the track, which is used for other trains. From operation point of view, these problems may occur:

1. The stopping passenger train delays due to the ride of other train with higher priority.
2. Other train has to stop out of the railway station while the stopping passenger train is waiting for passengers' boarding.
3. First stopping train has to wait in the railway station until second stopping train is waiting for passengers' boarding.

1. Analysis of the railway operational problems

Operational problems can occur in case when other type of railway vehicle is used, because it determines the maximum speed of the train. Simple analysis is done on selected situation from the train timetable of regional passenger train no. 4765 and long-haul express train no. 273. Period for the analysis is one month (30 days) – November 2020. Analysis provides these outputs:

1. Regional passenger train was everyday operated by railway vehicle with maximum speed 80 kph instead of 120 kph as it had been planned for the timetable. It caused that average ride time from station Česká Třebová to station Opatov was 10 minutes instead of 7 minutes as it is done in timetable. Difference is 3 minutes. It led to situation that the long-haul express overtook regional passenger train 21 times (70%).
2. Average arrival delay was 3.57 minutes while average departure delay was 5.53 minutes. This means that the delay of regional passenger train was increased due to redundant waiting caused by operational situation described below.
3. Average ride time of the long-haul express from station Česká Třebová to station Opatov is 6.97 minutes but in timetable, 8 minutes of ride time for this type of train is there. Ride time could be

decreased to 6 minutes because current ride time involves also deceleration of this train in case when regional passenger train occupies the track.

Other situation that causes operational problems was analysed with one-month period (31 days) – October 2020. Dispatcher decided to prefer long-haul train from the direction Svitavy. Regional passenger trains had to wait. The analysis provides these outputs:

1. This situation occurred 10 times. Regional passenger train had to wait due to freight train four times and due to other passenger train.
2. Regional passenger train increased its delay about 3 minutes in average.

Due to the lower speed of some freight trains, it is not always advantageous to stop the regional passenger train so usually freight trains stop and regional passenger trains are prioritised. Stopped freight train waits until the regional passenger train depart from the platform. This situation will not delay the regional passenger train, but freight train has to wait. A similar type of situation can also occur in a combination of regional passenger train from the opposite direction Česká Třebová. Everything depends on dispatcher's choice and preference as well as current operational situation. This situation was also monitored in the same period – October 2020 when seven such cases occurred:

1. Just five freight trains were affected; one long-haul passenger express train and one regional passenger train were affected too.
2. In all cases, there was an increase in the delay of the train going from the direction Svitavy by at least 2 minutes, on average by 3 minutes. Combination of two passenger trains led to 2 minutes increase of delay while the delay of freight trains was increased by 3-5 minutes. It is mainly due to the higher weight of trains and thus longer time needed to acceleration.

2. Alternative solutions for operational problems

Operational problems in railway station Opatov is mainly caused due to the necessity that passengers should horizontally cross some station tracks when they want to board the train. It means that entrance to each platform in the station is on the same level as all station tracks. These level crossings also have an impact on station technology and organization of train routes there. The most difficult situation is the case when regional passenger train in the direction from Česká Třebová to Svitavy is led to station track no. 1 and another train in Opatov railway station does not overtake this train. High risk comes from trains with opposite direction, because their ride would directly endanger the safety of passengers who get on or get off the regional passenger train. This situation can be solved in two ways:

1. Regional passenger train will wait at the entrance of the station until the train of opposite direction pass the station.
2. Regional passenger train standardly arrives to the station while the train of opposite direction is waiting at the entrance of the station until the regional passenger train departs.

Both ways cause the delay of the train, because some of trains has to wait at the entrance of the station. This reason will increase the delay by an average of 3 minutes. The occurrence of this delay is directly evidenced by the platform-operating interval. Next part of the paper is aimed to description of three possible alternatives, which can solve operational problems as well as increase safety for the traveling public.

First alternative means that a new platform between tracks no. 1 and no. 5 will be built. This platform will be accessible only by underpass or overpass, so passengers will not cross directly and horizontally any station track. It is necessary to have much space for this new platform and PRM needs must be taken into account. It means that station track no. 3 will be cancelled, because new platform must have minimum 6.1 meters wide. Distance between each station tracks is only 4.75 meters therefore one station track (no. 3 as it was mentioned below) must be cancelled. Less station tracks will decrease the capacity of the station as well as the whole railway line, what is significant negative aspect of this alternative, what may cause other operational problems. First alternative is shown in the figure 2.

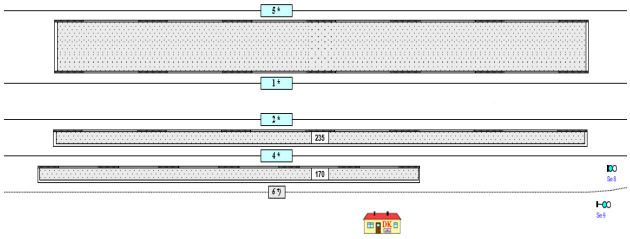

Fig. 2. First alternative – new platform between tracks 1 and 5

Second alternative means that a new platform behind the station track no. 5 will be built. This platform will be accessible only by underpass or overpass, so passengers will not cross directly and horizontally any station track. Advantage of this alternative is that platform-operating intervals will be eliminated. In the figure 3, there is proposed layout of the railway station Opatov according this alternative.

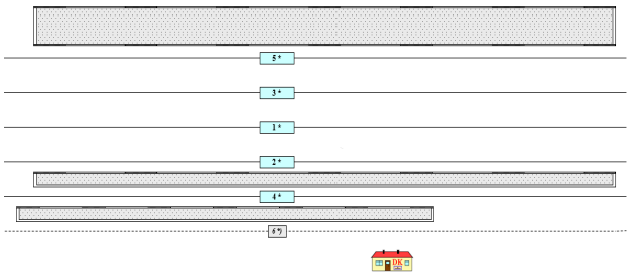

Fig. 3. Second alternative – new platform at track 5

In case that the same track layout is used for this alternative as well as all speed limits, it will negatively influence the ride time of regional passenger trains. Trains should follow junction speed limits, when their route is not on direct station track. Current junction speed limit is 40 kph therefore each train, which will use new platform, will be limited and the ride time will increase, but not significantly.

Third alternative means that two new platforms will be built according the figure 4. This alternative combines advantages and disadvantages of previous alternatives but it has not so negative impact to station tracks capacity as well as train ride will be influenced only partly in one direction, because it depends on junction speed limits.

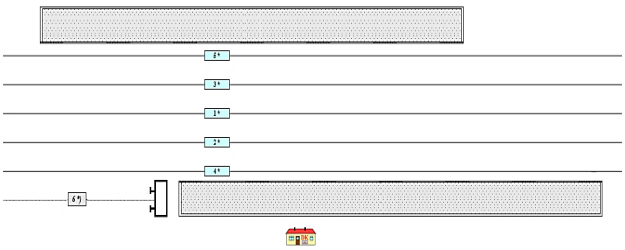

Fig. 4. Third alternative – new platforms at tracks 4 and 5

Description of each alternative points out that there are important issues with significant impact to overall evaluation – junction speed limits (JSL). Exact impacts to traveling times (TT) of regional passenger trains according the vehicle type is shown in the table 1.

Table 1. Comparison of riding times on different station tracks

TRAVELING TIME Svitavy-Lačnov → Semanín				
Vehicle (type)	**JSL** (kph)	**TT** (min)	**TT** (min)	**Δ TT** (min)
814	60	6.5	7	+0.5
841		5.5	6	+0.5
814	80	6.5	6.5	0
841		5.5	5.5	0
841	100	5.5	5.5	0

It seems that junction speed limit 100 kph is the best but this speed is not sufficient for both vehicles, because vehicle type 814 has the maximum speed just 80 kph. In case when the train is moving 100 kph (only vehicle type 841), it must brake therefore the potential will not be fulfilled. In case of acceleration, this type of vehicle cannot reach the speed 100 kph before junction therefore the potential will not be fulfilled too. This parameter is based on total length of station tracks, mainly those tracks, where are the platforms for boarding passenger trains. Station track length is limited so it must be also take into account. Optimal solution from traveling time point of view is junction speed limit 80 kph. It is necessary to prove that vehicles and traveling time will be influenced by this junction speed limit. It is proved in the figure 5.

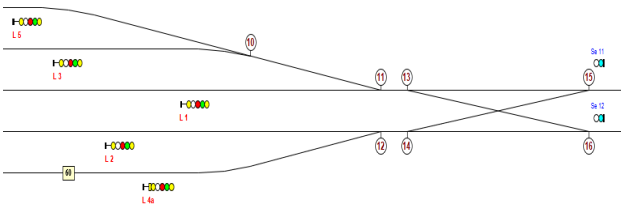

Fig. 5. Junction area in the station Opatov

Conclusions

Conclusions is done by multicriteria analysis and the comparison of presented alternatives. As it was described in previous chapters, operational problems result from platforms and track level horizontal crossings as well as number of station tracks, junction speed limits and vehicle type. These parameters and aspects directly influence traveling time of each train. Due to some unexpected situations, possible dangerous situations for the traveling public may occur. Alternatives offer solution for these problems as well as their impact to train delays and reasons of those delays. Table 2 shows criteria and current situation. Table 3 compares each alternative according the criteria. Problematic values are marked red while right values are marked green.

Table 2. Criteria and current situation

CRITERIA	**NOW**
Level crossings for direction Č. Třebová	Yes
Level crossings for direction Svitavy	Yes
Train route cross the passenger path	Yes
Interval – pass and arrive (min.)	+3
Interval – depart and pass (min.)	+2.5
Ride on track no. 5 speed above 40 kph	No
Ride on track no. 4 speed above 40 kph	No
Number of station tracks	5

Table 3. Comparison of alternatives according criteria

Alternative 1	**Alternative 2**	**Alternative 3**
Yes	Yes	No
No	No	No
No	No	No
0	0	0
0	0	0
No	Yes	Yes
No	No	Yes
4	5	5

Third alternative has only positive values in the comparison therefore this alternative seems to be the best. Complex solution is based on elimination of level crossings by building of new platforms with overpass or underpass. Number of station tracks in third alternative is the same as currently so track capacity is enough.

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